# ACCESSIBILITY- VS. MOBILITY-ENHANCING STRATEGIES FOR ADDRESSING AUTOMOBILE DEPENDENCE IN THE U.S.

by

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Prepared for the European Conference of Ministers of Transport
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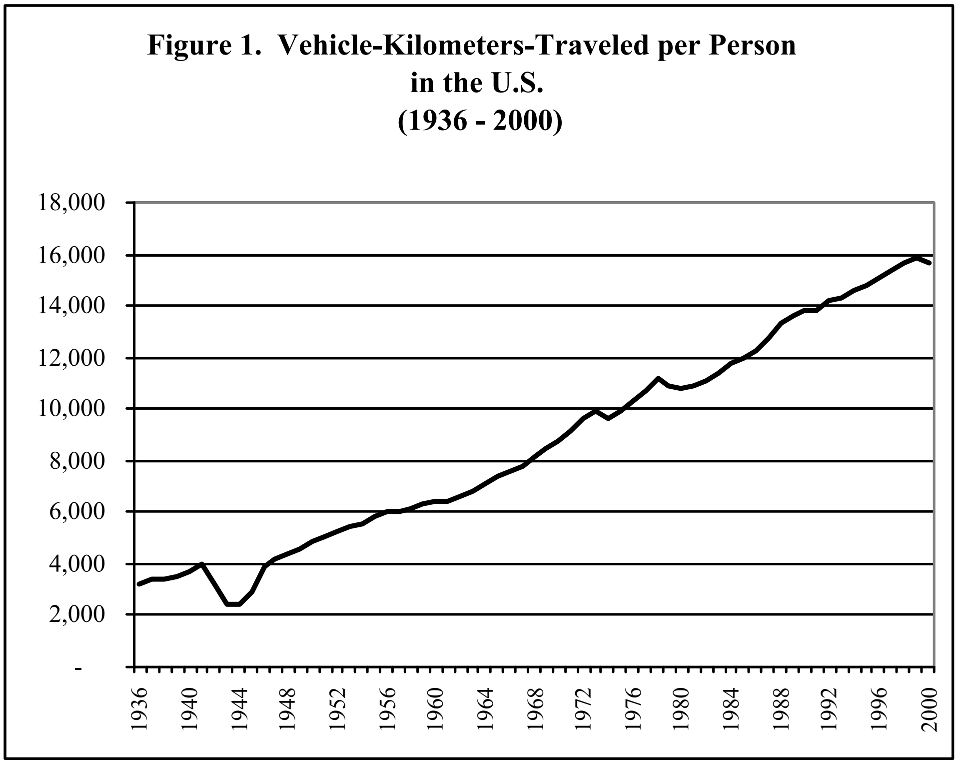
## 1. INTRODUCTION

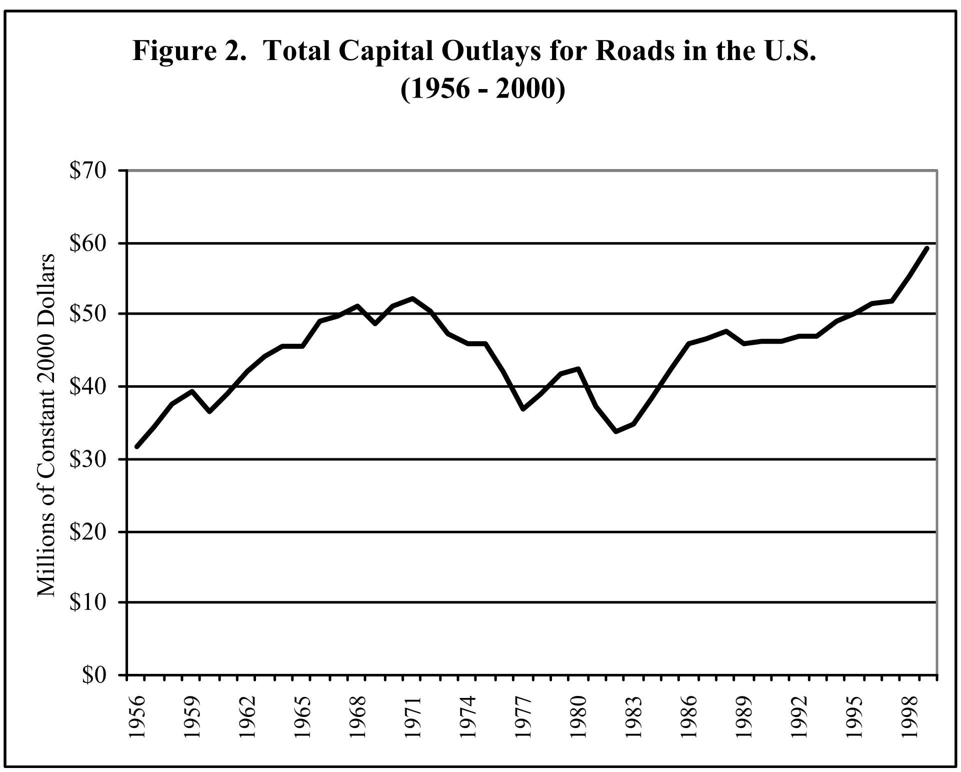
In 1995, the average American spent 56 minutes a day in a car, a 14 percent increase from only five years earlier (US DOT 2001). The average American household drove over 33,000 kilometers per year (US DOT 2001), and the average American car was driven over 19,000 kilometers per year (US DOT 2000a). The growth in total vehicle-kilometers-traveled in the U.S. has continued unabated for decades, far exceeding the growth in population (Figure 1). The U.S. is clearly the most auto-dependent society on earth, but other parts of the world are catching up. By 2000, there were more cars per person in Germany than in the U.S., and nearly as many in Sweden, France, and Canada (US DOT 2000a). The average vehicle in the United Kingdom was driven over 17,000 kilometers per year, just 11 percent behind the average in the U.S. (US DOT 2000a). Automobile dependence is growing throughout the world.

Growth in automobile travel has been well supported by public investments in roads. Total capital outlays for roads in the U.S. by all levels of government have totaled between $30 billion and $50 billion per year (in constant 2000 dollars) for decades and have approached $60 billion per year in recent years (Figure 2). By 2000, the U.S. had over 3.9 million miles of roads, including over 21,000 miles of freeways in urban areas, and the annual cost of maintaining this system had reached nearly $30 billion per year (US DOT 2000a). From the beginning, the mission of the U.S. Department of Transportation has been to accommodate the growing demand for vehicle travel. Today, the department has established “mobility” as one of its strategic goals and uses trends in vehicle travel as an indicator of progress towards this goal (BTS 2002). In its 2001 “Report to the American People,” the Federal Highway Administration said, “we must continue to invest in America’s highways in order to achieve our national goals” (FHWA 2001).

But the investments in roads have not kept up with the growth in vehicle travel. Between 1941 and 2000, total kilometers of roads in the U.S. increased by 145% but vehicle-kilometers-traveled increased by 724%. The gap is significant even when accounting for population growth: kilometers of roads per person increased by 16% while vehicle-kilometers-traveled per person increased by 290% between 1941 and 2000. As demand has outpaced supply, levels of congestion have increased. The Texas Transportation Institute (TTI) calculates that in the 68 largest metropolitan areas in the U.S. the average annual hours of delay per person grew from 11 in 1982 to 36 in 1999, an increase of 227% (TTI 2001). The estimated cost of this delay reached $77.8 billion in 1999. How much more road building would it take to eliminate this delay? TTI estimates that metropolitan areas added only 48% of the roads they needed to keep up with the growth in vehicle travel in 1999.




Source: U.S. DOT 2000, U.S. DOT 1985




Source: U.S. DOT 2000, U.S. DOT 1985

At the same time, the environmental consequences of this steady growth in automobile use are well known. Although air quality is better now in places like Los Angeles than it has been in decades, the problem is far from solved. In the U.S., emissions of volatile organic compounds from transportation have been decreasing steadily for the last three decades (BTS 2002), but emissions of nitrogen oxides have been going up, and 36 areas that are home to a total of 85 million people still fail to officially meet the national standards for ozone (EPA 2002). The transportation sector dumped 513 million metric tons of carbon dioxide, a major greenhouse gas, into the atmosphere in 2000, a 3.43% increase from the year before (BTS 2002). In 1999, the U.S. consumed 19.5 million barrels of oil per day, 26.5% of the world's consumption; 68% of oil consumption in the U.S. was for transportation, and consumption of oil in the U.S. for transportation alone exceeded total production of oil in the U.S. by 50% (Davis 2001). These statistics and others seem to provide ample justification for policies to reduce automobile use.

That leads to something of a dilemma for policy makers. Should policies focus on accommodating growing levels of vehicle travel because driving more is apparently what the public wants to do? Or should policies focus on limiting driving so as to reduce environmental and other costs? The former strategy has so far been more politically palatable, at least in the U.S., but it is also becoming increasingly unaffordable. The latter strategy means reversing a trend that has slowed only for wars and recessions and goes against American traditions of freedom of movement. So what's the right thing to do? One obvious approach is to push for further improvements in vehicle and fuel technologies that will reduce the environmental impacts of driving without in anyway limiting driving. But that leaves the problem that driving is growing faster than capacity possibly can. It also leaves the problem that a significant share of the population cannot drive or does not have access to a car, for reasons of income, age, or ability. An alternative approach that is gaining wide support in the U.S. is to reduce the need for driving by bringing activities closer to home, by improving the quality of transit, bicycling, and walking – by enhancing accessibility. Such an approach represents a fundamental shift from a traditional focus on enhancing mobility through road building. This report looks at what it means to focus on enhancing accessibility rather than enhancing mobility, first by defining these concepts then by reviewing the U.S. experience with mobility-enhancing strategies, accessibility-enhancing strategies, and others.

## 2. ACCESSIBILITY VS. MOBILITY

The terms "accessibility" and "mobility" are often used together in transportation plans but without clear distinction. For example, the long-range transportation plan for the Austin, TX metropolitan region has as a primary goal "to provide an acceptable level of accessibility and mobility for the region's residents with the least detrimental effects" (CAMPO 2000). The long-range plan for the Chicago metropolitan area establishes the goal of providing "an integrated and coordinated transportation system that maximizes accessibility and includes a variety of mobility options" (CATS 2002). The Transportation Equity Act of the 21st Century (TEA-21), passed by the U.S. Congress in 1998, requires that regional planning agencies consider the goal of increasing "the accessibility and mobility options available to people and for freight" (FHWA 1998). In none of these examples are these terms explicitly defined.

The distinction between the two concepts is important, however. The American Heritage Dictionary Fourth Edition defines "mobility" as "the quality or state of being mobile" and "mobile" as "capable of moving or of being moved readily from place to place" (Picket et al. 2000). The Oxford English Dictionary defines "mobility" as the "ability to move or to be moved… facility of movement" (OED 2002). In the context of transportation planning, mobility has been defined as the potential for movement, the ability to get from one place to another (Hansen 1959; Handy 1994). Traditional level-of-service measures used in transportation planning are measures of mobility; higher volume-to-capacity ratios mean slower travel times, less ease of movement, and thus lower mobility. Mobility is sometimes also measured by actual movement, either numbers of trips made or total kilometers traveled. Actual movement is not necessarily an accurate measure of the potential for movement, however. First, potential movement can exceed actual movement, for example, if individuals choose to drive less than they could. Second, increases in actual movement can mean decreases in potential movement, as is the case when roads are congested.

Accessibility has been both harder for planners to define and to measure. The American Heritage Dictionary Fourth Edition defines "accessibility" as "easily approached or entered" (Picket et al. 2000). The Oxford English Dictionary defines "accessibility" as "the quality of being accessible, or of admitting approach" (OED 2002). Accessibility was perhaps more clearly defined for the planning context by Hansen (1959) as "the potential for interaction." In most cases, measures of accessibility include both an impedance factor, reflecting the time or cost of reaching a destination, and an attractiveness factor, reflecting the qualities of the potential destinations. Researchers have used many different forms of accessibility measures and have raised many important issues about these measures (Handy and Niemeier 1996). Simple "cumulative-opportunities" measures, which count the number of destinations of interest within a certain time or distance of the origin point, seem to be coming into greater use in transportation planning. Choice is an important element of accessibility: more choices in both destinations and modes of travel mean greater accessibility by most definitions.

Part of the confusion in the use of these terms may stem from the relationship between them. Mobility, the potential for movement, is related to the impedance component of accessibility, in other words, how difficult it is to reach a destination. Policies to increase mobility will generally increase accessibility as well by making it easier to reach destinations. But it is possible to have good accessibility with poor mobility. For example, a community with severe congestion but where residents live within a short distance of all needed and desired destinations has poor mobility but good accessibility. In this case, accessibility is not dependent on good mobility. It is also possible to have good mobility but poor accessibility. For example, a community with ample roads and low levels of congestion but with relatively few destinations for shopping or other activities or with undesirable or inadequate destinations has good mobility but poor accessibility. Good mobility is neither a sufficient nor a necessary condition for good accessibility.

Planning efforts that focus on enhancing accessibility have very different consequences than planning efforts that focus on enhancing mobility. To plan for mobility is to focus on the means without direct concern for the ends: can people move around with relative ease? The traditional emphasis on road building in the U.S. is consistent with a planning-for-mobility perspective in that the aim is to accommodate growing levels of travel and increase the potential for movement. The planning process traditionally started with a projection of future traffic volumes that was followed by a determination of the capacity needed to accommodate those volumes at acceptable levels-of-service. The focus was on the performance of the system. Many of the Intelligent Transportation System (ITS) applications being implemented and proposed today can also be classified as mobility-enhancing strategies in that their goal is to improve the efficiency of the system. To plan for accessibility, in contrast, is to focus on the ends rather than the means and to focus on the traveler rather than the system: do people have access to the activities that they need or want to participate in? This perspective broadens the range of possible strategies beyond road building and ITS to strategies that enhance accessibility without necessarily increasing travel, including the use of land use policies and telecommunications technologies to provide accessibility, as discussed in the sections that follow.

Although planning for mobility can be compatible with planning for accessibility, the entrenched focus on mobility in transportation planning in the U.S. has over time helped to decrease accessibility, primarily by encouraging sprawling patterns of development that limit choices. In the suburban areas of metropolitan regions, transit service is relatively sparse and destinations are generally beyond walking distance, leaving residents with no option but to drive. Growing homogeneity in destinations as a result of the proliferation of chain stores, especially "big box" stores, further limits choices. The result is a decline in accessibility, at least for those who need or would like to travel by modes other than the automobile and those whose needs and desires are not met by the kinds of shopping, services, and other activities found in the suburbs. But even for those residents who prefer to drive, accessibility is threatened. Accessibility in suburban areas depends on driving, but this dependence leads to increases in driving, and as driving increases, traffic increases, and accessibility ultimately declines (Handy 1993).

Planning for accessibility rather than mobility can create benefits by expanding choices and reducing the need to drive. For example, a city might adopt policies to encourage small-scale retail development in residential areas, thereby bringing shops within walking distance, or a city might operate a circulator bus route that links residential areas to commercial areas, or a city might provide access to its services via the Internet and eliminate the need for a trip to city hall altogether. Instead of being forced to deal with increasingly pervasive traffic, residents can then choose to participate in needed and desired activities without driving. Everyone wins: residents get to do the things they need and want to do while reducing the time and cost they devote to driving, and the community as a whole gets potentially lower costs for building and maintaining roads as well as fewer negative impacts on the environment.

But there is no guarantee that planning for accessibility will actually reduce driving even if it succeeds in reducing the need for driving. Recent data in the U.S., presented earlier, suggests that the steady growth in vehicle travel has slowed but not stopped even as congestion levels have dramatically increased. These trends suggest that the demand for driving is relatively inelastic with respect to time, although this apparent inelasticity may have more to do with the lack of alternatives to driving than to a preference for driving. The effectiveness of accessibility-enhancing strategies to reduce driving may be constrained by the fact that certain segments of the population value driving more than they do the opportunity to drive less (Salomon and Mokhtarian 1998). Indeed, researchers have found evidence that driving has a positive utility for some individuals on some occasions, challenging the standard assumption that travel is purely a derived demand. Mokhtarian and Salomon (2001), in a survey of residents of the San Francisco Bay Area, found that three-quarters of respondents sometimes or often travel "just for the fun of it" and nearly two-thirds at least sometimes travel "by a longer route to experience more of your surroundings." Americans may complain about traffic and about spending too much time in their cars, but most Americans on at least some occasions actually enjoy driving. Whether providing good alternatives will get them out of their cars to a significant degree is uncertain, as discussed below.

What could more directly help to reduce the total amount of vehicle travel are strategies designed to limit mobility. While strategies to enhance accessibility may lead to changes in behavior by improving the alternatives to driving, strategies to limit mobility may lead to changes in behavior by reducing the utility of driving. Mobility-limiting strategies include physical barriers to driving, such as auto-restricted zones, and pricing strategies, including gas taxes, parking fees and congestion pricing. Mobility-limiting strategies on their own, however, offer little promise for reducing driving: there must be alternatives of the sort that accessibility-enhancing strategies can provide, or residents will simply pay more and spend longer getting to where they need to go. Together, accessibility-enhancing and mobility-limiting strategies have more potential to change behavior than either approach on its own. Together, they balance the need to ensure access to needed and desired activities with the imperative of reducing the environmental impacts of driving.

Both accessibility-enhancing and mobility-limiting strategies have received more attention in the U.S. in recent years as decision makers increasingly recognize that the funds available for road building and maintenance fall far short of the projected needs. The mobility-enhancing approach is deeply entrenched in transportation planning in the U.S., but the willingness to consider other approaches is growing. The case for accessibility-enhancing strategies is easier to make than the case for mobility-limiting strategies, given the value placed on freedom of movement and the unpopularity of taxes in the U.S. But accessibility-enhancing strategies pose significant challenges of their own, including traditional divisions between agencies with responsibilities for transportation planning and those with responsibility for land use planning. Still, the idea that planning should focus on expanding choices is catching on.

The remainder of this report reviews the U.S. experience with mobility-enhancing strategies, accessibility-enhancing strategies, and mobility-limiting strategies. The following sections will examine both the kinds of strategies that have been used and the available empirical evidence of their effectiveness. A growing body of evidence suggests that mobility-enhancing strategies, particularly road building, are not sustainable from either a financial or a mobility standpoint. The evidence on accessibility-enhancing strategies is surprisingly mixed, at least with respect to their ability to reduce driving. The evidence on mobility-limiting strategies is more promising, but the examples of their implementation are notably limited. In the end, this review points to the need for a new way of thinking about transportation in the U.S.

## 3. MOBILITY-ENHANCING STRATEGIES

Mobility-enhancing strategies generally focus on improving the flow of traffic and improving the performance of the system. Road building, both the construction of new roads and the expansion of existing roads, has long been the dominant mobility-enhancing strategy in the U.S. and the dominant transportation strategy, period. In the last decade or so, the field of Intelligent Transportation Systems (ITS) has evolved as another important mobility-enhancing strategy. Although ITS comprises lots of very different applications, the general aim of these applications is to improve the efficiency of the transportation system and make better use of existing capacity. The primary goal of both road building and ITS is to increase the potential for movement. However, at least in the case of road building, a growing body of evidence suggests that the effectiveness of this strategy is limited, and in the case of ITS, many questions about its effectiveness have not yet been addressed by the research. The primary issue is the degree to which mobility-enhancing strategies increase actual movement and, by doing so, offset improvements in potential movement.

### 3.1 Road building

Road building has a long and gloried history in the U.S. The most obvious example of this tradition is the Dwight D. Eisenhower Interstate System, first funded by the U.S. Congress in 1950s. This highway system, declared nearly complete at 47,794 miles and a total cost of $128 billion by the 1990s (FHWA 2002a), is often touted as the greatest public works program in history (e.g. Weingroff 1996; WashDOT 1996). But road building, in the form of the widening of existing roads and the building of entirely new roads, has not stopped. The Transportation Equity Act for the 21$^{st}$ Century (TEA-21), passed by Congress in 1998, authorized over $218 billion for surface transportation over a six-year period, 82% of it for highway programs. Although TEA-21 provided flexibility to shift funds from highways to transit and other projects, state departments of transportation “continue to focus on ‘core’ highway projects,” according to the Federal Highway Administration (FHWA 2002b).

Even with recent increases in funding available for highways, however, the projected needs far exceed the projected funds. In response to this shortfall, TEA-21 emphasized the need for innovative financing techniques and created new programs to help state departments of transportation raise sufficient funds to build needed roads sooner than later. The TIFIA (Transportation Infrastructure Finance and Innovation Act) program, for example, provided $2.4 billion in credit assistance in 2001 in the form of direct loans, loan guarantees, and standby lines of credit for selected projects across the U.S. GARVEE (Grant Anticipation Revenue Vehicle) bonds allow states to borrow against future transportation funding from the federal government. Selected states can now transfer up to 10% of federal funds into a State Infrastructure Banks (SIBs), which provide a revolving loan fund that local jurisdictions can tap to begin projects sooner than they would otherwise be able to. These programs, which increase the rate of borrowing against future transportation funding but do not increase the total amount of transportation funding, reflect a compromise between the American distaste of new taxes and the demand for new and wider roads.

But even if the available funding were sufficient to meet the projected needs, it is not clear that this strategy would actually work. The problem is that new road capacity may itself generate new travel in two ways, first, by increasing the potential for development in the corridor and, second, by reducing the cost of driving. Studies of the land use impacts of highways generally conclude that highways influence where in a region new development occurs but do not increase the rate of growth for a region (e.g. Boarnet and Haughwout 2002). If so, then the new development that occurs along a new or widened road generates traffic on that road but does not necessarily produce a net increase in traffic for the region. The possibility that new road capacity generates an increase in travel beyond any increases generated by new development has been called the "induced travel" effect. If significant, this effect represents a serious limitation on the effectiveness of the road building strategy.

The economic theory of supply and demand provides an explanation of the induced travel effect. New capacity reduces the price of travel by reducing travel times and, in economic terms, shifts the supply curve. As the price of travel goes down, the consumption of travel goes up; the supply curve intersects a new point on the demand curve. This effect should occur even without an increase in population, as existing residents choose to make more trips, longer trips, and more trips by car as a result of the decline in price. But it is important to note that only capacity increases that reduce travel times will have this effect. Definitions of these concepts and explanations of this theory are provided by Downs (1992), Litman (2000), Noland and Lem (2002), and Mokhtarian, et al. (2002), among others. Documenting the extent or even existence of this effect has been a significant challenge for researchers, however. Following a string of studies showing a strong connection, three recent studies failed to find a statistical link between increases in capacity and increases in driving.

The debate over induced travel seemed to have been put to rest over the last decade with series of studies showing a statistically significant connection between highway capacity and travel. A special session on the topic of induced travel was held at the 1997 annual meeting of the Transportation Research Board and summarized in four papers published as a Transportation Research Circular in 1998. The introduction to this circular notes that "the range of disagreement between highway proponents and opponents on the subject of induced travel has narrowed considerably." The decline in disagreement was attributed to a recognition on the part of highway proponents that new capacity induces a variety of changes in land use and travel behavior and on the part of highway opponents that the induced travel effect is a result of time savings rather than capacity increases per se.

Noland and Lem (2002) reviewed nine studies of induced travel and their estimates of the elasticity of vehicle-miles-traveled (VMT) with either travel time or lane miles. The studies reviewed in this paper had consistently estimated elasticities from at least 0.3 to as much as 1.1 for lane miles: a 10 percent increase in lane miles is associated with at least a 3 percent increase in VMT and as much as an 11 percent increase. The elasticities for travel time ranged from –0.3 to –1.0: a 10 percent decrease in travel time could lead to a 3 percent to 10 percent increase in VMT. These results do not take into account additional travel that might be generated by new development that occurs in response to the new highway capacity. The authors conclude: "The research evidence on induced travel effects clearly shows that behavioural responses are real and can have significant impacts on the congestion reduction benefits of capacity expansion projects."

However, a new article by Mokhtarian, et al. (2002) appears to refute the earlier studies. This study took a more disaggregate approach that matched 18 highway segments in California whose capacities had been expanded with similar segments whose capacities had not been expanded. The data set consisted of average daily traffic (ADT, a count of the number of vehicles passing a particular point) and design-hour-traffic-to-capacity ratio (DTC, a measure of congestion) for each of twenty years for each of the expanded segments and their matched pairs. Three different statistical approaches used to test for a difference in ADT and DTC between expanded and unexpanded segments consistently showed no statistically significant difference and thus "no evidence of induced demand." However, the researchers suggest several factors that might explain the apparent discrepancy between their results and those of earlier studies: regional differences in the induced effect, a stronger induced effect on vehicle-miles-traveled (VMT) rather than ADT, the possibility that the true effect lies somewhere between zero and the results of earlier studies that may have overestimated the effect, and the fact that the matched-pairs approach looked for an effect only on a selected set of segments rather than on the entire roadway system. However, additional evidence seems to be coming in that also suggests that the induced travel effect is limited. Choo, Mokhtarian, and Salomon (2001) developed a national-level model of VMT growth as a function of a variety of factors but found that the coefficient for highway capacity was not statistically significant. Using a path model that sorted out the causal links between freeway investments and traffic increases and that focused on operating conditions rather than amount of pavement, Cervero has reportedly found elasticities considerably lower than those found in previous studies (IURD 2002).

The debate will most likely continue as new data sets and more sophisticated statistical techniques are used to test for a relationship between the expansion of highway capacity and increases in the amount of driving. The degree to which increases in highway capacity have themselves contributed to the growth in vehicle travel or simply helped to accommodate the relentless growth in vehicle travel driven by rising incomes, changing lifestyle patterns, or other factors remains to be proved. What is beyond doubt is that vehicle travel has grown faster than highway capacity, population, the economy, or just about any other possible causal factor. If those trends continue, road building will fall far short of vehicle growth, even if the induced travel effect is minimal, and the potential for movement will eventually decline.

### 3.2 ITS Applications

Intelligent Transportation Systems (ITS) offer an alternative approach for enhancing mobility. ITS applications fall into many different categories, including traveler information, intelligent vehicles, commercial vehicles, transit, and traffic management, and involve a variety of technologies, including information processing, communications, and control technologies, among others. The primary goal of these applications is to improve the efficiency and the safety of the transportation system. According to ITS America, an international coalition of public and private organizations involved in the development of ITS that was initiated by the U.S. Congress in 1991, "Joining these technologies to our transportation system will save lives, save time, and save money" (ITS America 2001).

The federal government has played a significant role in encouraging the development and deployment of ITS. In 1996, the Secretary of the U.S. Department of Transportation, Frederico Pena, launched the "Operation TimeSaver" project, the goal of which was "to build the Intelligent Transportation Infrastructure (ITI) across the United States within a decade – to save time and lives and improve the quality of life for American's everywhere" (US DOT 1996a). At that time, the U.S. DOT estimated that Americans travel times would decline by 15% for Americans as a result of the ITS infrastructure. In 1998, TEA-21 authorized over $1.3 billion for "research, development, and operational testing of Intelligent Transportation Systems (ITS) aimed at solving congestion and safety problems" (FHWA 1998b). ITS America estimates that $209 billion will be spent on ITS between 2001 and 2011, with 80% of that total coming from the private sector (ITS America 1998).

TEA-21 also mandated that U.S. DOT work with ITS America to maintain and update a National ITS Program Plan, which was released in January 2002. This plan lays out a ten-year vision to improve the efficiency and safety of transportation systems and their operation. However, the stated goals of the plan go beyond the original ITS goals of safety and efficiency to include security, "mobility/access," and "energy/environment" (ITS America 2002). Under the goal of "efficiency/economy," the plan aims to save "at least $20 billion per year by enhancing throughput and capacity with better information, better system management, and the containment of congestion…" Under the goal of "mobility/access," the plan aims to provide "universally available information that supports seamless, end-to-end travel choices for all users of the system." Under the goal of "energy/environment," the plan aims to save "a minimum of one billion gallons of gasoline each year and to reduce emissions at least in proportion to this fuel saving."

Whether all these goals can be met simultaneously is far from certain. The plan does not explain how ITS will reduce fuel consumption and emissions, but others have outlined the possibilities (e.g. Washington, et al. 1994). Improvements in transit service, access to information about transit, and transitions between modes have the potential to reduce automobile use by increasing the attractiveness of transit and other alternatives. Control applications that improve the flow of vehicle traffic have the potential to reduce fuel consumption and emissions per kilometer of vehicle travel, as do applications that provide information that enables drivers to avoid congested conditions. However, if ITS enhances the "throughput and capacity" of the system as it supposed to do (ITS America 2001), it will effectively reduce the cost of driving and could thus increase the total amount of driving, the same way that road building at least in theory does. To reduce fuel consumption and emissions while at the same time increasing vehicle travel, ITS would then have to generate an even greater reduction in gas consumption and emissions per kilometer.

An early review of the experience with ITS concluded that "significant benefits have been recorded in areas such as accident reduction, time savings, transit customer service, roadway capacity, emission reduction, fuel consumption, and vehicle stops" (USDOT 1996b). In support of this conclusion, the report cites studies of freeway management systems, traffic signal systems, incident response programs, multimodal traveler information systems, transit management systems, electronic toll collection systems, and electronic fare payment systems. The report examines several studies in each of these areas that show reductions in travel times, improvements in travel speeds, and reductions in traffic stops. But the studies cited have important limitations. For one thing, savings in fuel consumption and emissions are apparently estimated based on the measured changes in traffic flow and are not measured directly. For another, these studies do not explore long-term changes in patterns of development that the time savings might produce, nor do they account for the possibility that these time savings might themselves generate additional travel. In addition, they focus on changes in the performance of the system rather than changes in individual travel behavior and thus provide a limited understanding of the underlying causal mechanisms involved.

Unfortunately, the available empirical evidence on the impact of ITS on individual travel behavior is limited (Mahmassani 1999). Much of the published research on the impact of ITS on travel behavior falls into one of three categories: theoretical studies that establish frameworks for understanding the impacts of ITS on travel (e.g. Stern 1999); experimental studies that use simulators, stated preferences, or other techniques to predict traveler response to information provided by ITS systems (e.g. Kraan, et al. 2001; Shah, et al. 2001; Mahmassani and Liu 1999; Fujiwara and Sugie 1995); or marketing-type studies that measure the attitudes and preferences of travelers for ITS applications (e.g. Bottom, et al. 2002; Pagan, et al. 2000). Given the diversity of ITS applications, the empirical studies that are available in most cases measure the impacts of specific applications of ITS on the travel behavior of specific populations (e.g. Viswanathan, et al. 2000; Furuya, et al. 1995). The emphasis on research that indirectly measures the impacts of ITS reflects the limited applications of ITS available for study, at least in comparison to the extensive ITS deployment envisioned for the U.S. and elsewhere. As that deployment progresses, the research opportunities will increase. In the meantime, the purported impacts of ITS on travel behavior remain more theoretical than proven.

## 4. ACCESSIBILITY-ENHANCING STRATEGIES

The goal of accessibility-enhancing strategies is to improve access to needed and desired activities. Although improved access may be one of the stated goals of road building and ITS applications, it is not necessarily the outcome of these strategies. Strategies that more directly impact access include a variety of land use strategies and strategies to provide services via telecommunications technologies. All of these approaches have an important potential advantage over mobility-enhancing strategies: they more directly ensure better access at the same time that they reduce the need for travel. As a result, they have the potential to both meet the needs of individuals and reduce the negative impacts of automobile dependence. The emphasis must be on "potential," however: if these strategies succeed in enhancing accessibility, the potential for interaction, they may contribute to an increase in actual interaction that produces an increasing in driving as a side effect. The idea that land use policies and telecommunications services can be used to address transportation problems is relatively new in the field of transportation planning, and their effectiveness in actually reducing automobile travel is still uncertain. Nevertheless, these approaches have received considerable attention for both their potential transportation benefits and their potential benefits to quality of life.

### 4.1 Land use: New Urbanism, Transit-Oriented Development, Infill Development, and more

If accessibility is defined as including both a travel impedance element and a destination attractiveness element, then land use strategies can play an important role in enhancing accessibility in two ways. First, land use strategies that affect the distribution of activities can reduce travel impedance by reducing the distances between activities. For example, traditional zoning practices in the U.S. are often blamed for segregating land uses and increasing the distances between them; innovative zoning practices that encourage a mix of land uses may help to decrease distances. Second, land use strategies that affect the aesthetic qualities of a place can increase destination attractiveness. For example, ordinances that require landscaping or that require bicycle racks at retail centers can increase the attractiveness of that center for shoppers. Existing land use policies of all sorts have contributed to the automobile-oriented development patterns pervasive in the U.S. However, a growing list of promising new land use strategies aim to reduce automobile dependence. These interrelated strategies include the New Urbanism, transit-oriented development, infill development, Main Street programs, and street connectivity, among many others.

### *4.1.1 New Urbanism*

The New Urbanism movement encompasses many different land use strategies, including all of those described below in some form, and has been an effective force in advocating for these strategies. As defined by the Congress for the New Urbanism (CNU), this movement embraces urban design and planning principles that both create great public places and reduce automobile use. According to the CNU, one of the primary tenets of the New Urbanism is the idea that "communities should be designed for the pedestrian and transit as well as the car" (CNU 2002a). Authors identified with the New Urbanism have articulated specific design characteristics to achieve this goal, including interconnected street networks, narrow streets with sidewalks, mixes of housing types, front porches and other traditional design features, commercial areas and public facilities within walking distance of residential areas, access to transit, and so on (e.g. Duany and Plater-Zyberk 1991; Calthorpe 1993; Katz 1994). These authors and other supporters claim that by putting the activities of daily living within walking distance and providing an interconnected network of streets and sidewalks, walking will increase and driving will decrease. According to the CNU, over 210 new urbanist projects are under construction or complete in the U.S. as of mid-2002 (CNU 2002b). The most famous of these developments include Seaside, Florida, featured in the film "The Truman Show," and Celebration, Florida, built by the Disney Company. The movement has received considerable attention not just in professional planning and design circles but also in the popular press as an alternative to suburban sprawl. A growing number of cities in the U.S, including Austin and San Antonio, Texas, have adopted "traditional-neighborhood ordinances" that reflect the principles of the New Urbanism and encourage or even require narrower streets, shorter setbacks from the street, front porches, access to parks, and other traditional design features.

### *4.1.2 Transit-Oriented Development*

Transit-oriented development, defined as relatively high-density, mixed-use, pedestrian-oriented development in transit station areas, capitalizes on the ability of transit to deliver large numbers of people to a particular destination and increases the numbers of people transit is likely to carry. The concept of transit-oriented development under various labels has had, perhaps, the longest history of all these accessibility-enhancing land use strategies. The development potential of transit was explicitly recognized in plans for modern rapid transit systems, beginning with the Bay Area Rapid Transit (BART) system in the San Francisco Bay Area, both as a way to generate revenues for transit agencies and as a way to increase potential ridership. Although the development around BART stations has been more limited than planners expected, joint-development efforts involving partnerships between public agencies and private enterprises in Washington, DC, and Atlanta, Georgia were successful in increasing the density of development, especially office development, around transit stations (Landis, et al. 1991). However, a 1995 report by the Transit Cooperative Research Program concluded that cities outside of the U.S. have been more successful in using transit as a tool to shape development, thanks largely to greater involvement by regional planning agencies and the involvement of local governments in buying considerable amounts of land around proposed stations that could later be sold or leased to developers, a strategy not legally available to U.S. transit agencies (TCRP 1995). Another form of involvement by the public sector is the development and adoption of design guidelines for development in station areas. These guidelines do not ensure that development will happen, but they do help to ensure that, if it does happen, it is designed in such a way as to be supportive of transit use. Design guidelines for transit-supportive development have been used in numerous communities in the U.S. and Canada; as of 1993, 26 transit agencies had prepared and adopted design guidelines, and 12 more were in the process of preparing them (Cervero 1993). The Federal Transit Administration promotes transit-oriented development in several ways, including its inclusion of transit-supportive land use in the criteria by which it evaluates proposed urban rail projects (FTA 2002).

### *4.1.3 Infill Development*

Infill development can be broadly defined as development within the existing limits of an urbanized area. Considered an important element of "smart growth" in that it helps to slow the expansion of urbanized areas, infill development also offers potential benefits for transportation by increasing densities and reducing the distances between activities, thus increasing the viability of transit, walking, and bicycling. The U.S. Environmental Protection Agency promotes infill development as an "antidote to sprawl" and says that "Infill developments not only keep greenfields green, they are able to take advantage of proximity to a larger pool of potential employees, transit, and utility infrastructures" (EPA 1999). A report by the Municipal Research & Services Center argues, "Infill development offers increased mobility for those who can't drive or prefer not to drive. It is also an important part of the formula for minimizing traffic congestion. In-city living offers other transportation choices in addition to the automobile" (MRSC 1997). In one version of infill development, development occurs on previously unused land, sites that for one of any number of reasons have not been developed in the past. In most cases, these sites are relatively small, for example, one or two individual lots in a residential neighborhood. The bias towards large-scale real estate development in the U.S. often means that such lots remain vacant for decades, at least until rising land values warrant their use. In another version, development occurs on land that has been previously used. The redevelopment of industrial land, or "brownfield development," may involve the clean-up of industrial wastes. The adaptive reuse of historic industrial buildings in central cities and their conversion to offices, shopping, or loft apartments is one type of brownfield development that can be found in cities throughout the U.S. The redevelopment of underutilized or abandoned retail sites, or "grayfield development," is growing in popularity in older suburban areas in the U.S. Countless examples of all three kinds of infill development can be found throughout the country, not just in central cities but also in older suburbs, and the trend seems to be towards more infill development in response to a combination of market forces and government encouragement. In 2001, Los Angeles issued more building permits for housing inside the city that in any year in the prior decade (Egan 2002). Many important infill projects have been tied to transit systems. For example, in the San Francisco Bay Area, a mixed-use neighborhood is being developed on land formerly owned by the U.S. Navy and scheduled to be the site of a new station for the BART system (Newman 2001). Also in the Bay Area, a new mixed-use community called The Crossings was developed on the site of an abandoned shopping mall next to a commuter rail station (Benfield, et al. 2001).

### *4.1.4 Main Street Programs*

In 1980, the National Trust for Historic Preservation launched its Main Street Program with the goal of helping communities across the U.S. revitalize their traditional or historic commercial areas (NTHP 2002a). Most cities that have participated in the program are outside of metropolitan areas, but the program has been adapted for commercial areas within metropolitan areas as well. A total of 1650 communities have participated, resulting in an estimated total investment in these communities of $16.1 billion (NTHP 2002b). Although this program is motivated by the goal of historic preservation, it may have important benefits for transportation by encouraging shopping and services in a pedestrian-oriented setting within walking distance of residential areas. The Main Street concept has spread to other cities not officially involved in the formal program. Metro, the regional planning agency in Portland, Oregon, published a *Main Street Handbook* in 1996 to help local communities preserve their traditional shopping districts. Many other efforts to preserve neighborhood shopping have sprung up around the U.S., motivated more often by community development goals than by potential transportation benefits. For example, the Cleveland Neighborhood Development Corporation created a retail Commercial Support Initiative and a Main Street Initiative to provide technical assistance, advocacy, and training opportunities "to help neighborhoods strengthen their retail base" (CNDC 2002). In 1996, Norfolk, Virginia established a Neighborhood Commercial Corridor Program and has spent $3.9 million to revitalize neighborhood commercial areas through infrastructure improvements (City of Norfolk 2002). The mayor of Chicago has proposed a new zoning ordinance that would provide more locations for neighborhood services, such as bakeries, banks, restaurants, and dry cleaners, "within walking distances from people's homes" (City of Chicago 2002). Efforts to restrict "big-box" stores, such as Wal-Mart, Home Depot, and numerous others, complement these efforts to promote neighborhood shopping districts. Some retailers, such as Walgreen's drug stores, have adopted a strategy of building small stores in neighborhood areas, and even Home Depot has now developed a neighborhood-scale hardware store concept (Washburn 1997). In other places, the problem is not to attract new businesses but rather to save already vibrant shopping districts from intrusion by chain stores and/or ground-level offices that reduce the local character of the district. A growing number of communities have adopted ordinances to restrict ground-floor spaces to retail uses (Kline and Schutz 2001), and many others are finding ways to restrict "formula" businesses, particularly restaurants (Institute for Local Self-Reliance 2002). Both kinds of efforts reflect a growing appreciation of the value of the traditional Main Street shopping district.

#### *4.1.5 Street Connectivity*

Policies to increase the connectivity of the local street network might at first seem to be more about enhancing mobility than about enhancing accessibility, but they are often combined with other land use strategies in efforts to improve neighborhood design, particularly in new urbanist projects. Street connectivity policies are a response to the standard style of street network found in suburban subdivisions in the U.S. developed after World War II. This style is characterized by cul-de-sacs, loop streets, and limited connections between residential streets and arterial streets. Often labeled "curvilinear" or "disconnected," this style was itself a response to the growing use of the car and reflects the efforts of engineers, planners, and developers to minimize the impact of automobile traffic on residential areas through the establishment of a hierarchy of streets (Handy 1993). The street hierarchy concept, which differentiates between the access and movement functions of streets, became entrenched in transportation engineering practices as early as the 1950s and provides the basis for the design requirements for streets found in zoning codes throughout the U.S. still today. However, a growing number of cities in the U.S. have now adopted street connectivity ordinances that require shorter distances between intersections and more intersections relative to street length (Handy, et al. 1999). The goal of these ordinances is to more evenly distribute automobile traffic, improve emergency access to neighborhoods, reduce travel distances within the network, and increase the feasibility of walking and biking. However, residents are often resistant to giving up the relative quiet and safety of cul-de-sacs, and developers are mostly resistant to giving up the greater profits associated with cul-de-sacs. An effort to pass a street connectivity ordinance in Austin, Texas met considerable opposition from the development community and ultimately lost a crucial vote of the city council. Still, interest in promoting connectivity more generally seems to be growing. Many cities in the U.S. have recognized the importance of providing local connections across freeways, which form significant barriers to local movement. Cities such as San Antonio, Texas, and Davis and Berkeley, California, have recently built pedestrian and bicycle bridges or paths to link areas on either side of their freeways. The Texas Department of Transportation is exploring the possibility of depressing an Interstate freeway in Austin, Texas, at least in part to improve the physical and social connections between the middle- and upper-income west side of the city and the lower-income and predominantly minority east side of the city.

#### *4.1.6 Discussion*

These examples represent a small sample of the efforts underway in the U.S. to change the way in which communities are designed and to improve the quality of new and existing communities. The Congress for the New Urbanism has perhaps been the most visible advocate of better community design, but many other organizations have pushed similar or related agendas. In 1994, the Federal Transit Administration established its Livable Communities Initiative, and in 1996 the Federal Highway Administration joined the initiative. In its publication, "Building Livable Communities Through Transportation," the U.S. Department of Transportation argued that "The location and appearance of transportation facilities, the design of streets and sidewalks, and the placement of on-street parking can make all the difference in how we experience our daily activities" (US DOT 1996c). Numerous environmental organizations and other non-profit advocacy groups have also pushed for better design, many times as a part of more general "smart growth" efforts designed to counteract suburban sprawl. The Natural Resources Defense Council, for example, published a guide to model smart growth efforts from throughout the U.S. that make use of a wide variety of strategies (Benfield, et al. 2001). State governments are getting into the act, too. The State of Maryland, as a part of its Smart Growth Initiative, has put into place policies to support existing communities and neighborhoods and reduce the need for costly new infrastructure, including the establishment of priority funding areas, a brownfield redevelopment program, and a "live near your work" program (Maryland 2002). The efforts across the U.S. are far too extensive to fully catalog here.

Concerns about the environment and about quality of life are the dominant motivations behind these efforts, and the belief that land use strategies will reduce driving and promote transit use, walking, and bicycling relates to both of these concerns. However, the available empirical evidence does not provide conclusive support for this belief. The idea that land use and design policies could be used to influence travel behavior was not widely tested by researchers until the 1980s. Early interest focused on the connection between density and transit use. The 1977 study by Pushkarev and Zupan is often taken to suggest that transit use can be increased through polices that increase densities. A heated debated ensued in the early 1990s over analysis by Newman and Kenworthy of the correlation between densities and gasoline consumption for a sample of international cities (Newman and Kenworthy 1999). In response to the emergence of the new urbanism movement, more recent studies have taken on the broader question of the link between travel behavior and characteristics of the built environment more generally and have set out to test the hypothesis that policies that shape the built environment can be used to reduce automobile travel. Since the early 1990s, studies of the link between the built environment and travel behavior have appeared in the literature with increasing frequency. Recent literature reviews document over 70 studies published during the 1990s that have explored and quantified these relationships (e.g. Handy 1996a; Boarnet and Crane 2001a; Ewing and Cervero 2001).

Studies that focus on land use strategies fall into three general categories: simulation studies, aggregate studies and disaggregate studies (Handy, et al. 2002). Simulation studies use travel demand forecasting models to estimate the impacts of changes in the built environment on travel behavior. This approach has been most often used to test the impact of the design of the street network on vehicle travel (e.g. Kulsah, et al. 1990; McNally and Ryan 1993). Aggregate studies use data on average travel characteristics in zones or tracts (or sometimes cities or regions) to test for correlations between travel patterns and characteristics of the built environment such as density or era of development (e.g. Cervero and Gorham 1995; Friedman, et al. 1992). Disaggregate studies use individual or household-level data to model the relationships between characteristics of the built environment and travel behavior. Most of these studies have focused on the frequency of trips or amount of travel by different modes (e.g. Cervero and Kockelman 1997; Boarnet and Crane 2001b; Handy and Clifton 2001). Cutting across these three categories are differences in the travel characteristic used as the dependent variable (e.g. vehicle kilometers traveled, trip frequency, trip length, mode choice) and the characteristics of the built environment used as independent variables (e.g. density, era of development, network characteristics, access to jobs or shopping, etc.). Most studies have focused on travel in general, while some studies have distinguished between work travel and nonwork travel.

One of the challenges in these studies has been to sort out the relative importance of socio-economic characteristics and characteristics of the built environment in explaining travel behavior. Ewing and Cervero (2002), after one of the most thorough reviews of these studies, came to the conclusion that the built environment is more significant than socio-economic characteristics in predicting trip lengths, but that socio-economic characteristics are more significant than the built environment in predicting trip frequencies and mode choice. They also concluded that characteristics of the built environment are much more significant predictors of vehicle-miles-traveled, which depends on the combination of trip lengths, trip frequencies, and mode split. In other words, it appears that land use strategies have the potential to reduce vehicle travel by bringing activities closer to home and thereby reducing the length of trips.

In a form of meta-analysis, Ewing and Cervero (2002) estimated elasticities for vehicle-miles-traveled and vehicle trips based on the results of all available studies as well as original data analysis for available data sets. The results showed a statistically significant but rather limited link between characteristics of the built environment and travel behavior. A 10% increase in local density, for example, was associated with only a 0.5% decline in vehicle trips and vehicle-miles-traveled. The highest elasticity was for regional accessibility rather than density, design characteristics, or land-use mix: a 10% increase in a certain measure of regional accessibility was associated with a 2% decline in vehicle-miles-traveled. It is important to note that almost all of the available studies have used a cross-sectional design that compares travel behavior for different people or places at one point in time. These studies thus reveal correlations between the built environment and travel behavior but do not prove causality. In other words, it is not possible to say that a 10% increase in local density in a particular neighborhood will lead to a 0.5% decline in vehicle trips and vehicle-miles-traveled.

The available research suggests two reasons why land use strategies do not seem to reduce driving any more than that. First, enhancements to accessibility produced by these land use strategies may actually increase travel. Although these land use strategies reduce the need for driving, they also tend to increase the potential for driving. Although residents may drive shorter distances on average, the may also choose to drive more frequently. A study of shopping behavior in neighborhoods in the San Francisco Bay Area found evidence that residents made use of local shopping areas when they were available but that they continued to make use of shopping areas beyond their neighborhoods. In other words, residents made trips to local stores in addition to rather than in place of trips to larger, more distant stores (Handy 1992; Handy 1996b). A study of six neighborhoods in Austin, Texas found similar results for grocery shopping: the overall amount of driving for grocery shopping did not vary significantly across neighborhoods, even for neighborhoods in which residents frequently walked to a local grocery store (Handy and Clifton 2001). In both studies, stores and shopping areas that offered an especially attractive environment drew residents from a considerable distance. Both studies also found evidence that even if local shopping did not lead to a reduction in driving, residents valued the opportunity to drive less when they chose to.

Second, land use strategies are only effective if people respond to the changes in the built environment those strategies produce, and whether or not they respond depends on deeplyseated attitudes and preferences. So far, only Kitamura, et al. (1997) have looked at the importance of attitudes and preferences relative to the built environment in a substantial way, and they found that attitudes were a more significant predictor of travel behavior than either socio-economic characteristics or the built environment. These results suggest that this issue has not been given the emphasis it needs in the research to date. A related problem with the available studies is the issue of "self-selection," the possibility that individuals who would prefer to drive less choose to live in neighborhoods more conducive to driving less. In other words, the characteristics of the built environment did not cause them to drive less, rather their desire to drive less caused them to select a neighborhood with those characteristics – the reverse of the presumed causality. Handy and Clifton (2001) found both quantitative and qualitative evidence that residents of an Austin neighborhood where the average frequency of walking to the store is significantly higher than in other neighborhoods did in fact choose that neighborhood because they like to walk to the store. In this case, the preference to walk was at the root of the walking behavior, not the design of the neighborhood. On this same issue, one of the few longitudinal studies of the link between the built environment and travel behavior found that residents who move to higher access neighborhoods drive less than when they lived in lower access neighborhoods (Krizek, forthcoming). What this study did not show is whether residents who haven't chosen to live in a high access neighborhood would drive less if they suddenly found themselves living there.

Besides the need for more research, these issues suggest that hopes for land use strategies as a tool for reducing automobile use should be tempered. But they do not suggest that efforts to employ these strategies should be aborted, in fact, quite the opposite. These strategies create greater diversity in the kinds of places available for living, working, shopping, recreating, etc., and may guarantee residents the choice not to drive. Without such strategies, there is little question that Americans will continue to drive most of the time because they have little choice. With such strategies, there is the possibility that Americans will choose to drive at least a little less.

### 4.2 Telecommunications

Information and telecommunications technologies (ICT) also represent an important strategy for enhancing accessibility by reducing travel impedance to essentially nothing. The ability to work, shop, bank, recreate, and engage in all kinds of activities from home without travel expands access to these activities beyond what can be reached by physical travel. Access to such activities from home has been available in one form or another for decades – shopping by catalog and telephone, banking by mail, bringing work home from the office, and so on. But the Internet has vastly increased the range of activities available from home and, arguably, the ease of engaging in those activities from home. Exactly what impact the Internet has had on accessibility is hard to measure, although available data on the Internet supports the conclusion that it is significant. As of 2000, the Internet reportedly offered 1.2 billion "unique, publicly available" web pages, with the number of pages growing by 7 million per day (Cyveillance 2000). The dramatic growth in the use of the Internet perhaps provides the best indicator of its impact. By the end of 2000, 104 million American adults or 56% of the adult population in the U.S. had access to the Internet, and on a typical day, 58 million Americans logged onto the Internet (Pew 2001). In December 2001, an estimated 18.7 million households in the U.S. shopped online, despite the slow economy, spending a total of $5.7 billion, and total on-line sales for 2001 reached $47.6 billion (Forrester Research, Inc. 2002). Worldwide, an estimated 544.2 million people are online in 2002 (Nua 2001).

Of the long list of ICT applications that potentially enhance accessibility, telecommuting has the longest history in the field of transportation planning. Telecommuting is generally defined as working at home in place of commuting to an office or other work site or as traveling to a "telecenter" located closer to home than the usual work site (Handy and

Mokhtarian 1995). Use of the Internet or other telecommunications technologies is not essential to this definition, although these technologies may enable telecommuting for many kinds of workers. Because of its potential for reducing travel, telecommuting has been widely pushed as a transportation demand management strategy by federal, state, and local governments in the U.S. The Environmental Protection Agency promotes telecommuting as a part of its Commuter Choice Leadership Initiative, designed to encourage employers to provide more commuting choices for their employees (EPA 2002). The General Services Administration has actively promoted telecommuting for federal employees and operates a network of telework centers in the Washington, DC area that are open to employees of any federal agency (GSA 2002). The states of Washington, Oregon, California, Arizona, and Texas have joined forces to form the Telework Collaborative, the mission of which is to "accelerate the acceptance and adoption of telework programs in public and private organizations" (Telework Collaborative 2002). As early as 1990, the County of Los Angeles and the City and County of San Diego had telecommuting programs for their employees (Rathbone 1992).

The available empirical evidence suggests that telecommuting has not had the impact on vehicle travel that early proponents had hoped. First, employers and employees have not adopted telecommuting to the extent expected. In 1993, the U.S. Department of Transportation released a report that predicted that anywhere from 7.5 million to 15 million workers or 5.2% to 10.4% of the workforce in the U.S. would be telecommuting 3 to 4 days per week by 2002 (US DOT 1993). The available data on current levels of telecommuting are extremely problematic but suggest that the number of telecommuters is towards the lower end of that range and that the frequency of telecommuting is closer to 1 to 2 days per week (Choo, et al. 2001). Employers are not always comfortable with allowing their employees to telecommute, and workers themselves are often not interested in telecommuting even when given the option. Despite the obvious savings in travel time and cost, workers may miss the social interaction of being in the office, fear that they will not be evaluated fairly at promotion time, find that the rest of the household puts greater burdens on them to take care of household chores, or for many other reasons choose not to telecommute (Mokhtarian and Salomon 1994).

Second, savings in vehicle travel not a given for those who do choose to telecommute (Mokhtarian, et al. 1995). Although by definition telecommuters eliminate or reduce their commute travel, they may at the same time increase their travel for purposes other than work. In addition, other members of the household may travel more, due to the increased availability of car or because the telecommuter previously took care of household chores on the way to or from work. Some telecommuters may have previously taken transit, so that telecommuting reduces transit travel but not automobile travel. In the long run, telecommuters may choose to live farther from work, thereby increasing their commute distances on the days they do not telecommute. The limited empirical evidence available so far suggests that the savings in driving for commute trips outweighs other increases in driving, resulting in a net savings. But the limitations of the data available to study these issues mean the results are far from conclusive. A recent study concluded at a 90% level of confidence that telecommuting reduces vehicle-miles-traveled in the U.S. by somewhere between 0 and 2% (Choo, et al. 2001).

The impacts on travel of other ICT applications are even less clear. Most of the speculation on this topic has focused on online shopping, e-shopping, B2C e-commerce, or what researchers have for some time referred to as teleshopping. Three important questions need to be addressed. The first question is the extent to which consumers will choose to shop online. Surveys by Forrester Research, Inc. and others show steady growth in online sales, although the share of total retail sales in the U.S remains relatively small at 1-2%. As outlined by Mokhtarian (2001), potential benefits of shopping online include unlimited selection, lower prices and search costs, information, personalization, convenience, and speed. But store shopping continues to offer potential benefits over online shopping: sensory information, tangibility, immediate possession, social interaction, entertainment, movement, and the ability to link shopping with other activities. Consumers weigh these costs and benefits in deciding whether to store shop or shop online. The second question is whether online shopping will lead to a decline in personal travel. Rather than substituting for a trip to the store, an online purchase or visits to online shopping sites may represent additional shopping activity. Information available via the Internet might even increase the amount of travel for shopping, for example, by making consumers aware of new produces or more distant stores. In addition, purchases of travel – airline tickets, car rentals, hotels – represents over a quarter of total online sales (Mokhtarian, 2001). One study of teleshopping from pre-Internet days asked survey participants about their last purchase from a catalog and what they would have done had they not found that item in the catalog: 31% said they would not have made a purchase, 40% said they would have looked for the item on their next trip to the store, and only 20% said they would have made a special trip to the store, suggesting that few catalog purchases actually decrease trips to the store (Handy and Yantis 1994). Finally, the third question is the degree to which an increase in freight travel offsets any possible declines in personal travel. The net impact on travel of online shopping today is simply not known, and the likely impacts in the future are even more uncertain.

The conclusions for telecommunications strategies are thus similar to those for land use strategies. There is little evidence that telecommunications strategies will significantly reduce travel and convincing arguments that these strategies may actually increase vehicle travel. However, these strategies clearly enhance accessibility by making it possible to participate in work, shopping, and other kinds of activities from home. They increase the potential for interaction without an increase in actual movement.

## 5. MOBILITY-LIMITING STRATEGIES

Although accessibility-enhancing strategies expand the range of choice for individuals and increase the possibility of driving less, they do not ensure that individuals will actually choose to drive less. If the goal is to reduce vehicle travel – for environmental, social, or other reasons – then drivers will need additional discouragements. Strategies to limit mobility by car, including pricing strategies and road restriction and removal strategies, help to reduce the attractiveness of the driving choice relative to the alternatives. If the alternatives can be sufficiently enhanced – through strategies like those outlined in the previous section – then the amount of driving may decline. Mobility-limiting strategies on their own may also reduce driving, but at the cost of reducing the ability to participate in needed and desired activities. When combined, accessibility-enhancing strategies and mobility-limiting strategies together have the potential to reduce the potential for movement but enhance the potential for interaction.

### 5.1 Pricing Strategies

Pricing strategies include a wide variety of techniques designed to increase what drivers directly pay for their use of the road system. Two arguments are offered in support of pricing strategies. First, drivers take into account only a small subset of the full costs they incur when making day-to-day decisions about driving. In many cases, drivers may not consider any costs other than time. In reality, they have paid the cost of the vehicle itself, maintenance, insurance, roads, parking, and so on in one form or another. If the perceived cost is much lower than the actual cost, drivers will over consume and drive more than is economically efficient. Second, drivers do not take into account the costs they impose on other drivers, the "externalities" of their driving, including the emissions, noise, and other pollutants from their vehicles and the delays they create for others. If drivers were forced to pay the monetary equivalent of these costs, through a process of "internalizing the externalities," they would choose to drive less.

Several pricing strategies have been proposed in the U.S., but few adopted. Proposals generally fall into one of three categories: road, distance, or parking pricing strategies. Successful efforts can be found in all three categories, and technology is often important to the feasibility of these strategies.

### *5.1.1 Road Pricing Strategies*

Toll roads and toll bridges are common in many parts of the U.S., but in most cases tolls are collected to pay off the bonds used to construct and maintain the facility rather than as a demand management tool. Texas and other states where toll roads have not been common are now turning to toll roads, often privately constructed and operated, as a way to build more roads more quickly. Although toll roads mean that drivers pay more directly for their use of the road, they do not take full advantage of the potential of road pricing to manage transportation demand. The concept of congestion pricing, in which fees are imposed for using the road system during congested times of day, has been widely praised in academic circles for decades as a strategy for making more efficient use of the existing road system. But the concept was unpopular with decision makers and the public and eventually was given the more positive label "value pricing." The Transportation Equity Act for the 21st Century authorized $55 million for a Value Pricing Pilot Program to fund the development and implementation of value pricing projects, most of which have been one of two types (UMN 2002a). First, value pricing has been implemented in the U.S. on selected bridges that were already tolled. Higher tolls during peak periods were implemented on the New Jersey Turnpike in 2000 and on several bridges and tunnels linking New York and New Jersey in 2001; peak period tolls are now 25% higher than off-peak rates for the bridges and tunnels. In 1998, Lee County, FL took a different approach and reduced the toll on two bridges during the times just before and after peak period. Second, value pricing has also been implemented in Texas and Southern California in the form of high-occupancy/toll (HOT) lanes, lanes on an otherwise untolled freeway that are reserved for high-occupancy vehicles (carpools, buses) and for single-occupant vehicles willing to pay the price. On Interstate 15 in San Diego, California, an existing but underutilized high-occupancy vehicle (HOV) lane was converted to an HOT lane in 1996. Tolls on this facility vary from $0.50 to $4.00 depending on the level of congestion on the main lanes of the freeway, and commuters are issued transponders that pay charge tolls electronically and eliminate the need for stopping at a toll booth. The Katy Freeway in Houston, Texas, has a slightly different system: only carpools with three or more passengers are allowed to use the HOV lane, but carpools of two people are now allowed to "buy-in" to the HOV lane for a $2 charge; this program also uses electronic transponders for toll payment. However, HOT lanes have been criticized as exclusive and elitist and are sometimes dubbed "Lexis lanes" for the high-priced cars expected to use them. In response, the Federal Highway Administration has proposed the idea of "FAIR lanes" that provide drivers with the choice of paying for the use of express lanes or earning "credits" for sitting in traffic in the regular lanes (UMN 2002a). The goals of these value pricing projects include time savings, environmental benefits, reduced frustration and delay, increased travel choices, more efficient modal choices, revenue generation, increased economic productivity, and improved highway investment decisions (FHWA 2002c).

### *5.1.2 Distance Pricing Strategies*

Raising the gasoline tax, a relatively direct user fee that is paid roughly in proportion to the distance driven, seems like an obvious approach to discouraging automobile travel but has little chance of succeeding politically in the U.S. In fact, pressure to reduce the gas tax seems to grow every time that gas prices rise a significant amount, particularly if gas prices rise during the summer vacation season. Gas taxes in the U.S. are considerably lower than elsewhere in the world, as are per gallon prices: sales tax accounted for $0.37 of the $1.13 per gallon cost of gasoline in the U.S. in 1999, compared to $2.78 of the $3.66 per gallon cost in Germany , $3.00 of the $3.79 per gallon cost in France, and $3.02 of the $3.97 cost per gallon in the United Kingdom (Davis 2001). Other pricing strategies based on distance have also been proposed and seem to be more politically palatable. Mileage-based auto insurance, called "pay-as-you-drive" or PAYD insurance, in which rates are set based on the amount the amount the vehicles is driven rather than where its owner lives (the standard practice in the U.S.), has generated interest on the part of transportation planners as well as insurance companies (Paul 2002). Progressive Auto Insurance recently implemented a pilot program with over 1,200 Texas drivers that charges them by the amount of time, time of day, and places they drive (UMN 2002b). The Federal Value Pricing Pilot Program has funded simulation studies of PAYD in Georgia and Massachusetts. In these studies, data on the travel behavior of the participants before and after implementation of the program will be collected and analyzed (UMN 2002b). In-vehicle global positioning system (GPS) units have enabled more sophisticated approaches to PAYD insurance. Earlier proposals for PAYD included pay-at-the-pump insurance, which drivers purchase as a percentage fee on top of the price of gas, and odometer-based registration fees (Wenzel 1995).

### *5.1.3 Parking Pricing Strategies*

Another obvious pricing strategy is to raise fees for parking, but parking fees are perhaps even more unpopular in the U.S. than gas taxes, for the simple reason that most Americans rarely have to pay for parking, at least not directly. According to the Nationwide Personal Transportation Survey, parking is free for 99% of the vehicle trips in the U.S. (Shoup 2002). However, where parking is not free, mostly in urban centers where parking is relatively scarce, several options exist. In many downtown areas, parking fees already vary to reflect peak and off-peak periods of demand. These price variations help to encourage commuters to use transit during peak periods but do not overly discourage evening and weekend visitors. Many downtown employers, however, lease parking for at least some of their employees who then do not directly bear the cost of parking and thus have less incentive not to drive. Those employees who choose not to take advantage of the leased parking are usually not compensated for the expense their employer saves. Parking "cash-out" programs were developed to address these problems: employers offer employees the option of receiving a (taxable) cash payment or transit passes in place of the parking subsidy (UMN 2002c). Although these programs do not force drivers to pay for parking, they do help to balance the pricing incentives between driving and transit. Unfortunately, parking cash out programs are rarely workable in suburban areas.

### *5.1.4 Discussion*

Pricing strategies clearly have an impact on driving, although just how much impact is often uncertain. The impacts of pricing strategies on travel are usually quantified as elasticities, the percentage change in travel associated with a given percentage change in price. The Victoria Transport Policy Institute has compiled estimated elasticities from available studies from the U.S. and elsewhere and provides one of the most thorough summaries available on this topic (VTPI 2002). Not all of the proposed pricing strategies have been adequately studied yet, but the available evidence suggests their potential. For example, studies of road pricing generated estimated elasticities ranging from –0.1 to –0.2 for the U.S., indicating that a 10% increase in prices would lead to a 1% to 2% decrease in vehicle trips. Studies of parking pricing generated estimated elasticities ranging from –0.1 to –0.3, indicating that a 10% increase in prices would lead to a 1% to 3% decrease in vehicle trips. Even if the payment per trip is the same, the form of payment can make a difference: the U.S. Environmental Protection Agency estimated that a $1 increase in parking fees would have the same effect on travel as a $1.50 to $2.00 increase in gas taxes per trip (EPA 1998). Elasticities also vary depending on the purpose of the trip: not surprisingly, commute trips tend to be less elastic than shopping and other kinds of non-work trips. Elasticities may also vary over time and tend to be lower in the short run and higher in the long run, as drivers find more ways to adjust to the increases in prices. Given the evidence, the question isn't whether pricing strategies could significantly reduce driving. Rather, the question is whether pricing strategies sufficient to significantly reduce driving can be adopted.

The resistance to pricing strategies comes from both a pervasive American dislike of taxes (and thus an unwillingness on the part of politicians to raise taxes) and concerns about the impacts of pricing on lower-income households. Low-income households in the U.S. depend on automobiles to a surprising degree, despite the significant cost of owning and operating even a cheap car. According to the 1995 Nationwide Personal Transportation Survey, 74% of low-income households in the U.S. owned an automobile, as many as had a telephone in their house, and many that don't own an automobile borrow one or accept rides from family and friends who do (Murakami and Young 1997). Imposing new tolls and other fees on drivers disproportionately impacts lower-income households, who already pay a higher share of their income for transportation than middle-income households. The issue of equity can be addressed in a number of ways. First, a portion of the revenues raised by the toll or fee can be devoted to improving the alternatives to driving, particularly transit. Second, a portion of the revenues can be used to offer reduced tolls or fees to lower income households. Third, the fixed costs of driving can be reduced to offset increases in out-of-pocket costs so that the overall cost of driving does not increase. Proponents of pricing strategies often make the case that these strategies are ultimately more equitable in that they charge drivers more directly for their actual use of the system and for their impacts on their environment. Under the current pricing structure, those who drive relatively little are subsidizing those who drive a lot. Finding a politically acceptable solution to these equity issues is challenging but not impossible.

### 5.2 Road restrictions and removals

Mobility can also be limited through restrictions on the use of roads and on the actual removal of roads. The imposition of vehicle restrictions on selected roads at all times or at selected times of day reduces mobility by temporarily reducing the total capacity of the road system. In effect, road restrictions and removals increase the price of driving and may thus lead to a decrease in driving. In general, restrictions and removals force drivers to use other roads, other modes, or other destinations, or to travel less. The impact of these strategies thus depends on the availability of routes that can be used in place of the restricted or removed facilities, the availability of transit or other modes, the availability of other possible destinations that meet the needs of the traveler, and the importance to the traveler of making that trip. The removal of roads represents a more extreme approach to limiting mobility and has been employed only rarely and usually for goals other than a reduction in mobility. Neither road restrictions nor removals are common in the U.S., but they are not unheard of.

Road restrictions are more common in Europe than the U.S. American cities, for example, have had few successes with pedestrian-only districts in downtown areas. Popular in the 1960s and 1970s as downtown shopping districts faced increasing competition from suburban shopping malls, pedestrian malls proved to be largely a failure, and at least half of the 200 pedestrian malls that once existed in the U.S. have been transformed in one way or another (Steinhauer 1996). The Pearl Street pedestrian mall in Boulder, Colorado is often cited as a success, but many other cities, including Baltimore, Pittsburgh, and Seattle, have given up on pedestrian malls, re-opening them in recent years to car traffic. Many of the remaining "car free" areas in the U.S. are found in tourist destinations (Carfree.com 2002). Another form of road restriction found in older areas in the U.S. is the closing of residential streets to through traffic, creating cul-de-sacs out of traditional street grids. Programs in cities like Los Angeles and Houston have been motivated by a desire to reduce crime in residential areas. Although these programs have succeeded in reducing traffic and crime in neighborhoods, they have also come under attack for racial and class segregation (Williams 1994). A more extreme approach, justified on the same grounds but criticized on the same points, is to put gates on the neighborhood. The mixed-income, mixed-race Five Oaks neighborhood in Dayton, OH, installed gates and barricades in 1992 after a doubling of robberies in five years. They apparently succeeded: crime dropped and "the only universal complaint about gates, one cited by opponents and proponents alike, seems to be that of inconvenience" (Owen 1994). Other kinds of restrictions on cars are rare, with the exception of restrictions relating to weather and construction, although restrictions on trucks are not uncommon. In the wake of 9/11, New York City implemented restrictions on single-occupant vehicles coming into southern Manhattan during the morning peak period from 6am to 10am. Although the ban was dropped on three entry points, it remains in effect on two tunnels and three bridges (NYC 2002). These restrictions are by far the most ambitious ever in the U.S. and reflect the exceptional circumstances facing New York in recent months.

Believe it or not, a handful of cities in the U.S. have chosen to remove freeways in downtown areas (Schreibman 2001). In San Francisco, the Embarcadero Freeway was originally planned to link the Bay Bridge to the Golden Gate Bridge, but only a mile or two was ever constructed because of resistance from residents of the city to the construction of a freeway along their waterfront. The short stub of freeway that was built was unpopular with residents but perceived as necessary for bringing tourists into the city. In the early 1980s, a ballot initiative on the removal of the freeway stub failed to gain approval of a majority of voters. However, in 1989 the Loma Prieta earthquake severely damaged the freeway stub, and the city together with the California Department of Transportation took advantage of the situation to remove the stub and rebuild the waterfront boulevard for transit and pedestrians as well as cars. When another freeway stub in the city was closed, the expected increases in traffic did not occur, and traffic along several major corridors actually decreased (Schreibman 2001). Under the leadership of a dynamic mayor, Milwaukee, Wisconsin has also decided to remove the stub of a freeway that had never been completed and that created a barrier between downtown and neighborhoods to the north. The removal is partly motivated by the estimated cost of repairing the aging freeway stub and partly motivated by the development potential of the land consumed by the freeway structure (Schreibman 2001). Although the U.S Department of Transportation does not generally encourage road removals, federal transportation funds were used for both of these projects. Hard evidence on the impacts of road removals on traffic is scant, but a 1976 study by the New York Department of Transportation found that traffic counts dropped by 53% on the West Side Highway in Manhattan after a portion of the highway was closed and that only 7% of that traffic reappeared on other streets (Kruse 1998). Although it would be hard to justify the removal of freeways solely to reduce traffic, freeway removal projects motivated by other concerns will nevertheless reduce the potential for movement and may reduce actual movement as a result.

## 6. CONCLUSIONS

The appropriateness of adopting mobility-enhancing, accessibility-enhancing, or mobility-limiting strategies depends on the goal to be achieved. Mobility-enhancing strategies aim to increase the potential for movement by increasing the capacity of the system and the speed of travel. Accessibility-enhancing strategies aim to increase access to needed and desired activities, by bringing activities closer to home, enhancing the alternatives for reaching those activities, and expanding the choices among activities. Mobility-limiting strategies aim to decrease the potential for movement by increasing the monetary or time cost of travel. The challenge in choosing between these strategies is to balance the needs of the individual with the environmental and societal costs of their choices. The evidence reviewed in this report suggests that a combination of accessibility-enhancing strategies and mobility-limiting strategies achieves this balance better than mobility-enhancing strategies do.

Other strategies not reviewed in this report also offer promise. A variety of interesting strategies fall into a category that might be called accessibility-oriented mobility strategies – strategies that enhance mobility in ways specifically designed to enhance accessibility, that increase the potential for movement so that the potential for interaction is also increased. The concept of "new mobility" focuses on strategies that use technologies to provide mobility options that generate fewer environmental impacts than privately-owned, gasoline-powered cars and that may be more tailored to the specific mobility needs of each household (Shaheen and Sperling 2001). These options might include car-sharing programs, neighborhood electric vehicles, and "smart" paratransit. Transit service more generally can be an accessibility-oriented mobility strategy, especially when bus routes and rail lines are designed to the serve specific needs of specific segments of the population. Efforts under the label of "community transportation" have focused on filling the gaps in service provided by regular transit systems through more personalized service for transit-dependent segments of the population, but the philosophy could be applied more widely in transit planning. The Community Transportation Association of America argues that while a mobile society is essential to a free society, our approach to providing mobility has become outdated (CTA 2001). Not all mobility-enhancing strategies are created equal, and the most important ones are those that also enhance accessibility.

There is no question that Americans have come to expect and demand good mobility. Congestion is seen as a threat to personal freedom, and freeway building is justified on the grounds of preserving that freedom. For example, Mary Peters, the administrator of the Federal Highway Administration, recently testified before a committee of the U.S. Senate that "mobility is one of our greatest freedoms" and that "congestion must be addressed with a long-term strategy to increase capacity" (FHWA 2002d). In its 2001 *Report to the Nation*, the Federal Highway Administration declared that "our highway transportation system serves to unify America and sustain the American way of life" (FHWA 2001). Implicit in such statements is the belief that Americans have a right to drive and, more specifically, that Americans have the right to drive anywhere they want at any time of day they want at speeds unimpeded by congestion. Time and monetary losses resulting from congestion are officially measured relative to free flow conditions, thereby establishing free-flow conditions as the unquestioned standard. Mobility may be essential to the economy and to quality of life, but just how much mobility can we rightly expect and demand?

Accessibility-enhancing strategies can also be justified on the grounds of personal freedom. The importance of expanding choices through such strategies is gaining more recognition. For example, the Strategic Plan for the U.S. Department of Transportation, adopted in 2000 under the Clinton administration, stated that "Transportation, at its core, is about more than concrete, asphalt, and steel – it is about people and their access to work, school, loved one's, and nature's bounty" (US DOT 2000b). Norm Mineta, the Secretary of the U.S. Department of Transportation, recently commended pioneering efforts by public agencies and private organizations to provide “choices for commuters” in “dealing with congestion and the challenge of getting to work” (FHWA 2002e). These statements both reflect an emerging new mindset in transportation planning in the U.S., one that focuses on enhancing accessibility. This new mindset may or may not challenge the dominance of mobility-enhancing strategies in the long run, but it is at least fostering an important discussion about the direction of transportation planning in the U.S. in the short run.

## REFERENCES


Benfield, F. Kaid, Jutka Terris, and Nancy Vorsanger. 2001. *Solving Sprawl: Models of Smart Growth in Communities Across America*. Natural Resources Defense Council, New York.

Boarnet, Marlon G. and Randall Crane. 2001a. *Travel by Design: The Influence of Urban Form on Travel*. New York: Oxford University Press.

Boarnet, Marlon and Randall Crane. 2001b. The Influence of Land Use on Travel Behavior: Empirical Strategies. *Transportation Research, A: Policy and Practice*, Vol. 35, No. 9, pp. 823-845.

Boarnet, Marlon G. and Andrew F. Haughwout. 2002. *Do Highways Matter? Evidence and Policy Implications of Highways' Influence on Metropolitan Development*. A discussion paper prepared for the Brookings Institution Center on Urban and Metropolitan Policy, Washington, DC, August.

Bottom, Jon, Masroor Hasan, and Jane Lappin. 2002. Traveler Response to Information: Who Responds and How? *TR News*, No. 218 (January-February), pp. 25-30.

Bureau of Transportation Statistics (BTS). 2002. *Transportation Indicators*. U.S. Department of Transportation, Washington, DC, April.

Calthorpe, Peter. 1993. *The Next American Metropolis: Ecology, Community and the American Dream*. New York: Princeton Architectural Press.

Capital Area Metropolitan Planning Organization (CAMPO). 2000. *CAMPO 2025 Transportation Plan*. Austin, TX, adopted June 12, modified August 7.

Carfree.com. 2002. *Carfree Places*. Available: http://www.carfree.com/carfree_places.html. Accessed: 5/27/02.

Cervero, Robert and Kara Kockelman. 1997. Travel Demand and the 3Ds: Density, Diversity, and Design. *Transportation Research Record D: Transport and the Environment*, Vol. 3, pp.199-219.

Cervero, Robert and Roger Gorham. 1995. Commuting in Transit Versus Automobile Neighborhoods. *Journal of the American Planning Association*, Vol. 61, pp. 210-225.

Cervero, Robert. 1993. *Transit-Supportive Development in the United States: Experiences and Prospects*. Federal Transit Administration, U.S. Department of Transportation, December.

Chicago Area Transportation Study (CATS). 2002. *2020 Regional Transportation Plan Summary*. Available: http://www.catsmpo.com/pubs/rtp-sum00.htm. Accessed: 5/28/02.

Chicago, City of. 2002. *Strengthening Chicago's Neighborhood Retail Districts*. Available: http://www.ci.chi.il.us/Mayor/Zoning/ordin_3.html. Accessed: 5/21/02.

Choo, Sangho, Patricia L. Mokhtarian, and Ilan Salomon. 2001. *Impacts of Home-Based Telecommuting on Vehicle-Miles Traveled: A Nationwide Time Series Analysis*. Prepared for the California Energy Commission, December.

Choo, Sangho, Patricia L. Mokhtarian, and Ilan Salomon. 2001. *Impacts of Home-Based Telecommuting on Vehicle-Miles Traveled: A Nationwide Time Series Analysis*. Prepared for the California Energy Commission, Sacramento, CA, December.

Cleveland Neighborhood Development Corporation (CNDC). 2002. *Retail/Commercial*. Available: http://www.cndc2.org/retail_commercial.htm. Accessed: 5/21/02.

Community Transportation Association (CTA). 2001. *What is Community Transportation?* Available: http://www.ctaa.org/about/. Accessed: 5/29/02.

Congress for the New Urbanism (CNU). 2002a. *CNU Charter*. Available: http://www.cnu.org/aboutcnu/index.cfm. Accessed: 1/29/02.

Congress for the New Urbanism (CNU). 2002b. *CNU History*. Available: http://www.cnu.org/aboutcnu/index.cfm. Accessed: 5/21/02.

Cyveillance. 2000. *Internet Exceeds 2 Billion Pages*. Press Release, July 10. Available: http://www.cyveillance.com/web/newsroom/releases/2000/2000-07-10.htm. Accessed: 5/23/02.

Davis, Stacy. 2001. *Transportation Energy Data Book: Edition 21*. Oak Ridge National Laboratory, Office of Transportation Technologies, U.S. Department of Energy, Oak Ridge, TN, October.

Downs, Anthony. 1992. *Stuck in Traffic: Coping with Peak-Hour Traffic Congestion*. Washington, DC: Brookings Institution.

Duany, Andres and Elizabeth Plater-Zyberk. 1991. *Towns and Town-Making Principles*. New York: Rizzoli.

Egan, Timothy. 2002. Sprawl-Weary Los Angeles Builds Up and In. *The New York Times*, March 10, pp. 1, 30.

Environmental Protection Agency (EPA). 1998, Technical Methods for Analyzing Pricing Measures to Reduce Transportation Emissions, USEPA Report #231-R-98-006, Available: www.epa.gov/clariton/clhtml/pubtitle.html.

Environmental Protection Agency (EPA). 1999. *Antidotes to Sprawl: Infill Development*. Available: http://www.epa.gov/region5/sprawl/infill.htm. Accessed: 5/29/02.

Environmental Protection Agency (EPA). 2002. *Commuter Choice Leadership Initiative*. Available: http://www.commuterchoice.gov/index.htm. Accessed: 5/23/02.

Environmental Protection Agency (EPA). 2002. *USA Air Quality Nonattainment Areas*. Office of Air Quality Planning and Standards, Washginton, DC. Available: http://www.epa.gov/airs/nonattn.html. Accessed 5/9/02.

Ewing, Reid and Robert Cervero. 2001. Travel and the Built Environment. *Transportation Research Record*, No. 1780 87-114.

Federal Highway Adminstration (FHWA). 1998a. *TEA-21 Fact Sheet: Metropolitan Planning*. September 14. Available: http://www.fhwa.dot.gov/tea21/factsheets/metropln.htm. Accessed: 5/28/02.

Federal Highway Adminstration (FHWA). 1998b. *TEA-21 Fact Sheet: Intelligent Transportation Systems Program*. September 14. Available: http://www.fhwa.dot.gov/tea21/factsheets/its.htm. Accessed: 5/28/02.

Federal Highway Administration (FHWA). 2001. *Unifying America: Report to the American People*. U.S. Department of Transportation, Washington, DC. [check date]

Federal Highway Administration (FHWA). 2002a. *The Dwight D. Eisenhower Interstate System*. Available: http://www.fhwa.dot.gov/programadmin/interstate.html. Accessed 5/17/02.

Federal Highway Administration (FHWA). 2002b. *Investing in Our Future: An Analysis by the Federal Highway Administration*. Updated as of February 4, 2002. Available: http://www.fhwa.dot.gov/tea21/teafunds.htm. Accessed: 5/17/02.

Federal Highway Administration (FHWA). 2002c. *Value Pricing Pilot Program: Notice of Grant Opportunities*. U.S. Department of Transportation. Available: http://www.fhwa.dot.gov/policy/vppp.htm. Accessed: 5/25/02.

Federal Highway Administration (FHWA). 2002d. *FHWA Administrator Testifies That Growing congestion Threatens Nation's Economy, Quality of Life*. Press Release, May 21.

Federal Highway Administration (FHWA). 2002e. *U.S. Transportation Department Recognizes Commuter Choice Pioneers*. Press Release, May 14.

Federal Transit Administration (FTA). 2002. *New Starts Evaluation and Rating Process*. Available: http://www.fta.dot.gov/library/policy/ns/nserp.htm. Accessed: 5/22/02.

Forrester Research, Inc. 2002. *December Shopping Up From Last Year Despite Slow Economy*. Press Release, 2/24. Available: http://www.forrester.com/ER/Press/Release/0,1769,678,00.html. Accessed 5/24/02.

Friedman, Bruce, Stephen P. Gordon, and John B. Peers. 1992. *The Effect of Neotraditional Design on Travel Characteristics*. Compendium of Technical Papers. Anchorage, Alaska: Institute of Transportation Engineers, 1992 District 6 Annual Meeting;195-208.

Fujiwara, A. and Y. Sugie. 1995. *Influence of Pre-Trip Information on Traveler's Choice Behavior*. Paper presented at "Steps Forward," the Intelligent Transport Systems World Congress, Yokohama, Japan, November.

Furuya, H., K. Nishii, and Y. Asakura. 1995. *User Evaluation and Response to Parking Guidance and Information system in a Central City Shopping Area in Japan*. Paper presented at "Steps Forward," the Intelligent Transport Systems World Congress, Yokohama, Japan, November.

General Services Administration (GSA). 2002. *Interagency Telework/Telecommuting* Site. Available: http://www.telework.gov/. Accessed: 5/23/02.

Handy, Susan. 1992. Regional versus Local Accessibility: Neo-Traditional Development and its Implications for Non-Work Travel. *Built Environment*, Vol. 18, No. 4, pp. 253-267.

Handy, Susan. 1993. A Cycle of Dependence: Automobiles, Accessibility and the Evolution of the Transportation and Retail Hierarchies. *The Berkeley Planning Journal*, Vol. 9, pp. 21-43.

Handy, Susan. 1994. Highway Blues: Nothing a Little Accessibility Can't Cure. *Access*, No. 5, pp. 3-7.

Handy, Susan. 1996a. Methodologies for Exploring the Link Between Urban Form and Travel Behavior. Transportation Research D, Vol. 1, No. 2, pp. 151-165.

Handy, Susan. 1996b. "Understanding the Link Between Urban Form and Nonwork Travel Behavior," *Journal of Planning Education and Research*, Vol 15, No. 3, pp. 183-198.

Handy, Susan L, Marlon Boarnet, Reid Ewing, and Richard G. Killingsworth. 2002. How the Built Environment Affects Physical Activity: Views from Urban Planning. *American Journal of Preventative Medicine*. Forthcoming.

Handy, Susan L. and Kelly J. Clifton. 2001. Local Shopping as a Strategy for Reducing Automobile Travel. *Transportation*, Vol. 28, No. 4, pp. 317-346.

Handy, S. and D. Niemeier. 1997. Measuring Accessibility: An Exploration of Issues and Alternatives. *Environment and Planning A*, Vol. 29, pp. 1175-1194.

Handy, Susan and Patricia L. Mokhtarian. 1995. Planning for Telecommuting: Measurement and Policy Issues. *Journal of the American Planning Association*, Vol. 61, No. 1 (Winter), pp. 99-111.

Handy, Susan, Robert Paterson, Andrew De Garmo, Christina Stanland. 1999. *Street Connectivity: A Report to the City of Austin on Cities with Connectivity Requirements*. Community and Regional Planning Program, University of Texas at Austin, August

Handy, Susan and Tom Yantis. 1994. *The Impacts of Telecommunications Technologies on Nonwork Travel Behavior*. Report No. SWUTC/97/721927-1, Southwest Region University Transportation Center, Center for Transportation Research, University of Texas at Austin, Austin, TX, January.

Hansen, W.G. 1959. How Accessiblity Shapes Land Use. *Journal of the American Planning Institute*, Vol. 25, pp. 73-76.

Institute for Local Self-Reliance (ILSR). 2002. *Formula Business Restrictions*. Available: http://www.newrules.org/retail/formula.html. Accessed: 5/22/02.

Institute of Urban and Regional Development (IURD). 2002. Induced travel effects not so dramatic. *IURD Developments*, Vol. 12, No. 1, p. 3.

ITS America. 1998. *ITS offers a new approach*. Available: http://www.itsa.org/resources.nsf. Accessed: 5/20/02.

ITS America. 2001. *What is ITS?* Available: http://www.itsa.orb/whatits.html. Accessed: 5/20/02.

ITS America. 2002. *Delivering the Future of Transportation: The National Intelligent Transportation Systems Program Plan: A Ten-Year Vision*. January.

Katz, Peter. 1994. *The New Urbanism: Toward an Architecture of Community*. New York: McGraw-Hill.

Kitamura, Ryuichi, Patricia L. Mokhtarian and Laura Laidet. 1997. A Micro-Analysis of Land Use and Travel in Five Neighborhoods in the San Francisco Bay Area. *Transportation*, Vol. 24, No. 2, pp. 125-158.

Kline, Kelly and Jim Schutz. 2001. Getting in the Ground Floor. *Planning*. August, pp. 14-17.

Kraan, Mariette, Hani S. Mahmassani, and Nhan Huynh. 2001. Traveler Responses to Advanced Traveler Information Systems for Shopping Trips: Interactive Survey Approach. *Transportation Research Record*, No. 1725, pp. 116-123.

Krizek, Kevin. Forthcoming. Residential Relocation and Changes in Urban Travel: Does Neighborhood-Scale Urban Form Matter? *Journal of the American Planning Association*.

Kruse, Jill. 1998. Closing Roads. *Urban Land*. May, pp. 64-65.

Kulash, Walter, Joe Anglin, and David Marks. 1990. Traditional Neighborhood Development: Will the Traffic Work? *Development*, Vol. 21, pp. 21-24.

Landis, John, Robert Cervero, and Peter Hall. 1991. *Transit Joint Development in the U.S.: An Inventory and Policy Assessment*. Institute of Urban and Regional Development, University of California at Berkeley.

Litman, Todd. 2000. Generated Traffic: Implications for Transport Planning. *ITE Journal*, Vol. 71, No. 4.

Mahmassani, Hani S. 1999. Traveler Behavior and Intelligent Transportation Systems. *Transportation Research Part C*, Vol. 7, pp. 73-74.

Mahmassani, Hani S. and Yu-Hsin Liu 1999. Dynamics of Commuting Decision Behaviour Under Advanced Traveller Information Systems. *Transportation Research Part C*, Vol. 7, pp. 91-107.

Maryland, State of. 2002. *Smart Growth in Maryland*. Available: http://www.op.state.md.us/smartgrowth/. Accessed: 5/22/02.

McNally, Michael G. and Sherry Ryan. 1993. Comparative Assessment of Travel Characteristics for Neotraditional Designs. *Transportation Research Record*, No. 1607, pp. 105-115.

Metro. 1996. *Main Street Handbook: A User's Guide to Main Streets*. Portland, OR, March.

Mokhtarian, Patricia L. 2001. *The Impacts of B2C E-Commerce on Transportation and Urban Form*. Prepared for the Conference on Electronic Commerce (B2C) and its Consequences for Urban Development and Transportation, University of Stuttgart, November 23.

Mokhtarian, P.L., S. Handy and I. Salomon. 1995. Methodological Issues in the Estimation of the Travel, Energy and Air Quality Impacts of Telecommuting. *Transportation Research Part A*, Vol. 29A, No. 4, pp. 283-302.

Mokhtarian, P.L. and I. Salomon. 1994. Modeling the choice of Telecommuting: Setting the Context. *Environment and Planning A*, Vol. 26, No. 5, pp. 749-766.

Mokhtarian, Patricia L. and Ilan Salomon. 2001. How derived is the demand for travel? Some conceptual and measurement considerations. *Transportation Research Part A*, Vol. 35, pp. 695-719.

Mokhtarian, Patricia L., Francisco J. Samaniego, Robert H. Shumway, & Neil H. Willits. 2002. Revisiting the notion of induced traffic through a matched-pairs study. *Transportation*, Vol. 29, pp. 193-220.

Municipal Research & Services Center (MRSC). 1997. *Infill Development: Strategies for Shaping Livable Communities*. Report No. 28, June. Available: http://www.mrsc.org/textfill.htm#E19E1. Accessed: 5/29/02.

Murakami, Elaine and Jennifer Young. 1997. *Daily Travel by Persons with Low Income*. Paper for NPTS Symposium, Bethesda, MD, October. Available: http://www-cta.ornl.gov/npts/1995/Doc/LowInc.pdf. Accesssed: 5/29/02.

National Trust for Historic Preservation (NTHP). 2002a. About the Main Street Program. Available: http://www.mainst.org/AboutMainStreet/aboutmain.htm. Accessed: 5/22/02.

National Trust for Historic Preservation (NTHP). 2002b. *Historic Preservation Equals Economic Development: The Main Street Program's Success*. Available: http://www.mainst.org/AboutMainStreet/numbers.htm. Accessed: 5/22/02.

New York City (NYC). 2002. *Getting Around New York City*. Available: http://www.nyc.gov/html/dot/html/get_around/emergencyinfo.html#restrictions. Accessed: 5/27/02.

Newman, Morris. 2001. In Bay Area, Mass Transit Inspires Project. *The New York Times*, June 17, p. 38.

Newman, Peter and Jeffrey Kenworthy. 1999. *Sustainability and Cities: Overcoming Automobile Dependence*. Washington, DC: Island Press.

Noland, Robert B. and Lewison L. Lem. 2002. A review of the evidence for induced travel and changes in transportation and environmental policy in the U S and the UK. *Transportation Research Part B*, Vol. 7, pp. 1-26.

Norfolk, City of. 2002. *Neighborhood Commercial Areas*. Available: http://www.norfolk.va.us/now/commercial.htm. Accessed: 5/21/02.

Nua. 2001. *How Many Online?* Available: http://www.nua.ie/surveys/how_many_online/index.html. Accessed: 5/24/02.

Owens, Mitchell. 1994. Saving Neighborhoods One Gate at a Time. *The New York Times*, August 25, pp. B1-B2.

Oxford English Dictionary. 2002. *OED Online*. Oxford: Oxford University Press. Available: http://dictionary.oed.com/entrance.dtl. Accessed 5/9/02.

Pagan, Y.L.L., H.S. Mahmassani, and M. Kraan. 2000. *Trip Planning Behavior of Tourists: San Antonio Case Study*. Report No. SWUTC/00/472840-00073-1, Southwest Region University Transportation Center, Center for Transportation Research, University of Texas at Austin, January.

Paul, Katherine J. 2002. Advocating Mileage-Based Auto Insurance. *Conservation Matters*, Vol. VIII, No. 3 (Spring), pp. 31-33.

Pew Research Center. 2001. *More Online, Doing More*. Press Release, February 18. Available: http://www.pewinternet.org/releases/release.asp?id=15. Accessed: 5/24/02.

Pickett, Joseph, P. et al., editors. 2000. *The American Heritage® Dictionary of the English Language: Fourth Edition*. Boston: Houghton Mifflin. Available: http://bartleby.com/61/. Accessed 5/9/02.

Pushkarev, Boris S. and Jeffrey M. Zupan. 1977. *Public Transportation and Land Use Policy*. Bloomington: Indiana University Press.

Rathbone, Daniel B. Telecommuting in the United States. *ITE Journal*, December, pp. 40-45.

Salomon, Ilan and Patricia L. Mokhtarian. 1998. What Happens When Mobility-Inclined Market Segments Face Accessibility-Enhancing Policies? *Transportation Research D*, Vol. 3, No. 3, pp. 129-140.

Schreibman, Lisa. 2001. On a Tear. *Planning*, January, pp. 10-13.

Shah, Vishali P., Karl Wunderlich, and James Larkin. 2001. Time management Impacts of Pretrip Advanced Traveler Information Systems: Findings from a Washington, DC, Case Study. *Transportation Research Record,* No. 1774, pp. 36-43.

Shaheen, Susan and Daniel Sperling. 2001. *Center for New Mobility Research*. Institute of Transportation Studies, University of California at Davis, Spring.

Shoup, Donald. 2002. Roughly Right or Precisely Wrong. *Access*, No. 2 (Spring), pp. 20-25).

Steinhauer, Jennifer. 1996. When Shoppers Walk Away From Pedestrian Malls; Downtown Retailing Trend Again Favors a Car Culture. *The New York Times*, November 5, p. D1.

Stern, Eliahu. 1999. Reactions to Congestion Under Time Pressure. *Transportation Research Part C*, Vol. 7, pp. 75-90.

Telework Collaborative. 2002. *Our Mission*. Available: http://www.teleworkcollaborative.com/. Accessed: 5/23/02.

Texas Transportation Institute (TTI). 2001. *2001 Urban Mobility Study*. Available: http://mobility.tamu.edu/ums/. Accessed: 2/4/02.

Transit Cooperative Research Program (TCRP). 1995. *An Evaluation of the Relationships Between Transit and Urban Form*, Research Results Digest, No. 7, June.

Transportation Research Board (TRB). 1998. *Highway Capacity Expansion and Induced Travel: Evidence and Implications*. Transportation Research Circular Number 481, February.

U.S. Department of Transportation (US DOT). 1993. *Transportation Implications of Telecommuting. Washington*, DC. April.

U.S. Department of Transportation (US DOT). 1996a. *Operation TimeSaver: Taking Transportation into the 21st Century*. Washington, DC.

U.S. Department of Transportation (US DOT). 1996b. *Intelligent Transportation Infrastructure Benefits: Expected and Experienced*. Prepared by the MITRE Corporation, Washington, DC, January.

U.S. Department of Transportation (US DOT). 1996c. *Building Livable Communities Through Transportation*. Washington, DC, October 1.

U.S. Department of Transportation (US DOT). 2000a. Highway Statistics 2000. Washington, DC.

U.S. Department of Transportation (US DOT). 2000b. Strategic Plan. Washington, DC. Available: http://stratplan.dot.gov/. Accessed: 5/29/02.

U.S. Department of Transportation (US DOT). 2001. 1995 NPTS Databook. Federal Highway Administration, Washington, DC, October.

University of Minnesota (UMN). 2002a. *Road Pricing*. Available: http://www.hhh.umn.edu/centers/slp/conpric/learn/types_a.htm. Accessed: 5/25/02.

University of Minnesota (UMN). 2002b. *Vehicle Use Pricing*. Available: http://www.hhh.umn.edu/centers/slp/conpric/learn/types_b.htm. Accessed: 5/25/02.

University of Minnesota (UMN). 2002c. *Parking Pricing*. Available: http://www.hhh.umn.edu/centers/slp/conpric/learn/types_c.htm. Accessed: 5/25/02.

Victoria Transport Policy Institute. 2002. *Transport Elasticities*. Available: http://www.vtpi.org/tdm/tdm11.htm#_Toc5666150. Accessed: 5/25/02.

Vishwanathan, Krishnan, Konstandinos G. Goulias, Paul P. Jovanis. 2000. *Use of Traveler Information in the Puget Sound Region: A Preliminary Multivariate Analysis*. Paper 00-1368, presented at the 79th Annual Meeting of the Transportation Research Board, Washington, DC, January.

Washburn, Dan. 1997. Hardware Store Chains: New Interest in Old Format. *Home Improvement Market*, Vol. 234, No. 8 (August), pg. 196.

Washington Department of Transportation (WashDOT). 1996. *Washington's Interstate Highways: 40 Years of Service*. October.

Washington, S., R. Guenseler, and D. Sperling. 1994. *Emission Impacts of Intelligent Vehicle Highway Systems*. Transportation Planning and Air Quality II.

Weingroff, Richard F. 1996. Engineering Marvels. *Public Roads*, Vol. 6, No. 1 (Summer). Available: http://www.tfhrc.gov/pubrds/summer96/p96su.htm. Accessed: 5/17/02.

Wenzel, Tom. 1995. *Analysis of National Pay-as-You-Drive Insurance and Other Variable Driving Charges*. Report No. LBL-37321, Lawrence-Berkeley Laboratory, Berkeley, CA, July.

Williams, John. 1994. Probe of street closings examines racial issues. *The Houston Chronicle*, 15 December, p. 1.