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DEFINING AN URBAN BICYCLE TRANSPORTATION SYSTEM FOR MINNESOTA CITIES

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For Minnesota Cities

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TABLE OF CONTENTS

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1. INTRODUCTION

Bicycle transportation has long been hailed by some as a solution to many local and global environmental problems. These problems include pollution, congestion, dwindling urban real-estate, urban sprawl, land-use misapplications, disruption of neighborhoods by traffic, declining urban centers, air pollution and dependency on fossil fuels.

The Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) recognized and sought to address these problems. It also acknowledged an important role for the bicycle as a form of transportation in this regard by the policy language set forth in the act. Bicycle transportation, along with pedestrian transportation, is specifically cited by ISTEA as a way of solving problems generated by automobile transportation systems:

> *It is in the national interest to encourage and promote the development of transportation systems embracing various modes of transportation in a manner which will efficiently maximize mobility of people and goods within and through urbanized areas and minimize transportation-related fuel consumption and air pollution. To accomplish this objective, metropolitan planning organizations, in cooperation with the State, shall develop transportation plans and programs for urbanized areas of the State. Such plans and programs shall provide for the development of transportation facilities (including pedestrian walkways and bicycle transportation facilities) which will function as an intermodal transportation system for the State, the metropolitan areas and the Nation. The process for plans and programs shall provide for consideration of all modes of transportation and shall be continuing, cooperative and comprehensive to the degree appropriate, based on the complexity of the transportation problem.*[1] (Emphases added.)

A review of the literature on bicycle transportation shows there have been many studies and publications that present good arguments as to why we should foster the use of the bicycle as a mode of utilitarian transportation. However, this literature tells us little to help understand how to implement a bicycle transportation system in an orderly and systematic way.

This is particularly true for urban roadway transportation literature in the United States. There is clear attention to individual and detailed aspects of bicycle facilities, but the issue of how to integrate these pieces into a whole working system is essentially unaddressed. For example: There are specifications that give dimensions for bicycle lanes, but these specifications do not define a method of thinking about how to join these lanes together to form a system of functioning linkages. Just as the dimensions of a lane for motor vehicle use do not define a system for motor vehicle transportation, neither do bicycle lane dimensions define a bicycle transportation system. Necessary strategies have not been offered to use the patterns of the urban fabric, together with roadway planning and design alternatives to foster non-motorized transportation and accommodate multi-modal roadway transportation in the United States.

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1 Congress, U. S. (1991) *The Intermodal Surface Transportation Efficiency Act of 1991*. H. R. 2950, 1991. Section 1024, Metropolitan Planning.

In the middle part of this century, transportation design engineers developed a system definition for a highway transportation system prior to the allocation of funds and the implementation of the system. This system is most commonly referred to as the functional classification of streets and it has become institutionalized in official policy.[2] Most know it by its principle classifications of street hierarchy: Arterial, collector and local streets.

Historically, this system definition has been so successful that it has become embedded in our thinking, forming the basic assumptions of all roadway transportation discussions. It has framed and guided the development of urban roadway systems in such a widespread way, that it is difficult to conceive of any other possibility. It has also resulted in the rolling out of a system of roadways across the nation and within our cities that is staggering to the imagination to think of in total. As a result, any other type of roadway system that also accommodates and integrates other modes of roadway transportation, such as bicycles, is difficult to visualize and understand.

This system definition was direct, simple, and easily understood by everyone involved. It was this aspect of the system that undoubtedly helped foster its speedy implementation and later application to urban roadways. There is no similarly direct, simple and easily understood definition for a roadway system that supports to bicycle transportation. For this reason, planners, designers, engineers, decision makers, and the general public have difficulties conceptualizing and communicating systematic thought about roadways for bicycles. Consequently, visualizing a configuration logic for bicycle roadway integration is even more difficult.

2 American Association of State Highway and Transportation Officials (AASHTO).(1984) *A Policy on Geometric Design of Highways and Streets.* Washington, D. C.: AASHTO, pp. 1-18.

2 APPROACH

The intention of this study was to identify a systematic way by which use of the bicycle as utilitarian transportation in Minnesota cities could be increased.[3] History suggests that a conceptual construct of a roadway system that not only merely accommodates, but is also driven toward aggressively satisfying the broad range of bicycle transportation needs would be a powerful tool in this direction. Toward this end, the study focused on identifying essentials of such a vision for a bicycle transportation system and articulating the attributes most likely to bring it success in application on the land in the urban areas of Minnesota.

The approach taken in this study was simple. It focused on attempting to answer two general questions

1. <u>How can the bicycle effectively compete with the automobile as a mode of urban transportation?</u>

   and

2. <u>What can be learned from the apparent success of the urban motor vehicle roadway transportation that can be applied to foster expanded use of bicycling as urban transportation?</u>

To answer the first question, answers to another question were sought: What characteristics of bicycle use could provide realistic, competitive advantages over automobile use? To answer this question deductive reasoning was applied to the general observation that transportation technology has historically served to augment human powers to conquer space and time, specifically, the powers of *individuals* in this regard. Both the bicycle and the automobile provide mechanical advantages to reduce the amount of time needed to traverse space over walking. This observation was then used to identify components of the functional appeal of the bicycle and compare them to the appeal of the automobile in similar capacities. Chapter Three discusses and compares areas of functional appeal where use of the bicycle offers potential competitive advantages

To answer the second question, an analysis was undertaken of the historical development of the motor vehicle roadway transportation system and the policies that define its character today. Systems theory was used to provide a structure for organizing, understanding and critically analyzing the motor vehicle roadway transportation system in terms of historical development and current policy relationships and their impact on system function and form. Questions pursued in included:

- How was this success created?
- What can we learn from it to foster expanded use of bicycling as urban transportation?
- What opportunities does this legacy offer to bicycle transportation?

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3 From a grant proposal prepared for the Center for Transportation Studies at the University of Minnesota under the title of "Land Design for Bicycle Transportation in Minnesota." (U of M Office of Research Administration contract number is MNADM/02130-93190.)

- What problems and obstacles does it present?

Today's motor vehicle transportation system offers an instructive model for thinking about how to establish and effective bicycle transportation system. Our motor vehicle roadway system has been wildly successful in extending automobility to all facets of life in urban America, driving a transformation of urban structure and form. This transformation has become the hallmark of urban life in America.

3. The Bicycle: Identifying Competitive Transportation Advantages

Bicycle transportation has long been identified as non-polluting and efficient, and as a spatially non-consumptive mode of transportation.[4] These attributes of bicycle transportation address broader human concerns of a social, economic and environmental nature. However, appealing to these features as a primary reason for taking steps to increase bicycle use relies on the individual transportation users to make choices for abstract and long term reasons in the face of conflicting immediate and practical needs. The time-pressed lifestyles of modern society make it difficult for such an appeal to be successful because it does not directly address the primary demands of daily life. In other words, such arguments are altruistic, stating what proponents believe ought to be good for us all, assuming this is enough to persuade people to change. One may agree or disagree with the 'rightness' of these broader concerns. However, they do not recognize the principal practical problem facing American urban transportation users: shortage of time to effectively meet increasing individual needs and wants.

The intention of this portion of the study was to identify and develop ideas to captialize on the comparative advantages of the bicycle as a mode of transportation in practical terms and build arguments and strategies for promoting bicycle use. This chapter addresses the question: How can the bicycle effectively compete with the automobile as mode of urban transportation? In answering this question we first looked for answers to another question: What characteristics of bicycle use could provide realistic, competitive advantages over automobile use?

To answer this question we examined the bicycle in the context of positive aspects of urban transportation characteristics provided by the automobile, and identified several areas where the bicycle offered comparative essential attributes. The following attributes of bicycle transportation were identified as offering potentially competitive strengths, in comparison to the automobile, for urban transportation use:

- The characteristics of personal transportation as compared to mass transportation.

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4 See, Congress, U. S. H. R. 2950, (1991). *The Intermodal Surface Transportation Efficiency Act of 1991.*

Transportation, U.S. Department of. (1980) *Bicycle Transportation for Energy Conservation*. (DOT OS-90092). Federal Highway Administration.

Transportation Study Board. (1990) *Bicycle Transportation, Preliminary Findings.* Minnesota State Legislature (Item #2.)

Minnesota Department of Transportation (MNDOT). (1990) *Economic Benefits of Bicycling: Toward Identifying Appropriate Public Investment Levels in Programs to Encourage Bicycle Transportation.*

Minnesota Department of Transportation (MNDOT). (1991) *Comprehensive State Bicycle Plan (Plan B).*

- The capacity to fulfill trip travel time requirements for individual travelers for a large percentage of urban trips.
- The capacity to provide access defined as getting individual travelers close to the door of trip destinations (time saving in the form of convenience at trip ends).
- The capacity to maneuver in the urban setting.
- The efficiency of fit to urban space constraints.

3.1. THE APPEAL OF THE BICYCLE AS PERSONAL TRANSPORTATION

The ability to move about one's world as an individual is described by terms like personal mobility, personal transportation, personal travel and personal transit. In its broadest sense, "personal mobility" is used to describe one's ability and opportunity to move about by whatever means available and includes all modes of transport (air, automobile, train, bus, motorcycle, bicycle, foot, etc.).

For the purposes of this discussion **personal transportation** means those modes of transportation that offer a user the ability and opportunity to move from place to place *on demand* alone or with persons of their own choosing.[5] This distinguishes personal transportation from mass transportation. Table 5.1A highlights the differences between personal and mass transportation.

Modes of personal transportation are *available on demand* and *give a broad range of choices to the individual* regarding places of trip origin and destination, one's traveling companions, route, and times of arrival and departure. Modes of mass transportation are available only as scheduled by the transportation provider and require the individual to adjust his schedule to conform to travel offerings regarding places of trip origin and destination, fellow travelers, route, and times of arrival and departure. With mass transportation, there is a narrower range of accommodation for unexpected or late changes in personal schedule. Also, where mass transportation provides a limited schedule of stops, the user is also often required to leave much earlier or later than desired (compared with personal transportation) to use the system.

The bicycle and its primary transportation competitor, the automobile, both possess all of the attributes of personal transportation. For this reason it is important to understand the nature of personal transportation and its role within a transportation context in order to understand in what ways the fulfillment of the personal transportation requirements of individuals could be used to promote increased bicycle transportation use.

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5 The idea of personal transportation is simply an extension to transportation in general of the ideas developed in the area of Personal Rapid Transit (or PRT) technology. A very basic discussion of the the personal service attributes of PRT may be found in Irving, Jack H., ed. (1978) *Fundamentals of Personal Rapid Transit.* Lexington, Massachusetts: D.C. Heath and Company pp. 1-4.

PERSONAL TRANSPORTATION	MASS TRANSPORTATION
MODES OF TRANSPORTATION THAT *ALLOW* THE TRAVELER TO:	MODES OF TRANSPORTATION THAT REQUIRE THE TRAVELER TO:
• Use the transport vehicle at a place of trip origin chosen by the traveler	• Meet the transport vehicle at a prescribed place of trip origin
• Use the transport vehicle to arrive at a place of trip destination chosen by the traveler	• Arrive at the place of trip destination that is prescribed by the transport vehicle's schedule
• Use the transport vehicle at any time, on demand	• Meet the transport vehicle at a scheduled time
• Have a choice of routes to the place of destination, subject only to constraints imposed by the infrastructure provided for the vehicle	• Travel on a prescribed route to the place of destination
• Travel alone or with chosen traveling companions	• Travel with others not of the traveler's choosing
• Includes private travel by automobile, motorcycle, moped, bicycle, in-line skate, wheelchair, and walking	• Includes public travel (in mass) by rail, bus and airplane

TABLE 3.1A COMPARISON OF CHARACTERISTICS OF PERSONAL TRANSPORTATION AND MASS TRANSPORTATION[6]

Distinguishing characteristics that are critical to understanding transportation preferences are described by the distinctions between:

- 'Transportation on demand' and 'transportation on a schedule'

  and

- 'Personal transportation' and 'mass transportation.'

Mass transportation focuses on moving large numbers of people in groups from a collecting point to a central destination. It requires organization on the part of the transportation provider. Groups of people must be in the right place, at the right time to be transported *en masse*. Scheduling is essential. Mass transportation is provided only according to a prescribed schedule over which the individual traveler has reduced freedom and little control.

Transportation on demand gives one freedom from and control over scheduled departure and arrival times, and places of trip origin and destination -- limited only by the infrastructure provided for the vehicle. Because transportation on demand provides

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6 This table is based on a similar one developed by Dr. J. Edward Anderson, Ph.D. former professor of mechanical engineering at the University of Minnesota and Boston University, pioneer in personal rapid transportation technology, inventor of the Taxi 2000 Personal Rapid Transit System, and chairman of the board of the Taxi 2000 corporation. His articulation of this distinction between personal and mass transportation was fundamental to directing his work on the Taxi 2000 system.

this flexibility, each individual has maximum control over his or her transportation schedule.

In fully motorized societies, personal transportation offers greater freedom of movement, or mobility, to those individuals using such modes. This gives these individuals greater efficiency in the use of personal time, as well as personal convenience in carrying out the tasks, the business, and the leisure-time activities of life. Mass transportation, by necessity, places more limits on these qualities of everyday life, because it must establish and meet pre-scheduled departure and arrival times and prescribed places of trip origin and destination.

Motorization of America increasingly accommodated the automobile by implementing a transportation system and infrastructure to support it. As this occurred, the automobile's ability to save personal time and provide personal transportation significantly increased. At the same time the individual's degree of autonomy and freedom (at least as perceived if not in fact) increased, and broadening the ranges of individual control and experience. This expansion of individual "freedoms" was not limited to a select few or several select classes of people. The expansion of infrastructure together with capability of almost everyone to become a licensed motor vehicle operator extended 'the freedom of mobility' to practically every member of the motorized society. This profoundly changed the cultural, social and economic foundations of that society. As freedom of mobility became more commonplace, it became taken for granted that the extension of the freedom of mobility (that is, licensing) became routine to the point of almost being a right in practice.

Personal mobility has profoundly influenced 20th century psychological, sociological and cultural values and their symbols. Two writers on the role of transportation in shaping modern society capture the immensity of change brought about and tied to the idea of personal mobility. In his essay, *LA Freeway*, David Brodsley observes:

> *Every time we merge with traffic we join our community in a wordless creed: belief in individual freedom, in a technological liberation from place and circumstance, in a democracy of personal mobility.*[7]

In speaking of the impact of increased personal mobility encompassing all forms of transportation, Wilfred Owen states:

> *...Altogether, the opportunities and extended horizons made possible by personal mobility play an important part in the American economy, while for many low-income countries the lack of such mobility has meant isolation and stagnation.*
>
> *The changing picture can be attributed to the automobile and the airplane in particular, but to buses and trains as well. <u>They have emancipated human beings from the immobility that once compelled most people to live and work in the immediate vicinity of their birth.</u> Whereas in earlier times only soldiers, explorers, and the wealthy were privileged to travel any distance from home, the twentieth century has democratized mobility and has conferred its benefits on millions of ordinary citizens....*

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7 Brodsley, David. (1981) *L.A. Freeway: An Appreciative Essay.* Berkeley and Los Angeles, Ca.: University of California Press, p. 5.

...The relationships are understandable. Personal mobility is an essential ingredient of most economic activity, providing workers with a wide choice of jobs and enabling business to recruit workers from a large geographic area. Ease of travel has made it possible to transport large numbers of children to school and has added to the informal learning process that stems from contact with new places, people, and ideas.[8] (Emphasis added.)

The idea of personal mobility is clearly a powerful one. The concept of personal transportation is clearly tied to personal mobility, but it also names a special class of transportation that provides the most freedom of choice in the hands of the individual. The importance of this freedom of choice for Americans is embedded in the ideas upon which the country was founded and has likewise been expressed in American transportation choices.

The overwhelming preference for the automobile, and similar motorized modes of personal transportation, is demonstrated by the information shown in Table 3.1B. The table shows the percentage of all person-trips made by each transportation mode using 1983 and 1984 data. The modes are grouped by personal transportation, mass transportation, and other.

MODES OF TRANSPORTATION

PERSONAL				MASS					
Auto & Similar Motor Vehicles [1]	Bicycle	Walk	Total	Bus, Train, & Subway [2]	School Bus	Airplane	Total	Other	Total
81.90	0.76	8.62	91.28	2.28	2.65	0.04	4.97	3.75	100.0

[1] Includes persons traveling in station wagons, vans, pickup trucks, jeeps, dune buggies and as passengers in automobiles.

[2] Includes intercity buses, mass transit, shuttle buses, senior citizen or similar bus services, trolleys, streetcars, cable cars and elevated trains. Does not include public or private buses operated for the convenience of employees, or contracted or chartered buses.

TABLE 3.1B PERCENTAGES BY MODE OF ALL PERSON TRIPS[9]

In addition to showing the preference for personal automobile transportation, these data suggest the bicycle's potential as a viable transportation option. Notice that the data, expressed as percentages of person-trips,[10] show that at least 91.28% of the population use personal modes of transportation instead of mass transportation modes.

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8 Owen, Wilfred. (1987) *Transportation and World Development.* Baltimore: The Johns Hopkins University Press, p. 85-6.

9 Personal Travel in the United States:1983-1984 Nationwide Personal Transportation Study, Vol. 2. (1986) U.S. Department of Transportation, Table E-108.

10 A person-trip represents the trip that is taken every time an individual travels.

For 81.90% of their trips, people choose some kind of personal mode of motor vehicle transportation. An additional 8.62% person trips are made by walking. Only 0.76% person trips are trips made by bicycle. The bicycle shares all the characteristics of personal transportation with walking and driving. The bicycle also provides a significant mechanical advantage over walking (the reason for its invention). Its mechanical advantage brings an exponentially larger area of land (and destinations) into the individual's range of travel, for less energy expended by the individual in the same amount of time. For these reasons, it should be able to capture a significantly larger number of person-trips than walking, yet it does not. Why not?

These trips outside of walking distance are certainly being made by way of other modes of transportation. Could it be that it is simply more difficult that it appears to use the bicycle as urban transportation to make these trips? Or could it be that these trips are mostly made to destinations outside the practical range of the bicycling? There is a case to be considered that bicycling *actually is* more difficult for making these trips than is apparent at first glance. This possibility is best understood in the context of personal transportation. The second question, pertaining to practical range and destinations, is explored in Section 3.2 Bicycle Trip Travel Time.

The concept of difficulty is relative. A better way of stating the question of difficulty would be: Is bicycle use for trips beyond walking distance more difficult than other options? The most obvious option to consider first is the only other remaining personal transportation option, the automobile.[11] For trips beyond walking distance, automobiles have a very formidable advantage that bicycles generally do not. That advantage is a continuous, integrated system of roadway infrastructure designed to support its use. This roadway infrastructure has ubiquitousness in urban life and is specifically directed toward accommodating the motor vehicle. By contrast, a roadway infrastructure for bicycling can be characterized spotty, discontinuous, un-integrated, non-specifically designed to support bicycling and generally lacking or absent. A simple windshield survey of most Minnesota central cities will show that currently there is more space dedicated and designed for automobile use than for bicycle use. Similarly, nearly every central city street has more and better space designed for pedestrians than bicycles. In central cities, sidewalks paralleling the roadway are common, yet there is no similar frequency of bicycle lanes, or even simple space for using bicycles.

By state law, bicycles are governed by the same traffic code as motor vehicles, even though their operating speed capabilities are quite different. Similarly, the bicycle can also operate at near to walking speeds. The result is that in practice, bicyclists can operate on streets with motor vehicles when their speeds are similar. Where this is not the case, cyclists often move onto sidewalks. In other words, in most cases, a trip taken by a bicyclist is not supported by a, continuous, organized infrastructure. Instead, the cyclist just makes do with what infrastructure there is for motor vehicles and pedestrians, taking advantage of the bicycle's essential adaptability. In comparison to the automobile and walking, the bicycle has been largely left out in the design of urban infrastructure for transportation.

All of this points to the lack of a continuous, supporting infrastructure as an explanation of why bicycles haven't taken a larger share of trips beyond walking distance in the personal transportation category. The lack of an integrated, systematic,

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11 From this point on, the term 'automoble' is used to represent station wagons, vans, pickup trucks, jeeps, dune buggies and automobiles, all of which can and are used as personal transportation vehicles.

and supporting infrastructure certainly makes travel more difficult. This appears to be even more the case when compared with the extensive and complete infrastructure provided for the mode in the personal transportation that seems to have absorbed much of the bicycle's potential users: the automobile. As we shall see in examining the history of the motor vehicle roadway transportation system later in this report, the organization of infrastructure was critical to the success of the automobile.

The mass transportation modes shown in Table 3.1B, either have their own specific infrastructures (trains and subways) or make using the same infrastructure as automobiles (buses). Buses also have several advantages in using that automobile infrastructure brought about by systematic accommodations to help tailor that infrastructure to support them such as bus stops, schedules and planned, identifiable routes. These advantages may well account for a portion of higher mass transportation use, in that is simply better supported than the bicycle for trips that extend beyond walking distance. Such trips might have been taken by bicycle except for the lack of infrastructure support.

When looked at from a supporting infrastructure point of view, bicycle use is in a double jeopardy situation. It does not have the advantage of a roadway infrastructure designed to support its use. In comparison to the automobile it also has the disadvantage of having no continuous, ubiquitous, integrated system roadway infrastructure in those cases where some infrastructure improvements have been made to support urban bicycle transportation. Bicycling is at a clear disadvantage in the realm of personal transportation because of a shortage of investment in infrastructure to support it. Such investment would seem to be foundational to taking advantage of any other competitive advantages that bicycle transportation may offer.

Among these potential competitive advantages, are those offered by the attribute of the personal transportation offered by bicycles. These advantages are best understood in contrast to the attributes of mass transportation. Mass transportation is based on the idea of groups of people as a means of achieving efficiency; that is, it always entails providing transportation *en masse* with people unfamiliar to the traveler. Modes of personal transport allow one to travel alone or to choose one's traveling companions. Modes of public transport do not allow choice regarding traveling companions unless one personally charters the transport service (an exception, not the rule). The advantages of personal transportation in this context are two-fold: on the personal user level and on the community level. They become more clear in light of what is known about crowding and human behavior.

There is a body of literature that has examined behavior, crowding and privacy, and the individual's ability to manage physical and social relationships with other individuals. In his book, *The Hidden Dimension*, Edward T. Hall examines "...social and personal space and man's perception of it. Proxemics is the term [he] coined for the interrelated observations and theories of man's use of space as a specialized elaboration of culture."[12] Hall references animal behavior, biochemical and sensory physiology, sensory perceptions, and compares cross-cultural human behavior to develop four different kinds of distances in which human activity takes places: intimate, personal, social and public.

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12 Hall, Edward T. (1966) *The Hidden Dimension.* Garden City, New York: Anchor Books, Doubleday and Co., Inc., p. 1.

The hypothesis behind the proxemic classification system is this: it is in the nature of animals, including man, to exhibit behavior which we call territoriality. In so doing, they use the senses to distinguish between one space or distance and another. The specific distance chosen depends on the transaction; the relationship of the interacting individuals, how they feel, and what they are doing. The four-part classification system used here is based on observations of both animals and men.[13]

Varying degrees of psychological comfort or discomfort are felt depending on the type of space involved and its appropriateness to the entire situation and its players. Hall describes the psychological and physical stress that occurs when the private realm of intimate space is violated in a public (i.e., mass transit) setting:

Crowded subways and buses may bring strangers into what would ordinarily be classed as intimate spatial relations, but ... riders have defensive devices which take the real intimacy out of intimate space in public conveyances. The basic tactic is to be as immobile as possible and, when part of the trunk or extremities touches another person, withdraw if possible. If this is not possible, the muscles in the affected areas are kept tense.... In crowded elevators the hands are kept at the side.... The eyes are fixed on infinity and are not brought to bear on anyone for more than a passing glance.[14]

In comparison, social and public distances provide more psychologically comfortable and less stressful spaces for the individual who is carrying out public activities. Of these distances, Hall comments:

A proxemic feature of social distance (far phase)[15] *is that is can be used to insulate or screen people from each other.*

At twelve feet an alert subject can take evasive or defensive action if threatened.[16]

The importance of these kinds of distances in urban settings and the proxemic options we provide urban citizens directly affect the planning and design of our cities. A city's transportation system, including the number of transportation vehicles it allows, the amount of urban space dedicated to transportation, and the kinds of modal offerings that are available to the individual directly effect the varieties of proxemic relationships that the city provides the individual. Hall comments on this relationship between behavior and the kinds of distances that the built environment permits (or compels):

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13 Ibid. p. 125.

14 Ibid. p. 118.

15 Hall describes far-phase social distance as occurring approximately between 7-12 feet and public distance as being 12 feet and beyond.

16 Ibid. p. 123.

The ability to recognize these various zones of involvement and the activities, relationships and emotions associated with each has now become extremely important. The world's populations are crowding into cities, and builders and speculators are packing people into vertical filing boxes -- both offices and dwellings. If one looks at human beings ... simply in terms of the limits of the body, one pays very little attention to the effects of crowding. If, however, one sees man surrounded by a series of invisible bubbles which have measurable dimensions, architecture can be seen in a new light. It is then possible to conceive that people can be cramped by the spaces in which they have to live and work. They may even find themselves forced into behavior, relationships, or emotional outlets that are overly stressful.... When stress increases, sensitivity to crowding rises -- people get more on edge -- so that more and more space is required as less and less is available.[17]

More recently, Motloch has also addressed the issue of distance or density and the built environment.[18] In examining human-environment relationships through planning and design, he reviews an array of literature addressing basic mechanisms that operate to determine personal and cultural needs and preferences regarding environment and where people choose and prefer to live. Within his review, he presents research that provides a rationale for regarding privacy as a value and a need of human beings. Regarding crowding and privacy in residential environments, Motloch states the following:

Social Density is the perception of other people or their possessions. Density that results in social overload, an absence of privacy, and degradation of quality of life is referred to as Crowding ... which reduces social interaction and the rate of acculturation. If other people and their artifacts are unfamiliar, the person must constantly read these people and their gestures to reduce uncertainty. Information load in this instance is high. Where one seeks to reduce information load, the need to constantly 'read' other people is a problem....

As in other perceptual stimuli, actual density is less important than perceived density. Perceived density can be reduced and privacy can be increased by managing social interaction, and information about the presence of others. This usually involves managing physical, spatial, and temporal and social relationships.

One of the keys to whether social densities and interpersonal encounters are positive lies in free choice.... When interaction is unwanted or forced, the individual seeks privacy and withdraws from social contact. Conversely, when one has the ability to withdraw, socializing and the probability of seeing the presence of others as positive increases[19]....(Emphases added.)

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17 Ibid. p. 129.

18 Motloch, John L. (1992) Delivery Models for Urbanization in the Emerging South Africa. Pretoria, South Africa: University of Pretoria, Department of Landscape Architecture

19 Ibid.

Though Motloch's thesis deals with residential environments, the literature he cites regarding privacy and forced interaction can be applied to transportation mode choice. An individual's transportation mode choice, or preference, can be seen as an extension of 'home lifestyle.' In other words, given the resource of personal transportation, where the traveler can choose traveling companions or travel alone, people can use their transportation mode choice as one of the tools in managing the "information load" and level of social interaction in their lives.

The observations of Hall and Motloch and other researchers demonstrate that privacy, or the ability to control one's privacy by controlling the social densities encountered in one's daily life, is of value to the individual. Their work indicates that the opportunity to travel alone or with chosen traveling companions should be significantly important to the transportation consumer because of the opportunity for relief from daily stress, particularly due to density or crowding. Modal preference should, therefore, tend to those modes of transportation that protect the traveler's personal space by providing a more public distance during the trip and which permit the traveler to control information load and level of social interaction.

The value of these characteristics to the transportation consumer is supported by the following from the 1980 census (1990 data are not yet available in tabular format, but reflect similar preferences). The data show that people decidedly prefer to travel alone, rather than, with others. This includes even travel with companions of their own choosing. Despite incentive and disincentive programs in recent years to curb this practice by increasing mass transportation use or carpooling, statistics show that for trips to and from work, the average number of passengers per vehicle is 1.3. In central cities, it drops to 1.2 passengers. The average number of passengers for shopping trips is 1.8, and for all types of trips, it is 1.7.[20] In 1992, the press reported a similar preference for traveling alone among commuters in the Twin Cities metropolitan area.[21]

Drive Alone	85%
Carpool	10%
Transit	04%
Other	01%

Aside from reflecting a value or a need for privacy, these data can also reflect the value or need people place on the personal flexibility that traveling alone affords them. When one travels with traveling companions, particularly on a regular basis with car-poolers, one must still accommodate or negotiate scheduled departure and arrival

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20 Personal Travel in the United States:1983-1984 Nationwide Personal Transportation Study, Vol. 2. (1986) U.S. Department of Transportation, Table E-122. Trips include travel to and from work, work related business, shopping, other family or personal business, doctor/dentist, school/church, vacation, visit friends or relatives, pleasure driving, and other social or recreational trips.

21 Blake, Laurie. "In Twin Cities, Free(way)'s a Crowd: More Commute, but Fewer are Using Car Pools or Buses." *Minneapolis Star Tribune* June 30, 1992: p. 1B. That there were 1.12 persons per vehicle on trips to and from work in the Twin Cities metropolitan area was also reported. This information presented in this article was taken from the Twin Cities' Metropolitan Council study of travel patterns in the Twin Cities area, conducted in 1990.

times and places of trip origin or destination with the car-pooler. This makes it difficult to handle unplanned travel requirements, such as working late or leaving work early, accomplishing errands on the noon hour or after work, socializing with friends after work or responding to family emergencies. To do so requires one to pursue cumbersome or inconvenient alternatives such as using mass transportation or making other travel arrangements either with family, friends or the car-pooler. This reduction in the amount of daily, personal flexibility, cannot only make a daily schedule more hectic and stressful for the car-pooler, but contributes to a reduction in the amount of autonomy and freedom that commuting alone provides the individual. In sum, even carpooling presents more similarities to mass transportation than it does to personal transportation.

SUMMARY OBSERVATION. Because the bicycle is a mode of personal transportation, it offers all of the dimensions of personal flexibility and freedom associated with that type of travel. It offers the supreme preference of urban travelers: to travel alone. This means that within its effective range of trip lengths, the bicycle can offer all of the freedoms and flexibility in trip planning and actual travel enabled by the automobile. When used for transportation, the bicycle can free the individual from dependence upon the needs or performance of others to travel. One can be spontaneous in making travel decisions. One can leave work early or late, as needs arise, without the task of re-organizing transportation plans with others. One can socialize with friends after work before commuting home, and respond unexpected needs for travel. Bicycling offers as much control over travel plans as does the automobile -- although within a smaller travel range (however we shall see in the next section, that range is not nearly as limiting as one might expect).

RECOMMENDATION 3.1-1. *The planning and design of facilities to support bicycle transportation should especially attend to supporting and maximizing the personal transportation attributes of the bicycle, and do nothing to diminish them. This means developing facilities that systematically extend individual freedom, convenience and ease of use for utilitarian bicycle transportation.*

3.2. The Appeal of the Bicycle in Terms of Travel Time

Another important question needs to be asked in order for the bicycle to be an effective competitor with the automobile. Can the bicycle fulfill a significant proportion of the trip travel time requirements of the urban traveler? That is, can the individual make significant use of the bicycle as transportation and not spend excessive amounts of time in doing so?

The time that it takes an individual to complete a trip is an important factor in determining an individual's choice of transportation mode. Other factors such as degree of comfort, convenience of access, safety, reliability, usefulness of traveling time (the ability to use it for other purposes such as reading or, in the case of the bicycle, aerobic exercise), service frequency, and the traveler's itinerary, can significantly affect the mode choice that an individual makes. Despite all of these influences, trip travel time still remains a primary factor in mode choice regardless of how the choice might be further altered or swayed by other factors.[22]

Prior to the advent of the automobile and the development of the infrastructure that supports its mobility and speed, people were limited in the distances they could travel by personal transport. One measure of this is the size of cities. Well into the 19th century, "...transportation involved feet, two if walking and four if riding."[23]

Our early cities were typically not much bigger than 20 square miles, only about four to five miles from edge to edge, and walking was the dominant mode of transportation. This placed most people at well under an hour's walk from the city's residential fringe to its commercial center for most trade and employment, similar to today's typical commuting time, 30-60 minutes.[24]

The mobility, convenience and speed of automotive travel greatly increased this distance. According to Owen, the mobility of the average person in the United States in 1900 was 436 miles per year. More recently, "The rapid growth of car ownership and ... the rising volume of air travel have increased per capita annual travel in the United States to twelve thousand miles."[25] Owen adds that 85 percent of total miles traveled is by automobile and so, 10,200 automobile miles are traveled on average by United

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22 Studies that address modal choice often compare the choice of a mode of personal transportation (usually, the automobile) with the choice of a mode of mass transportation. Studies that compare choice when only personal modes of transportation are considered (specifically, comparing automobile and bicycle transportation) appear to be absent in transportation planning literature.

23 Cushman, King. (1988) "Exploring the Land Development and Transit Connection." *Transit, Land Use and Urban Form.* Ed. Wayne Attoe. Austin, Texas: The Center for the Study of American Architecture, School of Architecture, University of Texas, p. 11.

24 Ibid, p.11.

25 Owen, Wilfred. (1987) *Transportation and World Development.* Baltimore: The Johns Hopkins University Press, p. 91 and 93.

States citizens. Of the 10 U.S. cities that Newman and Kenworthy studied in 1980,[26] the average passenger miles per capita was 7754, the highest (Houston) was 9900 and the lowest (New York City) was 4870.

Even though people travel more miles annually, the average commute time that individuals will tolerate on a daily basis, has remained remarkably constant throughout the centuries. National and local figures place the average commuting time for travel to and from work at around 20 minutes.[27] If we estimate travel time calculating the size of the Twin Cities Metropolitan area, the same figures for average trip travel times are achieved.

Figures from the Metropolitan Council, a 7-county regional planning body for the Twin Cities metropolitan area, placed the urbanized area of the Twin Cities in 1980 to be 1286 square miles.[28] If the area were perfectly round, its area would be described by a 20 mile radius, or a 40 mile diameter from border to border. Assuming a constant trip speed of 45 m.p.h., a trip from the edge of the circle to its center would take 27 minutes. This places many trips from the edge of the Twin Cities metropolitan area to its center within a 20-30 minute time frame. These figures reflect national average commute times as gathered from the national census, as well as figures obtained from the Twin Cities' Metropolitan Council study of travel patterns.

These data reflect a relationship between the size of cities and the ability of the individual to traverse the city on a daily basis and in a reasonable amount of time. They indicate that the average trip travel time for daily trips in urban areas has remained more or less constant throughout the centuries.

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26 The cities included: Houston, Phoenix, Detroit, Denver, Los Angeles, San Francisco, Boston, Washington, Chicago, and New York.

Newman, Peter W. G., and Jeffrey R. Kenworthy. (1989) *Cities and Automobile Dependence: An International Sourcebook.* Brookfield, Vermont: Gower Publishing Co., p. 36.

27 Most recently, *Personal Travel in the United States: 1983-1984 Nationwide Personal Transportation Study, Vol. 1.* U.S. Department of Transportation, 1986, states that the average commute time inside Standard Metropolitan Statistics Areas (SMSAs) is 20.9 minutes and outside SMSAs is 18.4 minutes. The total average commute time is 20.4 minutes. (p. 7-3).

In the Twin Cities' Metropolitan Council study of travel patterns in the Twin Cities area, conducted in 1990, the average commute time was found to be 21 minutes. Blake, Laurie. "In Twin Cities, Free(way)'s a Crowd: More Commute, but Fewer are Using Car Pools or Buses." Minneapolis Star Tribune June 30, 1992: 1B.

28 The definition for "urbanized area" is that definition used in the Federal-Aid Highways Act (title 23 USCS p. 101) which defines it as follows: "The term "urbanized area" means an area so designated by the Bureau of the Census, within boundaries to be fixed by responsible State and local officials in cooperation with each other, subject to approval by the Secretary. Such boundaries shall, as a minimum, encompass the entire urbanized area within a State as Designated by the Bureau of the Census."

Data Base for the Metropolitan Council of the Twin Cities Metropolitan Area. (1980) Metropolitan Council Transportation/Land Use Inventory

How well can the bicycle provide historically acceptable trip travel times of 20 to 30 minutes? Regarding the travel speed of various types of cyclists, the American Society of Civil Engineers[29] provides the most information. They say:

- Serious cyclists travel at speeds of 18-20 miles per hour,
- Skilled cyclists "who may not spend the same effort in details of the art or participate in rigid training as the racer [would find] speeds of about 12-16 miles per hour enjoyable,"
- Unskilled cyclists, or "newcomers" travel at speeds of 8-12 miles per hour.

Given these speed ranges, we can begin to approximate some optimal trip travel times that would be possible for cyclists of different skill levels with respect to a five mile trip:

- A cyclist traveling at an average speed of 15 miles per hour could make a trip of 5 miles in 20 minutes.
- At an average speed of 12 miles per hour, a cyclist would complete the same trip in 25 minutes.
- At an average speed of 10 miles per hour, the trip time would be 30 minutes.
- At an average speed of 8 miles per hour, a 2.67 mile trip would have a travel time of 20 minutes and a 4.0 mile trip would have a travel time of 30 minutes.

Given these potential trip travel times, a 5 mile cycling trip approximates the outside limit of effectiveness for the bicycle in terms of producing the historically acceptable urban trip travel time of 20-30 minutes. This means that for trips longer than five miles, it is not possible for the bicycle to produce acceptable trip travel times, (except by some serious or competitive cyclists). For trips less than five miles in length, the bicycle has the best opportunity for producing competitive or acceptable trip travel times.

At this point it is important to address the objection that speeds of travel quoted from ASCE do not equal trip travel time. That is, the trip travel times discussed above are dependent upon the ability to maintain the average speed assumed for the entire length of the trip. This is not often possible in urban conditions. The conditions which work against achievement of acceptable travel times include such variables as the number of required stops, directness of routes, availability of appropriate pavement surfaces and many other factors. This means the extent to which bicyclists can achieve acceptable trip travel times in the zero to five mile trip range is directly related to the character and directness of the route used to make the trip.

This disparity between estimates based on comfortable travel speed and actual trip travel time does not invalidate the idea that the zero to five mile trip range is the most likely for success in mode share capture by cycling. It is reasonable to infer that person-trips with lengths closer to the low end of this trip length range are much more susceptible to shifting toward bicycling as a mode choice. It also suggests that the succeptibility to such a mode-shift of person trips in the upper end of this range is likely to be elastic in response to the character and directness of the travel route presented to

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29 American Society of Civil Engineers. (1980) *Bicycle Transportation: A Civil Engineer's Notebook for Bicycle Facilities*. Ed. Bicycle Transportation Committee. New York: American Society of Civil Engineers.

the cyclists. This means that route character and directness must be carefully considered when making planning and design decisions regarding bicycle transportation systems intended to shift large numbers of person-trips to cycling. A closer look at patterns of person-trips is helpful to better understand the potential leveraging power of route design on the production of competitive trip travel times within the zero to five mile trip range.

How does this five mile benchmark for acceptable utilitarian cycling distance relate to modern travel patterns? In pre-industrial, pre-electronic societies, the ability to physically transport individuals, groups of people and goods in an amount of time reasonable to the task at hand for communication, trade and physical control were entirely fulfilled by roadway (or waterway) transportation systems. Technological achievements in transportation, communication, and weaponry have removed many requirements previously placed on roadway transportation systems. It is no longer necessary for people to live and work within a certain distance from one another in order to communicate within a reasonable amount of time. Electronic advances in communications equipment has removed the need for people to physically meet in order to carry out many aspects of everyday business and personal tasks. It is also no longer necessary for governments to totally rely on the transportation system for communication or maintaining a physical presence with those that are governed. Modern transportation, communication and weapons systems have provided a global sphere of activity and influence to all individuals and governments that are willing and wealthy enough to use these systems. Modern modes of transportation and communication have increased our spheres of activity, knowledge, and influence to a global scale with convenience and efficiency.

Despite this, our individual movements through our daily lives remain small in terms of trip distance. Table 3.2A shows that the daily sphere of activity for most individuals continues to be very local. The table shows percentages of person-trips by trip type and trip category for different ranges of trip distance using information collected in 1983 and 1984.

Person-Trip Distance Ranges (in miles)	Person-Trips % 0-5 miles	Person-Trips % 6-10 miles	Person-Trips % 11-15 miles	Person-Trips % 16-20 miles	Person-Trips % 21-30 miles	Person-Trips % 30+ miles	Total Type Trips as % of All Trips/Total % of Trips for Type
Utilitarian Person-Trip Types							
To or From Work[30]	11.15 *54.15*	4.19 *20.37*	2.20 *10.67*	1.26 *6.14*	1.08 *5.25*	.071 *3.43*	20.59 *100.00*
Work Related Business	1.28 *56.02*	0.36 *16.00*	0.22 *9.72*	0.14 *6.03*	0.11 *4.85*	0.17 *7.38*	2.28 *100.00*
Shopping	13.58 *74.56*	2.55 *13.98*	0.93 *5.08*	0.49 *2.71*	0.37 *2.04*	0.30 *1.63*	18.21 *100.00*
Other Family or Personal Business	11.46 *71.10*	2.49 *15.45*	0.90 *5.58*	0.45 *2.78*	0.38 *2.36*	0.44 *2.73*	16.11 *100.00*
Doctor/Dentist	0.55 *44.43*	0.41 *32.83*	0.11 *8.76*	0.06 *4.72*	0.06 *4.46*	0.06 *4.80*	1.24 *100.00*
School/Church	8.77 *73.83*	2.17 *18.24*	0.53 *4.48*	0.21 *1.73*	0.12 *0.99*	0.09 *0.73*	11.88 *100.00*
Vacation[31]	0.05 *21.35*	0.03 *11.57*	0.00 *0.45*	0.01 *2.85*	0.01 *3.72*	0.13 *60.06*	0.22 *100.00*
Visit Friends/Relatives[32]	6.54 *59.99*	1.94 *17.81*	0.74 *6.80*	0.60 *5.47*	0.52 *4.74*	0.57 *5.19*	10.89 *100.00*
Other Social/Recreational[33]	10.29 *65.16*	2.67 *16.90*	1.07 *6.80*	0.62 *3.92*	0.52 *3.28*	0.62 *3.94*	15.80 *100.00*
Subtotal Utilitarian Trip Types %s	63.67	16.81	6.70	3.84	3.17	3.09	97.22
Recreational Person-Trip Types							
Pleasure Driving	0.14 *28.13*	0.09 *18.55*	0.09 *17.78*	0.04 *8.24*	0.07 *15.12*	0.06 12.18	0.49 *100.00*
Other	1.56 *67.92*	0.41 *17.77*	0.15 *6.42*	0.06 *2.81*	0.05 *2.26*	0.06 *2.83*	2.29 *100.00*
% All Trips by Distance Range	65.35	17.30	6.93	3.93	3.29	3.20	100.0

30 The top number in each box is the percentage of all trips taken regardless of purpose. The bottom number in each box is the percentage of trips taken for the purpose indicated at the beginning of the row. For example: The first box on the commuting row shows the percents of person-trips taken within the range of 0 to 5 miles from trip origin -- the top number indicates these trips are 11.15% of all trips taken for all purposes, the bottom number (in italics) indicates these trips are 54.15% of all commuting person-trips.

31 The category vacation includes trips reported by the respondent as "vacation." It is assumed that most vacationers use a mode of transportation to arrive at a destination where vacation activities take place, rather than use travel itself as the vacation activity.The transportation used is utilitarian, even though the destination of the trip is of a recreational nature. The transportation itself is not recreational.

32 Even though visiting friends or relatives is often a recreational activity, the transportation used to accomplish this is practical, or utilitarian, since it is not the point of the trip itself to provide recreation to the traveler, but to move the traveler to the destination.

33 Other social and recreational includes going to dinner with friends, attending movies/ theater, etc. The destination of the trip is of a recreational nature, the transportation itself is not.

TABLE 3.2A % PERSON-TRIPS BY TRIP TYPE AND TRIP DISTANCE[34]

Person-trips shown in Table 3.2A provide a good measure of modal decision points for the traveler. Since a person-trip occurs every time an individual travels from a place of origin to some destination, person-trips describe a decision that is made, or a habit followed, regarding the choice of transportation mode used to make the trip. For this reason, the use of person-trips (as opposed to person-miles) is important for those promoting, planning, and designing bicycle transportation systems.

Table 5.2A shows that nearly two-thirds of all person-trips taken in 1983-4 were five miles or less in length. Of special interest is the following information about commuting trips from the same study of person trips in 1983-4: *31 percent of all person-trips to and from work were less than two miles.*[35] All of these trips could be completed in less than 15 minutes by even unskilled cyclists traveling at an average speed of 8 miles per hour. Allowing for reasonable infrastructural delays generating slower average speeds, all are within 20 minutes travel time by nearly all cyclists. This means, in terms of acceptable trip travel time, the bicycle is already a very competitive travel choice for nearly one-third of all trips to and from work.

In addition, capture of commuting person-trips is not the only area where gains could reasonably be made on the basis of trip travel time. Since only 21 percent of all person-trips were for commuting to and from work, then 79 percent were non-commuting trips. For those non-recreational person-trips that are within the distance range where cycling can produce acceptable travel times (under five miles in length), 82 percent were non-commuting trips and 18 percent were commuting trips -- a four to one ratio. These data show that non-commuting person-trips make up the bulk of personal daily travel and thereby offer an even larger potential target for increasing the bicycle's share of all person-trips than do commuting trips.

Each trip shown in Table 3.2A represents a decision about which method of travel to use for each type of trip. The information shown in the table can give us some sense how large a proportion of these decisions are potentially open to influence toward bicycle use. To develop this sense, it is helpful to look at each trip type and the proportion of the total trips of that type that could be within reasonable trip travel time by bicycle:

54% of all trips to and from work ....were 5 miles or less

56% of all work related business trips ....were 5 miles or less

75% of all shopping trips ....were 5 miles or less

71% of all family & personal business trips......were 5 miles or less

44% of all trips to the doctor or dentist...........were 5 miles or less

78% of all trips to school or church ....were 5 miles or less

21% of all vacation trips ....were 5 miles or less

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34 U.S. Department of Transportation, (1986)*Personal Travel in the United States: 1983-1984 Nationwide Personal Transportation Study, Vol. 2.* U.S. Department of Transportation, Table E-106.

35 U.S. Department of Transportation, (1986)*Personal Travel in the United States: 1983-1984 Nationwide Personal Transportation Study, Vol.1.* U.S. Department of Transportation, p. 3-3.

60% of all visits to friends or relatives ....were 5 miles or less

65% of social and recreational trips................were 5 miles or less

28% of all trips taken for pleasure driving........were 5 miles or less

These are all very substantial shares of total person-trip travel within each category. The highest proportions are in types of travel where a bicycle could easily be used in terms of the circumstances of the trip type. Such trips would include: shopping trips (75 percent); personal business trips (71 percent); trips to and from school (78 percent); social and recreational trips (65 percent) and trips to visit friends and relatives (60 percent).Clearly, the more urban conditions can be made to enable 20 to 30 minute bicycle travel times for trips under five miles, the more cycling will become a realistic and attractive choice for making person-trips for broad range of purposes.

On the other hand, all of this suggests that efforts to plan or construct bicycle transportation facilities intended to serve utilitarian trips that extend beyond five miles in length are probably misplaced. Substantially fewer trips are made by all modes of transportation of such distances. This may be seen by looking at each trip type and the proportion of the total trips of that type that extend beyond the five mile length. Table 3.2B presents this comparison.

Types of Person-Trips	Type's % Share of All Person-Trips	% of Type Person-Trips over 5 miles	% of Type Person-Trips 0 to 5 miles
trips to and from work	20.59	45.85	54.15
work related business trips	02.28	43.98	56.02
shopping trips	18.21	25.44	74.56
family & personal business trips	16.11	28.90	71.10
trips to the doctor or dentist	01.24	55.57	44.43
trips to school or church	11.88	21.17	73.83
vacation trips	00.22	78.65	21.35
visits to friends or relatives	10.89	39.01	59.99
social and recreational trips	15.80	34.84	65.16
trips taken for pleasure driving	00.49	71.87	28.13
Other	02.29	32.08	67.92

TABLE 3.2B COMPARISON OF PERCENTAGES OF PERSON-TRIPS BY TRIP TYPE BY COMPETITIVE AND NON-COMPETITIVE DISTANCES[36]

36 U.S. Department of Transportation, (1986)*Personal Travel in the United States: 1983-1984 Nationwide Personal Transportation Study, Vol. 2.* U.S. Department of Transportation, Table E-106.

A complete picture of commuting and non-commuting person-trips in terms of actual travel patterns cannot be assembled from these data. Though the data show that non-commuting trips claim the larger share of total trips in this travel range, they do not break out those trips that are accomplished *while* commuting to and from work. In other words, if a person cycled to and from work, and stopped to shop on the way, the number of total trips counted for the data above would be 2 (1 commuting and 1 shopping). We cannot tell to what extent these person-trips were really separate forays from home and how many were concatenated segments of a larger travel pattern between home and work. In other words, working with existing data, we do not have information about how these short trips may or may not chain together, making a clearer picture of short trip patterns difficult to assemble. This suggests a closer look at this phenomenon is important to better understand the relationship between person-trips and travel patterns and their potentials for bicycle use.

It is reasonable to say that these higher percentages of short trips for non-commuting purposes do *not* suggest that community planning should place less emphasis on providing support for bicycle commuting to and from work and turn to non-commuting trips. The unavailability of data that shed light on the number and kind of combined trips muddies understanding of the distribution and character of trips, but it does not redirect attention from the zero to five mile trip range as the focus for bicycle competitiveness in terms of appealing trip travel times.

Regardless of the manner in which the non-commuting trip was taken -- as part of travel to or from work, as an independent trip, or as travel combining non-commuting trips -- the distances of a large share of the individual trips are well within reasonable trip travel time for bicycle use. A similar kind of chaining together of different trips may be accomplished by bicycle if the combined travel times produce efficiency in terms of the individual traveler's daily travel needs. In fact, it makes common sense that the errands and tasks accomplished while traveling to or from work are important daily time savers to the traveling population. This tendency to combine trips to improve the efficiency of travel suggests that bicycle transportation planning should aim more broadly than simply focusing on the commuting trip.

All of this suggests a potential for a much wider role for utilitarian bicycling that one might think by viewing transportation only through the prism of commuting. Table 3.2B dramatically shows that in 1983-1984, in a country where "the trend is towards each driver having at least one vehicle,"[37] almost two-thirds of all person-trips (65.35%) are still under 5 miles in length. This does not support the myth that we travel far and wide on a daily basis. Despite our ability to travel and communicate at a global scale, *our individual, day-to-day worlds remain close in physical size to pre-motorized settlements* . Because of this, our lives are, in fact, very much amenable to using the bicycle as a practical, every-day mode of transportation.

A number of significant conclusions about planning and design directions for bicycle transportation can be deduced from this discussion of trip distance and trip travel time considerations.

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37 U.S. Department of Transportation, (1985) Summary of Travel Trends: 1983-1984 Nationwide Personal Transportation Study. U.S. Department of Transportation,p. 7.

Statistics given in this summary show that in 1983, there were 2.7 persons and 1.7 vehicles per household and there were 1.0 vehicles per driver in the U.S. p. 5.

SUMMARY OBSERVATION. On the basis of historically acceptable trip travel times and the rates of travel by cyclists, trips less than five miles in length are those for which the bicycle is most likely to deliver acceptable urban trip travel times for utilitarian purposes.

SUMMARY OBSERVATION. On the basis of the pattern of modern person-trips, and the rates of travel by cyclists, a maximum of nearly two-thirds of all person-trips could potentially be made by bicycle within historically acceptable urban trip travel times.

SUMMARY OBSERVATION. On the basis of the pattern of modern person-trips, and the rates of travel by cyclists, nearly one-third of all person-trips could already be made by bicycle within historically acceptable urban trip travel times.

SUMMARY OBSERVATION. On the basis of the pattern of modern person-trips, and the rates of travel by cyclists, as many as four out of five of all non-commuting person-trips could potentially be made by bicycle within historically acceptable urban trip travel times.

RECOMMENDATION 3.2-1. *The actual bicycle trip travel time is a critical determinant of the effective range of bicycle competitiveness, especially for trips approaching five miles or more in length. If communities wish to maximize the use of bicycle transportation, the longer the distance that cyclists must travel, the more direct and continuous the route must be in order to meet or approximate tolerable trip travel time requirements. It is therefore critical to any bicycle transportation infrastructure that bicycle facilities used for longer distance trips be especially designed to minimize trip travel time. This means absolutely minimizing the number of stops that must be made on such facilities. This also means that the route of such facilities must be continuous and without interferences that prevent serious cyclists from attaining their maximum comfortable speeds.*

RECOMMENDATION 3.2-2. *Because nearly 2/3 of all mode choice decisions are made for trips less than 5 miles in length, and because 8 out of 10 person-trips are non-commuting five miles or less in length, a bicycle transportation facilities must be ubiquitous. They must systematically blanket communities and providing bicycle transportation service to all places in the area or community served. This means that a focus on merely connecting employment centers with bicycle facilities is likely to miss the opportunity for the bicycle to address the major portion of the urban trips that are potentially within its reach. In order for a bicycle transportation system to address its maximum potential effectiveness, it must be everywhere, just like the motor vehicle roadway system. This suggests a change in focus in developing bicycle facilities, away from emphasis on building long linear bicycle facilities in places where rights-of-way become available, to creating networks of interconnecting bicycle facilities of various service levels carefully integrated everywhere in targeted districts of the urban fabric.*

3.3. THE APPEAL OF BICYCLE IN TERMS OF ACCESS AND MANEUVERING CAPABILITIES

An important derivative of personal transportation is that it also tends to provide more tailored access to most destinations than do most forms of public, scheduled transportation. With the automobile, this is due to the characteristics of travel on demand together with its greater maneuverability and smaller size when compared to modes of mass transportation. The bicycle while fulfilling all of the requirements of travel on demand, also provides excellent maneuvering and access capabilities. To better understand this it is important to contrast the capacity of the bicycle to provide tailored access to the way access is thought about for the automobile.

In our present-day motor vehicle roadway transportation system, the term 'access' is defined largely from the viewpoint the roadway itself in terms of making required connections or using control of access as a means of managing traffic flow. Three facets of this viewpoint are articulated: 1) access points to land or access to property, 2) access to a terminal facility (e.g., usually, parking lots) and 3) access to the roadway itself [38] (These confusing and conflicting definitions of access are also discussed in the analysis of the existing transportation system in section 5.4.2.) Simply put, the focus is on the relationship between public right-of-way (as transportation system property) to adjacent land parcels that are usually privately owned and thus regarded to be outside the concern of the transportation system. The relationship between abutting land uses and the right-of-way tends to be seen as input and output of vehicles across a property line, and whether those movements are acceptable to the roadway in terms of quantities and position.

The bicycle offers an alternative way to think about this, requiring consideration of the individual's whole trip. Within the context of the whole trip, access must be considered to be the degree to which a particular mode of transportation facilitates the departure and the arrival of traveler at the doors of places in the community. A traveler is a human being who is making a trip to get to a particular location with very particular attributes in terms of his life needs, wants and values; from a particular location with very particular attributes in terms of his life needs, wants and values. In sum, people travel from a place to a place. The urban design idea of place goes beyond the idea of destination as mere location -- it includes the social and cultural dimensions of human use of urban space.[39] From this point of view, destinations are very human in scale and context of meaning. Transportation considerations are only an instrumental part of the trip idea that is destination driven. The true destination is place where human beings get needs and wants met. The human trip ends when one walks through the door of the place where this happens.

The importance of access to the doors of places, rather than access to the property line, is embodied in a number of physical arrangements we see today. In parking lots at retail locations, spaces near the door are often reserved for customers, rather than employees. At corporate offices, they are often reserved for company executives. Direct access from the residential garage to the home has evolved so that the individual drives through the door of the garage attached to the house and is but a few steps from the interior of the home, usually the kitchen, the "heart and hearth" of many homes.

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38 American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets.* Washington, D. C.: AASHTO, pp.105-110.

39 A good concise overview of place theory in urban design may be found in Trancik, Roger, (1986) *Finding Lost Space: Theories of Urban Design.* New York: Van Nostrand Reinhold, pp. 112-124. Trancik surveys work in this area by its principle thinkers, including Martin Heidegger, Christian Norberg-Schulz, Aldo Van Eyck, Peter Smithson, Kevin Lynch, Donald Appleyard, Leon Krier, and Gordon Cullen.

In general, scheduled modes of transport do not give the traveler as much access to the door as do personal modes of transport. There are exceptions to this. For example, an automobile disincentive program that places city parking lots on the fringe of the downtown, while providing city bus stops on each downtown corner gives a greater degree of access to travelers who use the scheduled mode of transport (bus riders) than those who use the personal mode of transportation on demand (motorists). In this case, the traveler using the public mode of transport relinquishes the autonomy and freedom offered by modes of personal transportation and usually also accepts a lower degree of mobility in exchange for better access to and from the door.

As a personal mode of transportation, the bicycle can offer excellent access to the doors of destinations. The physical size of bicycles is very much smaller than other modes of personal transportation (except walking). This small size affords the possibility of better access to the doors of destinations by bicycles than by automobiles. For example, eight to ten bicycles can be parked in the space needed for one automobile (9 feet by 18 feet). Also, the mass represented by such a cluster of parked bicycles is visually less formidable than that same space occupied by an automobile. The more human scale of the bicycle, the smallness of its component parts and comparative transparency, all help it to be very well accepted when parked at the entries to buildings. For this reason, several bicycles can usually be parked almost adjacent to the doors of destinations, giving cyclists superior access to the door over users of any other transportation mode. Walking is the exception to this, but it also has a much more limited range than bicycling.

<u>SUMMARY OBSERVATION.</u> Close access to the door of destinations is an important aspect of making a trip to a particular place. The ability to provide such access has been recognized as important in parking lot management for commercial destinations and in bicycle disincentive programs. Bicycle systems that capitalize on the bicycle's ability to park adjacent to the doors of destinations and afford the bicycle better access to all "doors" in the community, should achieve a higher degree of success than those bicycle systems that do not.

<u>RECOMMENDATION 3.3-1</u>. *When planning and designing transportation systems, and especially bicycle systems, access should be defined as follows: The capacity to get individual travelers close to the door of trip destinations (time saving in the form of convenience at trip ends). This shifts thinking to include the trip segment that occurs between the traveler's door of origin (or destination) and the roadway that provides mobility between origin and destination. Couched in these terms, environmental detail and the comfort and convenience of the person moving between the door and the roadway become a much more important objective.*

As with the automobile, <u>a critically important environmental detail tied to the access capabilities of the bicycle is the provision of parking facilities</u>. Because the bicycle can get you closer to the door of your destination, it is essential that plenty of bicycle parking be provided is close as possible to the door in order for cyclists to reap the benefits of better access. Bicycle parking located far from the door, at a second class door, or farther from the door than automobile parking all result in the loss of the potential access advantage of the bicycle.

Also, it is critical that the bicycle parking facilities provided actually work and don't damage the bicycle. Just as automobile users are not expected to park their cars in spaces that are too small, difficult to access or likely to do damage to their vehicles, neither should cyclists be assumed to make use of comparably bad facilities for their parking needs.

In addition to superior access capabilities, the bicycle has maneuvering capabilities that can make it equally or even more mobile than the automobile in many urban and suburban settings. This is particularly true in places and at times where automotive mobility is restricted or almost entirely absent, due to congestion. The paradox of mobility is: that as more individuals seek to exercise it within a particular space, the less actual mobility each can achieve. This relationship can extend to the point of losing mobility entirely (gridlock). This can be true of any mode of transportation, including bicycle and pedestrian modes. However, the size and maneuverability of the bicycle allow it to be a powerful solution to problems of automobile congestion in the United States. Present-day right-of-way widths, as well as roadway (lane) widths, dedicated to the automobile in U.S. communities are generous and in many cases, sufficient to accommodate large numbers of utilitarian cyclists, particularly when the number of cyclists replaces an equal number of automobiles.

Maneuverability combined with excellence in access create a strong competitive advantage for the bicycle as a utilitarian transportation. In bicycle literature this type of effort is normally described as making bicycle transportation "convenient." The major way in which convenience is provided to the bicyclist as transportation consumer, is by cutting overall trip travel times and thereby, making cycling more attractive as a practical, transportation option. The superior maneuverability of the bicycle can in some situations, make a more direct (shorter) and continuous route to the destination possible, reducing trip travel times. Though the statistics regarding trip travel times do not include the walk from parking space to the door of the destination, careful planning regarding access to the door for cyclists, can greatly improve their overall trip travel times in reality. In addition, capitalizing on the superior access and maneuvering capabilities of the bicycle can make a trip less stressful and, even pleasant, to the transportation consumer.

SUMMARY OBSERVATION. Viewed in this way, the bicycle also presents an advantage for many businesses. Because the bicycle is smaller and more maneuverable than the motor vehicle, more individuals (cyclists) can take advantage of superior access to the doors of business, than if automobile access was the only access provided. This is particularly important in commercial and retail locations where an accommodating bicycle infrastructure and ample amounts of bicycle parking can increase the convenience of access to more business patrons.

RECOMMENDATION 3.3-2. *Reduce overall trip travel times for cyclists by catering to the access and maneuvering capabilities of the bicycle -- capabilities that are far superior to those of the automobile. Access privilege for cyclists can be used at either end of the travel segment of a trip to reduce trip travel times and further increase the attractiveness of bicycle transportation. In addition, capitalizing on the maneuvering capabilities of the bicycle can, in some cases, enable the establishment of more direct and stop free routes to the cyclist, also reducing trip travel times.*

3.4 THE APPEAL OF THE BICYCLE IN TERMS OF FIT TO URBAN SPACE FACTORS

Though the automobile is the most widely used mode for providing the positive characteristics of personal transportation to the transportation consumer, it is the least desirable in terms of its effect on the physical and social environment of the city. Hall comments:

There is ... a technical artifact built into our culture which has completely altered our way of life.... The automobile is the greatest consumer of public and personal space yet created by man. In Los Angeles, Barbara Ward found that 60 to 70 per cent of the space is devoted to cars (streets, parking, and freeways). The car gobbles up spaces in which people might meet....

Automobiles insulate man not only from the environment but from human contact as well. They permit only the most limited types of interaction....[40]

The relationship Hall talks about becomes more clear with a look at the spatial implications of human proxemic distances (distances at which certain behaviors can operate) and automobile infrastructure. The social distance (4-12 feet) and public distance (12-25 feet)[41] described by Hall, are the distances of space separation between people regarded as critical to enabling social and public interaction, respectively. Conservatively fully 50% of our urban land area is devoted to machines (automobiles) and the pavement on which they operate. These pavements routinely range from 26 feet, to 44 feet or more[42] in width. In this way virtually every street dedicates the major portion of the street to the metal box that is the automobile and places people at the edges of the street. This means the spaces between buildings are dominated by spaces separating the people walking in and out of buildings by distances that exceed the social and public distances for human behavior. This drastically reduces the potential for human interaction in streets that was traditional before the advent of the motor vehicle.

From another perspective, the central space of the street is consumed by larger-than-human scaled machines whose large movements and rapid speed could contribute to the information load of which Motloch speaks. The central space bulges with groups of moving and stationary objects with which humans have no desire to interact. The automobile, despite attempts of auto manufacturers to make it attractive as a vehicle, by virtue of its physical size, reduces personal and social contact and interaction. To interact in this way, people need to achieve specific distances of separation, and read facial expressions and body postures. In this way our cities have increasingly come to be molded by a transportation system that is dedicated to efficiently moving automobiles. At the same time they have become places that inhibit the social and public interaction of people, rather than places that foster these basic offerings that cities give communities of people.

The scale and maneuverability of bicycle and pedestrian transportation make them superior to the automobile for providing an urban structure that fosters the interaction of people. Unlike the automobile, the bicycle's scale is close to that of the human body and it is visually transparent, permitting a clear view of people and objects beyond it. Bicycles do not visually consume the street as do automobiles and they allow

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40 Hall, Edward T. (1966) *The Hidden Dimension.* Garden City, New York: Anchor Books, Doubleday and Co., Inc., p. 175 and 177.

41 Beyond 30' details of facial expression, movement and voice are lost.

42 The American Society of Civil Engineers (ASCE), and The National Association of Home Builders (NAHB), and the Urban Land Institute (ULI).(1990) *Residential Streets, second edition.* Washington D.C.: ASCE, NAHB, and ULI.

the variety of detail of the built and human environment of the street to be more readily experienced.

The bicycle offers potential for addressing the problems of automobile domination that have produced physical arrangements of the city that exacerbate conditions of social and personal segregation and alienation -- conditions that are ultimately stressful both to society and the individual. They also place the bicycle on equal footing with the automobile in offering the individual maximum control over transportation use.

A bicycle transportation system cannot be defined in a vacuum: cars are not going to go away and neither are pedestrians. For the bicycle to succeed as a mode of transportation, it must also fit into the transportation contexts of the automobile and the pedestrian. If the bicycle cannot conveniently, comfortably, and safely be used in commuting and shopping situations where sometimes it must share space with the pedestrian and sometimes it must compete for space with the automobile, it will not be used as transportation to any appreciable degree. A bicycle transportation system designed without consideration of the requirements and operating characteristics of other modes of roadway transportation will necessarily fail because these other modes of transportation, specifically, automobiles and pedestrians, are major components of the bicycle's operating environment.

The concepts that frame a transportation system to accommodate the bicycle, must necessarily frame it in terms of its relationship to other modes of roadway transportation. The bicycle possesses characteristics that place it in a truly unique position among roadway users. Its scale and function endow it with a chameleon-like ability to adapt to urban spaces dedicated to other modes of transportation -- sometimes it is like a car, and sometimes it is like a pedestrian -- and often, it can assume both the car-like and pedestrian-like characteristics at the same time. These characteristics place the bicycle in the middle of a continuum of roadway transportation types that includes other modes of roadway transportation that accompany its use and share its space.

The scale and function of any mode of transportation are of primary importance in formulating the system definition of a transportation system and in planning and designing roadway systems. The attributes of scale and function of the bicycle that give it its adaptability as far as a system definition is concerned, include:

- Its physical form and size,
- Its range of speeds,
- Its function and its destination.

The bicycle's physical form and size place it close to the pedestrian on the roadway transportation continuum. First of all, the bicyclist is, when compared to the motorist, virtually unprotected from injury. A sheath of metal does not encompass the cyclist or the pedestrian, and both are equally vulnerable to the same kinds of injuries from the motor vehicle. In addition, when the bicyclist slows down to the speed of the pedestrian, the cyclist is on very nearly equal terms with the pedestrian when size and physical presence are considered. A pedestrian and a slow-moving cyclist moving together are more similar to two pedestrians walking together than is a pedestrian walking alongside a slow-moving automobile. Finally, the bicycle's access and maneuvering capabilities are nearly equivalent to the access and maneuvering capabilities of the pedestrian. The superior access and maneuvering capabilities of each are mainly due to their forms and sizes.

Whereas the physical presence of the bicyclist clearly places the bicycle closer to the pedestrian, than the motor vehicle, the bicycle's range of speeds enables it to be close in scale to either the pedestrian or the automobile. A bicycle can be as deadly to a pedestrian when an accident occurs between the two, as can a motor vehicle to a bicyclist. In addition, when the dangers of roadway speed are considered, the bicycle can *simultaneously* be pedestrian-like or automobile-like, depending on conditions in the roadway. That is, the cyclist moving through a roadway where pedestrians and motor vehicles are simultaneously present can be both presented with danger and present a danger to others.

As utilitarian transportation, the bicycle's function and its destination are identical to those of the pedestrian and the automobile for the majority of urban trips. In such cases, the purpose of the bicycle in the roadway and the reason the bicycle is in the roadway are the same as the purposes and the reasons that the pedestrian and the motor vehicle are using the roadway.

<u>SUMMARY OBSERVATION.</u> Because the bicycle possesses very adaptive chameleon-like characteristics, it plays a pivotal role in thinking about the relationship between urban form and transportation. The two endpoints of today's roadway transportation continuum are described by the pedestrian and the motor vehicle. On the pedestrian end, mobility (speed) is the lowest and individual maneuverability and ability to access the door and are the highest. On the motor vehicle's end of the continuum, the reverse is true. The bicycle's adaptability characteristics -- where sometimes it is like a car, sometimes like a pedestrian, or sometimes simultaneously, like both -- place it not only between the two endpoints of the roadway transportation continuum, but in a position that is not fixed (like the pedestrian and motor vehicle endpoints), but moving along the continuum of roadway transportation types, depending on circumstances in the roadway.

<u>RECOMMENDATION 3.4-1</u>. *The development of a community bicycle transportation plan offers the opportunity to re-think the relationship between land use and transportation. To the largest extent possible, the establishment of a bicycle transportation system should be used to direct and contribute to the improvement of the urban fabric and reformulate the relationship between motor vehicle travel priorities and alternative modes, as needed, to maximize the utilitarian cycling and pedestrianism.*

4. System Design: Formulating a System Definition

Before analyzing the thinking that propelled the creation of today's roadway transportation system in order to understand the problems and opportunities it presents to increasing the use of bicycle transportation, the basic notion of system design and the components of a system definition need to be understood to provide a language and reference framework.

The motor vehicle transportation system is a uni-modal transportation system and the accommodation of bicycle transportation, along with pedestrians on our roadways, necessarily implies that a transfer of thinking toward multi-modal point of view. A roadway transportation system that accommodates more than one mode of transportation necessarily becomes more complicated and complex than a uni-modal one. Likewise, the planning and the definition for a multi-modal roadway system become more complicated and complex.

For these reasons, it is important to understand the process of system design and what a system definition entails. This chapter provides this information so that today's system can be analyzed and a system definition for a multi-modal roadway transportation system can be proposed and outlined.

The hierarchical construct used today in the definition of our roadway transportation system is insufficient if another mode of transportation, such as the bicycle, is to be introduced and successfully accommodated by the system (section 5.3.1.). It is unlikely that the designers of the motor vehicle transportation system were aware of its system definition from a systems point-of-view because it was only later that system design and definition were described as processes and products in any way. That these designers were unaware of systems theory is not important. What is important is that a system was indeed created and that the system is described by the relationships and components found in its system definition.

System design is the process of defining exactly what a system does and how it works. Some systems are simple; a lawnmower for example is a self-contained mechanical system. Other systems embody such complexity that all aspects of the system must be carefully and precisely scrutinized, and then defined, in order that people may create, operate, use, and enhance the system. Examples of complex systems include computers, the space shuttle, accounting systems, and transportation systems.

Any thing or system that is designed to be used, be it by a human being or another system or machine, must embody and express a logic that is understandable to the planners, builders, and users of the system. A *system definition* precisely describes how the system works and includes descriptions of identified parts or components of the system, as well as the interactions and interfaces of the parts. If an adequate system definition is lacking or if a system's definition does not accurately reflect the workings of the system, the system is difficult to build, alter, and use.

All system definitions have a characteristic of magnitude about them: some are lengthy and involved and often describe complex systems that can be used in many different ways; others are concise and simple and often describe systems that are tailor-made to operate in a single way. For example, the system definition for studio recording equipment is probably larger and more complex than is the system definition for a telephone answering machine. The former must accurately record and distinguish many types of sound from many sources, and must be able to mix those sounds and perform other functions according to instructions given by a recording engineer. The answering machine must record sounds coming through a single telephone line and record, replay, save, and erase them in a serial fashion. In a sense, the relative magnitude of a system definition indicates its complexity, its degree of user interaction, the number of functions it performs, and the number of and internal and external interfaces it has.

A multi-modal roadway transportation reference frame allows the construct of a flexible definition of a transportation system that can be planned and used in many different ways. In other words, the definition is not tailor-made to only accommodate bicycles or to only accommodate bicycles and automobiles, but is intended to be extendible to any mode of existing or future roadway transportation. For example, in-line skates are a primary mode of transportation in some urban areas. This suggests a need for a system definition for multi-modal roadway transportation that could be used to plan and design an integrated transportation system for in-line skaters in addition to the currently targeted modes (e.g., bicycles, motor vehicles and pedestrians). This kind of flexible system definition could be compared to a properly formulated system definition for a computer that permits a variety of existing software to be used and allows new software applications to be written for it.

4.1. FOUNDATIONS OF A DEFINITION

System design can be visualized as a kind of pyramidal type of process. At the top of the pyramid is a single, or a small set of initiating requirements for the system. All design requests begin like this. Often the initiating requirements are stated as goals or objectives. The initiating requirement set is expanded and refined into a larger and more precise set of system requirements during a process that considers different kinds of requirements, including: the ultimate goals and values of the requesters, the characteristics and needs of the users, and the environment within which the system will operate.

As the design process proceeds down the pyramid, *the statement of requirements is refined into the definition of the system*; that is, precisely how the system will fulfill the requirements. The system definition includes not only a description of the parts and their function, but also the interactions between the parts, and the interfaces to the users of the system. For our current transportation system, these are found in the definition of the movement hierarchy and the functional classification of streets.

At the base of the pyramid are the most precise details of how the system works. For roadway transportation systems, these are the details of the roadway design practices sanctioned by American Association of State Highway Officials (AASHTO) and the Institute of Transportation Engineers (ITE) and include things such as turning radii, horizontal and vertical alignment, pavement types, and so forth.

The elements at the base of the triangle must collectively implement all of the requirements found at the top of the triangle. A well-conceived system definition provides a framework for maintenance, alteration, and enhancement, and a structure for developing knowledge about system performance.

The process of system design is an iterative process. As designers refine the system definition and proceed to lower levels of the pyramid in detail, it may be discovered that higher order decisions were inaccurate or are impossible to implement as stated. In this case, higher-order definitions must be changed in light of more technical details. Likewise, it may be discovered that some of the system requirements are not stated with accurate enough precision, that some requirements could be combined into one, or that the formulation of a new system requirement is necessary. The nature of system design necessarily implies the iterative nature of the design activity in the middle portion of the pyramid. Designers of the system at this level of definition are obligated to constantly and thoroughly review the emerging system definition to ensure that it fulfills the requirements of the system (looking up on the pyramid) and simultaneously to look at the system's definition in more detail to determine if it can operate, or be implemented, as defined (looking down on the pyramid).

4.2. SYSTEM REQUIREMENTS

System requirements describe what is needed of the system and what the system itself needs to properly function. System requirements originate from different sources. Those who request that the system be created often state requirements in terms of goals. The users of the system usually state their requirements in practical and personal terms that describe how they want to, or how they must use the system. The operating environment of the system; that is the environment in which the system exists or is operated, usually dictates requirements that the system itself has in order to function properly. Some systems may be defined by all of these types of requirements and some may be defined by a subset of them.

System requirements that stem from those who request the system form the initiating requirement set. These kinds of requirements often express goals for the system and why the system is to be created. System designers must keep the initiating requirements in mind and revisit them as refinement of the requirement set proceeds with the inclusion of user and operating requirements, and as formulation of the system definition proceeds. This must be done to ensure that the emerging system does not stray from its original intention or the original reason that it was to be defined and built.

Two examples of a goal or objective driving the creation of a system and forming its initial requirement set are the congressional mandates, stated in separate acts of Congress, to create a competitive space program and to create the National System of Interstate and Defense Highways. These two requirement sets represent national goals or objectives that were to be met through the implementation and use of a system (the physical systems and scientific programs of NASA and the System of Interstate and Defense Highways, respectively). The objective of the space program was to make the U.S. competitive, particularly with the USSR, in space. The objective of the mandate to provide interstate highways was to foster economic growth and provide for the national defense. The Intermodal Surface Transportation Efficiency Act (ISTEA) expresses goals that are totally different from the ones described by the Federal Aid Highways Act. ISTEA's initiating requirement set, which is large, should be examined and analyzed as the topic of further research that begins to formulate a more exacting system definition for urban roadway transportation systems.

User requirements are often initially expressed by the users of the new system themselves. For example, the users of a new accounting system would state their needs in terms of their information needs, their record keeping and other company procedures, among, probably, a host of other requirements. Users of roadway systems include anyone using the roadway system (motor vehicle operators, cyclists, pedestrians, people in wheelchairs, etc.), as well as users for which the roadway as transportation was not intended (e.g., people whose businesses or homes line the corridor). The initial set of user requirements are refined by the system designers, sometimes in conjunction with interviewed user groups, and are eventually expressed with a high degree of precision during the beginning and middle stages of the system definition process.

Determining the characteristics and needs of a system's users should always preferably include surveys or interviews with the system's potential users. The designer should never assume knowledge about a system's users. However, the designer should also critically examine all user statements regarding user characteristics, user needs, and user requirements of the new system. It is not uncommon for potential users of a new system to see the new system in terms of the old one or in terms of the present state of affairs. For example, it is difficult for many accomplished bicycle commuters to envision a transportation system that truly accommodates them and meets their transportation requirements.

It is also human nature for people to see their needs and their environment only in terms of themselves. Designers, by the nature of their work, are forced to see new possibilities, new combinations of system components, new user interfaces, and a new operating environment with the new system. Therefore, if a user states that something is a requirement, this statement must not be taken at face value, but analyzed and examined in light of the characteristics, operating environment, and user interfaces of the *new* system. Finally, the system designer should be sensitive to non-verbal cues given by users or by their operating environment and should be willing to look at these cues and analyze hunches to determine their validity as potential user requirements.

Another type of requirement set is usually formulated to meet the needs imposed by the environments within which the system will operate. Systems never operate and are never used in a void. (If such a system was requested, this, in itself, would be a demanding requirement of the operating environment.) A host of environmental requirements dictate how the system must be defined. These environmental requirements can come from any physical or non-physical realm in the world. Sometimes the environmental requirement set includes interfaces with other systems or with system users (discussed in section 7.6). An example of a physical requirement comes from the early days of computer technology, when the computer itself was physically sensitive to a variety of environmental factors, including fluctuation in temperature and severe jostling. Computers that were to be used by the Navy had to be "ruggedized" to withstand extremes in temperature and buffeting by wave action in the ocean. Today, these requirements for ruggedization are met, by-and-large, by run-of-the-mill personal computers.

An operating environment that embodies consideration of various physical (both human and mechanical), cognitive, and psychological factors is the multi-modal roadway. Many requirement subsets for the multi-modal operating environment are born by obvious physical factors such as the physical structure of roadways, land use, the existing transportation system, the physical structure of the city, the weather, and so forth. Not so obvious is that each type of user in the multi-modal roadway becomes part of the roadway's operating environment because roadway users physically exist within and move through the system themselves. This state of affairs introduces a set of requirements that is unique to the operating environments of spatial systems; e.g., transportation systems, building systems, ecological systems and the encapsulated systems of space vehicles. In these systems, the users are a part of the operating environment of the system and their movement through the system constantly changes that environment.

It is crucial that all system requirements be thoughtfully and accurately formulated in order for the system to fulfill its requirements. System designers must ensure the accuracy of the requirements by continually scrutinizing them and what they mean in various contexts. If a system is properly defined and if it is implemented according to the system definition, the system's requirements and objectives are embodied in the system, the workings of the system, and the product of the system, if there is any system output. All system requirements should be stated simply and concisely and should be refined as necessary during the system design process.

It is always helpful to prioritize system requirements, should tradeoffs become necessary during the formulation of the system definition or the implementation of the system. In addition, if the entire requirement set embodies a list of objectives, it is helpful to separately prioritize the objectives as well. Tradeoffs occur when the system cannot meet all of the requirements (demands) put on it at once. For this reason, it is necessary to fulfill one set of requirements before meeting other requirements or to fulfill one set of requirements at the expense of another set of requirements.

Putting requirements and objectives in priority reflects either the values or degree of importance that others (usually, the system's requesters or the system's users) place on the system's requirements. This allows designers and those who implement the system to make informed decisions without regard to their own personal values or preferences, should tradeoffs become necessary. In fact, it is not uncommon for a designer or those implementing the system to have no personal value or preference regarding decisions when tradeoffs are necessary. In such cases the implementation of a feature to fulfill a requirement could be totally arbitrary. Sometimes, it is not possible to put some or, even, all of the system requirements in priority. When this occurs, a note is made of such an impasse with a narrative description as to the relative merits of each and why a priority ranking could not be made.

4.3. USER DESCRIPTIONS

An important component of the set of system requirements that is formed during system design is user descriptions. Users of a system can be human beings or other animals or things. A good example would be a transportation system where users include not only human beings, but vehicles and the capabilities and requirements of each vehicle in the roadway. Another is the personal computer that can access remote computers and data bases. All of the computers in this arrangement, as well as the telephone lines connecting them, are users to each other -- in computer lingo, 'they must talk to each other.' Each has requirements in order for the network arrangement to work.

During system design, a detailed description of all of a system's potential users, and the requirements that spring from such a description, should be included as a distinct effort during the formulation of the system's requirements. As the design process proceeds, user descriptions are refined and distilled into the set of user requirements that is documented within the system definition.

User descriptions are separate from the requirements that users give for the system. System users usually possess characteristics that effect how they use the system or their ability to use the system. The most important of these characteristics are those that the user cannot or will not verbally state for whatever reason. Often the user may not know that they possess a certain characteristic that would effect their ability to use the system effectively. For example, a user may not state that he or she is dyslexic, but this condition may directly affect how this user and other dyslexic users are able to use the system.

Today, many users of systems are not knowledgeable about the systems that they are using and do not have the background or inclination to self-educate themselves about the system. Witness Johnny Carson's famous (and frequent) jokes about his inability to figure out how to set his VCR. The designers of Johnny's VCR did not include an adequate user description prior to formulating the user interfaces to the VCR and provided ones that were too complicated for the system's average users (but, probably made sense to them as system designers and engineers). Johnny was not alone, however, since new models of VCRs now include the ability to set them with simple codes that are printed next to each show listed in TV program guides. This is a good example (and a common one in the early days of computers) of system designers imposing their own personal abilities and preferences on the system they are designing and being oblivious to the user descriptions of most of the system's users.

4.4. System Constructs

All systems are organized according to some kind of logic. Systems possess no inherent ordering mechanism or specific structure, but are organized and structured by the people that create them, use them, and manipulate them. Systems that are manipulated or implemented in the real world are organized according to some set of principles or rules that are established to provide a conceptual order that allows the system to be physically implemented as an ordered system and manipulated in a logical and easy-to-understand fashion. Otherwise, it would not be possible for people to understand and use the systems around them.

This document uses the term "system construct" or "conceptual construct" to refer to the ordering mechanisms that are used to organize and structure systems that people create. System constructs are abstract cognitive tools used to bring order to that which is difficult to understand or manipulate in the real world. The influence of system constructs is profound when they are applied to structure the systems in the real world -- they permit or prohibit specific system functions and interactions.

When ordering mechanisms are used to structure systems, the system must be broken down into components, or distinct parts, so that the system's structure can be revealed and understood. A system component always interacts with at least one other system component or with system users; otherwise, the component is not a part of the system.

All component interactions in a system are governed by a set of rules that permit some interactions and prohibit others. Rules for component interaction are governed by the system's construct.

The nature of some systems requires that the system's construct be flexible and adaptable, not permanently prohibiting interactions that occur (or not prohibit interactions that might need to occur in order for the system to operate effectively). Many organizations have recognized that the structure that the hierarchical construct gives a group and its interactions is insufficient and deleterious to the organization's functioning and production. For this reason, many organizations have reorganized into what are called matrix organizations, where the organization and its activities are structured in a two-dimensional matrix. The people in the organization are listed across the top of the matrix (along the x-axis). The projects, products, or services of the organization are listed along the side of the matrix (the y-axis). The boxes in the middle indicate which people work on which projects or products. Compared to the hierarchical organization, this kind of arrangement facilitates communication among all projects and all people in the organization, as well as the movement of people between projects. The matrix organization is based on the principles of the systems approach.

The systems approach is another example of a conceptual construct. The systems approach is a flexible construct that permits all kinds of system interactions as long as rules for their interaction are established and followed. The kinds of interactions that are permitted and prohibited by the systems approach are established by the system's designers during the system definition process and *not* by the construct itself: the systems approach is applied to systems according to the nature of the system -- how it operates, what it does and the kinds of interactions it requires.

The conceptual construct that is developed during the system definition process for a new system should be understandable, sufficient, and flexible for defining, implementing, maintaining, and altering the system. In order to select a system's construct, knowledge is needed regarding the functions of the system (what the system must do) as well as the interfaces of the system (how it will do it and how it will be used). The construct that is used to order the system should not be inextricably married to the system's functions and interfaces. A system's construct provides the set of organizing principles for the system and should be independent of the products or services that the system offers and its interfaces for accomplishing its tasks. A system's construct should not have to be altered when functions and interfaces change. A system's construct should be a framework for the system and flexible enough so that it remains unchanged as the system changes with additions, deletions, alterations and enhancements of system components and their interactions.

4.5. System Functions

The functions of a system are the work that it performs or the services that it provides. Some systems perform a single function. For example, the can opener is a simple, mechanical system that performs a single, designed function: opening cans. Other systems perform many functions; e.g., a word processor supplies a variety of functions to the user for producing and manipulating documents. Sometimes, systems that perform many functions perform functions that are hidden to users of the system. For example, a user may tell a computer to print a document. The user does not see that the computer is performing a number of functions internal to the computer in order to transfer the document bit-by-bit to the printer and then translate it to written characters that the user can understand.

All functions, whether hidden or manifest, have interfaces to each other or to the system's users. While the system construct should not be inextricably married to the system's functions and interfaces, function and interface must be closely linked. Internal interfaces connect a system's internal functions to each other, and external interfaces connect users of the system to its functions -- to its products or its services. If functions and interfaces are not working compatibly or in close concert with each other, the system can either malfunction, not function at all, be difficult to use, or not function efficiently.

5. TODAY'S SYSTEM DEFINITION: MOTOR VEHICLE ROADWAY TRANSPORTATION

Today's motor vehicle transportation system offers an instructive model for thinking about how to establish and effective bicycle transportation system. Our motor vehicle roadway system has proved to be wildly successful in extending automobility to all facets of life in urban America. This, in turn, has created a transformation of urban structure and form. This transformation has become the hallmark of urban life in America. How was this success created? What can we learn from it to foster expanded use of bicycling as urban transportation? What opportunities does this legacy offer to bicycle transportation? What problems and obstacles does it present? This chapter attempts to understand the history of urban motor vehicle roadway transportation systems, from a systems point of view, as a means to answer these questions.

Interestingly, the motor vehicle roadway transportation systems appear never to have had a serious attempt at systems thinking per se with respect to *intra*-urban applications. Recent transportation literature has acknowledged that the roadway transportation systems that have been designed for our cities have erroneously been based on a system requirement set and a system definition that were described and developed to define our interstate highway system.

The mid-century Federal-Aid Highway Acts enacted by the U.S. Congress always clearly stated that the goals of the highway system were to provide a surface transportation system for <u>*inter*</u>city, personal, motorized transport for purposes of national economic growth and later, the national defense. *Urban Transportation Planning in the United States: An Historical Overview*, published by the U.S. Department of Transportation states:

> *The importance of the system within cities was recognized, but it was not intended that these highways serve urban commuter travel demands in the major cities. As stated in the report, "...it is important, both locally and nationally, to recognize the recommended system... as that system and those routes which best and most directly join region to region and major city to major city." (U.S. Congress, 1944)*[43]

King Cushman, in presenting historical perspectives on the growth of our system of roads, concurs:

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43 Edward Weiner for the Office of the Assistant Secretary for Policy and International Affairs for the U.S. Department of Transportation. (1988) *Urban Transportation Planning in the United States: An Historical Overview.* Ed. Office of the Secretary of Transportation. Washington, D.C.: U.S. Department of Transportation, 1988. p. 14.

The report, *Interregional Highways*, to which this quote refers, was the result of an investigation conducted by the National Interregional Highway Committee, appointed by President Roosevelt in 1941 to determine the need for "a limited system of national highways to improve the facilities available for interregional transportation."

The federal interstate highway program was initially conceived in 1944....It was proposed as a key component of our national defense system, assuring logistical intercity access and connections all across the country and it was originally intended as an intercity, not intracity, highway system.[44]

The 1960s and the 1970s saw growing concerns and reactions to urban transportation planning because little or no consideration was given to community and environmental impacts of the roadway transportation system, as well as the growing number of automobiles with their attendant traffic and congestion problems in urban areas. The result of these concerns was the birth of the idea that urban residential streets should be "livable." This was expressed by Don Appleyard in his book, *Livable Streets*:

The protection and creation of livable streets is not simply a matter of increasing the comfort and safety of urban living. The street has other functions. As the place where most children grow up, it is a crucial mediator between the home and the outside world, where the child learns to confront strangers and environments on his own. It should be a receptive and reasonable safe environment that the child can explore, manipulate, and use as a setting for all kinds of activities. The street has personal and social meaning for adults and old people, too. It symbolizes one's position in the world almost as much as the house one lives in. And the social relations that take place on the street, its potential for neighborliness and street life, are values of urban life to be treasured... there are inherent values in encouraging people and families who live in propinquity to work out their relationships without having them suppressed by the presence of passing strangers in motorized vehicles....[45]

In April 1980, the Bucks County Planning Commission (Doylestown, Pennsylvania) seminal work *Performance Streets: A Concept and Model Standards for Residential Streets* was published and in 1981, the Bucks County Planning Staff received the Design for Transportation National Award for Design Excellence from The U.S. Department of Transportation and the National Endowment for the Arts for their work. They describe the purpose of residential streets as follows:

In the past residential streets have been designed using modified highway standards as a guide. Streets have been viewed as serving the needs of cars and have typically been laid out with an eye to moving traffic more efficiently.

It was often forgotten that residential streets become part of the neighborhood and are eventually used for a variety of purposes for which they were not designed. Residential streets provide direct auto access for the occupant to his home; they carry traffic past his home; they provide a visual

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44 Cushman, King. (1988) "Exploring the Land Development and Transit Connection." *Transit, Land Use and Urban Form.* Ed. Wayne Attoe. Austin, Texas: The Center for the Study of American Architecture, School of Architecture, University of Texas, pp.9-37.

45 Appleyard, Donald. (1981) *Livable Streets.* Berkeley and Los Angeles, California: University of California Press, p.364.

setting, an entryway for each house; a pedestrian circulation system; a meeting place for the resident; a play area (whether one likes it or not) for the children, etc. To design and engineer residential streets solely for the convenience of easy automobile movement overlooks the many overlapping uses of a residential street.[46]

By the latter part of the 1980s, official recognition was given by transportation professionals to the notion that past design criteria and specifications for our urban streets, particularly our residential streets, have mistakenly been drawn from the design criteria for interstate highways. This can be seen in official handbooks, design and engineering guidelines, and policy statements of transportation engineers and highway officials. Most notable are *Recommended Guidelines for Subdivision Streets*, published by the Institute of Transportation Engineers (ITE) and *Residential Streets* (2nd ed.) by the American Society of Civil Engineers (ASCE), National Association of Home Builders (NAHB) and the Urban Land Institute(ULI). Their acknowledgment of the inappropriate application of highway design concepts and criteria on urban streets is also directed toward the residential or local street:

A major obstacle to the acceptance of more effective or innovative land development and improvement designs was a deep-rooted, traditionally rigid design philosophy, particularly as applied to street design. Public officials and professional associations have often promulgated standards that, while reasonable for major thoroughfares, are inappropriate for local residential streets. The traffic characteristics of and construction, maintenance, and performance requirements for residential streets differ significantly from those for highways.[47]

Similarly, the "Objectives in Subdivision Planning" set forth by the Institute of Transportation Engineers in 1984 stands in marked contrast to the philosophies espoused by mid-century transportation engineers who "believed their task was to build highways, not ruminate about the general needs of cities."[48]

The primary objective of subdivision design is to provide maximum livability. This requires a safe and efficient access and circulation system, connecting homes, schools, playgrounds, shops, and other subdivision activities for people living there.

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46 Bucks County Planning Commission. (1980) *Performance Streets: A concept and Model Standards for Residential Streets.* Doylestown, Pennsylvania: Bucks County Planning Commission, p. 44.

47 American Society of Civil Engineers (ASCE), National Association of Home Builders (NAHB), and Urban Land Institute (ULI). (1990) *Residential Streets.* 2nd ed. Washhington D.C.: ASCE, NAHB and ULI, p. 17.

48 Altshuler, Alan A. (1983) "The Intercity Freeway." *Introduction to Planning History in the United States.* Ed. Donald A. Krueckeberg. New Brunswick, New Jersey: The Center for Urban Policy Research, Rutgers University, p. 202.

Transportation considerations in subdivision design may be classified in two general areas: (a) the actual layout of the streets and pedestrian systems as related to land use, and (b) the engineering dimensions for vehicular, pedestrian and any bicycle facilities. But neither the street system nor the individual design element should be analyzed separately. They must both be considered in order to design a safe and efficient transportation system.[49]

The "residential street movement" within the transportation professions has focused on local streets, specifically concentrating on lower residential street speeds and the excessive use of pavement. Urban design professions have also addressed the role of the residential street. The end product has been that some residential streets are dominated by the automobile to lesser degrees. The degree of dominance depends on the extent to which these ideas are applied.

The "residential street movement" marks an important change of position by transportation engineers in their admission that highway design criteria are not appropriate in at least some urban areas. Other issues, such as the role of the automobile on *non-residential,* urban streets, and the accommodation of non-automotive modes of personal transportation, have not been fully addressed within the context of the street or the city -- much less within the context of a system of transportation.

As might be expected in light of such a history the system definition developed for the interstate highway system is instructive as to the problems and opportunities presented by our current transportation system. There are fundamental problems inherent in the system's requirement set and definition that present significant obstacles to a serious and complete integration of non-motorized transportation within the constructs developed for the planning and design of today's roadway transportation systems for the motor vehicle.

5.1. SYSTEM REQUIREMENTS

In order to better understand our current roadway transportation system as a system, it is important to organize and analyze the policies and decisions that formed the requirements that guided the development of the system's definition and its planning and design parameters. This review explains why the roadway transportation system is what it is today; illuminates its strengths and shortcomings, and makes evident what possibilities it offers for making changes to properly integrate the bicycle as a viable transportation alternative.

The examination that follows includes attention to the following issues regarding the urban motor vehicle roadway system:

- The role of requirements within the system's definition and specifically, how requirements drive fundamental assumptions about the nature of the system.
- How the refinement of the requirement set relate to the system's goals within (a.) the context of the system's operating environment and (b.) prevailing cultural, economic, and social forces;

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49 Institute of Transportation Engineers (ITE). (1984) *Recommended Guidelines for Subdivision Streets: A Recommended Practice.* Washington D.C.: Institute of Transportation Engineers, p. 1.

- How this intermediate, and not fully developed, requirement set describes fundamental characteristics of the system that is to be defined;
- How the requirement set (and thereby, an appropriate system definition) for an *urban* transportation system was left undeveloped due to mid-century events during its planning;
- What can be learned from this experience about the planning and design of the urban environment, especially with respect to bicycle transportation.

Even though this chapter describes the major requirements for the motor vehicle's transportation system, it is not, and need not be, exhaustive of the entire requirement set in order to illustrate the role of requirements in forming today's system definition for roadway transportation.

5.1.1. GOALS OF INTERCITY MOTOR VEHICLE TRANSPORTATION: THE FEDERAL COMMERCE & DEFENSE MANDATE.

Throughout this century, Congress has passed successive versions of the Federal Aid Highways Acts. These are mandates that provided the goals for the design and construction of roadways in the United States. The Federal Aid Highways Act of 1956 not only began the allocations of the massive amounts of funding necessary for the design and construction of our current roadway transportation system, but also stated the system goals in clear and unequivocal terms as follows:[50]

Section 116. Declarations of Policy with respect to Federal-Aid Highway Program

(a) It is hereby declared to be in the national interest to accelerate the construction of the Federal-Aid highway systems, including the Interstate System, since many of such highways, or portions thereof, are in fact inadequate to meet the needs of local and interstate commerce, the national and civil defense.[51]

Requirements that can be taken from the policy statement include:

1. The highway systems are to meet the needs of local and interstate commerce, and the national and civil defense.
2. The construction of the system is at some level of national interest and priority (because the construction is to be accelerated).

Other sections of the act provide information that refines these requirements:

Section 108. National System of Interstate and Defense Highways

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50 In order to present information in this section in an understandable fashion, text that originated in the Federal Aid Highways Act or legal commentary on it, is in italics. Requirements, as they are developed or refined, are in regular type.

51 U.S. Congress. (1957) "Federal Aid Highways Act of 1956." *United States Statutes at Large, Vol 70.* Washington, D.C.: U.S. Government Printing Office, p. 385.

(a) Interstate System. ...Because of its primary importance to the national defense, the name of such system is hereby changed to the "National System of Interstate and Defense Highways". Such National System of Interstate and Defense Highways is hereinafter referred in this Act as the "Interstate System."[52]

and

It is hereby declared that the prompt and early completion of the National System of Interstate and Defense Highways... is essential to the national interest and is one of the most important objectives of this Act.[53]

3. The interstate system is of *primary* importance to the national defense and the construction of the system is at the highest level of national priority.

In requirement number three, requirement number two (above) is refined with the forthright statement describing the system's role in the national defense strategy and with the legal opinion that the prompt and early completion is <u>essential</u> to the national interest.

4. The interstate system is of such importance that its timely completion is one of the most important objectives of the mandate itself.

Previously, the term "acceleration" was used to qualitatively describe the system's construction time table. Acceleration is a relative descriptor and therefore, weaker in its impact. One can ask, "Faster than what?" The legal opinion above clarifies this by stating that the early completion of this system is one of the system's most important requirements.

All of these statements indicate that the construction of the interstate system was one of the major goals and priorities of the country. This places a qualitative emphasis on the system definition and the process of defining the system. The emphasis on priority and national interest required that the system definition (and the architects, or creators, of that definition) accomplish a *timely, efficient, and complete fulfillment* of other system goals that addressed the requirements for interstate transportation.

... existing highways located on an interstate route shall be used to the extent that such use is practicable, suitable, and feasible, it being the intent that local needs, to the extent practicable, suitable, and feasible, shall be given equal consideration with the needs of interstate commerce.[54]

5. Legal opinion has interpreted the mandate to mean that local needs are secondary to the needs of interstate commerce. They are to be given equal consideration to the extent that they are "practicable, suitable and feasible" to the fulfillment of the requirements for interstate commerce.

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52 Ibid., p. 378.

53 <u>United States Code Service (USCS)</u>. (1983) Rochester, N.Y.: The Lawyers Co-Operative Publishing Co., Volume 23, §101, p. 8.

54 Ibid. p. 9.

The following statements, taken together, address the scope and the kind of connectivity that Congress prescribed for the interstate system:

The term "highway" includes roads, streets, and parkways, and also includes rights-of-way, bridges, railroad-highway crossings, tunnels, drainage structures, signs guardrails, and protective structures, in connection with highways. It further includes that portion of any interstate or international bridge or tunnel and the approaches thereto....[55]

6. The system (National System of Interstate and Defense Highways) includes all roadway types, as well as their rights-of-way and anything within these rights-of-way. Thus, federally owned streets and parkways in urban areas are a part of the system and are required to conform to the user descriptions, functions, interfaces, and design parameters of the system definition for the interstate transportation system.

That the language used for interstate travel is used to describe travel in urban areas is important in terms of the qualitative character that this gives streets so designated in the urban area. Since the major requirement for this system is to provide interstate roadway connectivity, the largeness of scale that this brings to the system definition was carried to urban roadways as well.

The term "urban area" means an urbanized area or,... an urban place as designated by the Bureau of the Census having a population of five thousand or more....[56]

8. The interstate system's definition and its requirements extend to fairly small urban areas.

The interstate mandate issued by the U.S. government contained the initial set of goals from which the requirement set for the interstate transportation system could begin to be formulated. Organizing the statements from the Act in terms of system requirements gives a better understanding of the system purpose, scope, and importance. These parameters begin to describe the degree of system complexity and degrees of system priority, both for the system as a whole and for priorities within the system itself; that is, within the system's definition. Reformulated and categorized for system definition these parameters look something like this:

<u>Purpose of the System</u>

1. The purpose of the system is to provide a system of roadways that fulfills the needs of local and interstate commerce, the national and civil defense.

<u>Scope of the System</u>

2. The system definition for the interstate system is to apply to interstate roadways, as well as designated streets and parkways in urban areas.
3. The interstate system serves communities of 5000 or more. In other words, all communities in the nation, from rural towns to the largest of cities, are parts of the system.

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55 Ibid. p. 6.

56 Ibid. p. 8.

4. Local needs are secondary to the needs of interstate commerce. They are to be given equal consideration to the extent that they are "practicable, suitable and feasible" to the fulfillment of the requirements for interstate commerce.

Importance of the System

5. The system is of national interest and national priority.
6. The system is of primary importance to the national defense (and thereby, of primary importance to all of the objectives embodied in the mandates and plans for the national defense).
7. The timely completion of the system is one of the most important objectives of the system itself.

SUMMARY OBSERVATION. The Federal Aid Highways mandate contained the system's goals that comprise the system's initiating requirement set. These requirements are stated in broad terms; i.e., build an interstate highway system for purposes of national economic growth and the national defense. The scope of the task at hand was clearly stated in the mandate. The system was to blanket the country by serving national economic and defense needs. The mandate specified both large and small settlements in the system. Due to the language of the act, qualitative characteristics that addressed the importance of the system, the formulation of its definition, and the efficient and exacting execution of its planning and design processes were emphasized.

RECOMMENDATION 5.1-1. *The history of the motor vehicle roadway transportation system suggests that to promote widespread development of bicycle transportation facilities, clear policy mandates should be given at the appropriate levels of government describing the (1)purpose, (2) scope and (3) importance of this endeavor. The highest return on investment, in terms of bicycle person-trips generated per unit of investment, will likely be for trips less than five miles in length (see chapter 3). This suggests that the local level of government is likely to be the most critical level at which such policy needs to be enacted. To facilitate this at the state level, enabling legislation could be enacted and a model policy could be developed for adoption by local units.*[57]

RECOMMENDATION 5.1-2. *To facilitate the widespread development of bicycle transportation facilities, policy mandates should include policy language defining three areas of system requirements:*

Purpose of the System

1. *The purpose of the system is to provide a system of urban bicycle roadways that fulfills the needs of local commerce and personal mobility by bicycle.*

Scope of the System

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57 On the national level this policy statement has already been enacted through the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) acknowledged an important role for the bicycle as a form of transportation in this regard by the policy language set forth in the act. This act was passed in the middle of this study effort. The complete text of the act may be found in: Congress, U. S. H. R. 2950, (1991). *The Intermodal Surface Transportation Efficiency Act of 1991.*

2. *The system definition for a system of urban bicycle roadways is to apply to all land use settings and environmental contexts in urban areas.*

<u>Importance of the System</u>

3. *The establishment of the a system of urban bicycle roadways is of primary importance to state and local transportation and environmental interests.*
4. *The timely completion of a system of urban bicycle roadways is one of the most important objectives of the system itself.*

Further requirement analysis for the system continues with an analysis of the operating environment of the system.

5.1.2. OPERATING ENVIRONMENT: INTERSTATE TRANSPORTATION & THE MID-CENTURY MILIEU

In order to understand the operating environment of the system, the interstate highway system requirements that are embodied in the goals of the Federal Aid Highways Acts are examined and the system's requirements are further refined by considering the context of the system's operating environment, as well as the mid-century zeitgeist within which the system's requirements were set.

The context of a system's operating environment refers to all of the physical realities of the environment within which the system will operate. The zeitgeist, or "the spirit of the times," represents the social, political, economic and cultural contexts within which the systems initiating requirements (goals) were interpreted and refined.

The zeitgeist of an era bestows a position or stance -- an aura of opinion -- to the processes of requirement set refinement and system definition. It represents the opinions and positions held by *people* involved in the processes of requirement set refinement and system definition. The zeitgeist of an era influences the importance that people give aspects of their lives when they are dealing with the particulars of life. The zeitgeist of an era is always present and effects everything that is accomplished. No one defines, creates or makes anything in the absence of the opinion and stance that the zeitgeist of one's own social, political, economic, and cultural epoch contributes to the effort. Understanding and being aware of an era's zeitgeist -- a difficult, and sometimes impossible task, when trying to understand the zeitgeist of one's own era -- allow one to understand how goals and requirements are interpreted and therefore, defined and implemented.

That an era's zeitgeist affects that which is accomplished is undoubtedly true. People are affected by their times whether they agree with prevailing thought and sentiment or not. We can look back at the mid-century zeitgeist; its social, economic, political, and cultural realities and demonstrate how the zeitgeist affected the refinement of the interstate system's requirements.

America's mid-century zeitgeist, displayed the well-known confidence and euphoria in technology, anything that was modern, and confidence in American "know-how." However, it was also seriously influenced by traumatic national experiences from the previous two decades of the 1930s and 1940s that spilled into the personal lives of every American. Following World War II, there were two great fears of national import: that the country would slip back into the Depression of the 1930s and that it would be unable to defend itself if under attack unless positive steps were taken to change the situation.

Thus the requirement for interstate and intercity connectivity stemmed from two pressing national concerns. The first, connectivity using roadways for purposes of national economic growth carried a long history of national priority. National self-reliance, stability and strength were seen to depend on an interconnected economic structure of all states and cities. (This was not new. Congress first recognized the need for a "national pike" in 1796.) The need for this kind of stability was acutely felt mid-century, following World War II which many felt only temporarily eased the economic pain of the Great Depression. If there was no infrastructure on which an efficient and productive economy could grow and thrive, it was felt that it was entirely possible for the country to slip back into depression. The roadway transportation infrastructure -- that is, the System of Interstate and Defense Highways -- was a key part of this economic infrastructure.

The other pressing national concern was fueled by the intensity of the Cold War animosities that quickly developed after the war, as well as the efficiency and speed of the modern weaponry used in World War II. The concern of a national invasion of United States territory had not been felt since the early days of the country and modern advances in transportation and weaponry meant that such an invasion would be massive and quick. Following World War II, the very real threat of the Cold War and near-instantaneous atomic annihilation further fueled concerns regarding the capability of the nation to quickly move goods and people through the country, and thereby, provide effective action against this kind of attack.

The system goal of providing for the needs of local and interstate commerce, and national and civil defense, colored by the significance and immediacy of the post-war economic and political milieu, took on a quality of largeness of scale. Numerous sources have noted that the infrastructure for the automobile in the U.S. is one of the largest public infrastructures ever built in the world. Whereas the establishment of information systems infrastructures (computers and their technology) represented a heavy private investment, the implementation of the automobile's infrastructure represented "one of the largest and most ambitious public works projects ever undertaken in the world, an incredible public investment in a network of concrete and asphalt, coast-to-coast and border-to-border."[58]

An analysis of the operating environment for this system reveals just how large and pervasive this system was to be.

1. The system had to accommodate and support the movement of all sizes and types of motor vehicles.

By the time Congress allocated sufficient funding for the interstate system, the personal modes of transport provided by the automobile and the truck were in wide use. Thus, use of the word "highway" (even today it is used in most roadway engineering documents to refer to urban streets) within the text of all Federal Aid Highway Acts and the absence of anything regarding mass transportation within the Acts, clearly implied that the system was to be a roadway system that met the requirements for *inter*state commerce and defense.

2. Since the automobile was a major user of the system, it was necessary that the system accommodate all of the characteristics of personal modes of transportation.

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58 Cushman, King. (1988) "Exploring the Land Development and Transit Connection." *Transit, Land Use and Urban Form*. Ed. Wayne Attoe. Austin, Texas: The Center for the Study of American Architecture, School of Architecture, University of Texas, p.21.

3. The motor vehicle itself, along with a human operator, was the primary system user. The system had to accommodate metal boxes of certain dimensions, traveling at speeds of 55-70 m.p.h.

These fast-moving metal boxes were potentially operated by any and all individuals of driving age in the U.S. This reality of the system's operating environment required the system to not only accommodate the mechanical realities of the fast-moving metal box, but all of the skills and handicaps of all of its potential operators.

4. Because the system had to provide a system of personal transportation using the automobile and the truck, each individual qualified to use the system would potentially use it and *could use it simultaneously.*
5. Not only did the system have to provide mobility for vehicles (people and goods) to ensure economic stability and growth, it had to efficiently move vehicles (potentially large numbers of people and goods moving in great haste) in times of military crisis. These national goals from which the system's requirements were developed, bestowed a largeness of scale on the system with respect to its use and its importance.
6. By virtue of the fact that the system was to accommodate the motor vehicle as a personal mode of transportation and also provide intercity and interstate connectivity, the system's service area was, literally, nationwide -- from home to work to all places of employment, production, commerce, service, government, and education in every city and state. This requirement also imparted a largeness of scale to the system: it was to be everywhere; it was to be ubiquitous, and blanket the country.

SUMMARY OBSERVATION. THE single most important aspect of these requirements that affects the system definition is their gargantuan scale. This hugeness is seen in:

- The great distances between U.S. cities and states that had to be traversed in network connecting all of them.
- The great numbers of personal vehicles that the system had to accommodate.
- The large relative scale imparted by user (motor vehicle) size and speed. The size, and particularly, the potential speed that motor vehicles could attain, brought a new largeness of scale previously unseen in personal transportation systems. Automobiles became machines for transforming human beings into super-beings with regard to movement and all roadways were to provide this "super-movement" function.
- The system's ubiquitous nature. Large, high-quality roadways were to be easily accessible to every vehicle owner.
- The requirement for interconnectivity implied a network of roadways was to be created. The system was not, for example, to provide linear connections or only connect a specified subset of the country.

RECOMMENDATION 5.1-3. *A bicycle roadway transportation system should not attempt to duplicate the massiveness of the motor vehicle system, but should be directed by the ideas embedded in its system requirements that promoted its expansion. Translation of such ideas into bicycle transportation system requirements might include the following:*

- *The system should attend to the issue of expansion to enable neighboring urban districts to connect via the bicycle roadway system.*
- *The system should be conceived and constructed to handle large numbers of cyclists.*
- *Because the bicycle adds significant mechanical advantage over travel on foot, there is necessarily a different scale of size and movement and relationships made possible by its extensive use for urban transportation. The effect of this change can and will have an impact on the overall urban environment. Because the bicycle is closer to a pedestrian in scale and movement than it is to an automobile, this should help create, over the long term, a more human scale environment.*
- *The bicycle roadway system should be ubiquitous nature. High-quality bicycle roadway space must be made easily accessible to every bicycle owner.*
- *The bicycle roadway system should require interconnectivity as areas become blanketed with bicycle roadways. This means attention should focus on establishing a network of bicycle roadways, and avoid providing linear connections or connections to only certain destinations in a city.*

SUMMARY OBSERVATION. The preceding has presented some major requirements for our interstate system of roadways. This section demonstrated how requirements become refined by considering them in different contexts -- in this case, the contexts of the economic and political milieu and some aspects of the system's operating environment. The discussion was certainly not exhaustive of all of the system's requirements, but serves as background for two points: that a system's definition and design parameters stem from the system's requirement set and that the requirements for an interstate roadway transportation system are inappropriate when applied within the context of the intra-urban environment and intra-urban transportation requirements. This at least partially explains why alternative forms of personal transportation, such as bicycling and walking, have not been more common in areas of urban expansion that have taken place in the Post World War II period.

RECOMMENDATION 5.1-4. *A specific re-thinking of the system definition for a intra-urban multi-modal transportation system is needed. Such an enterprise would provide the clarity and direction needed to better integrate alternative forms of transportation into the urban fabric. This re-thinking must necessarily turn to a more local frame of reference and be driven primarily by local issues and concerns.*

5.1.3. URBAN REQUIREMENTS: MID-CENTURY POLITICKING & PLANNING FOR THE AUTOMOBILE

The history of urban transportation planning is complicated, as is its influence on urban planning. Without a doubt, mid-century urban planning was dominated by transportation planning and transportation planning was dominated by a concern for efficiently moving motor vehicles at an intercity, interregional, and interstate scale. It is within this history that we find the planning decisions based on the automobile's transportation system -- the National System of Interstate and Defense Highways -- beginning to form the urban patterns that we see in place, and still promulgated, today. This history reveals the birth of today's philosophy, or point-of-view, regarding what an urban transportation system should be: that is, what the urban street should be and what an urban roadway network should be. Likewise, this history sheds light on urban transportation planning today: that is, how we go about planning urban roadway systems and their parts.

The transportation planning concepts and techniques developed for the interstate system were arguably helpful in providing a starting point for addressing pressing urban problems that were felt throughout the middle part of this century. However, the premise or the objective that guided those concepts -- that of the interstate movement of goods and people using the automobile or the truck -- can be questioned as appropriate as the premise for urban planning and design in general, and urban transportation planning and design, in particular. It can certainly be questioned as appropriate within the context of late 20th century urban planning.

Early and mid-century planners and policy makers were faced with a situation similar to ours regarding a search for solutions to urban transportation problems. Serious urban problems were being felt including exploding suburban growth, a deteriorating mass transit infrastructure, blossoming urban housing problems and urban blight, in general. Central to all of these problems was traffic congestion and an inadequate system of roads for accommodating the automobile. Today we have a similar situation, though the details are profoundly different. Late century cities are faced with pollution, traffic congestion, and domination and dependency on the automobile for transportation. As it was for our predecessors, it is difficult for us to visualize a new transportation system until it is framed as a system and described with rules for the design and operation of the system.

Mid-century urban and suburban problems required sophisticated planning techniques that could provide immediate and readily available solutions to address the foremost mid-century concern, that of regaining economic stability after World War II and the Depression of the 1930s. Within the context of the urban problems mentioned previously, and the start of the cold war, it was imperative that the United States establish a post-war stability by switching its war-time economy to a viable and vigorous peace-time economy. It would not have been possible to foster this new economy with an inadequate and clogged system of roads. People and goods could not be moved in the timely fashion or to the degree that they needed to be moved. The development of a viable peacetime economy was critical not only to the country, but to the solution of other urban problems. Likewise, the solutions to many urban problems were critical to fostering the new economy. This tangled web of needs and interdependencies elevated the urban planning and transportation planning needs of the country to top priority.

The growing mid-century need to provide a great infrastructure to move goods and solve the massive urban congestion problems of the automobile presented planners with problems that were new and unfamiliar because of their extreme dimension and scale. In the context of the mid-century urban problems, the planning profession as we practice it today was being born. Planning historian, Mark S. Foster, described the situation:

The planning profession grew rapidly between 1900 and 1940, but individual planners and professional organizations experienced constant, energy-draining struggles for formal recognition and for adequate funding and authority to effect their programs. In the maelstrom of both local and national political settings, planners were invariably pitted against seasoned politicians and more established bureaucracies. Those interests were generally slow to recognize a need for comprehensive planning. Planners were usually under intense pressure to develop prompt solutions for immediate urban problems.[59]

An equally serious problem for planning that still had not been satisfactorily addressed by mid-century, when the need for urban transportation planning came to the fore is described by Altshuler as:

... [the] paradox that although [the] profession enjoined [the planner] to plan comprehensively, it did not provide [the planner] with a comprehensive set of criteria for making value choices.[60]

Foster concurs and characterized the difficulty in this way:

Planners realized that they needed to develop both a comprehensive philosophical framework and a set of concrete, practical objectives, but they soon learned the difficulty of achieving either. Some dreamed up bold futuristic schemes, but political and financial realities suggested cautious, limited proposals for minor adjustments.[61]

Even though the planning profession was in the throes of self-discovery, interstate transportation planning had strong footing prior to World War II. Though the automobile made its presence felt in a massive permeation of post World War II society, it and the movement to the suburbs were not unknown in previous decades.

In the late 19th century and the early 20th century, unhealthy and undesirable living conditions in industrial cities, coupled with the development of electric trolley systems, fostered the movement of larger and larger middle class populations from the

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59 Foster, Mark S. (1981) *From Streetcar to Superhighway: American City Planners and Urban Transportation, 1900-1940.* Philadelphia: Temple University Press, p. 6.

60 Altshuler, Alan A. (1983) "The Intercity Freeway." *Introduction to Planning History in the United States.* Ed. Donald A. Krueckeberg. New Brunswick, New Jersey: The Center for Urban Policy Research, Rutgers University, p. 231.

61 Foster, Mark S. (1981) *From Streetcar to Superhighway: American City Planners and Urban Transportation, 1900-1940.* Philadelphia: Temple University Press, p. 30.

central city to new suburban developments. The advent of the automobile in the 1920s further eased commuting trips to the city.

> *By the early 1930s, the objective of constructing a system of two-lane roads connecting the centers of population had largely been completed. It was then possible to travel around the country on a smooth, all-weather highway system.*[62]

In the 1930s, there were three significant developments in the field of transportation planning. Similar developments in the field of planning had not taken place. First, the planning of transportation routes was recognized as important and necessary in the Federal Aid Highway Act of 1934, which began formal authorization and funding of transportation planning activities. "1-1/2 percent of the amount apportioned to any state annually for construction could be used for surveys, plans, engineering, and economic analyses for future highway construction projects."[63] Second, the act also recognized the need to promulgate a uniform understanding of the interstate system throughout the country by establishing relationships between federal and state transportation agencies. It "created the cooperative arrangement between the U.S. Bureau of Public Roads (now the U.S. Federal Highway Administration) and the state highway departments, known as the statewide highway planning surveys. By 1940, all states were participating in this program."[64]

Perhaps the most significant development in the 1930s regarding transportation planning and engineering as it relates to urban planning and urban transportation planning is that the system definition for the interstate transportation system was formed as were its accompanying lower level design and engineering specifications for the roads themselves. An official history of the U.S. Department of Transportation describes what occurred:

> *As new knowledge became available on the performance of vehicles and highway design features, there was a need to incorporate it into practice. The Committee on Planning and Design Policies of the American Association of State Highway Officials (AASHO)*[65] *was formed in 1937 for this purpose. The committee's mode of operation was to outline a program of work that was performed by the BPR*[66] *under the supervision of the Committee Secretary. The BPR gathered known information and developed draft guidance, known as*

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62 Weiner, Edward (1988) *Urban Transportation Planning in the United States: An Historical Overview.* Prepared for the Office of the Assistant Secretary for Policy and International Affairs for the U.S. Department of Transportation. Office of the Secretary of Transportation. Washington, D.C.: U.S. Department of Transportation, p.8.

63 Ibid. p.8-9.

64 Ibid. p.8-9.

65 Later changed to the American Association of State Highway and Transportation Officials (AASHTO).

66 Bureau of Public Roads.

policies,[67] *which were revised by the committee. The policies were finally approved by a two-thirds favorable vote of the States.*

In the period 1938 to 1944 the Committee under Secretary Joseph Barnett produced seven policies related to highway classification, highway types,[68] *sight distance, signing and intersection design for at-grade, rotaries and grade separations. These policies were reprinted without change and bound as a single volume in 1950 (American Association of State Highway Officials, 1950).*

The policies were updated, expanded and rewritten as a single cohesive document and issued as A Policy on Geometric Design of Rural Highways in 1954 (American Association of State Highway Officials, 1954). The policy contained design guidance on the criteria determining highway design, vertical and horizontal alignment, cross section elements, at-grade and grade intersections, and interchanges. The volume, which became known as the "Blue Book," went through seven printings by 1965. It received wide acceptance as the standard guide for highway design. The policy was again reissued in 1966[69] *in revised and updated form to reflect more current information (American Association of State Highway Officials, 1966).*

Much of the Material in the 1954 Rural Policy applied both to urban and rural highways. As new data and research results became available on urban highways, the AASHO Committee decided to issue a separate policy for the geometric design of urban highways (American Association of State Highway Officials, 1957).

The development of these policies typified the approach to highways standards. Research engineers collected data on the performance of vehicles and highways. These data were brought together in the form of design standards, generally by staff of the BPR under the guidance of AASHO. Eventually, they became part of highway design practice through agreement of the States. As a result of their factual basis and adoption through common agreement, the policies had immense influence on the design of highways in the United States and abroad.[70]

By starting in the 1930s and continually revising their highway planning and design concepts and their engineering standards, transportation professionals were well ahead of post-war urban planners when urban transportation issues became crucial in solving many national and local problems. This formation of a systematic way of

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67 AASHTO has always, and still, refers to their system definition with the term "policy."

68 Highway classification and highway types are the system definition for this system and express the hierarchical nature of the system.

69 And, again in 1984.

70 Weiner, Edward (1988) *Urban Transportation Planning in the United States: An Historical Overview.* Prepared for the Office of the Assistant Secretary for Policy and International Affairs for the U.S. Department of Transportation. Office of the Secretary of Transportation. Washington, D.C.: U.S. Department of Transportation, p. 10-11.

viewing how things should be and how they could be achieved, placed transportation planners and engineers in a position distinctly capable of solving problems from their point of view.

Planners had no such tools at their disposal for addressing mid-century problems. Donald Krueckeberg comments on this in *Introduction to Planning History in the United States* and describes the significance and impact of the mid-century urban transportation planning effort as well.

> *The initial impact of post-war suburbanization and urbanization on the planning field was more quantitative than qualitative and stemmed largely from the expanded influence of federally initiated programs. There were four programs of major significance: public housing, urban renewal, home mortgage insurance, and highway building....*
>
> *The fourth great federal force in this era, and probably the greatest of them all, was the Interstate Highway System built by the Highway Act of 1956. Its influence was overpowering because it represented not only its own billions of dollars of capital investment, altering patterns of national accessibility and local land use, but it acted as a catalyst that sped the interaction of the other three big programs in one great concerted metropolitan transformation. Its pathways through cities often displaced the poorer residents by demolishing their housing and thus increasing the need for public housing development. The joint planning of highways and urban renewal projects accelerated both programs and made possible the taking and remaking of ever larger quantities of central city land, as well as providing a private transportation system that supported the insured-mortgage suburbs. They in turn fostered new suburban shopping centers that were less dependent on public transportation systems. By now the syndrome is familiar.*[71]

How did transportation engineers and highway departments come to mold the fates of urban centers in the United States? Alan Altshuler's historical account of the planning and design of the intercity freeway through St. Paul, Minnesota provides a description typical for all cities in the U.S. He begins by describing the roles of the public officials and private interests as follows:

> *Of the three sets of actors whose approaches to St. Paul's freeway program will be described -- highway engineers, organized private interests, and professional city planners -- only the first had technical procedures for predicting the precise benefits to be derived by building on the basis of any particular design. Only they and the private interest spokesmen had explicit notions of what they hoped to achieve. Only the planners lacked both a clear notion of what values their efforts should serve and procedures for discovering what values any specific proposal would serve.*[72]

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71 Krueckeberg, Donald A, ed. (1983) *Introduction to Planning History in the United States.* New Brunswick, New Jersey: The Center for Urban Policy Research, Rutgers University, p. 9-10.

72 Altshuler, Alan A. (1983) "The Intercity Freeway." *Introduction to Planning History in the United States.* Ed. Donald A. Krueckeberg. New Brunswick, New Jersey: The Center for Urban Policy Research, Rutgers University, p. 191.

The transportation engineer's position was formed by more than 20 years of experience developing their system definition and planning models, and both technically and politically polishing the interstate system and its implementation methodology. This experience and preparation was effective in assuring public officials that the transportation engineering profession was not only competent to solve problems, but that their solutions were the best solutions available. Altshuler explains:

The relative influence of engineering and city planning considerations on decisions concerning the intercity freeway illustrated a fairly simple point: clarity of standards and strength of conviction were extremely important political variables. When standards were clear, and a profession felt confident that they were right or "the best available," conscientious men could look to them for guidance and take on from them the energy that flowed from unclouded conviction. If those who proposed a project were perceived as moral and realistic men, their passionate conviction as technicians was likely to persuade doubting laymen to support their project. The formula was not perfect, of course. The project might seem too expensive, or it might threaten important vested interests or sacred beliefs. Some other group of technicians might testify passionately against it. But observers of politics had long recognized that other things being equal, the political value of having a clear sense of direction and honest conviction was substantial.[73]

Planners in this era had not developed (or did not have the opportunity to develop) their positions beyond their initial ideas. As a consequence, they were not successful in arguing any point-of-view that was different than the engineering point-of-view. Again, from Altshuler:

This is not to say that [planners] lacked ideas about how cities should be laid out. Their profession did provide them with such ideas, but not with standards for determining when and how to strive for their effectuation. Planners recognized that many important aspects of life had no price because they could not be bought or sold. They seemed to have made progress, however, in defining these aspects, discovering how they were affected in specific situations, or evaluating their importance. Consequently, planners in St. Paul were more or less forced to accept on faith the Highway Department's assumption that other effects of the freeway besides those involving traffic would somehow "balance off" or prove beneficial on balance. Lacking conviction that another plausible viewpoint was available, they accepted the engineering point of view -- except on a few matters of detail -- as their own.[74]

Transportation planners and engineers made no bones about their goals or objectives. Their jobs were to create highways and the function of highways was to provide for the efficient movement of motor vehicles. Their design criteria and specifications for the interstate system embodied an appropriate and successful response to the goals of intercity connectivity set forth for them by Congress in the early and mid-century Federal Aid Highway Acts.

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73 Ibid. p. 227.

74 Ibid. p. 232.

The Federal-Aid Highway Acts enacted by the U.S. Congress always clearly stated that the goals of the highway system were to provide a surface transportation system for *inter*city, personal, motorized transport for purposes of national economic growth and the national defense. *Urban Transportation Planning in the United States: An Historical Overview*, published by the U.S. Department of Transportation states:

> *The importance of the system within cities was recognized, but it was not intended that these highways serve urban commuter travel demands in the major cities. As stated in the report, "...it is important, both locally and nationally, to recognize the recommended system... as that system and those routes which best and most directly join region to region and major city to major city." (U.S. Congress, 1944)*[75] (Emphases added.)

King Cushman, in presenting historical perspectives on the growth of our system of roads, concurs:

> *The federal interstate highway program was initially conceived in 1944....It was proposed as a key component of our national defense system, assuring logistical intercity access and connections all across the country and it was originally intended as an intercity, not intracity, highway system.*[76]

However, the design specifications and design criteria that were developed to build our interstate highway system were applied to urban conditions and urban transportation requirements, even though they were intended as the response to the mandated goals for intercity connectivity. Altshuler describes the situation:

> *Two points characterized the original planning of the interstate system. First, engineers did the planning. In Minnesota, which was typical, their conception of the function of the highway system was highly specific: the solution of traffic problems. They frankly declared that they did not have time to concern themselves with other aspects of the program. Second, the engineers of the federal bureau and the state highway departments had hitherto worked primarily on rural roads. The cities had built their own streets, laying them out in most cases before buildings and other structures blocked the way. In Minnesota, the state Highway Department had had, beginning in 1933, some experience improving urban routes, but it had had virtually none locating new roads in urban areas. Nonetheless, its engineers now had to work quickly. The*

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75 Weiner, Edward (1988) *Urban Transportation Planning in the United States: An Historical Overview.* Prepared for the Office of the Assistant Secretary for Policy and International Affairs for the U.S. Department of Transportation. Office of the Secretary of Transportation. Washington, D.C.: U.S. Department of Transportation, p. 14.

The report, *Interregional Highways*, to which this quote refers, was the result of an investigation conducted by the National Interregional Highway Committee, appointed by President Roosevelt in 1941 to determine the need for "a limited system of national highways to improve the facilities available for interregional transportation."

76 Cushman, King. (1988) "Exploring the Land Development and Transit Connection." *Transit, Land Use and Urban Form.* Ed. Wayne Attoe. Austin, Texas: The Center for the Study of American Architecture, School of Architecture, University of Texas, 9-37.

war was rapidly nearing an end, and they wanted to be prepared to move quickly once the expected economic depression developed. There seemed to be no time to theorize about subtle differences between urban and rural planning problems.[77]

We know today that the so-called "subtle differences" between urban and rural transportation planning problems are indeed not subtle, but embody striking contrasts. Differences between intercity and intracity transportation requirements are large. Differences in the interstate and urban operating environments, as well as their scale and contexts of place, indicate a need to revisit all system requirements for urban transportation systems.

The most fundamental error that occurred when the interstate system definition and design criteria were applied to urban areas, was that the requirements for an urban roadway transportation system were not considered. The relative naiveté of the urban planning profession and the sense of urgency surrounding the effort did not permit it. If these requirements had been scrutinized and developed, an urban roadway transportation scenario different from the interstate scenario, would have appeared. Instead, the urban roadway systems we have today are based largely on a system definition for an inter-urban transportation system. The fit of this system with the urban patterns of development that it serves, presents many problems.

Today, professionals and lay persons alike understand how the automobile is accommodated within our urban centers. The rules and design of our current urban transportation systems are deeply embedded in our view of how streets *should be* designed and built. Because we so thoroughly understand how streets should be, the underlying system definition under which our transportation system was, and continues to be developed, is also deeply embedded in our views of how urban roadway transportation should be. In other words, it is difficult to imagine another way of thinking about personal, roadway transportation in our urban and suburban areas than the way we think today. This is because we have no conceptual framework, much less a system definition or design standards, that allows us to visualize a transportation system that accommodates the automobile, as well as non-motorized modes of transportation, such as the bicycle and the pedestrian, in a more compatible and satisfactory manner in urban settings. Because such a vision cannot be evoked, few steps can be taken to provide this kind of roadway transportation system.

SUMMARY OBSERVATION. It is important to grasp the most important lesson given by the mid-century history of our urban transportation system within the context of our present-day points-of-view regarding urban policy making, urban transportation, and urban design. The ideas that prevailed mid-century embodied a "clear sense of direction" and the system that was adopted was the one that exhibited a "clarity of standards." Within the mid-century urban context, when there was no urban transportation system that adequately accommodated the automobile, public officials were essentially in the same position as our public officials today. Without an explainable system with demonstrable design criteria, it was not possible to visualize what the new transportation system should be and how it would operate. The system

77 Altshuler, Alan A. "The Intercity Freeway." Introduction to Planning History in the United States. Ed. Donald A. Krueckeberg. New Brunswick, New Jersey: The Center for Urban Policy Research, Rutgers University, 1983. p. 195.

that was accepted was the one that first, could be explained and presented as a whole to public officials and second, showed that it could solve the problem at hand by possessing "technical procedures for predicting the precise benefits to be derived by building on the basis of any particular design."

RECOMMENDATION 5.1-5. *Develop a very simple, easy to understand vision of a bicycle roadway transportation system as a whole in order to explain its construct and communicate the basics of its design criteria political decisionmakers and public officials. As experienced with the motor vehicle roadway system, this is necessary to create a broad, shared vision of what is to be built and what its essential features must be. This is also important to galvanize broad political support, provide conceptual direction for decision makers, and establish a framework for understanding the technical requirements and potential benefits of creating a bicycle roadway transportation system. Perhaps more than any other recommendation presented in this study, this is the one most critical to the propagation of widespread development of a successful bicycle transportation system.*

In hindsight, the patent application of the interstate transportation system to the urban environment was wrong. It was not intended that the interstate system would be applied as an intra-urban system and it was not designed for that purpose. Goals, objectives, and requirements for the interstate system should have been reviewed to determine their applicability to urban transportation needs, but they were not. It is important to 'begin at the beginning' in order for our urban transportation systems to more adequately fit the urban setting and the needs of urban transportation users. By developing an appropriate set of urban transportation requirements and user descriptions, an appropriate urban transportation system definition can be developed. As we shall see, this offers many interesting and hopeful possibilities for not only bicycle transportation, but many other transportation alternatives, as well.

5.2. USER DESCRIPTION: REQUIREMENTS FOR THE MOTOR VEHICLE

Sections 4.2 and 4.3 described user requirements as an important component of any system's requirement set. This section discusses the primary user and the requirements of that user as currently described within the official design policy for our roadway transportation systems. It is apparent that the primary user of this system -- the user that is accommodated by the system and for whom the system definition was formulated -- is the motor vehicle. The detail with which this system user is described contrasts sharply with the kind of detail that is currently given the user description for other modes of transportation, specifically the bicycle.

The motor vehicle's user description is given according to two parameters: the physical characteristics of the vehicles and the performance of the driver.

The AASHTO policy book on the geometric design of highways and streets devotes twenty pages to the description of the physical characteristics of motor vehicles. The description begins as follows:

The physical characteristics of vehicles and the proportion of variously sized vehicles using the highways are positive controls in geometric design. Therefore, it is necessary to examine all vehicle types, select general class groupings, and establish representatively sized vehicles within each class for design use. Design vehicles are selected motor vehicles with the weight, *dimensions, and operating characteristics used to establish highway design controls for accommodating vehicles of designated classes....*

Two general classes of vehicles have been selected, namely, passenger cars and trucks....

The dimensions for ten design vehicles representing vehicles within these general classes are given....[78]

Thus, the design parameters that implement the definition of today's system include the detailed description of ten different motor vehicle types.

The description of the physical characteristics of motor vehicles continues in detail with vehicular acceleration and deceleration rates. The descriptions of the minimum turning paths for each of the design vehicles include the following:

The principal dimensions affecting design are the minimum turning radius, the tread width, the wheelbase, and the path of the inner rear tire. Effects of driver characteristics (such as the rate at which the driver approaches centripetal acceleration) and of the slip angles of wheels are minimized by assuming that the speed of the vehicle for the minimum radius (sharpest) turn is less than 10 mph.[79]

Operator characteristics are given equal weight. Twenty more pages describe driver performance including the driving task, the guidance task (lane placement and road following, car following, overtaking and passing, and other guidance activities), the information system (reaction time, primacy, expectancy), and driver error (due to driver deficiencies and due to situation demands).[80]

It is clear that the user requirements for the motor vehicle and its operator have been stated in detail and to a precise degree. The guidelines give a passing nod to non-automotive system users in stating:

Additional emphasis has been placed on the joint use of transportation corridors by pedestrians, cyclists, and public transit vehicles [and] designers must recognize the implications of this sharing of the transportation corridors.[81]

The descriptions of bicyclists and pedestrians and their needs and requirements are not nearly as accurate or as detailed as those for the motor vehicle and its operator. This strongly suggests a low level of importance given to bicycles and pedestrians as modes of transportation by policy and decision-makers responsible for building and maintaining our urban roadways.

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78 American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets.* Washington, D. C.: AASHTO, p. 19.

79 Ibid. p. 20.

80 Ibidl. p. 38-47.

81 Ibid. p. *xlviii*..

SUMMARY OBSERVATION. Since the user description for any design is paramount to the results or solution the design effort produces, it becomes apparent that the bicycle and the pedestrian were not integral to the thought that formed our roadway transportation system. This, then, necessarily means that neither the bicycle nor the pedestrian are integrated into the framework and rules that describe the system. They are tacked-on to the motor vehicle's system and not integrated in a systemic fashion. This is echoed in the forward to the guidelines that states that:

> *These guidelines are intended to provide operational comfort, safety and convenience for the motorist... and to produce highways that are safe and efficient for users and acceptable to non users and the environment.*[82]
> (Emphasis added.)

SUMMARY OBSERVATION. The current detailed description of the motor vehicle and motor vehicle operator as system users evolved through an iterative system design and definition process. When the system definition for the motor vehicle's roadway transportation system was in its infant stage, similar to that of bicycle transportation today, this amount of user detail and requirement description was not in place. It could not have developed merely by thinking about the users of the system, but must have developed iteratively, along with the system definition as it progressed into a more complete, complex, and sophisticated description of roadway transportation as a system.

Non-motorized user descriptions are not as nearly sophisticated as those developed for the motor vehicle and the standard policy that gives shape to the physical form of our roadway transportation system clearly reflects this in its conceptualization of roadways as motor vehicle spaces, not multi-purpose spaces.

RECOMMENDATION 5.2-1. *As was the case with the development of motor vehicle roadway systems, it is not necessary to have a sophisticated bicycle user requirement set in place in order to begin planning and implementing bicycle transportation systems. However, as these systems mature, and a history of experience is developed, a complete user description and requirements set should be developed, updated in a regular review cycle and published by AASHTO and the ITE in their professional publications.*

5.3. SYSTEM CONSTRUCT: MOVEMENT HIERARCHY & FUNCTIONAL CLASSIFICATION

In today's system definition, the system's construct -- the principles that are used to organize the system, define it, plan it, and design it -- is tightly and inextricably interwoven with the functions that are identified for the system.[83] Ideally, a system's construct and its functions should not be inextricably married to one another.

A system's construct provides a set of organizing principles that allow the system to be visualized, managed, manipulated, and altered with ease. A system's functions, whether they are internal or external functions, are services or products that

82 Ibid. p. *xlviii*..

83 Though, as will be shown, only one function -- mobility -- is identified.

the system provides. A system's construct should make it possible for system functions to be added, deleted, and altered without affecting the construct itself and the principles by which the entire system is organized. The system's construct should be inclusive and flexible enough so that it need not be changed as functions for the system change: marrying construct with function usually results in an inflexible and exclusive conceptual framework for defining the system.

5.3.1. A HIERARCHY OF MOBILITY

The conceptual construct that is used to define the present-day roadway transportation system is the "movement hierarchy."[84] The hierarchy is clear and straight-forward, yet conceptually brittle with respect to expression of relationships in a system. As applied in the system definition for roadway transportation systems, hierarchy is intended to be the mechanism that gives order to the identity of the parts of the system and the way those parts interact.

The purpose of a system component in a hierarchy, as in any system construct, is the role it plays in the entire system. Each component has a purpose and each component has rules for interaction with other components.

In a hierarchy, system components are either above or below other components in the system. Because of this, the interaction of system components occurs up or down the hierarchy. In a hierarchy, a component usually only interacts with the component that is directly above or directly below it in the hierarchy's tree-like arrangement. Occasionally, a component interacts with a component that is two positions away in the hierarchy. If enough special rules are created that allow components to interact with components that are found further up or down the hierarchical tree or across branches of the tree, the systemic nature of the hierarchy increasingly breaks down. When this occurs, a hierarchy used to organize system interactions becomes misleading and useless.

An example of a hierarchical system is a hierarchical organization. Participants in such an organization normally interact with their 'boss' or with 'their people' (the people they supervise within the organization). Organizational interaction two levels up the hierarchy (with one's boss's boss) is unusual, in fact, it is discouraged in hierarchical organizations. Interaction three levels up a hierarchical organization rarely occurs. Likewise, interaction with participants two levels or more down in the hierarchy is unusual, though it is not usually discouraged because of the scalar aspect of the hierarchy. The boss has more power and can thus do, what he or she wants, regardless of the system structure.

A dominant feature of the hierarchy is scale. Those components that are larger in scale (e.g., power, size, speed and so forth) are nearer the top of the hierarchy and those that are smaller in scale are closer to the bottom. Because of this scalar characteristic of hierarchies, the focus of the hierarchical construct of relationships and thereby, the focus of a system or an organization that is ordered by the hierarchy, tends to be toward the top. For example, in hierarchical organizations, people at lower levels of the hierarchy tend to be more knowledgeable about the people who are at higher levels in the hierarchy; they usually know their names are often aware of their responsibilities and activities. People found near the top of hierarchical organizations usually tend to not know the individuals at lower levels of the hierarchy, and, quite

84 This is AASHTO's name for their system construct.

often their responsibilities and activities. Within hierarchical organizations, the leverage for change and action is vested in the higher levels -- "as the higher levels go, so goes the whole organization." These conditions are brought about by something more than the fact that there are fewer individuals or things at the top of hierarchical structures and larger numbers of people or things at lower hierarchical levels. It is the construct itself that focuses attention to the upper levels, to the levels that carry more power and control and are larger in scale.

The hierarchical rule of interaction for the roadway transportation system extends to each system component almost exclusively in terms of mobility. In order to understand this, one must have an understanding of the "functional classification" of roadways; that is, how the functions of streets are outlined and detailed within the system definition (see Table 5.3.1A). Today's system recognizes the functions of a roadway in terms of:

- Motor vehicular *speed,*
- *Volume* of motor vehicles,
- *Distances served,* i.e., how long the roadway is and, thereby, the magnitude of the trips that it serves.

These functions are provided and permitted in varying magnitudes by the design of the roadway. Roadways are classified according to how much speed they permit, how many vehicles they allow, and the amount of distance they cover. Roadways are classified as highway, arterial, collector, and local, in descending order of the amount of mobility and volume they provide and the distances they serve. As can be seen in Table 5.3.1A, no other functions are *detailed* for streets.[85]

<u>SUMMARY OBSERVATION.</u> When this concept of a hierarchy of mobility is compared to the competitive attributes of the bicycle as transportation (Chapter Three) it is clear that the conceptual structure of the relationship of parts in the motor vehicle roadway transportation system presents a formidable disadvantage for bicycle use. The bicycle is best at providing access to the door and serving short trips at comparatively low speeds. The hierarchy a structure based on mobility (not access), with the most favored position reserved for the most mobile. That is, any decisions about relative importance of parts are sorted out by applying a value structure that says the roadway with the most speed, the largest volume of vehicles and serves the largest trip distances should dominate. The evidence for this can be seen at nearly every roadway intersection in America. In the face of this kind of decision-making bicycle use has a difficult time gaining ground.

With the functional classification of roadways in mind, the system's hierarchy is described. AASHTO describes the highway and street system components as follows:

A complete functional design system provides a series of distinct travel movements. The six recognizable stages in most trips include main movement, transition, distribution, collection, access and termination.... Each of the six

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85 The access function is given consideration only within the context of the movement function. See section 5.4.2.

stages of a typical trip is handled by a separate facility designed specifically for its function.[86]

The system components of the automobile's hierarchy represent the six recognizable stages of most trips and together, as a system, they provide a series of distinct *travel movements*. Physically, the system components are realized by distinct types of roadways in a one-to-one correspondence with the stages of a trip. Figure 5.3.1B is AASHTO's depiction of what they call "the hierarchy of movement."

86 American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets*. Washington, D. C.: AASHTO, p. 1-2.

Classification	*Function*	*Continuity*	*Direct Land Access*	*Speed Limit (mph)*	*Comments*
Freeway and Expressway	Traffic movement	Continuous	None	45-55	Supplements capacity of arterial street system & provides high speed mobility
Primary Arterial	Inter-community & intra-metro area. Primary -- traffic movement. Secondary -- land access.	Continuous	Limited -- major generators only.	35-45 in fully developed areas	
Secondary Arterial	Primary -- inter-community, intra-metro area, traffic movement. Secondary- land access.	Continuous	Restricted - some movements maybe prohibited; number & spacing of driveways controlled.	30-35	Backbone of street system
Collector	Primary-- collect/distribute traffic between local streets & arterial system. Secondary -- land access. Tertiary -- inter-neighborhood traffic movement.	Not necessarily continuous;should not extend across arterials	Safety controls; limited regulation	25-30	Through traffic should be discouraged
Local	Land access	None	Safety controls only	25	Through traffic should be discouraged

TABLE 5.3.1A TODAY'S FUNCTIONAL CLASSIFICATION OF STREETS[87]

87 Homburger, Wolfgang S., et al. for the Institute of Transportation Engineers, (1989) *Residential Street Design and Traffic Control.* Englewood Cliffs, New Jersey: Prentice-Hall Inc., Table 4-1, p. 82.

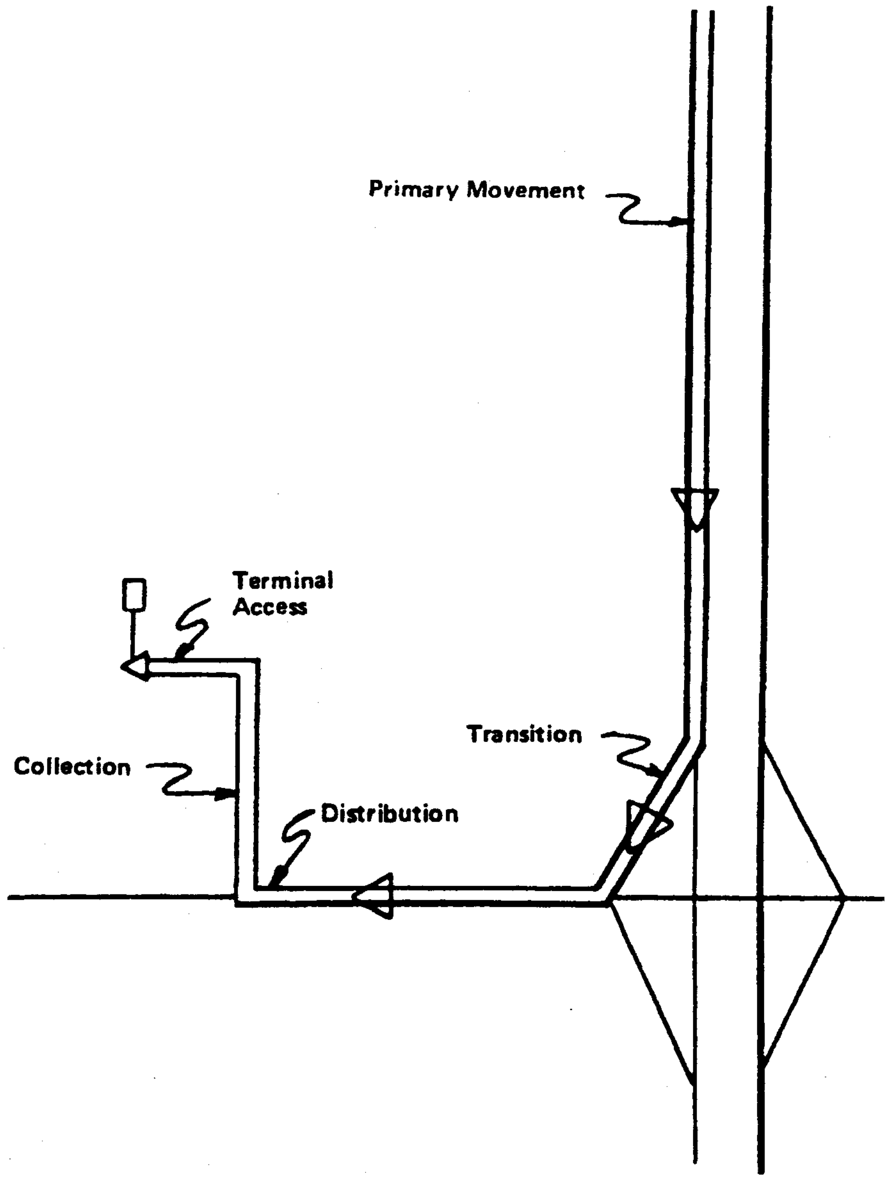

FIGURE 5.3.1B AASHTO'S DEPICTION OF THE SIX RECOGNIZABLE TRIPS STAGES. (HIERARCHY OF MOVEMENT)[88]

Some of the classification parameters found in this table in Homburger have been removed due to space restrictions in this report. The removed classifications include: typical percent of surface street system mileage, spacing (miles), typical percent of surface street system vehicle-miles carried, minimum roadway intersection spacing and parking.

88 American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets*. Washington, D. C.: AASHTO, p. 3.

In addition to the one-to-one correspondence with the stages of a trip, the levels of the movement hierarchy also correspond to the different kinds of roadways that are described within the functional classification.

The hierarchy of the functional systems consists of principal arterials (for main movement), the minor arterials (distributors), collectors, and local roads and streets.... (Emphasis added.)[89]

A component's purpose in systems organized by hierarchy is based on its position in the hierarchy. And, because the levels of the movement hierarchy correspond to the functional classification, each hierarchical level corresponds to a scalar accounting for amount of movement (speed) provided, amount of traffic accommodated (volume), and amount of distance covered. AASHTO comments directly about the relationship between the movement hierarchy, component position in the hierarchy and volume: traffic.

Because the movement hierarchy is based on the total amount of traffic volume, freeway travel is generally highest in the movement hierarchy, followed by distributor arterial travel, which is in turn higher in the movement hierarchy than travel on collectors and local access routes.[90]

A "rule of collection" describes the rules for component interaction in the movement hierarchy. The "rule of collection" reflects the linear up-and-down nature of interaction inherent in all hierarchical constructs. The volume and spacing of traffic -- that is, some level of traffic flow -- on the higher component comprise the rules that determine when and which components of the hierarchy interact.

...each element of the functional hierarchy can serve as a collecting facility for the next higher element, but an element must be present only where the intermediate collection is necessary to satisfy the spacing and traffic volume requirements of the next higher facility. By defining the spacing and volume requirements for a system element, it is possible to determine in which cases it is necessary to use the full system and in which cases intermediate elements may be bypassed.[91]

Notice how exceptions are forthrightly stated within the declaration of the rules for interaction of hierarchy components. Ideally, a system construct incorporates all conditions of component interaction in the system. That is, the system construct is descriptive (and prescriptive) of the system and all of its interactions. Using a less than ideal construct, exceptions to the rules are true exceptions or anomalies and do not occur on a regular basis. Here, in the basic statement of rules for interaction in the movement hierarchy, we see *exceptions stated along with the ground rules.* As stated earlier, if enough special rules for interaction are created to allow components to interact with other components that are found further up or down the hierarchy, the systemic nature of the hierarchy increasingly breaks down and the hierarchy as an ordering, and useful, system construct eventually becomes disordered and useless.

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89 Ibid. p. 11.

90 Ibid. p. 1-2.

91 American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets.* Washington, D. C.: AASHTO, p. 5.

Today's system definition uses the hierarchy as its mechanism for bringing a conceptual and physical order to roadway transportation systems in a way that causes the focus of the entire system to be that of efficiently moving large volumes of motor vehicles over large distances. This occurs because the functional classification describes roadways in terms of movement, volume, and distances served and then applies the scalar aspects of these characteristics (i.e., scales of more movement and less movement, more volume and less volume, and more distance and less distance) to the levels of the hierarchy. Because of the scalar characteristics of the hierarchical construct -- where those components that are larger in scale (e.g., power, size and speed) are near the top of the hierarchy and possess more system importance -- efficiently moving large volumes of motor vehicles becomes the most important aspect of the ordering construct and thereby, the system itself. This, then affects the overriding philosophy, or view, of the entire system, including those levels that are at the bottom of the hierarchical tree. The efficient movement of motor vehicles becomes the overriding concern of the entire transportation system and the design of all of the components in it.

In addition to the problems created by describing the system's construct in terms of the system's functions, the problems of hierarchy as an ordering construct for roadway systems include its inability to be descriptive of many urban transportation conditions. If our roadway transportation system was implemented as described by hierarchy, the only type of roadway pattern that would be found in urban areas would be a dendritic, or branching, pattern (see Figure 5.3.1.C).

The dendritic pattern begins and ends in a dead-end, or cul-de-sac, local street that connects to a facility with a higher level of motor vehicular service (the collector), which in turn connects with a larger facility and so on. Hierarchical rules for component interaction with neighboring components up and down the hierarchy creates a system definition that is descriptive *only* of the branching dendritic pattern. Common interactions that occur between different types of streets in the ubiquitous grid and in radial-type patterns of streets are not described using the hierarchical construct.

AASHTO recognizes the hierarchy's inability to adequately describe all of the kinds of transportation interactions that are found in cities by admitting that the complete hierarchy and its rules for interaction apply "especially" to low-density, suburban development:

The complete hierarchy of circulation facilities relates especially to conditions of low-density suburban development where traffic flows are cumulative on successive elements of the system.[92]

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92 American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets.* Washington, D. C.: AASHTO, p.2.

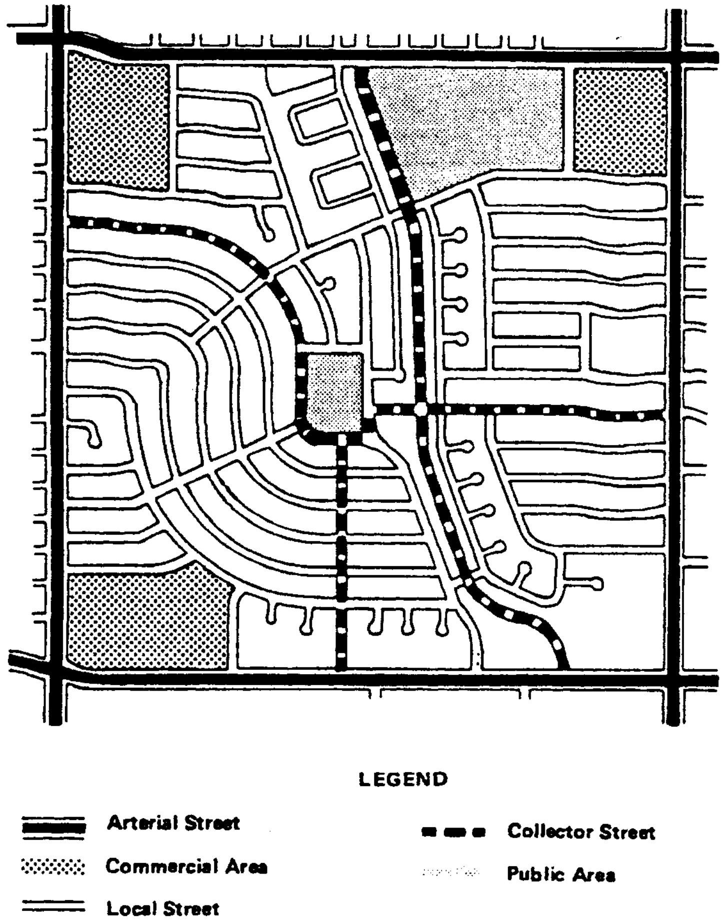

FIGURE 5.3.1.C THE DENDRITIC, OR BRANCHING, PATTERN IS THE ONLY TYPE OF ROADWAY PATTERN THAT THE HIERARCHICAL DEFINITION OF ROADWAY TRANSPORTATION DESCRIBES. [93]

93 After American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets*. Washington, D. C.: AASHTO, p. 8.

The question can be asked, "How, then, does it apply to conditions of high-density development in central cities?" AASHTO also recognizes that the hierarchy's rule for interaction is too rigid when it states:

> *...each element of the functional hierarchy can serve as a collecting facility for the next higher element, but an element must be present only where the intermediate collection is necessary to satisfy the spacing and traffic volume requirements of the next higher facility.*[94]

In other words, even though the system definition states that roadways should only feed into roadways of the next higher order, one can skip the intermediate roadways if spacing and volume requirements indicate the intermediate facility is unnecessary.

Likewise, regarding the applicability of hierarchical rules for component interaction, the Institute of Transportation Engineers (ITE) says:

> *Each element of a functional hierarchy serves as a collecting/distributing facility for the next higher element of the system. Each functional class should intersect with facilities of the same and adjacent classifications. Thus, for example, theoretically arterials should intersect only with other arterials and collectors or their private-access equivalents.*[95] (Emphasis added.)

In this way, *theoretically*, the movement hierarchy's rules for interaction should produce a roadway system that provides succeeding and scalar, collecting and distributing facilities. In reality, however, the system is not like this.

The frequent component interactions that occur in common patterns of urban streets, such as the grid and radial patterns, are not described by the hierarchical construct. An example is the intersection of local streets and arterials, including major arterials. This is a common condition along almost all arterials in gridded and radial patterns of urban streets and yet, according to the up-and-down rules for component interaction in hierarchies, this interaction is technically (and theoretically) not allowed. As far as the rules for the ordering construct of hierarchy are concerned, this condition should be an exception, and yet it occurs with great frequency in many of our roadway networks. Because common roadway patterns and their transportation interactions are not described by the hierarchical construct, many conditions of the interaction of roadway types are left undescribed in the system definition. However, a system definition should be descriptive and inclusive of common conditions found in the system and these conditions should not be exceptions within the system's definition and the construct that are used to order and plan it.

SUMMARY OBSERVATION. The shortcomings of the roadway hierarchy are frequently and unflinchingly discussed in transportation literature, especially when identifying situations where it has to be ignored. The need for large numbers of exceptions raises the question of whether the hierarchical construct should continue to

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94 Ibid. p. 2.

95 Stover, Vergil G. and Frank J. Koepke for the Institute of Transportation Engineers (ITE). (1988) *Transportation and Land Development.* Englewood Cliffs, New Jersey: Prentice Hall, p. 239.

provide the ordering mechanism for, even, motor-vehicle roadway systems. A conceptual construct that works in theory, but so frequently fails in application that many exceptions must be made, is self-defeating. A better system construct is needed. If this is clear for uni-modal systems, what happens when other modes must be integrated into the roadway system?

SUMMARY OBSERVATION. When one proceeds to attempt to conceptually (and physically) integrate bicycle transportation (or any other mode) into the movement hierarchy, the construct becomes unfathomable and even more unusable. Is the bicycle system hierarchical too? If so, how is it placed within the structure of the motor vehicle's movement hierarchy? Is it a shadow-like, hierarchical system, residing next to the motor vehicle hierarchy with each of its branches residing next to the branches of the motor vehicle hierarchy? Since the bicycle and automobile roadways must physically intersect, how is the intersection of the two systems described with a hierarchical construct? When components of the two systems intersect on the land, how is dominance to be determined?

Alternatively, is the bicycle's hierarchy melded into the motor vehicle's hierarchy? If so, the bicycle's scale and speed certainly place all bicycle transportation facilities close to the bottom of the hierarchy. However, potential volumes of cyclists could place some bicycle roadways nearer the top of the hierarchy. So, within this conceptual construct, where would one place the bicycle arterial, at the bottom or the top? In the current construct, it would seem that the automobile would always have preference. The hierarchical approach to component relationships presents more impediments than positive direction in attempting to integrate a bicycle roadway transportation system with the motor vehicle roadway system.

RECOMMENDATION 5.3-1. *A different transportation system construct is needed to allow us to better envision, plan, and design an integrated bicycle transportation system within the context of other modes of roadway transportation.*

5.3.2. FUNCTIONAL CLASSIFICATION

AASHTO's notion of the functional classification of streets describes the functional relationships of system components in terms of their "character of service," which is solely described in terms of movement:

> *Functional classification thus groups streets and highways according to the character of service they are intended to provide. This classification recognizes that individual roads and streets do not serve travel independently. Rather, most travel involves movement through networks of roads and can be categorized relative to such networks in a logical and efficient manner. Thus, functional classification of roads and streets is also consistent with categorization of travel.*[96]

AASHTO further relates road classification to the travel distances served by the particular road class type and to the notions of moving and 'not moving' or, in the their vernacular, 'accessing property or land'. Within the context of lines of travel desire, the

96 American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets.* Washington, D. C.: AASHTO, p. 5-6.

longer the distance between origin and destination, the larger the facility and the greater the need for mobility.

> *...the concept of traffic categorization leads logically not only to a functional hierarchy of road classes but also to a similar hierarchy of relative travel distances served by these road classes. This hierarchy of travel distances can be related logically to functional specialization in meeting the property access and travel function. Local rural facilities emphasize the land access function. Arterials for main movement or distribution emphasize the high level of mobility for through movement. Collectors offer approximately balanced service for both functions.*[97]

ITE echoes these views regarding the relationship between movement, access, and function as follows:

> *A functional system of streets and highways must provide for a graduation of traffic flow from the movement function to the access function. The entire system can be schematically classified by relating the proportion of movement function to that of access function. At one extreme is the freeway or expressway that carries no local-access traffic; at the other extreme is the local cul-de-sac street that carries no through traffic. The access function is characterized by the degree of use of the street for access purposes and the decreasing degree of access restriction exercised. Access control ranges from complete control in the case of the freeway to no control in the case of the cul-de-sac.*
>
> *It is important to note that the classification according to movement and access is a continuum from unrestricted access (no through traffic) to complete access control (no local traffic). While the higher classes of streets, as a group, carry larger traffic volumes than the lower classes, actual (counted) traffic volumes are not an element in functional classification.*[98] *Once the existing and future street system has been properly classified as to function, there should be no need or justification to change it unless there is a significant change in the urban comprehensive plan.*
>
> [Figure 5.3.2B][99] *schematically shows the relationship between access and movement. As indicated, three general classes of facilities (arterial, collector, and local) are recognized. Each in turn is subdivided into various facility types and typical cross-sectional designs to meet the specific needs of a particular political jurisdiction or development. In large urban areas, a number of facility types and typical designs will be required; in a small municipality*

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97 Ibic. p. 9.

98 Note how this contradicts AASHTO's statement above. Functional classification is clearly used to implement the hierarchy and its levels of service, which are described in part, by traffic volumes.

99 Though the exact figure and table in this report are not taken from Stover and Koepke, they are the same as those found in their document. (This is common in transportation literature where many sources use the same diagrams and tables.)

only three to five typical cross sections may be required. The general types of facilities and their characteristics are summarized in [Table 5.3.1A].[100]

The foregoing embody the notion that movement and access are mutually exclusive activities along a continuum of movement and access. When considered from the perspective of a person or a vehicle, movement and access are mutually exclusive because neither can be in a state of movement along the roadway and in a state of accessing property adjacent the roadway at the same time. In the former one is maintaining or attempting to maintain speed and course. In the latter, one is slowing to turn and changing course. However, the mutually exclusive relationship of mobility and access applies only to individuals or individual vehicles. Transportation systems and their components -- that is, streets -- most often simultaneously supply *both* mobility and access. That is, one person may be using the street for movement between two places and another may simultaneously be using it for accessing property.

Diagrams that show mobility on one "side of the fence" and access on the other (figure 5.3.2A) or movement along one axis and access along another (figure 5.3.2B), are misleading. Figure 5.3.2A depicts a mutually exclusive relationship of access and mobility, which, as discussed earlier, is the case for individual travelers and individual vehicles, but is not descriptive of a street that supplies both at the same time, and, often, in varying ratios of access to mobility depending on time of day, time of year, and special events. Figure 5.3.2B is more accurate in its depiction of the duality of streets as far as access and mobility are concerned, but it does not show the qualitative aspects of access.

The use of the term "functional classification of roadways" suggests that the many characteristics of streets and highways are considered in the classification of street types, including qualitative characteristics. For example, with a system of functional classification, one would expect to see the ability to differentiate shopping areas lining arterial streets in older, central cities from shopping areas that are found in suburban strip developments. Though both areas are similar in some ways (shops are linearly arranged along the roadway), they can be distinguished in other important ways.

Arrival at shops along the city's arterial is often accomplished on foot, along city sidewalks that provide the connecting link between transit stops or parking facilities at a distance from the arterial shopping street. Arrival at shops along the strip development's arterial is most often by foot from automobiles parked directly in front of the shops. If there is parking along the arterial in the city, it is usually parallel parking and provides limited amounts of parking space. Parking in front of strip developments is usually head-in parking and the parking area usually provides additional circulation space in the parking lot for purposes of gaining access to the parking spaces and, sometimes, an additional row of parking facing the street. The parking lot in front of the strip development usually provides more than adequate parking for shop customers due to today's zoning requirements. Thus, one street is lined with shops that hug the street. These shops are fronted with sidewalks used by a variety of pedestrians; that is, people that are not necessarily on the street for the purpose of patronizing the shops. At most, a single row of parallel-parked cars creates the major edge between sidewalk and street. The strip development is lined with shops

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100 Stover, Vergil G. and Frank J. Koepke for the Institute of Transportation Engineers (ITE). (1988) *Transportation and Land Development.* Englewood Cliffs, New Jersey: Prentice Hall, p. 80-81.

that are at a greater distance from the street, fronted by a thicker row of head-in parked cars and additional circulation space in the parking lot.

These are two different kinds of arterial streets. Their character is different. The spaces created by the street, the buildings lining the street and the parking facilities are different. *Functionally*, they are different in the way that people access the shops and in the way that the structure of the street permits people to use the street and park their cars. In addition, motorists usually use these two types of streets in different ways because of the nature of the parking facilities and the kinds of access that vehicles *and pedestrians* use along the street.

A functional classification of urban streets might also consider the diverse types of streets depending on the context of the street. However, today's functional classification of streets provides a limited description, and thereby a limited vocabulary for planners, designers, and engineers by only describing varying degrees of the movement function (i.e., more or less movement, access, volumes of vehicles, and distances served by the facility). Other characteristics of streets reflect the context of the street; that is, the role of the street in relation the immediate area around the street, and in relation to the neighborhood and the city, as a whole. Consideration of context would include an accounting of land use, the surrounding urban landscape (plants, landform, and structure) and density.

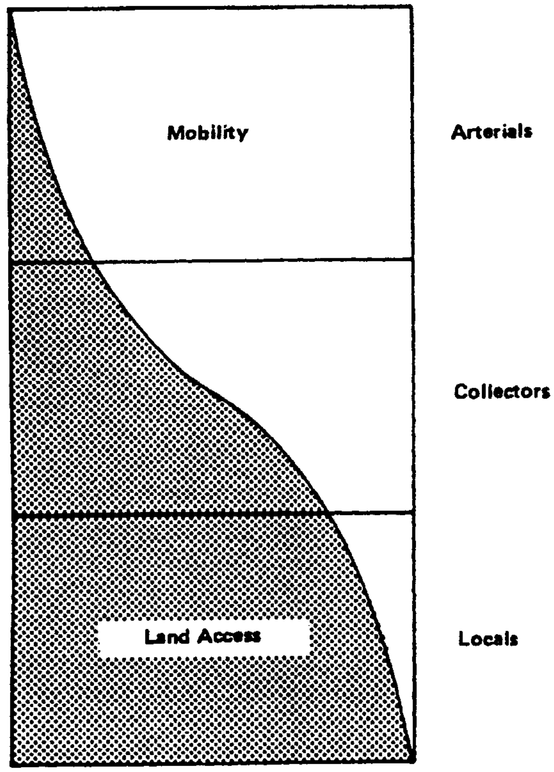

FIGURE 5.3.2A AASHTO LABELS THIS DIAGRAM "RELATIONSHIP OF FUNCTIONALLY CLASSIFIED SYSTEMS IN SERVICE TRAFFIC MOBILITY AND LAND ACCESS."[101]

101 After American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets.* Washington, D. C.: AASHTO, p. 8.

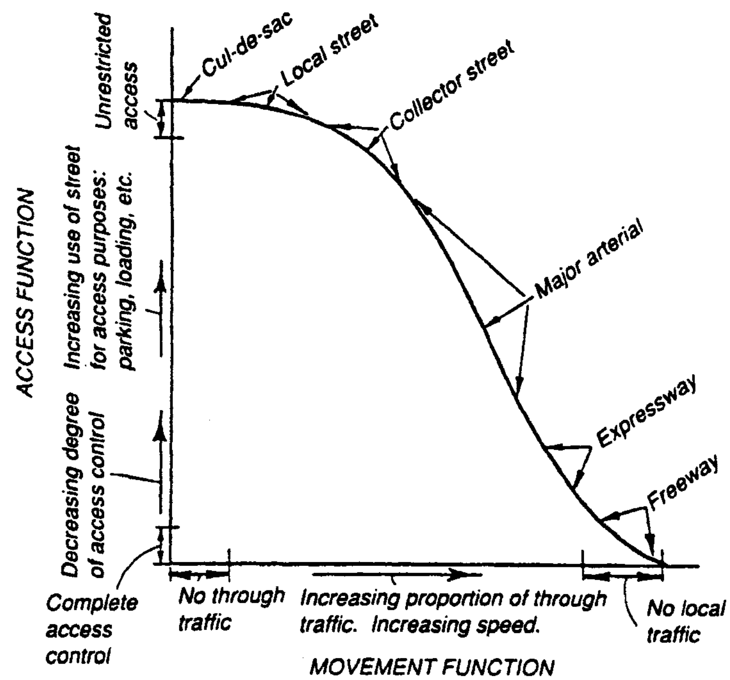

FIGURE 5.3.2B THE ITE'S DEPICTION OF THE "SCHEMATIC RELATIONSHIP BETWEEN ACCESS AND MOVEMENT ON URBAN STREETS"[102]

SUMMARY OBSERVATION. The notion of *functionally* classifying roadways only in terms of moving or not moving ignores the role of streets in urban areas. When transportation planners and engineers consider degrees of movement as the only functions for streets, the street is relegated to being a conduit only, serving no other purpose to people other than moving motor vehicles though the space of the street. A descriptive, useful and functional classification of streets considers the use of the street by *people*, as well as a variety of vehicles, both motorized and non-motorized.

RECOMMENDATION 5.3-2. *In order for a functional classification to provide a picture of all of the characteristics of streets, the following must be included in the classification:*

- *A movement function for all motorized and non-motorized modes of transport;*
- *An access function that includes not only the access of vehicles to property, but the access of people to places where they want or need to be, which then, necessarily, includes consideration of qualitative and contextual aspects of access;*
- *The role of the street, according to the contexts of its immediate surroundings, its neighborhood and the city, including considerations of:*
    - *Land use*

102 After Homburger, Wolfgang S. et al. for the Institute of Transportation Engineers, ed. (1989) *Residential Street Design and Traffic Control.* Englewood Cliffs, New Jersey: Prentice-Hall Inc., p. 20.

- *Landscape*
- *Density*

If this kind of functional classification were developed for urban streets, the system definition for urban roadway transportation systems would be more descriptive of conditions found in all urban areas, and of all the transportation functions of urban streets. The system definition would also be more prescriptive of change and intended use. Such a functional classification would bring the use of the street by people into the picture and non-automotive modes of transportation into consideration. Such a classification would be more useful to planners, designers, engineers, city officials, and decision makers as they make plans and decisions about the complex relationships found in the city and its streets.

RECOMMENDATION 5.3-3. *More research is needed to develop the access function to a more precise and descriptive degree than currently exists in today's system definition. Just as today's functional classification considers different kinds of movement within the contexts of trip stage, distances served, speeds allowed, and volumes accommodated, the expanded definition of access considers access in a contextual manner as well. When the definition of access considers context, the context of the street becomes more important.*

SUMMARY OBSERVATION. The simplicity of the functional classification of streets provides an instructive model for establishing the simple and clear system construct for bicycle transportation system articulated in Recommendation 5.1-5. In its essentials the functional classification of streets describes three or four basic types of street functions with regard to automobile use, with their relationship to each other framed primarily in hierarchical terms and secondarily by specific functional criteria. A similarly simple construct could be developed for the bicycle system without the problems of a hierarchical frame by focusing on description of the role of system components. Such construct could be developed prior to any overall multi-modal conceptual reorganization of roadway transportation system because determination of the specific importance relationships would still be open to refinement.

RECOMMENDATION 5.3-3. *Develop a simple articulation of a bicycle roadway transportation system's major component categories as a system construct. These categories should be described primarily in terms of function and and not in terms of relationship dominance and connectivity, so as to keep decisions about relative importance and relationship issues grounded in function. This construct should not be more than three to five generic types of components, to allow them to be easily memorized and thought about as a whole system structure. Each general type would then also be open to further refinement and sub-classification with respect to context and urban design considerations to allow differentiation with in each type for specific applications.*

5.4. SYSTEM FUNCTIONS

Mobility and access are the only two functions identified for today's roadway transportation systems. Their functional definitions were clearly guided by the original mid-century system requirements for interstate highway transportation. The point-of-view that these requirements fostered is still prevalent today regarding the functions of mobility and access, and the solutions that are sought for conditions of congestion.

5.4.1. MOBILITY

The system requirements set forth for our current roadway transportation system stemmed from national goals of intercity connectivity for purposes of national economic stability and growth, and the national defense in times of military crisis. Analysis of the system reveals a network infrastructure of vast physical scale in terms of surface distances and numbers of personal motor vehicles that are served by the system. Congressional motives for mandating this vast system were of utmost national concern.

The vastness of scale and the critical degree of national priority necessarily pointed to a qualitative system objective of *efficiency* to ensure success in moving large numbers of vehicles over large distances as quickly as possible. Therefore, as the system definition for the motor vehicle's transportation system was refined, a basic objective of all transport systems -- that of providing a movement function for the system -- evolved into the notion of providing a system of *efficient* movement for motor vehicles. The objective of efficiently moving motor vehicles for providing access to all land and property further shifted the objective of the movement function to provide efficient movement for *all individual motor vehicles* on the roadway systems. These are significant and largely unacknowledged qualitative and quantitative leaps in defining system movement function.

As requirements for the system were considered and refined, the system definition evolved from:

- The basic objective of all transportation systems -- of providing an efficient system that provided a movement function,

  to

- A system that provided efficient movement for motor vehicles

  to

- A system that provided efficient movement for every individual motor vehicle in every road and at any time.

As the system and its definition evolved, efficient motor vehicular movement became not just a high priority for roadway transportation, but *the major purpose* of roadway transportation itself. Efficient movement for the motor vehicle permeates the system definition and the system's design parameters, as well as present-day transportation planning approaches, transportation research approaches, and attitudes toward transportation held by the general public and by decision makers.

Valid questions to ask today are, "Is efficiency a *sufficient* criterion for urban transportation systems in today's world?" and "What is *efficient* vehicular movement?" In the past, the answer to the first question has been, "Yes" and the answer to the last question has equated efficient motor vehicular movement with motor vehicular speed. This is readily apparent in transportation engineering guidelines. Regarding the relationship of speed to mobility, AASHTO says:

Speed is one of the most important factors to the traveler in selecting alternate routes or transportation modes. The value of a transportation facility in *carrying people and goods is judged by its convenience and economy, which are directly related to its speed.*[103]

Regarding AASHTO's authority, the Institute of Transportation Engineers (ITE) states the following in their periodically published reference, *Traffic Engineering Handbook*:

The American Association of State Highway and Transportation Officials (AASHTO) has emerged as the source of most of the design values and criteria used in geometric highway design. Although most states and other agencies have developed their own design standards, the design approach and design values shown in the AASHTO policies are accepted by consensus and form the basis for individual state design practices. The Federal Highway Administration (FHWA) has adopted the AASHTO policies for design construction and major reconstruction of Federal-Aid highways.[104]

The importance of speed to today's roadway transportation system is evident in the following description of design speed from ITE:

The design speed of a highway is one of the basic controls that defines its physical and operational characteristics. Design speed is the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of the highway govern. This definition strongly implies that a design speed should be selected based on driver expectations, the type of highway, and terrain and topography.

The selection of a design speed is among the most critical, early decisions in the highway planning and design process. The design of the basic geometric features -- including horizontal and vertical alignment, sight distance and in many cases cross section -- is sensitive to design speed. While a higher design speed will generally result in slightly higher construction costs and/or more difficulties in design, there are serious implications of selecting too low a design speed. Drivers may overdrive critical locations, thus creating safety problems, correction of a design problem related to too low a design speed is usually costly and often impossible to accomplish.

The recommended range for design speeds for the basic functional highway types is summarized in [Table 5.4.1A]. *These design speeds should be used regardless of political or legal restraints such as the 55 mph national speed limit or municipal speed restrictions.*[105]

The parameters in Table 5.4.1A have been set to guide the design and construction of roadways that are used to traverse great distances with few obstacles that would impede mobility between origin and destination. The design of highways (i.e., and streets, in the AASHTO policy) is put forth with no attention paid to urban

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103 American Association of State Highway and Transportation Officials (AASHTO)(1984) *A Policy on Geometric Design of Highways and Streets.* Washington, D. C.: AASHTO, p. 59.

104 Neuman (P.E.), Timothy R. (1992) "Roadway Geometric Design." *Traffic Engineering Handbook.* Institute of Traffic Engineers (ITE). Englewood Cliffs, New Jersey: Prentice-Hall, p. 155.

105 Ibid. p. 155-156.

densities, land use, or the contexts of site and place, with the broad exceptions of street type (defined by today's limited notion of functional classification), and terrain and topography (Table 5.4.1A).

SUMMARY OBSERVATION. In AASHTO policy regarding the design of highways and streets little or no attention has been paid to specific common urban conditions such as the occupation and use of streets by people, the need for people to obtain access places along multi-purpose streets (in convenient, comfortable and even, pleasant ways) and the role of the street within the context of site and community. These additional considerations all tend to mitigate limit for the design of streets and interfere with the goal of uninterrupted, efficient motor vehicular movement.

Terrain	**Rural**	**Urban**
	Freeways	
Flat	70-80	70
Rolling	60-70	60-70
Mountainous	50-60	50-60
	Arterial Highways	
Flat	60-70	30-60
Rolling	40-60	30-50
Mountainous	30-50	30-50
	Collector and Local Roads	
Flat	30-50	30-40
Rolling	20-40	20-40
Mountainous	20-30	20-30

TABLE 5.4.1A "RECOMMENDED RANGE OF DESIGN SPEEDS BY LOCATION AND FUNCTIONAL HIGHWAY CLASSIFICATION (SPEEDS IN MPH)"[106]

106 Ibid.

In addition, the recommended ranges for design speeds are too wide in order to take specific urban conditions into account. Worse yet, the engineer is cautioned to design for higher speeds because "there are serious implications of selecting too low a design speed. ...Correction of a design problem related to too low a design speed is usually costly and often impossible to accomplish."[107] The engineer is professionally advised to use standards other than the legal speed limit, as well as local transportation policies: "...these design speeds should be used regardless of political or legal restraints such as the 55 mph national speed limit or municipal speed restrictions."[108]

One reason that could be given for designing for higher speeds is to provide a safer facility for those motorists that do speed -- personal safety being one of the primary objectives of federal, state, and local transportation departments. This is a valid reason for designing to higher design speeds on larger facilities, such as highways, non-urban roadways, and some urban arterials and collectors where the singular purpose of the roadway is to provide movement.

SUMMARY OBSERVATION. The philosophy of designing for higher than posted speeds is problematic in most urban settings where urban density increases and different types of land use require slower speeds, or at least, motorists who proceed with more caution along roadways that are not devoted entirely to movement. Under such conditions, the philosophy should be to plan and design the system and, most importantly, the roadway so that it is physically impossible to speed. An example of techniques used to accomplish this is the traffic calming techniques used in Europe. Traffic calming techniques physically control vehicle speed within the space of the street. Traffic calming makes it *physically impossible* to accelerate the vehicle to a dangerous speed. Though traffic calming techniques are usually thought to be appropriate for residential areas only, they are also used in commercial, retail and industrial areas in Europe.

RECOMMENDATION 5.4-1. *Roadway design practices and policy in the U.S., regarding speed and the design of roadways, should be changed from designing for higher speeds and unimpeded movement on all roads to a set of design practices and policy that:*

- *More carefully and explicitly acknowledge urban transportation conditions and the urban context,*

  and

- *Provide safe roadways for other roadway users as well as motorists by including design practices and policies that make it physically impossible to speed on roadways where land use, the use of the street, and density require slower speeds.*

These changes, in addition to helping make urban streets safer to use, would also tend to create an environment that is more compatible with bicycle use with respect to vehicle speeds, by bringing the actual operation speeds of motor vehicle closer to those of the bicycle.

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107 Stover,Vergil G. and Frank J. Koepke for the Institute of Transportation Engineers (ITE). (1988) *Transportation and Land Development.* Englewood Cliffs, New Jersey: Prentice Hall, 1988. p 2.

108 Ibid.

Roadway planning guidelines and design parameters[109] are the means by which a transportation system's definition is physically realized. They, therefore, embody the system's definition. Today's system definition and its emphasis on efficient motor vehicular movement, or motor vehicular speed, is revealed in decisions that are made regarding urban transportation problems and how the solutions are implemented.

Today's urban transportation problems often revolve around relieving problems of increased trip travel times and decreased roadway capacity; that is, of relieving problems of congestion. When the purpose of a transportation system is to get individual motor vehicles from origin to destination as efficiently as possible, congestion represents a failure of that system in fulfilling its purpose. This philosophy of efficient motor vehicular movement, looks to trip travel time only as it relates to suitably high user (motor vehicle) speeds. When the actual speed of vehicles drops some degree below the desired speed, due to the density of vehicles using the transport system, the system becomes inadequate in meeting system requirements for mobility. The system becomes congested and, within the context of this kind of system, inefficient and unusable. The only solution with the philosophy of efficient motor vehicular movement is to provide more, bigger, and better designed facilities for movement.

Solutions to major roadway transportation problems have historically involved and continue to involve:

- Providing either more roadway or more lanes for motor vehicles,
- Widening traffic lanes, and
- Providing straighter and smoother roadway alignment.

All of these measures are seen to provide more efficient motor vehicular movement or speed, which is often expressed as improved trip travel times or increased roadway capacities and thereby, levels of roadway service for the motor vehicle.

Until recently, most transportation research in the United States has focused on relieving problems of congestion by providing more and better roadway space for the motor vehicle. Though there is ample evidence and thought to contraindicate the continued expansion of our roadways, attempts to find other solutions and provide other means of solving problems of congestion are virtually non-existent in practice.

Experience for at least the last 30 years has shown that whenever roadway size and capacity are increased, that problems of mobility and congestion are not solved. In other words, the maxim, "Build it and they will come" accurately describes the historical experience for automobile transportation systems. The Institute of Transportation Engineers (ITE) calls this the "transportation-land use cycle," and describes it as follows:

> *The construction of a new arterial street, or major reconstruction of an existing thorough-fare, modifies the accessibility of an area; this, in turn, leads to development and increased traffic demands. The strip development along major arterials, with closely spaced or poorly designed access, creates numerous and overlapping conflict points. This results in reduced capacity, traffic delays, high levels of motorist discomfort, accidents, and reduced levels of traffic service. In order to better accommodate the increased traffic demand,*

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109 The transportation community, as represented by AASHTO, call these "policy."

further roadway improvements are required and a cycle of events occurs which requires continuing capital investment for arterial improvements or relocation ....

Reconstruction to increase the level of service of an existing arterial is generally very costly and, without careful access management, will provide only temporary relief. The improved service will stimulate increased business activity, which in turn will generate more traffic, resulting in an ultimate decrease in traffic service.... In the more severe cases, the arterial must be relocated because of functional obsolescence, and the process starts all over again in a new location.[110]

The ITE has characterized the transportation-land use cycle in terms of its effects on fairly localized land use patterns. The following characterizes this approach to transportation planning in terms of impacts on regional land use, quality of life, and the prudent investment of monetary resources:

Initial investments in improved highway facilities result in greater ease of travel and hence altered travel patterns -- an increase in average trip length and in the number of trips being made. Over time, ... this increased demand stimulated by the initial investment in increased transport supply fuels the need for even more facilities, and the feed back process repeats itself.

This commonly observed phenomenon has been call the black-hole theory because some people now claim that money invested in highways has no ultimate impact on reducing congestion. Investing in highways, then is like throwing money into a black hole. In fact, the only benefits that may accrue from this interactive loop (besides those which pertain to more jobs for engineers, road builders, and auto-industry employees) are the good aspects of living in lower-density environments. Believers in the black-hole theory think that at some point the attendant disbenefits of continued investment outweigh such potential benefits. The willingness to provide ever-expanded highway capacity is now portrayed as the villain causing smog, density levels too low to provide cost-effective transport options other than the private automobile, a pattern of development that makes the provision of other public services such as schools, garbage collection, and so on excessively expensive, and an overall reduction in our individually experienced sense of place.[111]

Whatever the emphasis and scale of the problems of automobility and congestion, today's planning literature recognizes that a solution of increased capacity through increased vehicular infrastructure does nothing to solve problems of mobility for more than a temporary amount of time. Perhaps the U.S. Congress was considering the state of personal mobility in the U.S. and the transportation-land use cycle when it stated in the Intermodal Surface Transportation Efficiency Act (ISTEA):

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110 Stover, Vergil G. and Frank J. Koepke for the Institute of Transportation Engineers (ITE). (1988) *Transportation and Land Development.* Englewood Cliffs, New Jersey: Prentice Hall, p. 2.

111 Plane, David A. (1986) "Urban Transportation: Policy Alternatives." *The Geography of Urban Transportation.* Ed. Susan Hanson. New York, New York: The Guilford Press, pp 389-390.

The National Intermodal Transportation System must be operated and maintained with insistent attention to the concepts of innovation, competition, energy efficiency, productivity, growth and accountability. Practices that resulted in the lengthy and overly costly construction of the Interstate and Defense Highway System must be confronted and ceased.[112]

A common argument for increasing roadway capacity to reduce congestion is that congestion, or the lack of automobility, increases fuel consumption, air pollution and wastes time due to increased trip travel times. Since vehicular congestion is the seeming cause of these problems, the solution can be nothing other than to improve vehicular mobility by increasing speeds, the number of large-scale roads (freeways and arterials) and the width of roadways. The numerous "experiments" across the country as evidenced by the numbers of massive urban freeway expansion projects that have proved the black hole theory, show that this point-of-view has obviously been held by engineers and policy makers in the United States as valid solutions to modern urban ailments attributed to automobile congestion.

Fuel efficiency and pollution arguments are commonly used justifications for many of the roadway expansion projects in the U.S. today. Such reasoning, however, is contraindicated in the findings of carefully conducted studies in other countries.

The fuel efficiency of individual vehicles is the best when the vehicle is allowed to travel at uninterrupted speeds of about 35-40 m.p.h. Likewise, the airborne pollution generated by individual vehicles is at its lowest under these conditions. Until recently, a faulty assumption was made in most congestion studies: that fuel efficiency would increase and pollution would be lowered if we could just provide more mobility for all cars -- that is, 'if we could just keep those cars moving!'

Peter Newman and Jeffrey Kenworthy, two Australian researchers, have conducted massive international studies on automobile use in cities and went a step further in their thinking by asking these questions:[113]

- Does free-flowing traffic cause increased vehicle use through decreases in other travel modes and changes in land use?
- If such increases occur, do they outweigh the gains in fuel efficiency, emissions and time savings for individual vehicles?
- Can traffic research be integrated into urban planning research to resolve this apparent trade-off between gains through vehicle efficiency versus losses due to increased vehicle use?

Their studies on congestion have combined "detailed traffic data involving fuel consumption of individual vehicles with an understanding of the land use patterns and transportation processes that influence resulting per capita gasoline use."[114]

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112 U.S. Congress. (1991.) "Intermodal Surface Transportation Efficiency Act (ISTEA)." *United States Statutes at Large, Vol. 105, Part 3.* Washington, D.C.: U.S. Government Printing Office, p. 1914.

113 Newman, P.W.G., J.R. Kenworthy, and T.J. Lyons. "Does Free-Flowing Traffic Save Energy and Lower Emissions in Cities?" *Search*_19.5/6 (September/November 1988): 267-272.

114 Ibid.

Their six page journal article, entitled "Does Free-Flowing Traffic Save Energy and Lower Emissions in Cities?"[115] succinctly describes their results, all of which answer "yes" to their questions for research stated above. These results are paraphrased and quoted here, because they stand in such marked contrast to previously held assumptions regarding fuel efficiency and pollution:

- In a study in Perth, they found that "vehicles in central areas have 19% lower fuel efficiency than the Perth average due to congestion, but the central area residents use 22% less actual fuel, and conversely, congestion-free outer suburban driving is 12% more fuel efficient than average but residents use 29% more actual fuel.[116]

  To understand these data more clearly, they looked at land-use modal split data for each area. They found that as the distance from the center city increases: density decreases by 75%, trip lengths almost double, public transport service drastically declines (from 12 to 0.4 km of service per hectare of urban land) and trips by car increase from 61-78%. In Perth, "this analysis also showed that gasoline usage patterns by suburb do not follow income patterns, i.e., density and income are not correlated nor are travel patterns and income. In other words the land-use is fundamental in determining how much people use a car.[117]

- A household survey collected by the Australian government confirmed these findings. "...for trips by people living at increasing distances from the Central Business District: the average speed of trips increases from 40 to 50 km/h, the vehicle efficiency improves by about 10% and the total fuel consumed per capita increases by about 80%."[118]

- As with fuel, a pattern emerges of a significant trade-off between attempting to control emissions through improving traffic flows and the overall effect this has on the actual amount of emissions produced. In other words higher average traffic speed appears to spread the city, creating lower density land-use, a greater need for cars, longer travel distances and reduced use of other less polluting or pollution-free modes. The benefits gained in terms of less polluting traffic streams appear to be overwhelmed by the sheer amount of extra travel and the resulting bulk of emissions.[119]

  CO (carbon monoxide) and HC (hydrocarbons) emissions in the Perth central areas were 17%/km and 27%/km more, respectively, than the average for Perth, but residents actually generated 19% and 21% less total CO and HC, respectively, due to less automobile use. The figures for outer areas of Perth were the opposite, generating 9%/km and

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115 Ibid.

116 Ibid.

117 Ibid.

118 Ibid.

119 Ibid.

16%/km lower emissions than average and 24% and 27% more total emissions due to the longer distances traveled.[120]

- An attitudinal survey of bus and train passengers revealed that 17% of bus passengers and 11% of train passengers would use automobiles if congestion was eased. "It was calculated that if only half of these passengers actually did transfer to cars, the extra gasoline use would be enough to cancel out the savings from a computer-coordinated set of traffic signals along the corridor designed to smooth out traffic flows."[121]
- An examination of bus patronage revealed that as congestion eased, bus patronage was down. When congestion increased, bus patronage was up.

The assumption that the solution to the problem of congestion is to "undo" the congestion by increasing automobility is contraindicated by the results of the studies by Newman and Kenworthy [122]who summarize the implications of their research for transportation planning and policy as follows:

- *The cost-benefit analyses of major road projects usually incorporate time savings, fuel savings and occasionally emissions in their justification. The research outlined here suggests that in urban situations the simple assumptions used in these models are probably wrong....*

  As millions of dollars of investments are directed annually into urban roads it would appear to be essential for their justification to be valid.

- *Traffic engineers must daily confront the problem of how to assess the impacts of traffic congestion and what solutions to offer. Their responses are conditioned by a general approach that traffic congestion is always a negative thing and must be eliminated as far as possible; the way they deal with congestion is necessarily determined by the way they think about it. The data in this study and especially the broad perspective gained from the international comparisons offer an alternative way of viewing congestion: that rather than being something which must always be eradicated, congestion can actually be creatively exploited as a tool in helping a city progress towards lower car dependency and lower energy use through a better balance between cars, public transport, walking and bicycling. This concept has sometimes been referred to as 'planned congestion.'*

  'Developments along these lines occurred in Europe in the 1960s .... and the same awareness has become much more common in Canadian cities in the past decade.

  Planned congestion could be seen as an opportunity to help contain the outer growth of cities, develop more efficient, concentrated nodes of

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120 Ibid.

121 Ibid.

122 Newman, P.W.G., J.R. Kenworthy, and T.J. Lyons. (1988) "Does Free-Flowing Traffic Save Energy and Lower Emissions in Cities?" *Search* 19.5/6 (September/November).

urban activity, shorten travel distances and in particular it could give priority to public transport. This approach has many benefits including the reduction of transport energy use in our cities....

- *This approach would not interfere with efforts to optimise traffic systems for fuel efficiency by reducing stops and idle periods without raising cruise speeds and average speeds. However, it would be a fundamentally different approach to the assessment of major urban traffic problems taking into account the positive benefits of congestion as outlined above. Thus the role of the traffic engineer can change from one of being primarily concerned with alleviating congestion to one of creatively managing congestion. This would place the role of traffic engineers in a much broader context where all actions are closely linking to the broader transportation and land-use planning goals of the city.*[123]

SUMMARY OBSERVATION. Congestion research like that of Newman and Kenworthy, and the knowledge we have gained through our experiences with the 'black hole theory' of highway investment, or the transportation-land used cycle, support the position that congestion is increased and exacerbated when more movement facilities are provided for the motor vehicle.

RECOMMENDATION 5.4-3 *This state of affairs raises important questions that should be addressed by policy and decision makers and by the roadway transportation systems that we define for the future (including bicycle systems).*

Is the system being efficient when it habitually fails to move individual motor vehicles with efficiency, or in many instances, fails to move them at all for long periods of time?

If the only objective of a roadway transportation system is to provide efficient movement for the motor vehicle and the system, as defined and implemented, cannot do that, has the system been properly conceived and designed for the conditions under which it must operate? Is there something wrong with the goals and objectives of the system that make them unsuitable for urban conditions of density and land use?

Is the system an efficient system in light of other national and local priorities? From the perspective of the overall goals and resource use of nation and community, is it efficient as a nation to spend massive amounts of monetary resources, and raw and recycled resources, on a gargantuan system of transportation that ferries motor vehicles around a sprawled community -- one that continually and frequently demands that more resources be used to expand it?

Does the system itself operate efficiently? The "build it and they will come" maxim certainly holds true for all freeway expansion projects. The experience with many has shown that congestion sets in almost immediately after construction is complete. Is then, such a transportation system efficient when it cannot correct, or at least ameliorate, its own problems?

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123 Ibid. All of the above bulleted quotes pp. 267-272.

Is movement efficiency for motor vehicles a sufficient transportation criterion when masses of vehicles and their operators, in fact, waste time using individual motorized transport?

- *Is efficiency a* <u>*sufficient*</u> *transportation criterion in today's world? Does the focus on movement efficiency for the motor vehicle justify world-wide, community, economic, and environmental impacts that occur when trip travel times are satisfied according to the travel time requirements of masses of motor vehicles.*
- <u>*Is the system definition a usable and useful definition for meeting urban transportation requirements in the most efficient way?*</u>

  And, therefore, <u>*is it a sufficient system definition for urban roadway systems?*</u> *Is an emphasis on the movement of motor vehicles within the system's definition appropriate? Is a construct that focuses attention to larger scales of motor vehicular movement useful for solving our current transportation problems and needs?*

<u>SUMMARY OBSERVATION.</u> The issues raised by the problems of congestion, and the results of solutions we have attempted in the past to relieve congestion, are instructive when reflected upon with an interest in identifying methods for expanding the use of bicycle transportation for the short urban trips that dominate urban person-trip patterns. The 'build it and they will come' phenomenon that seems to have arisen from application of the 'black hole' theory of highway and street investment suggests interesting tactical approaches to the expanding use of bicycle transportation in urban areas.

The notion of planned congestion (for the automobile) in urban areas described by Newman and Kenworthy [124]can be used as a planning tactic to relegate automobility to a position of less importance (and use) and raises other modes to positions of higher importance (and use). And, the tactic of planned congestion, along with a revision of the system definition for urban transportation as the framework that we use to envision and plan urban roadway networks, should increase the overall efficiency of urban transportation systems, *as systems.*

<u>RECOMMENDATION 5.4-3.</u> *Experiment with selective abandonment of the 'black hole' theory of highway and street investment as a remedy for motor vehicle congestion in carefully identified locations within a city, while at the same time establishing a bicycle transportation roadway network. As a result, congestion levels should should remain level or increase. This would increase pressure on individuals to seek viable transportation alternatives, such as the bicycle network. Any resulting gains in bicycle popularity would also tend to increase the political, economic and social pressure for investment in improving and extending the bicycle roadway infrastructure.*

In a perverse sort of way, the use of such planned congestion may also lead to a tolerance for longer bicycle trips among the travelling public. This could happen by congestion resulting in generally reduced expectations about what trip travel times could be achieved by motor vehicle (the current 'gold standard' of evaluating trip travel time) by recalibrating the individual guages of acceptability within the affected population. This would then tend to increase the share of potential trips that could be addressed by

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124 Ibid., pp. 271-272.

bicycles, or at lease make the choice of bicycling more appealing for those trips already within reasonable trip travel time by cycling.

RECOMMENDATION 5.4-4. *Build a bicycle roadway transportation system and the users will come. The history of our experience with the failure of the freeway expansion alternative to congestion relief offers very strong encouragement to apply a 'build it and they will come' approach to investment in bicycle transportation infrastructure. This runs headlong against the concerns of those who fear the facilities, once built, would have few users. There is no well tested means predicting bicycle trip generation from land use as there is for the automobile. This means that just as there is no accepted way to predict bicycle trip generation to support bicycle infrastructure proposals, neither is there a way to refute them. The approach recommended here seems a reasonable and is a historically proven approach to increasing the use of a transportation system -- a system that shares many of the personal transportation characteristics of bicycle transportation.*

5.4.2. ACCESS

In our present-day transportation system the term 'access' is defined largely from the viewpoint the roadway itself in terms of making required connections or using control of access as a means of managing traffic flow. Three facets of this viewpoint are articulated: 1) access points to land or access to property, 2) access to a terminal facility (e.g., usually, parking lots) and 3) access to the roadway itself.[125] The focus is on the relationship between public right of way as transportation system property to adjacent land parcels that are usually privately owned and thus regarded to be outside the concern of the transportation system. The relationship between abutting land uses and the right-of-way tends to be seen as considerations of input and output of vehicles across a property line, and whether those movements are acceptable to the roadway in terms of quantities and position.

Described in this way, the access function is incomplete as a functional concept within the context of a complete and descriptive system definition for urban roadway transportation systems. On one hand, access is defined as access to land. On another, it is defined as access to a terminal facility (with its own movement hierarchy) where vehicles are parked. On yet another level, it is defined in terms of access to and from the movement facility itself.

The most accurate description of access that these current definitions achieve is convenient, motorized access to a generic 'land parcel' or a 'real estate property.' In other words, the ability to get an automobile to a position where it can cross a property line safely. By implication, the curb cut or the parking lot is the destination. This seems to make sense if one is thinking about the transportation system as a means of moving automobiles from one location to another, and a trip as getting an automobile to a particular location. However, from the individual traveler's point of view the curb cut is not the destination (and neither is the parking lot). Today's approach focuses on a very limited aspect of access and ignores the context of the whole trip, focusing mainly on the portion of the trip made by motor vehicle, and not on the needs of individual using the motor vehicle to get somewhere.

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125 American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets.* Washington, D. C.: AASHTO, pp.105-110.

In today's system, the function of access is clearly secondary to the function of mobility. The definition of access has not been developed to the same degree as the function of mobility and, it is always defined in terms of movement (or lack of movement). There are two reasons why access is secondary to mobility. First, again, design of the automobile transportation system is concentrated on the mobility of individual vehicles as a system goal from the beginning. In a sense, access came to be seen as 'not moving,' a qualitatively negative characteristic, or as something that the motor vehicle does at the beginning or end of a trip. While this definition of access may be accurate as far as individual vehicles are concerned, urban transportation systems, as a whole, must often provide continual access along the length of urban roadways and in conjunction with and simultaneously with movement.

Another reason that access has not been defined to the same degree as mobility is that the sole user of the system -- the user for which the system and its functions were designed -- has always been the motor vehicle. Thus, access has always been defined in terms of access by motor vehicles to land and not in terms of access by people who drive motor vehicles to get themselves to places. Though the forward to AASHTO's guidelines states that "additional emphasis has been placed on the joint use of transportation corridors by pedestrians [and] cyclists,"[126] consideration of access by other users including cyclists and, most notably, pedestrians (since all travelers ultimately begin and end their trips as pedestrians) is noticeably absent.

In recent years, consideration has been given to an expanded notion of access that recognizes:

... the primary function of local roads and streets is to provide access (implementation of which causes a limitation of mobility).[127]

and

Some streets primarily are land service streets in residential areas. In such cases the overriding consideration is to foster a safe and pleasant environment. The convenience of the motorist is a secondary consideration. Other streets are land service only in part, and the feature of traffic service may be predominant.[128]

Despite these two acknowledgments of the access function of the local (residential) street, the basic system definition and the hierarchy retain the specification of access to land, as embodied in the notion of the "terminal facility."

In a lead chapter that discusses "The Concept of Functional Classification," the AASHTO *Policy on Geometric Design of Highways and Streets* tells us the hypothetical trip concludes when:

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126 American Association of State Highway and Transportation Officials (AASHTO). (1984) *A Policy on Geometric Design of Highways and Streets*. Washington, D. C.: AASHTO, p. *xlviii*.

127 Ibid. p. 9.

128 Ibid. p. 471.

The vehicles finally enter local access roads that provide direct approaches to individual residences or other terminations. At their destination, the vehicles are parked at an appropriate terminal facility.[129]

In describing "Access Needs and Controls," in the same chapter:

Access is a fixed requirement of the defined area. Mobility is provided at varying levels of service. Mobility can incorporate several qualitative elements, such as riding comfort and absence of speed changes, but the most basic factor is operating speed or trip travel time. (Emphases added.)[130]

Here we see mobility characterized by *qualities* whereas access is *fixed.* Access is 'just there,' and is thereby defined at a nominal level within the system definition.

More research is necessary to explore expanded ideas of access and the notion that the access function in urban settings, unlike the settings of interstate highways, is endowed with more qualitative characteristics than is the movement function.

Within the entire system definition, the access function -- as embodied in the terminal facility -- stands as a sort of punctuation mark, providing an abrupt end to the well-defined levels of movement service provided by the motor vehicle's movement hierarchy. The possibility that there may be more to the access function is not explored or defined. The access function in this system definition is defined as the access of the automobile -- its primary user -- to a lot or parcel boundary. No consideration is given to 'access to the front door'; that is, access by people -- pedestrians -- to places. This omission becomes particularly problematic in practice, when the emphasis of the system is on mobility and when design speeds for lower order streets are set without regard to an appropriately analyzed access function.

It is interesting that when any kind of definition is given for a terminal facility -- that is, a facility that presumably provides the access function -- the definition is provided in terms of movement:

The same principles of design are also relevant to terminal facilities that adjoin distributor arterials or collectors. The functional design of the facility includes each movement stage, with internal circulation in the terminal designed to accommodate the order of movement. The necessity of designing for all stages of the movement hierarchy varies with the size of the traffic generator. For relatively small generators, two or more stages may be accommodated on the same internal facility. For larger traffic generators, each movement stage must have a separate function facility.[131]

To further cloud the definition of access within the conceptual framework, is the notion of access to the roadway -- or "access control," a use of terms that gives yet another negative cast to the characteristics of access. Access control is used to define

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129 Ibid. p. 2.

130 Ibid. p. 9.

131 American Association of State Highway and Transportation Officials (AASHTO). (1984) A Policy on Geometric Design of Highways and Streets. Washington, D. C.: AASHTO, p. 4.

exit and entrance functions for vehicles to the facilities that provide the system's movement function.

In discussing access control, the following simultaneously shows how the notion of access to land is couched in terms of access to the roadway and how access to land continues to be defined in terms of system movement. Within this definition, the access function -- access to land -- is to be controlled so that movement within the system is not disturbed. Through this control, the definition of access -- an access function -- to the movement facility emerges. Again, from AASHTO:

> *The regulated limitation of access is called access control, which is achieved through the regulation of public access rights to and from properties abutting the highway facilities. These regulations generally are categorized as full control of access, partial control of access, and driveway and approach regulations....*
>
> *The principal advantages of control of access are the preservation of a high quality of service and improved safety [on the movement facility]. Fully controlled access highways or streets have no at-grade crossings and have carefully designed access connections....*
>
> *The principal operational or functional difference between a street or highway with or without control of access is the degree of interference with through traffic by other vehicles or pedestrians entering, leaving and crossing the highway. With control of access, entrances and exits are located at points best suited to fit traffic and land-use needs and are designed to enable vehicles to enter and leave safely with a minimum of interference with through traffic. Vehicles are prevented from entering or leaving elsewhere so that, regardless of the type and intensity of development of the roadside areas, a high quality of service is preserved and the accident potential is lessened. On streets or highways where there is no control of access and roadside businesses develop, interference from the roadside can become a major factor in reducing the capacity, increasing the accident potential, and eroding the mobility function that the facility was designed to provide....*
>
> *Full control of access is the most important single safety factor that may be designed into new highways. It is the key factor in the outstanding safety record of freeways.*[132]

Within these definitions of access, no attempt is made to distinguish access as functionally different from movement. Instead it seems to be a specification of a particular type of movement. Whenever a more detailed definition of access is attempted, it is always attempted within the well-defined and familiar concepts of mobility.

As the AASHTO's policy stated, "Access is a fixed requirement of the defined area. Mobility is provided at varying levels of service."[133] Being a fixed requirement, access to land becomes access to a generic "land." The generic "land" describes a place at the largest of scales and in the fuzziest of terms as far as a formal system definition is

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132 Ibid. p. 105-110.

133 Ibid. p. 9.

concerned. Defining an access function as "access to land" is similar to describing the movement function merely as "Movement from point A to point B."

SUMMARY OBSERVATION. Bicycles offer a high degree of mobility in urban settings because of the characteristics of personal transportation they possess, and because of their ability to satisfy trip travel time requirements for a majority of trips. They also offer accessibility that is superior to that of the automobile in urban areas. Their maneuverability makes it possible for bicyclists to ride virtually anywhere in the city. Unlike the motorist, bicyclists can travel directly to the doors of their destinations and be supported by a reasonable amount of parking at that location. In light of the current lack of development of thinking about access as a system function in the motor vehicle transportation system, focus on that aspect of a bicycle transportation system offers rich competitive opportunities.

RECOMMENDATION 5.4-5. *The current thinking about access together with the superior ability of the bicycle to get travelers to the doors of their destinations provide unusual opportunity for rethinking the access function as it is defined today and for providing improved access capabilities for people (as opposed to automobiles) in urban areas. Further research should be undertaken to explore the access function within the context of urban transportation systems and urban transportation needs in order to develop it as a system function that is distinct from the movement function within the functional classification of streets.*

RECOMMENDATION 5.4-6. *To capitalize on the current lack of depth in thinking about the access function in the motor vehicle transportation system, planners should emphasize attention to refining and providing for this function in establishing urban bicycle transportation systems. Such attention should include emphasis on the following: (1) provision of ample, functional, and appropriate bicycle parking facilities at the main entries to all destinations; (2)provision clear and functional means of getting bicycles to that parking from the public rights-of-way, and (3) promotion of other access support elements, such as availability of cyclist shower and locker facilities at employment centers, wherever possible.*

6. Comprehensive Recapitulation of Summary Observations and Recommendations.

SUMMARY OBSERVATION. Because the bicycle is a mode of personal transportation, it offers all of the dimensions of personal flexibility and freedom associated with that type of travel. It offers the supreme preference of urban travelers: to travel alone. This means that within its effective range of trip lengths, the bicycle can offer all of the freedoms and flexibility in trip planning and actual travel enabled by the automobile. When used for transportation, the bicycle can free the individual from dependence upon the needs or performance of others to travel. One can be spontaneous in making travel decisions. One can leave work early or late, as needs arise, without the task of re-organizing transportation plans with others. One can socialize with friends after work before commuting home, and respond unexpected needs for travel. Bicycling offers as much control over travel plans as does the automobile -- although within a smaller travel range (however we shall see in the next section, that range is not nearly as limiting as one might expect).

RECOMMENDATION 3.1-1. The planning and design of facilities to support bicycle transportation should especially attend to supporting and maximizing the personal transportation attributes of the bicycle, and do nothing to diminish them. This means developing facilities that systematically extend individual freedom, convenience and ease of use for utilitarian bicycle transportation.

SUMMARY OBSERVATION. On the basis of historically acceptable trip travel times and the rates of travel by cyclists, trips less than five miles in length are those for which the bicycle is most likely to deliver acceptable urban trip travel times for utilitarian purposes.

SUMMARY OBSERVATION. On the basis of the pattern of modern person-trips, and the rates of travel by cyclists, a maximum of nearly two-thirds of all person-trips could potentially be made by bicycle within historically acceptable urban trip travel times.

SUMMARY OBSERVATION. On the basis of the pattern of modern person-trips, and the rates of travel by cyclists, nearly one-third of all person-trips could already be made by bicycle within historically acceptable urban trip travel times.

SUMMARY OBSERVATION. On the basis of the pattern of modern person-trips, and the rates of travel by cyclists, as many as four out of five of all non-commuting person-trips could potentially be made by bicycle within historically acceptable urban trip travel times.

RECOMMENDATION 3.2-1. The actual bicycle trip travel time is a critical determinant of the effective range of bicycle competitiveness, especially for trips approaching five miles or more in length. If communities wish to maximize the use of bicycle transportation, the longer the distance that cyclists must travel, the more direct and continuous the route must be in order to meet or approximate tolerable trip travel time requirements. It is therefore critical to any bicycle transportation infrastructure that bicycle facilities used for longer distance trips be especially designed to minimize trip travel time. This means absolutely minimizing the number of stops that must be made on such facilities. This also means that the route of such facilities must be continuous and without interferences that prevent serious cyclists from attaining their maximum comfortable speeds.

RECOMMENDATION 3.2-2. Because nearly 2/3 of all mode choice decisions are made for trips less than 5 miles in length, and because 8 out of 10 person-trips are non-commuting five miles or less in length, bicycle transportation facilities must be ubiquitous. They must systematically blanket communities and providing bicycle transportation service to all places in the area or community served. This means that a focus on merely connecting employment centers with bicycle facilities is likely to miss the opportunity for the bicycle to address the major portion of the urban trips that are potentially within its reach. In order for a bicycle transportation system to address its maximum potential effectiveness, it must be everywhere, just like the motor vehicle roadway system. This suggests a change in focus in developing bicycle facilities, away from emphasis on building long linear bicycle facilities in places where rights-of-way become available, to creating networks of interconnecting bicycle facilities of various service levels carefully integrated everywhere in targeted districts of the urban fabric.

SUMMARY OBSERVATION. Close access to the door of destinations is an important aspect of making a trip to a particular place. The ability to provide such access has been recognized as important in parking lot management for commercial destinations and in bicycle disincentive programs. Bicycle systems that capitalize on the bicycle's ability to park adjacent to the doors of destinations and afford the bicycle better access to all 'doors' in the community, should achieve a higher degree of success than those bicycle systems that do not.

RECOMMENDATION 3.3-1. When planning and designing transportation systems, and especially bicycle systems, access should be defined as follows: The capacity to get individual travelers close to the door of trip destinations (time saving in the form of convenience at trip ends). This shifts thinking to include the trip segment that occurs between the traveler's door of origin (or destination) and the roadway that provides mobility between origin and destination. Couched in these terms, environmental detail and the comfort and convenience of the person moving between the door and the roadway become a much more important objective.

As with the automobile, a critically important environmental detail tied to the access capabilities of the bicycle is the provision of parking facilities. Because the bicycle can get you closer to the door of your destination, it is essential that plenty of bicycle parking be provided is close as possible to the door in order for cyclists to reap the benefits of better access. Bicycle parking located far from the door, at a second class door, or farther from the door than automobile parking all result in the loss of the potential access advantage of the bicycle.

Also, it is critical that the bicycle parking facilities provided actually work and don't damage the bicycle. Just as automobile users are not expected to park their cars in spaces that are too small, difficult to access or likely to do damage to their vehicles, neither should cyclists be assumed to make use of comparably bad facilities for their parking needs.

SUMMARY OBSERVATION. Viewed in this way, the bicycle also presents an advantage for many businesses. Because the bicycle is smaller and more maneuverable than the motor vehicle, more individuals (cyclists) can take advantage of superior access to the doors of business, than if automobile access were the only access provided. This is particularly important in commercial and retail locations where an accommodating bicycle infrastructure and ample amounts of bicycle parking can increase the convenience of access to more business patrons.

RECOMMENDATION 3.3-2. Reduce overall trip travel times for cyclists by catering to the access and maneuvering capabilities of the bicycle -- capabilities that are far superior to those of the automobile. Access privilege for cyclists can be used at either end of the travel segment of a trip to reduce trip travel times and further increase the attractiveness of bicycle transportation. In addition, capitalizing on the maneuvering capabilities of the bicycle can, in some cases, enable the establishment of more direct and stop free routes to the cyclist, also reducing trip travel times.

SUMMARY OBSERVATION. Because the bicycle possesses very adaptive chameleon-like characteristics, it plays a pivotal role in thinking about the relationship between urban form and transportation. The two endpoints of today's roadway transportation continuum are described by the pedestrian and the motor vehicle. On the pedestrian end, mobility (speed) is the lowest and individual maneuverability and ability to access the door and are the highest. On the motor vehicle's end of the continuum, the reverse is true. The bicycle's adaptability characteristics -- where sometimes it is like a car, sometimes like a pedestrian, or sometimes simultaneously, like both -- place it not only between the two endpoints of the roadway transportation continuum, but in a position that is not fixed (like the pedestrian and motor vehicle endpoints), but moving along the continuum of roadway transportation types, depending on circumstances in the roadway.

RECOMMENDATION 3.4-1. The development of a community bicycle transportation plan offers the opportunity to re-think the relationship between land use and transportation. To the largest extent possible, the establishment of a bicycle transportation system should be used to direct and contribute to the improvement of the urban fabric and reformulate the relationship between motor vehicle travel priorities and alternative modes, as needed, to maximize the utilitarian cycling and pedestrianism.

SUMMARY OBSERVATION. The Federal Aid Highways mandate contained the system's goals that comprise the system's initiating requirement set. These requirements are stated in broad terms; i.e., "build an interstate highway system for purposes of national economic growth and the national defense." The scope of the task at hand was clearly stated in the mandate. The system was to blanket the country by serving national economic and defense needs. The mandate specified both large and small settlements in the system. Due to the language of the act, qualitative characteristics that addressed the importance of the system, the formulation of its definition, and the efficient and exacting execution of its planning and design processes were emphasized.

RECOMMENDATION 5.1-1. The history of the motor vehicle roadway transportation system suggests that to promote widespread development of bicycle transportation facilities, clear policy mandates should be given at the appropriate levels of government describing the (1)purpose, (2) scope and (3) importance of this endeavor. The highest return on investment, in terms of bicycle person-trips generated per unit of investment, will likely be for trips less than five miles in length (see chapter 3). This suggests that the local level of government is likely to be the most critical level at which such policy needs to be enacted. To facilitate this at the state level, enabling legislation could be enacted and a model policy could be developed for adoption by local units.

RECOMMENDATION 5.1-2. To facilitate the widespread development of bicycle transportation facilities, policy mandates should include policy language defining three areas of system requirements:

Purpose of the System

1. The purpose of the system is to provide a system of urban bicycle roadways that fulfills the needs of local commerce and personal mobility by bicycle.

Scope of the System

2. The system definition for a system of urban bicycle roadways is to apply to all land use settings and environmental contexts in urban areas.

Importance of the System

3. The establishment of the a system of urban bicycle roadways is of primary importance to state and local transportation and environmental interests.
4. The timely completion of a system of urban bicycle roadways is one of the most important objectives of the system itself.

SUMMARY OBSERVATION. The single most important aspect of these requirements that affects the system definition is their gargantuan scale. This hugeness is seen in:

- The great distances between U.S. cities and states that had to be traversed in network connecting all of them.
- The great numbers of personal vehicles that the system had to accommodate.
- The large relative scale imparted by user (motor vehicle) size and speed. The size, and particularly, the potential speed that motor vehicles could attain, brought a new largeness of scale previously unseen in personal transportation systems. Automobiles became machines for transforming human beings into super-beings with regard to movement and all roadways were to provide this "super-movement" function.
- The system's ubiquitous nature. Large, high-quality roadways were to be easily accessible to every vehicle owner.
- The requirement for interconnectivity implied a network of roadways was to be created. The system was not, for example, to provide linear connections or only connect a specified subset of the country.

RECOMMENDATION 5.1-3. A bicycle roadway transportation system should not attempt to duplicate the massiveness of the motor vehicle system, but should be directed by the ideas embedded in its system requirements that promoted its expansion. Translation of such ideas into bicycle transportation system requirements might include the following:

- The system should attend to the issue of expansion to enable neighboring urban districts to connect via the bicycle roadway system.
- The system should be conceived and constructed to handle large numbers of cyclists.

- Because the bicycle adds significant mechanical advantage over travel on foot, there is necessarily a different scale of size and movement and relationships made possible by its extensive use for urban transportation. The effect of this change can and will have an impact on the overall urban environment. Because the bicycle is closer to a pedestrian in scale and movement than it is to an automobile, this should help create, over the long term, a more human scale environment.
- The bicycle roadway system should be ubiquitous nature. High-quality bicycle roadway space must be made easily accessible to every bicycle owner.
- The bicycle roadway system should require interconnectivity as areas become blanketed with bicycle roadways. This means attention should focus on establishing a network of bicycle roadways, and avoid providing linear connections or connections to only certain destinations in a city.

SUMMARY OBSERVATION. The preceding has presented some major requirements for our interstate system of roadways. This section demonstrated how requirements become refined by considering them in different contexts -- in this case, the contexts of the economic and political milieu and some aspects of the system's operating environment. The discussion was certainly not exhaustive of all of the system's requirements, but serves as background for two points: that a system's definition and design parameters stem from the system's requirement set and that the requirements for an interstate roadway transportation system are inappropriate when applied within the context of the intra-urban environment and intra-urban transportation requirements. This at least partially explains why alternative forms of personal transportation, such as bicycling and walking, have not been more common in areas of urban expansion that have taken place in the Post World War II period.

RECOMMENDATION 5.1-4. A specific re-thinking of the system definition for a intra-urban mulit-modal transportation system is needed. Such an enterprise would provide the clarity and direction needed to better integrate alternative forms of transportation into the urban fabric. This re-thinking must necessarily turn to a more local frame of reference and be driven primarily by local issues and concerns.

SUMMARY OBSERVATION. It is important to grasp the most important lesson given by the mid-century history of our urban transportation system within the context of our present-day points-of-view regarding urban policy making, urban transportation, and urban design. The ideas that prevailed mid-century embodied a "clear sense of direction" and the system that was adopted was the one that exhibited a "clarity of standards." Within the mid-century urban context, when there was no urban transportation system that adequately accommodated the automobile, public officials were essentially in the same position as our public officials today. Without an explainable system with demonstrable design criteria, it was not possible to visualize what the new transportation system should be and how it would operate. The system that was accepted was the one that first, could be explained and presented as a whole to public officials and second, showed that it could solve the problem at hand by possessing "technical procedures for predicting the precise benefits to be derived by building on the basis of any particular design."

RECOMMENDATION 5.1-5. Develop a very simple, easy to understand vision of a bicycle roadway transportation system as a whole in order to explain its construct and communicate the basics of its design criteria political decision makers and public officials. As experienced with the motor vehicle roadway system, this is necessary to create a broad, shared vision of what is to be built and what its essential features must be. This is also important to galvanize broad political support, provide conceptual direction for decision makers, and establish a framework for understanding the technical requirements and potential benefits of creating a bicycle roadway transportation system. Perhaps more than any other recommendation presented in this study, this is the one most critical to the propagation of widespread development of a successful bicycle transportation system.

SUMMARY OBSERVATION. The shortcomings of the roadway hierarchy are frequently and unflinchingly discussed in transportation literature, especially when identifying situations where it has to be ignored. The need for large numbers of exceptions raises the question of whether the hierarchical construct should continue to provide the ordering mechanism for, even, motor-vehicle roadway systems. A conceptual construct that works in theory, but so frequently fails in application that many exceptions must be made, is self-defeating. A better system construct is needed. If this is clear for uni-modal systems, what happens when other modes must be integrated into the roadway system?

SUMMARY OBSERVATION. When one proceeds to attempt to conceptually (and physically) integrate bicycle transportation (or any other mode) into the movement hierarchy, the construct becomes unfathomable and even more unusable. Is the bicycle system hierarchical too? If so, how is it placed within the structure of the motor vehicle's movement hierarchy? Is it a shadow-like, hierarchical system, residing next to the motor vehicle hierarchy with each of its branches residing next to the branches of the motor vehicle hierarchy? Since the bicycle and automobile roadways must physically intersect, how is the intersection of the two systems described with a hierarchical construct? When components of the two systems intersect on the land, how is dominance to be determined?

Alternatively, is the bicycle's hierarchy melded into the motor vehicle's hierarchy? If so, the bicycle's scale and speed certainly place all bicycle transportation facilities close to the bottom of the hierarchy. However, potential volumes of cyclists could place some bicycle roadways nearer the top of the hierarchy. So, within this conceptual construct, where would one place the bicycle arterial, at the bottom or the top? In the current construct, it would seem that the automobile would always have preference. The hierarchical approach to component relationships presents more impediments than positive direction in attempting to integrate a bicycle roadway transportation system with the motor vehicle roadway system.

RECOMMENDATION 5.3-1. A different transportation system construct is needed to allow us to better envision, plan, and design an integrated bicycle transportation system within the context of other modes of roadway transportation.

SUMMARY OBSERVATION. The notion of *functionally* classifying roadways only in terms of moving or not moving ignores the role of streets in urban areas. When transportation planners and engineers consider degrees of movement as the only functions for streets, the street is relegated to being a conduit only, serving no other purpose to people other than moving motor vehicles though the space of the street. A descriptive and useful, functional classification of streets considers the use of the street by *people*, as well as a variety of vehicles, both motorized and non-motorized.

RECOMMENDATION 5.3-2. In order for a functional classification to provide a picture of all of the characteristics of streets, the following must be included in the classification:

- A movement function for all motorized and non-motorized modes of transport;
- An access function that includes not only the access of vehicles to property, but the access of people to places where they want or need to be, which then, necessarily, includes consideration of qualitative and contextual aspects of access;
- The role of the street, according to the contexts of its immediate surroundings, its neighborhood and the city, including considerations of:
  - Land use
  - Landscape
  - Density

If this kind of functional classification were developed for urban streets, the system definition for urban roadway transportation systems would be more descriptive of conditions found in all urban areas, and of all the transportation functions of urban streets. The system definition would also be more prescriptive of change and intended use. Such a functional classification would bring the use of the street by people into the picture and non-automotive modes of transportation into consideration. Such a classification would be more useful to planners, designers, engineers, city officials, and decision makers as they make plans and decisions about the complex relationships found in the city and its streets.

RECOMMENDATION 5.3-3. More research is needed to develop the access function to a more precise and descriptive degree than currently exists in today's system definition. Just as today's functional classification considers different kinds of movement within the contexts of trip stage, distances served, speeds allowed, and volumes accommodated, the expanded definition of access considers access in a contextual manner as well. When the definition of access considers context, the context of the street becomes more important.

SUMMARY OBSERVATION. The simplicity of the functional classification of streets provides an instructive model for establishing the simple and clear system construct for bicycle transportation system articulated in Recommendation 5.1-5. In its essentials the functional classification of streets describes three or four basic types of street functions with regard to automobile use, with their relationship to each other framed primarily in hierarchical terms and secondarily by specific functional criteria. A similarly simple construct could be developed for the bicycle system without the problems of a hierarchical frame by focusing on description of the role of system components. Such construct could be developed prior to any overall multi-modal conceptual reorganization of roadway transportation system because determination of the specific importance relationships would still be open to refinement.

RECOMMENDATION 5.3-4. Develop a simple articulation of a bicycle roadway transportation system's major component categories as a system construct. These categories should be described primarily in terms of function and and not in terms of relationship dominance and connectivity, so as to keep decisions about relative importance and relationship issues grounded in function. This construct should not be more than three to five generic types of components, to allow them to be easily memorized and thought about as a whole system structure. Each general type would then also be open to further refinement and sub-classification with respect to context and urban design considerations to allow differentiation with in each type for specific applications.

SUMMARY OBSERVATION. In AASHTO policy regarding the design of highways and streets little or no attention has been paid to specific common urban conditions such as the occupation and use of streets by people, the need for people to obtain access places along multi-purpose streets (in convenient, comfortable and even, pleasant ways) and the role of the street within the context of site and community. These additional considerations all tend to mitigate parameters for the design of streets and interfere with the goal of uninterrupted, efficient motor vehicular movement.

SUMMARY OBSERVATION. The philosophy of designing for higher than posted speeds is problematic in most urban settings where urban density increases and different types of land use require slower speeds, or at least, motorists who proceed with more caution along roadways that are not devoted entirely to movement. Under such conditions, the philosophy should be to plan and design the system and, most importantly, the roadway so that it is physically impossible to speed. An example of techniques used to accomplish this is the traffic calming techniques used in Europe. Traffic calming techniques physically control vehicle speed within the space of the street. Traffic calming makes it *physically impossible* to accelerate the vehicle to a dangerous speed. Though traffic calming techniques are usually thought to be appropriate for residential areas only, they are also used in commercial, retail and industrial areas in Europe.

RECOMMENDATION 5.4-1. Roadway design practices and policy in the U.S., regarding speed and the design of roadways, should be changed from designing for higher speeds and unimpeded movement on all roads to a set of design practices and policy that:

- More carefully and explicitly acknowledge urban transportation conditions and the urban context,

  and

- Provide safe roadways for other roadway users as well as motorists by including design practices and policies that make it physically impossible to speed on roadways where land use, the use of the street, and density require slower speeds.

These changes, in addition to helping make urban streets safer to use, would also tend to create an environment that is more compatible with bicycle use with respect to vehicle speeds, by bringing the actual operation speeds of motor vehicle closer to those of the bicycle.

SUMMARY OBSERVATION. Congestion research like that of Newman and Kenworthy, and the knowledge we have gained through our experiences with the 'black hole theory' of highway investment, or the transportation-land used cycle, support the position that congestion is increased and exacerbated when more movement facilities are provided for the motor vehicle.

RECOMMENDATION 5.4-3 This state of affairs raises important questions that should be addressed by policy and decision makers and by the roadway transportation systems that we define for the future (including bicycle systems).

Is the system being efficient when it habitually fails to move individual motor vehicles with efficiency, or in many instances, fails to move them at all for long periods of time?

If the only objective of a roadway transportation system is to provide efficient movement for the motor vehicle and the system, as defined and implemented, cannot do that, has the system been properly conceived and designed for the conditions under which it must operate? Is there something wrong with the goals and objectives of the system that make them unsuitable for urban conditions of density and land use?

Is the system an efficient system in light of other national and local priorities? From the perspective of the overall goals and resource use of nation and community, is it efficient as a nation to spend massive amounts of monetary resources, and raw and recycled resources, on a gargantuan system of transportation that ferries motor vehicles around a sprawled community -- one that continually and frequently demands that more resources be used to expand it?

Does the system itself operate efficiently? The "build it and they will come" maxim certainly holds true for all freeway expansion projects. The experience with many has shown that congestion sets in almost immediately after construction is complete. Is then, such a transportation system efficient when it cannot correct, or at least ameliorate, its own problems?

Is movement efficiency for motor vehicles a sufficient transportation criterion when masses of vehicles and their operators, in fact, waste time using individual motorized transport?

- Is efficiency a sufficient transportation criterion in today's world? Does the focus on movement efficiency for the motor vehicle justify world-wide, community, economic, and environmental impacts that occur when trip travel times are satisfied according to the travel time requirements of masses of motor vehicles.

- Is the system definition a usable and useful definition for meeting urban transportation requirements in the most efficient way?

  Therefore, is it a sufficient system definition for urban roadway systems? Is an emphasis on the movement of motor vehicles within the system's definition appropriate? Is a construct that focuses attention to larger scales of motor vehicular movement useful for solving our current transportation problems and needs?

SUMMARY OBSERVATION. The issues raised by the problems of congestion, and the results of solutions we have attempted in the past to relieve congestion, are instructive when reflected upon with an interest in identifying methods for expanding the use of bicycle transportation for the short urban trips that dominate urban person-trip patterns. The 'build it and they will come' phenomenon that seems to have arisen from application of the 'black hole' theory of highway and street investment suggests interesting tactical approaches to the expanding use of bicycle transportation in urban areas.

RECOMMENDATION 5.4-3. Experiment with selective abandonment of the 'black hole' theory of highway and street investment as a remedy for motor vehicle congestion in carefully identified locations within a city, while at the same time establishing a bicycle transportation roadway network. As a result, congestion levels should remain level or increase. This would increase pressure on individuals to seek viable transportation alternatives, such as the bicycle network. Any resulting gains in bicycle popularity would also tend to increase the political, economic and social pressure for investment in improving and extending the bicycle roadway infrastructure.

RECOMMENDATION 5.4-4. Build a bicycle roadway transportation system and the users will come. The history of our experience with the failure of the freeway expansion alternative to congestion relief offers very strong encouragement to apply a 'build it and they will come' approach to investment in bicycle transportation infrastructure. This runs headlong against the concerns of those who fear the facilities, once built, would have few users. There is no well tested means predicting bicycle trip generation from land use as there is for the automobile. This means that just as there is no accepted way to predict bicycle trip generation to support bicycle infrastructure proposals, neither is there a way to refute them. The approach recommended here seems a reasonable and is a historically proven approach to increasing the use of a transportation system -- a system that shares many of the personal transportation characteristics of bicycle transportation.

SUMMARY OBSERVATION. Bicycles offer a high degree of mobility in urban settings because of the characteristics of personal transportation they possess, and because of their ability to satisfy trip travel time requirements for a majority of trips. They also offer accessibility that is superior to that of the automobile in urban areas. Their maneuverability makes it possible for bicyclists to ride virtually anywhere in the city. Unlike the motorist, bicyclists can travel directly to the doors of their destinations and be supported by a reasonable amount of parking at that location. In light of the current lack of development of thinking about access as a system function in the motor vehicle transportation system, focus on that aspect of a bicycle transportation system offers rich competitive opportunities.

RECOMMENDATION 5.4-5. The current thinking about access together with the superior ability of the bicycle to get travelers to the doors of their destinations provide unusual opportunity for rethinking the access function as it is defined today and for providing improved access capabilities for people (as opposed to automobiles) in urban areas. Further research should be undertaken to explore the access function within the context of urban transportation systems and urban transportation needs in order to develop it as a system function that is distinct from the movement function within the functional classification of streets.

RECOMMENDATION 5.4-6. To capitalize on the current lack of depth in thinking about the access function in the motor vehicle transportation system, planners should emphasize attention to refining and providing for this function in establishing urban bicycle transportation systems. Such attention should include emphasis on the following: (1) provision of ample, functional, and appropriate bicycle parking facilities at the main entries to all destinations; (2)provision clear and functional means of getting bicycles to that parking from the public rights-of-way, and (3) promotion of other access support elements, such as availability of cyclist shower and locker facilities at employment centers, wherever possible.

7. PROFILE OF RECOMMENDATIONS FOR THE ESTABLISHMENT OF AN URBAN BICYCLE ROADWAY TRANSPORTATION SYSTEM.

The profile presented here is simply that: an articulation of the essentials found in the forgoing discussion interpreted as a generic outline of a bicycle transportation system developed from summary observations and recommendations.

7.1 GOALS OF THE SYSTEM

On the state and local levels[134], establish policy mandates defining goals for establishment of urban bicycle transportation systems. Specifically they should attend to the following requirement areas with the following intentions[135]:

Purpose of the System

1. The purpose of the system is to provide a system of urban bicycle roadways that fulfills the needs of local commerce and personal mobility by bicycle.

Scope of the System

2. The system definition for a system of urban bicycle roadways is to apply to all land use settings and environmental contexts in urban areas.

Importance of the System

3. The establishment of the a system of urban bicycle roadways is of primary importance to state and local transportation and environmental interests.
4. The timely completion of a system of urban bicycle roadways is one of the most important objectives of the system itself.

Implementation should be directed by a 'build it and they will come' policy. The history of our experience with the failure of the freeway expansion alternative to congestion relief offers very strong encouragement to apply this approach to development of a bicycle transportation system.[136]

134 On the national level the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA) acknowledged an important role for the bicycle as a form of transportation in this regard by the policy language set forth in the act. This act was passed in the middle of this study effort. The complete text of the act may be found in: Congress, U. S. H. R. 2950, (1991). *The Intermodal Surface Transportation Efficiency Act of 1991.*

135 See Recommendations 5.1-1 and 5.1-2.

136 See Recommendation 5.1-4

7.2 SYSTEM CONSTRUCT AND DEFINITION.

Develop a very simple, easy to understand vision of a bicycle roadway transportation system as a whole in order to explain its construct and communicate the basics of its design criteria political decision makers and public officials. As experienced with the motor vehicle roadway system, this is necessary to create a broad, shared vision of what is to be built and what its essential features must be.[137]

That vision should be a simple articulation of a bicycle roadway transportation system's major component categories and general form as a system construct.[138] This articulation must be simple to be easily remembered and thought about as a whole system structure. The vision should emphasize two parts:

1. The system should be seen as a network of interconnecting bicycle roadways. This means providing space for the bicycle in a systematic way. This should be done by blanketing urban areas with bicycle transportation roadways of different types to provide a ubiquitous presence for the system within those areas, serving all destinations at some level. This also means a change in focus in developing bicycle facilities, away from emphasis on building long linear bicycle facilities in places where rights-of-way become available, to creating networks of interconnecting bicycle facilities of various service levels carefully integrated everywhere in targeted districts of the urban fabric.[139]

2. The system should be understood to be comprised of three to five generic categories of bicycle system components. These categories should be described primarily in terms of function and not in terms of relationship dominance and connectivity, so as to keep decisions about relative importance and relationship issues grounded in function. Each general category should be open to further refinement and sub-classification with respect to context and urban design considerations to allow differentiation with in each type for specific applications.[140]

   The system definition should include a specification of general categories of main system components. In addition to detailed functions, these specifications should take into account the various kinds of streets and contexts in which these general components would be applied to the actual range of urban conditions at hand.[141]

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137 See Recommendation 5.1-5

138 See Recommendation 5.3-3

139 See Recommendation 3.1-2.

140 See Recommendation 5.3-4.

141 Recommendation 5.3-2

7.3 User Description.

The system should identify its users as individuals preferring the attributes of personal transportation. For this reason it should aim to support the attributes of personal transportation that the bicycle offers.[142]

The system should identify its users as those making trips of five miles or less in length. This recognizes the fact that nearly 2/3 of all mode choice decisions are made for trips less than 5 miles in length.[143]

The system should identify its users as both commuters and non-commuters, because 8 out of 10 person-trips of lengths five miles of less are non-commuting trips.[144]

7.4 System Requirements

The system should systematically work to extend individual freedom, convenience and ease of use.[145]

The system should minimize actual trip travel time, especially for components serving longer lengths of travel distance approaching the five mile length. This means it is absolutely essential to minimize the number of stops required on these facilities as well as insuring the component provides a continuous bicycle roadway connection without interferences.[146]

The system should regard access as getting people to the door of their destinations. This should be one of its most important requirements. The system should cater to the superior access capabilities of the bicycle by providing ample, functional bicycle parking facilities adjacent to the main entries of all destinations.[147]

To the largest extent possible, establishment of a bicycle transportation system should be used to direct and contribute to the improvement of the urban fabric and the relationship of transportation to land use.[148]

The system should support and enable neighboring districts to connect their bicycle transportation networks.[149]

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142 See Recommendation 3.1-1.

143 See Recommendation 3.2-1.

144 See Recommendation 3.2-2.

145 See Recommendation 3.1-1

146 See Recommendation 3.2-1

147 See Recommendation 3.3-1

148 See Recommendation 3.4-1

149 See Recommendation 5.1-3

High quality bicycle roadway space should be easily accessible to every bicycle owner.[150]

7.5 SYSTEM FUNCTIONS

The system should excel at providing for the access to doors of destinations, including attention to the following: (1) provision of ample, functional, and appropriate bicycle parking facilities at the main entries to all destinations; (2)provision clear and functional means of getting bicycles to that parking from the public rights-of-way, and (3) promotion of other access support elements, such as availability of cyclist shower and locker facilities at employment centers, wherever possible.[151]

The system should excel at providing competitive travel times for trips less than five miles in length.[152]

The system should be conceived to handle large numbers of cyclists.[153]

150 See Recommendation 5.1-3

151 See Recommendation 5.4-6

152 See Recommendation 3.2-1

153 See Recommendation 5.1-3

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