PAS Essential

INFO PACKET

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Complete Streets

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APA

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Making Great Communities Happen

Articles and Reports

Alliance for Biking and Walking (formerly Thunderhead Alliance). 2006. Excerpts from *Guide to Complete Streets Campaigns*. Washington, D.C.: Alliance for Biking and Walking.

- Guide to help advocacy groups make the case for local complete streets policies. Revised guide (2010) will be available on the Alliance's website at www.peoplepoweredmovement.org/publications .

American Planning Association. 2006. *Complete Streets*. *PAS QuickNotes* No. 5.

- Handout to help explain the Complete Streets concept to residents and public officials.

Dowling, Richard, et al. 2008. *Multimodal Level of Service Analysis for Urban Streets*. Chapter 9. Integrated Multimodal LOS Model Framework. NCHRP Report 616. Washington, D.C.: Transportation Research Board.

- Describes model framework for evaluating level-of-service for cars, bikes, pedestrians, and transit.

Dumbaugh, Eric. 2005. "Safe Streets, Livable Streets." *Journal of the American Planning Association* 71 (3): 283-300. Published by Taylor & Francis, Ltd., www.informaworld.com

- Study shows that street trees enhance safety in urban roadways.

Klop, Jeremy. 2008. "Complete Streets." Sustainable Community Development Code. Research Monologue Series: Urban Form, Transportation. Denver: Rocky Mountain Land Institute.

- Explains the importance of the complete streets concept for sustainable land development.

LaPlante, John, and Barbara McCann. 2008. "Complete Streets: We Can Get There From Here." *ITE Journal* 78 (5): 24-28.

- Concise overview of the design variables involved in building complete streets.

Litman, Todd. 2008. "Introduction to Multi-Modal Transportation Planning: Principles and Practices." Victoria, B.C.: Victoria Transportation Policy Institute.

- Summarizes planning and evaluation techniques for multimodal transportation.

Lynott, Jana, et al. 2009. *Planning Complete Streets for an Aging America*. Chapter 4. Best Practices – Making Streets Work for Older Travelers. Washington, D.C.: AARP.

- Chapter 4 lays out planning and design principles as well as key design elements for older driver and pedestrian safety.
- Full report includes extensive ratings list of complete streets policies in effect as of December 2008; available at http://www.aarp.org/research/ppi/liv-com/transport/articles/Planning_Complete_Streets_for_an_Aging_America.html.

Lusher, Lindsey, Mark Seaman, and Sin-pei Tsay. 2008. *Streets to Live By: How Livable Street Design Can Bring Economic, Health and Quality-of-Life Benefits to New York City*. New York: Transportation Alternatives.

- Report detailing features and benefits of streets that promote nonmotorized transportation, transit use, and social interaction.

McCann, Barbara. 2005. "Complete the Streets!" *Planning,* May.

- A good overview of complete streets concept.

McCann, Barbara. 2007. "Complete the Streets for Smart Growth." *On Common Ground*, Summer.

- Profiles a number of complete streets success stories.

McCann, Barbara. 2009. "Complete Streets 2009." *On Common Ground*, Summer.

- Explains the health, safety, and economic value of complete streets.

Local Complete Streets Design Guides

Charlotte (North Carolina), City of. 2007. *Urban Street Design Guidelines*. Chapters 1 – 3.

- Detailed guidelines with a complete streets approach used by a local transportation department to help plan and design roadway projects in urban areas. The entire guidebook can be accessed at http://www.charmeck.org/Departments/Transportation/Urban+Street+Design+Guidelines.htm.

Louisville-Jefferson (Kentucky), City and County of. 2007. *Complete Streets Manual*.

- Detailed complete streets design guidelines that use the character of the local area to classify street types. Appendices with cross-sections available at http://services.louisvilleky.gov/media/complete_streets/complete_streets_manual.pdf.

Roanoke (Virginia), City of. 2007. *Street Design Guidelines*.

- Design guidelines that show how motorized and nonmotorized users can be accommodated by various street types. Additional guidelines for streetscape elements available at http://www.roanokeva.gov/85256A8D0062AF37/CurrentBaseLink/7C223BF47CE37256852575F2006CEDF8/$File/STREET_DESIGN_GUIDELINES.pdf.

Sacramento Transportation & Air Quality Collaborative. 2005. *Best Practices for Complete Streets.* Sacramento, California: Sacramento Transportation & Air Quality Collaborative.

- Best practices in street design for complete streets from a regional working group.

Excerpts from Local Plans

Champaign (Illinois), City of. 2008. *Transportation Master Plan*. Chapter 8. Roadway Vision.

- Describes the complete streets approach and presents a vision for complete streets in Champaign.

Hendersonville (Tennessee), City of. 2009. *Land Use and Transportation Plan*. Chapter 6. Complete Streets. Prepared by Kimley-Horn and Associates' Urban Resource Group.

- Outlines a strategy for implementing complete streets in Hendersonville and includes a street design priority matrix.

Sacramento (California), City of. 2009. *2030 Comprehensive Plan*. Part 2. Citywide Goals and Policies. Mobility. M4. Roadways. Goal M4.2. Complete Streets.

- Lists six broad policies to implement complete streets in Sacramento.

Scottsdale (Arizona), City of. 2008. *Transportation Master Plan*. Policy Element. 2.0. Complete Streets.

- Lists a number of policies and strategies to implement complete streets in Scottsdale.

West Palm Beach (Florida), City of. 2008. *Comprehensive Plan*. Chapter 3. Transportation Element.

- Developing complete streets is a guiding principle of West Palm Beach's transportation planning goals and policies.

Local Complete Streets Resolutions

Greenville (South Carolina), City of. 2008. *Resolution 2008-49*.

- Resolution to accommodate pedestrians, bicyclists, transit riders, and persons of all abilities in future transportation plans and projects.

Knoxville (Tennessee), City of. 2009. *Resolution R-287-09*.

- Resolution to balance the needs of pedestrians, bicyclists, and public transportation users in all future transportation projects. Instructs city staff to consult the Tennessee Department of Transportation's bicycle and pedestrian policy.

Missoula (Montana), City of. 2009. *Resolution Number 7473*.

- Resolution to accommodate users of all ages and abilities including pedestrians, bicyclists, transit riders, and motorists.

Roanoke (Virginia), City of. 2008. City of Roanoke Complete Streets Policy: Resolution No. 38042-031708.

- Resolution to accommodate users of all ages and abilities including pedestrians, bicyclists, transit riders, and motorists.

Saint Paul (Minnesota), City of. 2009. *Resolution 09-213*.

- Resolution to balance the need of all users including pedestrians, cyclists, transit, freight, and motor vehicle drivers and draws special attention to providing for the safety and convenience of vulnerable populations.

Pierce (Washington), County of. 2008. *Resolution No. R2008-89s*.

- Resolution to include a complete streets policy in the county's Transportation Plan Update.

Local Complete Streets Ordinances

Ferguson (Missouri), City of, and Municode. 2008. *Ordinance No. 2008-3375*.

- Ordinance adding a complete streets policy statement to the streets and sidewalks chapter of the city's municipal code.

Issaquah (Washington), City of. 2008. *Ordinance No. 2514*.

- Ordinance adding a chapter to the city code that requires all transportation projects to include bicycle and pedestrian facilities unless exempted by specific conditions.

Lansing (Michigan), City of. 2009. *Ordinance #1145*.

- Ordinance adding a section calling for the creation of a nonmotorized plan to implement complete streets to the city's codified ordinances.

Louisville-Jefferson (Kentucky), City and County of. 2008. *Ordinance No. 15, Series 2008*.

- Adopts a stand-alone complete streets policy as an amendment to an existing comprehensive plan.

San Francisco (California), City and County of. 2005. *Ordinance No. 209-5*.

- Requires pedestrian, bicycle, and transit improvements in accordance with existing plans and policies for all right-of-way projects.

Seattle (Washington), City of. 2007. *Ordinance 122386*.

- Ordinance declaring that Seattle's Department of Transportation will provide appropriate accommodations for "pedestrians, bicyclists, transit riders, and persons of all abilities, while promoting safe operation for all users." Also addresses the importance of balancing the needs of freight users.

Additional Online Resources

National Complete Streets Coalition: http://www.completestreets.org/

APA's Complete Streets Research Project: http://www.planning.org/research/streets/

Alliance for Biking and Walking (formerly Thunderhead Alliance for Biking and Walking): www.peoplepoweredmovement.org/site

Association of Pedestrian and Bicycle Professionals: www.apbp.org

Pedestrian and Bicycle Information Center: www.walkinginfo.org and www.bicyclinginfo.org

Articles and Reports

- Alliance for Biking and Walking (formerly Thunderhead Alliance). 2006. Excerpts from *Guide to Complete Streets Campaigns*. Washington, D.C.: Alliance for Biking and Walking.

- American Planning Association. 2006. *Complete Streets*. *PAS QuickNotes* No. 5.

- Dowling, Richard, et al. 2008. *Multimodal Level of Service Analysis for Urban Streets*. Chapter 9: Integrated Multimodal LOS Model Framework. NCHRP Report 616. Washington, D.C.: Transportation Research Board.

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- Litman, Todd. 2008. "Introduction to Multi-Modal Transportation Planning: Principles and Practices." Victoria, BC, Canada: Victoria Transportation Policy Institute.

- Lynott, Jana, et al. 2009. *Planning Complete Streets for an Aging America*. Chapter 4. Best Practices – Making Streets Work for Older Travelers. Washington, D.C.: AARP.

- Lusher, Lindsey, Mark Seaman, and Sin-pei Tsay. 2008. *Streets to Live By: How Livable Street Design Can Bring Economic, Health and Quality-of-Life Benefits to New York City*. New York: Transportation Alternatives.

- McCann, Barbara. 2005. "Complete the Streets!" *Planning,* May.

- McCann, Barbara. 2007. "Complete the Streets for Smart Growth." *On Common Ground*, Summer.

- McCann, Barbara. 2009. "Complete Streets 2009." *On Common Ground*, Summer.

EXCERPTS FROM:

GUIDE TO COMPLETE STREETS CAMPAIGNS

For Thunderhead Alliance
Member Organizations
March 2006

Produced by Thunderhead Alliance
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As part of Thunderhead's 50 States/50 Cities Project

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Complete version of the revised guide is available at
www.peoplepoweredmovement.org/site/index.php/site/memberservices/C410.

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- City of Fort Collins, Colorado
- City of Portland, Oregon
- City of Sacramento, California
- City of Santa Barbara, California
- City of St. Joseph, Missouri
- City of St. Petersburg, Florida
- City of West Palm Beach, Florida
- Florida Department of Transportation
- Knoxville Regional Transportation Planning Organization
- League of Illinois Bicyclists
- Marin County Bicycle Coalition
- North Carolina State University Institute for Transportation Research and Education
- Northeast Ohio Areawide Coordinating Agency
- Oregon Department of Transportation
- Pednet
- Rhode Island Department of Transportation
- Sacramento Area Bicycle Advocates
- SANDAG
- San Diego County Bicycle Coalition
- South Carolina Department of Transportation
- Tennessee Department of Transportation
- Virginia Department of Transportation

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If we forgot anyone, please forgive us and let us know. Then watch for your name in our next update.

Sue Knaup Gayle Stallings David Crites Dave Snyder Barbara McCann

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CHAPTER 1 – Introduction

Thunderhead Alliance

The Thunderhead Alliance is the national coalition of state and local bicycle and pedestrian advocacy organizations. 119 strong in 47 states and one Canadian province, Thunderhead's member organizations employ more than 187 full-time staff and reach a combined dues-paying membership of more than 94,000 people. Thunderhead's mission is to unite these organizations, help strengthen them, and create new ones where they are most needed.

Complete streets policies that require safe accommodation of all users of a street can eliminate most of this nation's barriers to bicycling and walking. Thunderhead's National Complete the Streets Campaign has a goal of helping our organizations win at least one complete streets policy, local or state-level, in all 50 states by 2008 in order to influence a federal-level complete streets policy through the reauthorization of SAFETEA-LU, the U.S. federal transportation law. This tapestry of local, state and federal policies will ensure that no transportation project can move forward without being complete!

If you are a leader or potential leader of a Thunderhead organization, this Guide to Complete Streets Campaigns is written for you. If you are not a leader of such an organization, this Guide will be your window into the world of bringing positive change to communities through professional bicycle and pedestrian advocacy. Read as if you are a leader of a Thunderhead organization and bring these elements of this powerful transportation reform campaign to your own officials. Sometimes all it takes is one determined, professional voice. And make sure to connect with your Thunderhead organization on our Links page at: www.thunderheadalliance.org/links.htm .

This Guide to Complete Streets Campaigns is a roadmap to winning a complete streets policy in your jurisdiction. It is also a guide to effective community organizing, as it is our hope that in winning a complete streets policy our Thunderhead member organizations will also gain strength, increase partnerships, and in many ways make their communities better with improved conditions for bicycling and walking.

The Concepts of Complete Streets and Complete the Streets Campaigns

Complete streets are thoroughfares that serve all users, moving by car, truck, transit, bicycle, wheelchair, or foot. Complete streets allow all their users to travel in a safe and welcoming way. You, as a leader of a Thunderhead organization, as a champion of bicycling and walking issues, as a bicyclist and pedestrian, will acknowledge that the vast majority of the current North American transportation system is not comprised of complete streets. Many streets lack sidewalks, few accommodate bicyclists well, most encourage traffic to travel too close and fast, many don't have curb ramps at intersections or across

driveways, and so on. We all know that these types of streets are less safe, less functional, and a hindrance to healthy communities and people.

The Cost Misconception: A common misconception is that complete streets cost more to build than incomplete streets. In fact, complete streets most often cost no more and many times can cost less than incomplete streets. For instance, a common street cross section that serves only cars is a four lane speedway with no shoulders, sidewalks or intersection treatments for people. Using the same right-of-way width, this design can be reshaped into two narrower through lanes, one center turn lane, and bike lanes and sidewalks on both sides. By using less width for the most expense elements, truck weight standard asphalt and subsurface, and adding less expensive sidewalks, this design, often referred to as a "road diet" when applied to existing roads, actually saves money. Not only that, this design has been proven to improve traffic flow and safety for motor vehicles by better controlling turning movements. Many other complete streets designs offer similar cost savings. You may even want to bring up the economic benefits of streets that attract visitors and offer access to more employees. Be sure to address this misconception early in your campaign so that you can focus your valuable time on instituting a policy for your communities.

Why Complete Streets Are Important
Bottom line: Bicyclists and pedestrians are dying! A full 13% of traffic deaths in the U.S. are bicyclists and pedestrians yet most roadways are still being built with only cars and trucks in mind.

CHAPTER 2 - Complete Streets Policies

Introduction
Complete streets policies represent a potentially powerful tool for you and your organization. They are the next step in transforming your streetscapes and your communities.

As the national coalition of state and local bicycle and pedestrian advocacy organizations, the Thunderhead Alliance invested in a national survey and analysis of complete streets policy statements, directives, legislation, resolutions, plans, ordinances, and design manuals that require routinely building and reconstructing streets to be safe and convenient for all users, including those on foot and bicycle. This chapter summarizes the results of the inventory of jurisdictions with some form of complete streets policy and adds information about policies we learned about or which were adopted since the survey was completed in December 2004. It makes specific recommendations for creating effective complete streets policies and campaigns.

Methodology
This analysis of complete streets policies was derived from a survey sent to leaders of Thunderhead organizations and state and local bicycle-pedestrian coordinators throughout the United States (see Appendix C for a copy of the survey form), as well as information informally collected on new and newly discovered policies. Respondents were self-selected, although an extra effort was made to get responses from jurisdictions where policies were known to be in place The fact that the responses came from both agency staff and

Thunderhead leaders means that, in some cases, different perspectives are reflected for a single policy. The two-part survey concentrated on the characteristics of the policy and on the steps taken that led to its adoption.

The baseline criteria for inclusion of a policy discussed in this chapter included: 1. calling for routine accommodation of walking and bicycling as a requirement, not as an option, and 2. covering all roads under the jurisdictions' control (this excludes bike/ped plans that only call for accommodation on certain streets). There was no evaluation on the effectiveness of these policies on the ground. However, since the survey came out, the National Complete Streets Coalition, a collaborative effort of organizations working for complete streets including the Thunderhead Alliance, has developed a standard for effective complete streets policies posted at: www.completestreets.org. For a list of active Coalition organizations see Chapter 5. Also, the Thunderhead Alliance has developed a Complete Streets Policy Checklist based on these recommended elements (see Appendix F) to help with evaluation of future policies. We have also become more familiar with what really works to create complete streets.

It should also be recognized that there is no perfect complete streets policy. Jurisdictions have taken a variety of different approaches, so these policies defy easy characterization. In addition, a policy that looks good on paper may have been essentially ignored within an agency, while a seemingly weak policy may have been implemented with gusto by local planners. So we define a good complete streets policy as one that achieves a planning, design and project development process with a constellation of new training, new procedures and design manual changes that put bicycling, walking, and transit on a par with motor vehicles. This chapter is the beginning of a learning curve, not a definitive account.

The Complete Streets Policy Checklist (Appendix F) still does not measure which policies are resulting in good outcomes on our roadways and in our communities. This will be an essential step for the future including performance measures. In addition, the analysis stops short of delving into the many design issues concerning completing the streets.

What does the Federal Guidance policy say? Because a number of the state and local policies are based on statements in the USDOT Design Guidance, a review of that document is pertinent here (see Appendix F, Example 1 for the full Guidance text). While the language in TEA-21, where it originated, fell short of requiring states to accommodate bicyclists and pedestrians, the subsequent Guidance recommends that each state make such accommodation routine. The policy states that:

> *…bicycle and pedestrian ways shall be established in new construction and reconstruction projects in all urbanized areas unless one or more of three conditions are met.*

The USDOT Design Guidance also calls for paved shoulders on rural roads and designs that are accessible for disabled people. It recommends using the best currently available design standards and guidelines. In a more general discussion of the approach to implementation, it recommends re-writing design manuals to include safe bicycle and pedestrian facilities while applying engineering judgment to roadway design.

The USDOT Design Guidance lists additional steps that should be taken, including:

- planning for the long-term anticipating future bicycle or pedestrian use,
- addressing the need to cross roadways, and
- requiring that exceptions be approved at a senior level and documented with supporting data.

With regard to exceptions, the Guidance lists three. They are where:

- the costs are excessive (defined as more than 20% of project costs),
- there is an absence of need (including future need), and
- bicyclists or pedestrians are prohibited from traveling by law.

The Thunderhead Alliance has developed a list of ways to enhance this Guidance for use in developing new complete streets policies. See these recommendations later in this chapter.

We use the term 'policies' loosely, because they take many forms. At the state level, five states have passed legislation: Oregon, Florida, Rhode Island, Massachusetts, and Maryland. Two states have policies that were issued by their State Transportation Commissions (North and South Carolina). Most other states have DOTs that have issued internal policies or directives.

The policies at the city, MPO, and county level include city and MPO plans, local resolutions and ordinances, and local design manuals. Some of the newest policies are tax ordinances in San Diego and Sacramento, California (approved by voters in November 2004).

Another way to analyze the policies is to look at the split between those achieved primarily through public or inherently political processes (interaction with elected officials or other political bodies) and those achieved through internal agency processes. Of the 36 policies, 13 are laws, resolutions, or ordinances and 23 are internal policies, plans, or design manuals. In several cases the internal agency-driven processes were greatly influenced by outside agents, particularly bicycle and/or pedestrian advisory groups. These policies may have also had to go through a public approval process. In addition, a comprehensive complete streets policy may take shape at several levels: first as a general policy statement in a resolution passed by an elective body, then fleshed out with administrative policies set by the implementing agency.

It is encouraging to see that complete streets policies can be achieved in many different ways at different government levels. While the statewide policies would be expected to have the most widespread effect, they commonly affect only state-owned and state-maintained roads. Oregon's state law is an exception as it affects all roads, no matter the jurisdiction. Other state polices may influence local communities and lead to the creation of more local policies. In California for example, Deputy Directive 64 seems to have spurred additional local action.

We have also discovered some complete streets policies that we call 'paper policies' because they look good on paper but are not being implemented. Bringing these policies to light is important in helping Thunderhead leaders and agency officials begin to work on their full implementation. See the implementation chapter for more details.

In the more detailed table below, you will find paper policies listed below model policies. The model policies are highlighted due to the fact that the leaders of the Thunderhead organizations serving those areas have found them to be helpful to their bicycle and pedestrian advocacy efforts. The paper policies have not yet been helpful to the Thunderhead leaders.

<u>When were policies adopted?</u> The move toward complete streets has been growing. Most have come about since 2001, and a significant portion were adopted in 2004 and 2005. This is in part a testament to the influence of the 2000 USDOT Design Guidance, "Accommodating Bicycle and Pedestrian Travel," which was issued in response to language included in the Transportation Equity Act for the 21st Century (TEA-21). This Guidance is an important base for many complete streets policies. A few of the inventoried policies precede

this era. For example, Oregon's was enacted in 1971 and offers an opportunity to evaluate longer-term impacts of these policies.

What do the state and local policies say? It is important to note that of all the policies included in the survey, only a few of the policies, laws, resolutions, ordinances, plans, or design manuals use the term 'complete streets.' Nonetheless most of these policies have great language setting out their vision. A few examples follow.

> *...bicycling and walking accommodations should be a routine part of the Department's planning, design, construction and operating activities.*
> (SC Department of Transportation Commission resolution)

> *Bicycle and pedestrian ways shall be established in new construction and reconstruction of road and bridge projects unless one or more of four conditions are met.* (Cleveland, Ohio MPO)

> *Footpaths and bicycle trails {bikeways and walkways} including curb cuts or ramps as part of the project, shall be provided wherever a highway, road or street is being constructed, reconstructed or relocated.*
> (Oregon statute)

> *This document outlines an approach to designing streets that are more "complete" in the sense of accomplishing all of the goals associated with the dominant form of public space in urban societies – our streets. ... Complete streets are those that adequately provide for all roadway users, including bicyclists, pedestrians, transit riders, and motorists, to the extent appropriate to the function and context of the street.*
> (Sacramento, CA Best Practices for Complete Streets)

Policy Issues

Does the policy really *require* accommodation? Many jurisdictions have plans and policies that express a *desire* to ensure the road serves all users. The most basic element of any complete streets policy is that it ensures that roads are built with everyone in mind. In some cases, policies use the word "consider." For example,

> *The Department fully considers the needs of non-motorized travelers (including pedestrians, bicyclists and persons with disabilities) in all programming, planning, maintenance, construction, operations and project development activities and products.*
> (CalTrans Deputy Directive 64)

This should raise a red flag for Thunderhead leaders, because 'consideration,' in the words of one Thunderhead leader, can give agencies "tons of wiggle room." That said, the California policy has been used effectively by Thunderhead leaders to press for localized complete streets initiatives. The way to turn 'consideration' into a more robust policy is to establish clear guidelines for what it means: filling out a checklist, getting approval of

exceptions, etc. Better yet, avoid the terms “consider” and “consideration” choosing instead stronger language such as “shall be included in every project.”

And always be sure to read beyond the initial lofty statement. Even with strong language in the initial statement, some policies may not function as complete streets policies. For example, while Arizona has a policy which states "It is Arizona DOT’s policy to include provisions for bicycle travel in all new major construction and major reconstruction projects on the state highway system,” the many exceptions and restrictions that are listed just after this statement set up hurdles that make it clear that providing complete streets will occur only in special circumstances, not as a matter of course.

> Our RECOMMENDATION is that you use stronger “shall be established” or “shall be included” language instead of “consider.” These will, in effect, require accommodation to be a routine part of all road design and re-design.

Exceptions: A more precise way to get at whether policies truly require complete streets is by looking at any specific exceptions, and how those exceptions are handled. By setting a rigorous, formal process for approving exceptions, agencies create a process that helps ensure compliance. Some of the policies list specific exceptions, including:

- excessive cost,
- absence of need,
- lack of right of way, and
- no need during simple repaving projects.

Other exceptions specified in some policies are public safety, environmental considerations, project purpose and scope, low traffic volumes, and conflicts with local plans. These exceptions go far beyond the USDOT Design Guidance, which lists three limited exceptions. As discussed previously in this chapter , these are:

- excessive cost,
- absence of need, and
- where bicyclists and pedestrians are prohibited.

The USDOT Guidance defines excessive cost as more than 20% of project costs and specifies that need should be defined in terms of potential *future* pedestrian or bicycle travel (we all know about the potential for significant latent demand).

Remember the Cost Misconception: A common misconception is that complete streets cost more to build than incomplete streets. In fact, complete streets most often cost no more and many times can cost less than incomplete streets. For instance, a common street cross section that serves only cars is a four lane speedway with no shoulders, sidewalks or intersection treatments for people. Using the same right-of-way width, this design can be reshaped into two narrower through lanes, one center turn lane, and bike lanes and sidewalks on both sides. By using less width for the most expense elements, truck weight standard asphalt and subsurface, and adding less expensive sidewalks, this design, often

referred to as a "road diet" when applied to existing roads, actually saves money. Not only that, this design has been proven to improve traffic flow and safety for motor vehicles by better controlling turning movements. Many other complete streets designs offer similar cost savings. You may even want to bring up the economic benefits of streets that attract visitors and offer access to more employees. Be sure to address this misconception early in your campaign so that you can focus your valuable time on instituting a policy for your communities.

When America Bikes, the coalition of eight national bicycle advocacy organizations working on the reauthorization of TEA-21, the federal transportation law, was seeking to place complete streets language in the new law, costs seemed to be a primary issue with members of Congress. America Bikes collected statements from DOT officials who said that integrating bicycle and pedestrian provisions from the beginning should not significantly increase costs. Of course one of the beauties of a complete streets policy should be that bicycle and pedestrian facilities are no longer fighting for the small pie of funds specifically designated for bicycling and walking (such as Enhancements or CMAQ), but are simply part of general transportation spending.

In line with these statements, cost did not seem to be a primary implementation issue for survey respondents. A few respondents did note that once initial budgets are set, including bicycle or pedestrian provisions can become almost impossible. Others noted that right-of-way acquisition can be the most expensive part of a road project, so wider roads with bike lanes may be a barrier. In such cases, reducing the number of travel lanes, otherwise known as a road diet as mentioned above, can complete the street actually at a cost savings.

It should be noted that the most common exception allowed is 'excessive cost,' often set at 20 percent of project cost. Michael Ronkin said it is important to be specific about what constitutes 'total project cost' since many projects are broken down into smaller parts. Sidewalks may be a significant cost if the project is defined as paving of a one-mile road subsection, but may make up a smaller portion when the project is defined more broadly to include all improvements in the whole corridor.

> Our RECOMMENDATION to you is that if your policy includes an "excessive cost" exception, make sure that it clearly states the broadest scope of the project so that sub-section cost breakouts are not possible.

<u>Exceptions Approval Process:</u> The next question is whether the policies require any formal approval when exceptions are made and all modes are ***not*** accommodated. The USDOT Guidance recommends that such exceptions should include documentation and require approval from senior management. Just nine of the 36 policies require such formal justification. The survey form did not ask about the exact method for documenting justifications, but in some cases survey respondents mentioned that there are design exemption forms or required checklists. Thunderhead leaders noted that a formal exemption process was valuable. One leader put it this way:

> *At least now, the engineers have to file a formal 'design exemption' outlining the reasons for not including bike or ped accommodation instead of just not doing it.*

Our RECOMMENDATION is that you should work for policies that have a limited set of exceptions, if any, and that require a formal approval process for each exception. Policies should reverse the current norm from having to justify accommodating all modes to having to justify NOT accommodating them.

While a reluctant agency can still find ways to use exemptions and other language to exclude accommodation, the process gives Thunderhead leaders both leverage and the opportunity to work with and change the attitudes of reluctant engineers and planners. At the end of this chapter, there are further recommendations for crafting policy language, as well as examples of good language already in use.

Design specifications: Another issue is how prescriptive the policies are with regards to actual street design. Few of the policies provide specific language on what types of accommodation should be undertaken (e.g. when and where to build bike lanes or add sidewalks with curb-and-gutter, etc) unless the policy is itself a design manual. Most of the documents are, instead, broad policy statements that refer to other guidelines or design manuals for design specifics. In some cases, jurisdictions have achieved complete streets by revising their standard street cross-sections to include other modes. The USDOT Guidance recommends that agencies should "design facilities to the best currently available standards and guidelines," mentioning AASHTO and ITE standards.

Our RECOMMENDATION is that you steer away from specifying design standards in your policy, especially in an initial complete streets policy campaign. The discussion of the intent (a commitment to build streets for all users) should be separated from the design discussion. As Thunderhead leaders, your role is to push for the *vision* of complete streets. Getting bogged down in arguing about narrow specifications could be deadly to the overall effort.

What modes do the policies cover? The ideal complete streets policy makes clear that roads must be built and reconstructed to serve all users including pedestrians, bicyclists, transit users, and travelers of all ages and abilities. Few of the existing 36 policies are that comprehensive. Several of the policies discuss accommodating transit and people with disabilities, but many do not. The USDOT Design Guidance makes specific reference to accommodating people with disabilities as follows:

> *The 1990 Americans with Disabilities Act, building on an earlier law requiring curb ramps in new, altered, and existing sidewalks, added impetus to improving conditions for sidewalk users. People with*

> *disabilities rely on the pedestrian and transit infrastructure, and the links between them, for access and mobility. (*USDOT guidance)

A few notable examples incorporate transit elements. For example, see San Francisco's Transit First policy. The Sacramento Transportation and Air Quality Collaborative's "Best Practices for Complete Streets," includes a section on designing the road for transit users, noting that, *"The key design issue in planning for transit is the out-of-vehicle time (time spent waiting and time spent walking to and from the transit stop) which often plays a more important role in the decision to use transit than time spent in the vehicle itself."*

> Our RECOMMENDATION is that you seek complete street policies that incorporate transit and active living. Why? This is one of the most significant differences between 'routine accommodation' and 'complete streets.' If complete streets by definition provide safe travel for all users, and if part of the intent of pursuing complete streets is to build alliances beyond bicycle and pedestrian concerns, advocacy leaders seeking to build alliances in a broad complete streets campaign will need to amend the language to discuss other issues.

Essentially, planning for transit is planning for pedestrians, and even for bicycle users, as bike-on-bus programs continue to expand.

The US DOT Design Guidance advocates this approach. In a section called "Rewrite the Manuals" Specific bicycle/pedestrian manuals are portrayed as an interim step toward a recommended total re-write of general street design manuals. At the same time, the Guidance also recommends allowing 'engineering judgment' to guide decisions on a case-by-case basis. All of the examples given show circumstances in which ***more*** bike/ped accommodations should be made than those identified by design standards.

> Our RECOMMENDATION is that you follow Oregon's example, if possible, and keep your policy language non-specific to responsible agencies.

<u>What roads are covered?</u> Most of the 36 policies cover only those roads that are under the direct responsibility of the agency in question. For example, many of the state DOT policies only cover state-owned roads. In the case of MPOs, they tend to cover roadway projects funded through MPO-disbursed funds (which are usually federal transportation dollars). The new sales tax ordinances in Sacramento and San Diego counties apply to all the projects funded under the ordinances. A few of the local policies are directed at developers building new subdivisions. Michael Ronkin, Oregon DOT Bicycle and Pedestrian Program Manager, notes that the passive grammar of Oregon's state law has helped ensure that it applies to every road. Oregon's law says, "wherever a road is constructed" without referring to the agency responsible for building or maintaining it.

Funding: Most of the policies identified do not include specific funding provisions. The USDOT Design Guidance does not mention funding (except a suggested restriction on excessive cost). The notable exception is Oregon, which set aside one percent of its state transportation funds for bicycling and walking facilities. More often, the policies make bicycle and pedestrian accommodation a prerequisite for funding that already exists – the MPO policies and the tax ordinances specify that funded projects must accommodate travel by alternative modes, usually foot and bicycle. The other policies usually assume that funding will come from standard sources. But, again, remember the misconception that complete streets always cost more. See more about this misconception earlier in this chapter.

Our RECOMMENDATION is that you think through funding issues ahead of time and identify, if possible, a funding stream for the policy for those complete streets projects that will add costs. This, along with a strong message that complete streets often do not cost more than incomplete streets, will help you secure your policy.

One Thunderhead leader mentioned that their state's restriction on spending gas-tax money only on roads may get in the way of local jurisdictions' implementation on their new MPO policy. Thirty states have such a restriction on the books, but it is unclear whether they have actually prevented funding of bicycle and pedestrian projects.[1]

So, what is a good policy?

All of this discussion makes complete streets policies seem pretty complex. To simplify things, we tried to distill the elements that do the most to contribute to that change in agency culture that leads to full integration of all modes. They include: inclusion of as many modes as possible; a process that requires any exceptions to be approved at a higher level, and a clear definition of those exceptions. We also checked on what implementation steps have been undertaken, and whether Thunderhead leaders deem the policy useful (even if it is not perfect). The table below gives the results of this scan highlighting those policies that have been helpful as models. You will find these model policies marked on the map for Thunderhead's National Complete the Streets Campaign at: http://www.thunderheadalliance.org/completestreets.htm . Our goal for this campaign is to help our organizations win at least one model complete streets policy, local or state-level, in all 50 states by 2008 in order to influence a model federal-level complete streets policy through the reauthorization of SAFETEA-LU.

[1] A list of state restrictions can be found in the Brookings Institution report, *Fueling Transportation Finance: A Primer on the Gas Tax* http://www.brookings.edu/es/urban/publications/gastax.htm.

Complete Streets Policies Table
Model policies followed by "paper" policies

State	Project title	Users?	Senior-level approval required for exceptions?	Extra Exceptions allowed (beyond cost, no need, prohibited)	Implementation steps undertaken	Thunderhead org leaders have found policy helpful
Model Policies						
CA	California Dept of Transportation Deputy Directive 64 internal policy	ped, bike, disabled	no	exceptions not specified	updated procedures; more?	**yes**
CA	Sacramento routine accommodation sales tax initiative	bike, ped	no	none specified	unknown	**yes**
CA	Sacramento	bike, ped				**yes**
CA	Bay Area MPO (MTC) Second Cycle Programming Policies, screening criteria	bike, ped	no	exceptions not specified	unknown	**yes**
CA	Santa Barbara Circulation Element, General Plan	all	no	insufficient ROW do not plan separate bike facilities on roads with 25 mph limits	unknown	**yes**
CA	San Diego City Street Design Manual		yes	Excessive cost Insufficient ROW	re-written manual	**yes**
CO	Colorado Springs Complete Streets Amendement to the Intermodal Transp. Plan	ped, bike, transit	not stated	unsafe impractical	rewriting manuals	**yes**
CO	Ft. Collins Colorado	ped, bike, transit	yes	none	restructured procedures - (LOS) rewritten design manuals	**yes**
CO	Boulder Multimodal Corridors & Transportation	ped, bike, transit	yes	none	restructured procedures re-written manuals	**yes**

State	Project title	Users?	Senior-level approval required for exceptions?	Extra Exceptions allowed (beyond cost, no need, prohibited)	Implementation steps undertaken	Thunderhead org leaders have found policy helpful
	Network Plans				training	
FL	West Palm Beach FL Transportation Element	ped, bike	not stated	exceptions not specified		**yes**
FL	Florida Bicycle & Pedestrian Ways statute	ped, bike	yes	excessive cost absence of need where contrary to public safety	unknown	**yes**
IL	DuPage County Healthy Roads Initiative	ped, bike	not stated	exceptions not specified	unknown	**yes**
MA	Bicycle-Pedestrian Access Law, Massachusetts staet legislature (Chapter 90E)	ped, bike	Yes	discretion of commissioner, safety environmental quality ROW conflicts	unknown	**yes**
MO	St. Louis Legacy 2030 Long-Range Plan	ped, bike, transit	not stated	no exceptions specified	checklist	**yes**
MO	Columbia Missouri Model Street Standards	ped, bike	No			**yes**
MO	St. Joseph MO bike-ped plan	ped, bike	yes	shoulders on rural roads	unknown	**yes**
NC	North Carolina DOT Bicycle Policy	ped, bike	No		unknown	**yes**
OH	Columbus Ohio MPO (MORPC) Bicycle and Pedestrian Planning Policy	ped, bike	yes		unknown	**yes**

State	Project title	Users?	Senior-level approval required for exceptions?	Extra Exceptions allowed (beyond cost, no need, prohibited)	Implementation steps undertaken	Thunderhead org leaders have found policy helpful
OH	Cleveland Ohio MPO (NOACA) Regional Transportation Investment Policy	ped, bike	yes	extreme topography/natural resource constraints low ADT - below 1,000 simple resurfacing projects	unknown	**yes**
OR	Oregon Bicycle and Pedestrian Statutes	ped, bike	yes	public safety	restructured procedures re-written manuals training	**yes**
SC	South Carolina DOT Commission Resolution	ped, bike	not stated	exceptions not specified	restructured procedures training	**yes**
TN	Tennessee DOT Bicycle and Pedestrian policy	ped, bike	yes	bridges insufficient ROW repaving	unknown	**yes**
VA	VDOT Policy for Integrating Bicycle and Pedestrian Accommodations	ped, bike	Yes	environmental impacts safety purpose & scope of Project	none	**yes**
VT	Vermont Bicycle Pedestrian Plan	ped, bike	not stated	not specified	training	**yes**
Paper Policies						
CA	SF Transit First policy city ordinance	ped, bike, transit	not stated	not specified	unknown	no
CA	San Diego County Transnet Tax Extension provision	ped, bike	not stated	exceptions not specified	unknown	too early to say
FL-AL	Florida-Alabama Transportation Planning Organization (TPO (bicycle plan)	ped, bike	not stated	no exceptions specified	updating procedures	too soon to tell
FL	St. Petersburg "citytrails" plan					no

State	Project title	Users?	Senior-level approval required for exceptions?	Extra Exceptions allowed (beyond cost, no need, prohibited)	Implementation steps undertaken	Thunderhead org leaders have found policy helpful
KY	Kentucky Pedestrian and Bicycle Travel Policy	ped, bike	not stated	exceptions not specified	none	no
MD	Maryland Transportation Code Ann. 2-602	ped, bike	not stated	exceptions not specified	none	unknown
MO	p. 24-25 of MoDOT's Practical Design Implementation Manual	ped, bike				Not yet
NC	Charlotte Urban Street Design Guidelines internal policy	ped, bike, transit	yes	None	restructured procedures	not yet
PA	Penn Bicycle & Ped Checklist Training (App. J to PennDOT Design Manual)	ped, bike	no	exceptions not specified	checklist	no
RI	Rhode Island state law and policy	ped, bike	no	public safety, environmental or scenic quality, ROW conflict at Director's discretion	unknown	no
TN	Knoxville MPO Bicycle Accomm. Policy		yes		unknown	not yet
TX	Capital Area MPO, Texas Mobility Plan 2030	ped, bike	not stated	demonstrated alternative plan	unknown	unknown

Overall Recommendations for Policy Development

First, here are some concluding policy observations:

1. Policies take many forms and have been adopted at all levels of government, with adoption accelerating in recent years.
2. Policies vary in how strict they are in requiring accommodation. Some have set specific exceptions. Most policies do not themselves give design specifications.

Despite imperfections, Thunderhead leaders see policies as providing important leverage for their efforts.

3. Most policies focus almost exclusively on bicycling and/or walking and do not significantly discuss transit users, people with disabilities, or other user groups.
4. Implementation issues are significant; the work does not end with policy adoption.
5. No policies include effective performance measures, and little data is being collected on how well they are working.

Also, we recommend including these elements specified in the "Elements of Complete Streets Policies" on the complete streets web site: www.completestreets.org :

ELEMENTS OF COMPLETE STREETS POLICIES

1. The Principle

- Complete streets are designed and operated to enable safe access for all users. Pedestrians, bicyclists, motorists and transit riders of all ages and abilities must be able to safely move along and across a complete street.
- Creating complete streets means changing the policies and practices of transportation agencies.
- A complete streets policy ensures that the entire right of way is routinely designed and operated to enable safe access for all users.
- Transportation agencies must ensure that all road projects result in a complete street appropriate to local context and needs.

2. Elements of a Good Complete Streets Policy

A good complete streets policy:

- Specifies that 'all users' includes pedestrians, bicyclists, transit vehicles and users, and motorists, of all ages and abilities.
- Aims to create a comprehensive, integrated, connected network.
- Recognizes the need for flexibility: that all streets are different and user needs will be balanced.
- Is adoptable by all agencies to cover all roads.
- Applies to both new and retrofit projects, including design, planning, maintenance, and operations, for the entire right of way.
- Makes any exceptions specific and sets a clear procedure that requires high-level approval of exceptions.
- Directs the use of the latest and best design standards.
- Directs that complete streets solutions fit in with context of the community.
- Establishes performance standards with measurable outcomes.

2.5 Implementation

An effective complete streets policy should prompt transportation agencies to:

- Restructure their procedures to accommodate all users on every project.
- Re-write their design manuals to encompass the safety of all users.
- Re-train planners and engineers in balancing the needs of diverse users.

- Create new data collection procedures to track how well the streets are serving all users.

Sample Policies
Many Thunderhead leaders and agencies have asked for sample complete streets policy language. Such samples are difficult to craft, as every jurisdiction has unique needs. A solid complete streets policy should:

a. require accommodation as a routine part of all road design,
b. set a clear procedure for specific exceptions that requires formal, high-level approval, and
c. direct agencies to use the best available design standards and guidelines.

For more details, see "Elements of a Complete Streets Policy" (above and on the complete streets web site). Links to a variety of existing policies can be found in the appendices of this Guide and on the complete streets website; finding a policy close by can be an effective starting point. Also see the Complete Streets Policy Checklist (Appendix F).

Starting with the US DOT Design Guidance
Since 2000, most of the strong complete streets policies have been modeled after the USDOT Design Guidance: Accommodating Bicycle and Pedestrian Travel (see Appendix E, Example 1) which includes a solid policy statement that can, and has been, adapted for a number of different formats and holds credibility with transportation agencies. Here are some ways it can be improved upon.

- Add a compelling case statement at the top. See Appendix E, Example 2, the introductory text to the MORPC Bicycle and Pedestrian Planning Policy. We suggest using the phrase 'complete streets' instead of 'routine accommodation.'

- Make sure you use stronger "shall be established" or "shall be included" language. Do not allow your agency, as some have done, to borrow the weaker points and very weak "consider" language from TEA-21.

- Look at eliminating a specific percentage for excessive cost, or specify that the percentage covers the entire project, as opposed to a single road segment. The 20 percent, oft-used figure for excessive cost has been disputed in some cases.

- Elevate two important points that are somewhat buried in item 4 of the USDOT Design Guidance:
  - that 'scarcity of need' should be considered in terms of future, rather than current use, and

- that exceptions should be approved at 'a senior level' and build on this by requiring the agency to justify not accommodating bicyclists and pedestrians through a detailed process.

- Add language to clarify the need to accommodate transit vehicles, transit users, as well as people with disabilities. To date, only a few policies include transit, and none follow the format of the Design Guidance.

- Consider adding language on measurement of progress toward creating complete streets.

Thunderhead leaders who are looking for a more general resolution on complete streets may want to consider the South Carolina Department of Transportation Commission's resolution (Appendix E, Example 3).

> Our RECOMMENDATION is that you strengthen your organization by using complete streets to build coalitions with natural allies: public health groups, smart growth groups, transit groups, children or senior advocacy groups. See Chapters 4 and 5.

Opposition: Seven respondents in the survey indicated public resistance, including landowner resistance to wider right-of-ways, worries about costs, and concerns about safety or appropriateness of accommodation. The most organized public resistance appears to be in Santa Barbara, where their circulation element, in place since 1995, has inspired a website called Cars are Basic: http://www.silcom.com/~cab/cab.htm.

Some respondents mentioned resistance from specific groups, including from within the DOT, from the local congestion management association (which saw the move as competing for funds), and from the development industry (in those cases where the developers are responsible for providing the roads).

A few sample comments from the survey:

> *People from our Board and Transportation Advisory Committee, in particular, county engineers, were leery. They insist we need a map with lines on it so they know where they* really *have to put facilities. At this time, NOACA doesn't have such a map and the BAC met recently to consider the idea and rejected it as inconsistent with our policy*. (Cleveland MPO)
>
> *Opponents have argued that Florida DOT implementation is wasteful (i.e., that bicycle lanes are underused, relative to cost) or is unsafe -- many members of the public feel that cyclists are more appropriately accommodated on separated paths. (Florida)*
>
> *There is a fear that bike lanes would invite children and inappropriate users to particularly busy roads.* (Illinois)

The good news is that in many cases the policies are not opposed, but may be resisted by planners or engineers mainly because they are not quite sure how to go about it. In South Carolina, initial resistance softened as the engineers applied themselves to the task of figuring out *how* to make accommodation. Thunderhead leaders can address this issue early by providing agency officials with options for training; contact the Association of Bicycle and Pedestrian Professionals for more information about consultants who can provide such assistance.

Our RECOMMENDATION is to be alert to the concerns of opponents in your early outreach efforts, and when possible find ways to directly address their concerns. See "Element 3 – Gauge Your Resources" in Chapter 4 for advice on opposition.

Keys to Policy adoption success: The survey asked Thunderhead leaders to summarize the roots of successful policy adoption in three key points. A few of their answers:

1. *Supportive, sympathetic staff at MPO.*
2. *Adoption of routine accommodation at rival MPO in northeast Ohio in fall of 2003, challenging leadership position of our MPO.*
3. *Threat to federal funding for local transportation projects if they do not adopt routine accommodation policy.*(Columbus Ohio MPO)

1. *Strong grass-roots support.*
2. *Constantly positive image in the media (we never engaged in public criticism of anyone).*
3. *Working the media.(*Columbia MO)

1. *Existence of DD64 [California statewide policy].*
2. *Supportive MTC [MPO] chairman who is a friend.*
3. *MTC prides itself on being progressive.* (CA Bay Area MPO)

In a broader sense, Thunderhead leaders should also see complete streets as just one part of making communities better for bicycling and walking. Much of what encourages people to walk, bicycle and use transit are the variety of destinations within a reasonable distance. Without land-use changes, sprawl will continue to erode the ability to walk and bicycle. Complete streets are a part of this mix because they are a way to make common cause with other organizations working for healthier communities that offer residents more choices and better access.

CHAPTER 3 - Implementation

Complete Streets Implementation Issues

Once a policy has been adopted, the hard work begins: effective implementation. A few of the policies identified in this Guide are no more than 'paper polices.' They hold promise, but little or nothing has been done to implement them and integrate new

practices into agency procedures. In some cases, few people even seem to know about them. See the detailed table in Chapter 2 for a list of these policies.

Your complete streets policy campaign will initially target a specific public policy decision by the legislature or the transportation agency. It is important however that throughout the campaign you keep your eye on your ultimate goal – major changes in the way all transportation decision-making is done to achieve a balanced multi-modal outcome.

For most transportation agencies, fully implementing complete streets will mean a fundamental shift in previous procedures and assumptions. Most agencies have focused on maximizing automobile throughput, and many engineers are trained primarily to achieve this goal. A shift that requires a broad assessment of the needs of all road users does not fit easily into this paradigm.

As with any bureaucracy, a transportation agency can have systemic inertia that is comprised of individual attitudes, long-standing habits and procedures, incomplete technical knowledge, and entrenched relationships. Any broad policy change at the top will travel a long road with many smaller policy and procedural changes along the way. The motivation of the leadership of the agency to implement this policy is going to make a big difference. The way the initial policy came about will also make a big difference. If a complete streets policy was forced on a recalcitrant agency, the battle for implementation will probably be long. If the legislative or policy campaign was used to get agency officials to see value in the policy, implementation will probably be easier.

In the survey, respondents identified a number of barriers to implementation. Some said agency implementers were not aware of the policies or could not agree on what they mean. Some said no steps were established to move toward implementation, including a failure to choose or create design standards. A couple of respondents noted the difficulty of increasing the width of a right-of-way, particularly in infill areas. Other implementation issues included a failure to include facilities in initial budgets, a lack of MPO input into design, and a resistance of the state DOT in working with a local jurisdiction. Some respondents in areas with a policy directed at new development noted that it is difficult to ensure that development agreements for specific projects include complete streets, since governments are often reluctant to make such requirements of developers (note that even when such requirements come in to existence, many developers will then work hard at seeking exceptions). Thunderhead leaders also mentioned a simple lack of resolve or a bias against bike lanes as implementation barriers, while some staff respondents cited resident resistance to the changes, particularly those that increased road width.

When creating your Complete the Streets campaign, consider implementation part of the campaign. Chapter 2 reviewed some of the barriers to implementing existing complete streets policies. They range from the avoidance of turning a policy document into effective procedures, to the misconceptions of costs, to standard agency resistance. Some agency implementers will claim that they are not aware of the policies or that there is no

agreement on what the policies mean. In this chapter, we will focus on working with your agency to set up an effective implementation procedure.

Keep in mind that even once the policy and procedures are in place, your organization will likely find itself fighting some familiar battles over transportation projects. It might help to think of a solid complete streets policy not as the complete solution, but as an important step in your advocacy. How can you make that tool most effective?

From Policy to Procedure
An effective, well-designed complete streets policy should prompt the following internal agency changes.

- Restructuring procedures to favor multi-modal planning.
- Re-writing design manuals.
- Retraining planners and engineers.
- Re-tooling measures to track outcomes (there is the possibility that they may not be tracking any outcomes now).

> Our RECOMMENDATION is that you simply understand that there will be some barriers. You will need to stay involved, even help, in the initial implementation stages and then check back periodically.

Your influence over this internal process may be formal, through an advisory committee, or informal, through your relationships with agency staff. Respect the agency's process and try to position yourself as a resource. You may be able to increase the credibility of your suggestions by referring to experience at other agencies and the recommendations made in the USDOT Design Guidance.

Your ongoing relationship with the legislators and elected officials that led to the initial policy change is a key to your influence on the agency. You will build respect and influence if you are seen as the one who communicates progress, or lack of progress, back to the people that they are accountable to.

Your strong relationship with and handling of the media also impacts your influence on an agency and with legislators and elected officials.

Restructuring procedures: Some agencies will see an opportunity in a complete streets policy to take a whole new approach to transportation planning, moving away from the traditional focus on volume-to-capacity ratios and Level of Service determinations. For example, Charlotte, North Carolina, in an effort to turn their paper policy into a model is instituting a new six-step planning process that begins by establishing the land use and transportation context of the project, identifying gaps and deficiencies in the network for all users, and then engaging in a clear process to meet the challenge of balancing the needs of all users. Boulder, Colorado has also developed a planning process to conduct an

initial evaluation of the needs of *all* users. Thunderhead leaders can make agencies aware of these opportunities to create fundamental change.

Other agencies will prefer to look for ways to adjust their existing procedures to remind them to take other users into account when working on projects. They may create checklists or similar tools.

Agencies must also establish a formal procedure for handling any exceptions that may have been included in the policy. This procedure must include high-level sign-off on a compliance document (as stated in the USDOT Design Guidance).

Re-writing design manuals: Note that the USDOT Guidance encourages a re-write of the *primary* design manual, and it suggests that the creation of separate bicycle-pedestrian manuals is only an interim step. A number of jurisdictions have created new design manuals that your agency can use as a model. The Transportation and Air Quality Collaborative in Sacramento, California is notable for developing 'best practices' guides for bicycles, pedestrians, transit – and a separate 'complete streets' best practices guide for putting them all together.

Training: The USDOT Design Guidance recommends "intensive re-tooling and re-training of transportation planners and engineers with the new information required to accommodate bicyclists and pedestrians." Training has already been a valuable outcome of existing policies. For example, California's Deputy Directive 64 inspired a series of trainings for engineers and the Palmetto Cycling Coalition is working with the League of American Bicyclists to plan trainings for South Carolina DOT personnel. You can help your agency connect with a number of organizations and consultants that offer bicycle and pedestrian training courses. Thunderhead organizations can also offer assistance by helping organize trainings (make sure to charge market rate consulting fees) to educate agency employees on implementation issues.

You may also simply need to push the agency to publicize the new policy.

New outcome measures: The best way to test these policies would be to look at what is happening on the ground. However, the most common answers to questions about outcomes in the survey were that it is just too soon to tell if the policies have succeeded, or that no records were being kept. Disappointingly, few localities are collecting any information about outcomes, whether you define those outcomes in terms of roads 'completed,' increases in walking or bicycling, or decreases in crashes. Even in exemplary Oregon, statistics are few at the state level. Bicycle and Pedestrian Program Manager, Michael Ronkin, observed that the state experienced a slight decline in bike/ped commuting from 1990 to 2000, but less than the rest of country; and that crashes are lower than other Western states. He also observed that statistics are extraordinarily difficult to keep. Thunderhead's Benchmarking Project that gathers and compares bicycling and walking data sets from across the country is designed to be a valuable tool in assessing the effectiveness of these policies. This is the only such measurement project that strictly adheres to government endorsed data sets that are uniform across all states.

For more information on Thunderhead's Benchmarking Project see: www.thunderheadalliance.org/benchmarking.htm .

An evaluation of the actual effectiveness of the policies included in the survey has not yet occurred. More investigation is needed on the impact of these policies and how to make them work. Thunderhead leaders indicated that even if their policy was not well implemented, it provides additional leverage in advocacy efforts. For example:

> *Internal [CalTrans] allies have seized momentum created by DD-64 to institute a series of bike/ped design trainings for DOT planners and designers. (*California)

> While few of the current complete streets policies have any sort of metrics, our RECOMMENDATION is that you try to get them included in yours. A very important element of future campaigns will be to include progress indicators or outcome measures, especially those that will easily plug into Thunderhead's Benchmarking Project.

Very few existing policies make any serious attempt to measure new outcomes from the transportation planning process. In fact, most don't even require measuring such conventional outcomes as crash statistics. However, we need these types of measures to document change and to create accountability. Here are a few brief suggestions:

- A new measurement system has been developed in Florida, where planners are using multi-modal level of service (LOS) to measure system quality. Details can be found at www.dot.state.fl.us/planning/systems/sm/los/default.htm.

- A National Highway Cooperative Research Program project on multi-modal LOS is due out March 2005. For details, please see www4.trb.org/trb/crp.nsf/All+Projects/NCHRP+3-70.

- However, don't think that a measurement has to be complex. The Thunderhead Benchmarking Project compares basic statistics about the bicycling, walking, and health environment and will serve as a national measuring tool for all complete streets policies. The League of American Bicyclists' Bicycle-Friendly Communities program also asks for basic statistics.

- Another approach is to create performance goals oriented to the end user, such as, "Can every child safely walk or bicycle from their home to the neighborhood school?"

Staying in close contact while the agency is setting up procedures could make the difference between a good policy, and one that does little to change the status quo. Be sure you have energy, time and resources ready for this stage.

Thunderhead leaders can influence the internal implementation process through a formal advisory committee, or through informal relationships with agency staff. Thunderhead leaders who respect the agency's process can position themselves as a resource, helping bring agency officials' attention to the growing number of documents available to help them implement complete streets.

Making Change on the Ground

Once procedures have been set, the next step is seeing the policy in practice. Continued challenges mentioned by survey respondents included budget issues in regards to projects already underway, right of way acquisition (or lack thereof, also regarding projects underway), public opposition, and tension between different agencies.

As a relatively new concept, we are still learning how to ensure that complete streets policies operate 100% effectively. And unfortunately at this point, little can be learned from the limited number of jurisdictions with policies as few of them are making any meaningful attempts to measure their success. As Complete the Streets campaigns mature, Thunderhead leaders will play a vital role providing important insight on what does work to move complete streets policies from paper to pavement, and what does not.

More implementation ideas can be found in some of the complete streets policies listed in Appendix D.

CHAPTER 4 - Campaigns
(blueprint for success)

Introduction

While this Guide focuses on complete streets campaigns, this chapter provides a blueprint for crafting and winning any kind of bicycle and/or pedestrian advocacy campaign. In each of seven basic elements of successful campaigns, this chapter will provide some core principles of effective campaigning to help you make the right choices at the right time — the heart and art of strategic campaigning.

Thunderhead Alliance Campaign Planning Blueprint

Successful campaigns are well thought out in advance and organized around a clear message and specific goal. Thunderhead's Seven Elements of Successful Campaigns are the basis of our proven Thunderhead Training Curriculum and will help you "keep your eyes on the prize."

1. Issue Focus: Selection and Definition
2. Organizational and Campaign Goals (Short-, Medium-, and Long-term)
3. Resource Assessment
4. Strategic Targets
5. Communication

6. Tactics & Timelines
7. Budget and Fundraising Resources

(This Chapter includes in depth analysis of successful campaigns and step-by-step guidance on how you can develop your own successful campaign. Make sure to get the full Guide before starting. You can also contact Thunderhead for specific materials you need. Please also check our Trainings page: http://www.thunderheadalliance.org/trainings.htm and register for a Thunderhead Training where you will be guided through this process with our expert coaches as you work with leaders of Thunderhead organizations from across the country.)

CHAPTER 5 - Communications (a toolkit)

Introduction

Complete streets is more than just a new name for what was once referred to as routine accommodation. The phrase is useful not just as a description of a policy, but also as an independent communications tool. This phrase is active, flexible, and imbeds a fundamental message we want to send: that streets are not complete until they are safe and convenient for travel by foot or bicycle, as well as for transit users, people with disabilities, and people in automobiles. A street without such safe passage is by default 'incomplete.' This puts us a step ahead of opponents who would like to characterize complete streets policies as mandates that are an "expensive special" accommodation. Since most Americans walk, and many bicycle, use transit, or have disabilities, this is an important reframing of the way we view the road network.

Even if you are not actively pursuing a specific complete streets policy, using the term can advance bicycle and pedestrian advocacy. This chapter is designed to help you do that.

The Cost Misconception: A common misconception is that complete streets cost more to build than incomplete streets. In fact, complete streets most often cost no more and many times can cost less than incomplete streets. For instance, a common street cross section that serves only cars is a four lane speedway with no shoulders, sidewalks or intersection treatments for people. Using the same right-of-way width, this design can be reshaped into two narrower through lanes, one center turn lane, and bike lanes and sidewalks on both sides. By using less width for the most expense elements, truck weight standard asphalt and subsurface, and adding less expensive sidewalks, this design, often referred to as a "road diet" when applied to existing roads, actually saves money. Not only that, this design has been proven to improve traffic flow and safety for motor vehicles by better controlling turning movements. Many other complete streets designs offer similar cost savings. You may even want to bring up the economic benefits of streets that attract visitors and offer access to more employees. Be sure to address this misconception early in your campaign so that you can focus your valuable time on instituting a policy for your communities.

When you are discussing bicycle and pedestrian friendly changes with decision makers, talk about remolding the same street materials into complete streets. Consider writing an article for your newsletter explaining the idea to your members, or updating your website. Use the term when speaking with reporters, in written testimony, and in meetings and conversations. In short, you will play a vital role in helping us propagate this term by using it whenever you can. We need this phrase to become the shorthand for our nation's transportation network that truly welcomes people on foot and bicycle.

This complete streets communications toolkit includes four components.

1. The basics for using complete streets.
2. Using complete streets in everyday communications.
3. The complete streets response to a cyclist or pedestrian death or injury.
4. Using complete streets to build coalitions.

The Basics for Using Complete Streets

The term complete streets is a description of streets that have been built for safe and convenient travel by all road users. It also describes policies that call for routinely providing for all modes when building and reconstructing streets. While the principle will most often be invoked for better walking and bicycling, complete streets should also provide safe and convenient transit access and provisions for people with disabilities. Making common cause with these users is an important element in promoting complete streets policies.

Note that complete streets is not capitalized in general use. The phrase is not proprietary and we wanted to discourage any trend toward a narrow definition of the ultimate 'Complete Street.'

A *campaign* to institute a complete streets policy can have a more formal name: Complete the Streets. Complete streets was initially coined by America Bikes in 2004 as part of the campaign to reauthorize the federal transportation law, and this campaign used the following two taglines:

- Complete the Streets - for safer bicycling and walkable communities.
- Complete the Streets - for safer bicycling and walking.

You can use these tags, but feel free to follow Complete the Streets with other secondary phrases. Already one organization has modified it for their campaign's name to include the health message: "Complete the Streets for Active Communities." You will want to choose one phrase and stick to it. Consistency is vital in good communications work.

The National Complete Streets Coalition, a collaborative of organizations working towards complete streets including the Thunderhead Alliance, has created some tools for those interested in advancing the complete streets cause. Many resources and a customizable PowerPoint presentation explaining the principle are available on the coalition's website www.completestreets.org

Using Complete Streets in Everyday Communications
You need to begin the complete streets transformation right away. Start by updating your existing communications. Then use it in new communications. Get your allies to start using complete streets; and have resources available for others to use.

Adjust your current communications: If you've been using the term 'routine accommodation' simply replace it with 'complete streets' in your communication materials. Look at:

- policy statements,
- brochures describing your organizational goals,
- newsletter articles, and
- website.

While you may have become comfortable using 'routine accommodation,' try your best to eliminate it in all of your communication materials. It does not resonate with decision makers or the general public like complete streets does.

Look for new places to use the phrase: Next, you need to seek out those materials and situations where you can promulgate complete streets. Think of things like:

- letters to the editor, and
- public hearing testimony.

Here is an example:

> *"If there is inequity in the transportation system, it lies in the fact that we as Americans fail to complete our streets for safer bicycling and walking." (letter to the editor, Asbury Park Press, by John Boyle, Bicycle Coalition of Greater Philadelphia 1/22/04)*

Ask your allies to use it: You have allies who want you, and our bicycle and pedestrian issues, to succeed. Asking them to use complete streets in their meetings, memos and discussions is a direct opportunity and easy way that they can help. Ask allies like:

- bicycle/pedestrian planners,
- MPO officials,
- elected officials,
- smart growth advocates, and
- safety advocates.

Disseminate complete streets resources: You can also put some of your organization's resources to work highlighting the principle. Consider:

- adding a link on your web site to Thunderhead's National Complete the Streets Campaign web page: www.thunderheadalliance.org/completestreets.htm as well as one for the coalition: www.completestreets.org
- presenting or posting to your website the complete streets PowerPoint (with updated, local images and information),

- creating a brochure or webpage about complete streets for your communities, and
- collecting photos of complete streets and streets needing to be completed in your community.

Avoiding pitfalls: In your communications work, don't get bogged down trying to do the job of an engineer or planner. Stay focused on communicating the principle of complete streets. Complete streets policies are by necessity flexible and do not prescribe a single type of accommodation.

If reporters or officials try to pin you down about whether a complete streets policy will result in a specific type of facility, defer to the expertise of planners and engineers and focus on achieving the *outcome* of complete streets. Say to them, for example:

> *"I'm not sure what the best answer is for Smith Street, but I know the engineers and planners can come up with a solution that makes sure this important roadway is a complete street with safe provisions for people on foot and bicycle."*

Be careful not to use complete streets to describe "poser" policies that leave so much wiggle room that they become meaningless, or that restrict accommodation only to roads in a bicycle or pedestrian plan. If you believe your complete streets policy is a strong policy, focus on how the policy will result in change on the ground.

APPENDIX E

Policy Examples

Example 1: United States Department of Transportation Design Guidance (Accommodating Bicycle and Pedestrian Travel)

1. Bicycle and pedestrian ways shall be established in new construction and reconstruction projects in all urbanized areas unless one or more of three conditions are met:
   - Bicyclists and pedestrians are prohibited by law from using the roadway. In this instance, a greater effort may be necessary to accommodate bicyclists and pedestrians elsewhere within the right of way or within the same transportation corridor.
   - The cost of establishing bikeways or walkways would be excessively disproportionate to the need or probable use. Excessively disproportionate is defined as exceeding twenty percent of the cost of the larger transportation project.
   - Where scarcity of population or other factors indicate an absence of need. For example, the Portland Pedestrian Guide requires "all construction of new public streets" to include sidewalk improvements on both sides, unless the street is a cul-de-sac with four or fewer dwellings or the street has severe topographic or natural resource constraints.

2. In rural areas, paved shoulders should be included in all new construction and reconstruction projects on roadways used by more than 1,000 vehicles per day, as in States such as Wisconsin. Paved shoulders have safety and operational advantages for all road users in addition to providing a place for bicyclists and pedestrians to operate.

   Rumble strips are not recommended where shoulders are used by bicyclists unless there is a minimum clear path of four feet in which a bicycle may safely operate.

3. Sidewalks, shared use paths, street crossings (including over- and undercrossings), pedestrian signals, signs, street furniture, transit stops and facilities, and all connecting pathways shall be designed, constructed, operated and maintained so that all pedestrians, including people with disabilities, can travel safely and independently.

4. The design and development of the transportation infrastructure shall improve conditions for bicycling and walking through the following additional steps:
   - Planning projects for the long-term. Transportation facilities are long-term investments that remain in place for many years. The design and construction of new facilities that meet the criteria in item 1) above should anticipate likely future demand for bicycling and walking

facilities and not preclude the provision of future improvements. For example, a bridge that is likely to remain in place for 50 years, might be built with sufficient width for safe bicycle and pedestrian use in anticipation that facilities will be available at either end of the bridge even if that is not currently the case.

- Addressing the need for bicyclists and pedestrians to cross corridors as well as travel along them. Even where bicyclists and pedestrians may not commonly use a particular travel corridor that is being improved or constructed, they will likely need to be able to cross that corridor safely and conveniently. Therefore, the design of intersections and interchanges shall accommodate bicyclists and pedestrians in a manner that is safe, accessible and convenient.
- Getting exceptions approved at a senior level. Exceptions for the non-inclusion of bikeways and walkways shall be approved by a senior manager and be documented with supporting data that indicates the basis for the decision.
- Designing facilities to the best currently available standards and guidelines. The design of facilities for bicyclists and pedestrians should follow design guidelines and standards that are commonly used, such as the AASHTO Guide for the Development of Bicycle Facilities, AASHTO's A Policy on Geometric Design of Highways and Streets, and the ITE recommended practice Design and Safety of Pedestrian Facilities.

Example 2: Mid-Ohio Regional Planning Commission Policy (Bicycle and Pedestrian Planning Policy, introductory section)

Many state, county and local jurisdictions are beginning to recognize the value and the need of routinely providing facilities for pedestrians or bicyclists. The inclusion of facilities in the early planning phases of new highway construction and residential and commercial development reduces the complexity and costs of attempting to retrofit years later. Mid-Ohio Regional Planning Commission (MORPC) encourages and supports those communities that have taken the step toward routinely accommodating pedestrians and bicyclists in the planning process. To others, MORPC encourages and supports the inclusion of routine accommodation by providing the following policy.

Project sponsors are required to accommodate bicycles and pedestrians in the planning and design of all proposed transportation projects using MORPC-attributable federal funds. Sponsors using local, state, or other federal funds are encouraged to accommodate bicycles and pedestrians in the planning and design of all proposed transportation projects. All transportation facilities on which bicyclists and pedestrians are permitted by law, including but not limited to streets, roads, highways, bridges, buses, trains, transit stops and facilities, and all connecting pathways shall be designed, constructed, operated and maintained so that all modes and pedestrians, including people with disabilities, can travel safely and independently.

Example 3: South Carolina Department of Transportation, Transportation Commission Resolution (on bicycling and walking)

RESOLUTION

WHEREAS, increasing walking and bicycling offers the potential for cleaner air, greater health of the population, reduced traffic congestion, more livable communities, less reliance on fossil fuels and their foreign supply sources and more efficient use of road space and resources; and

WHEREAS, in 2001 crashes involving bicyclists and pedestrians represented 13 percent of the traffic fatalities in S.C. and in the U.S.; and

WHEREAS, the Federal Highway Administration (FHWA) in its February 24, 1999 Policy statement "Guidance on the Bicycle and Pedestrian Provisions of the Federal-Aid Program" urges states to include bicycle and pedestrian accommodations routinely in their programmed highway projects; and

WHEREAS, bicycle and pedestrian projects and programs are eligible for funding from almost all of the major Federal-aid funding programs; and

WHEREAS, the South Carolina Department of Transportation Commission is strongly committed to improving conditions for walking and bicycling; and

WHEREAS, the Transportation Equity Act for the 21st Century (TEA-21) calls for the mainstreaming of bicycle and pedestrian projects into the planning, design and operation of our Nation's transportation system;

NOW, THEREFORE, BE IT RESOLVED that the South Carolina Department of Transportation Commission in meeting duly assembled this 14th day of January 2003, affirms that bicycling and walking accommodations should be a routine part of the department's planning, design, construction and operating activities, and will be included in the everyday operations of our transportation system; and

THEREFORE, BE IT FURTHER RESOLVED, that the South Carolina Department of Transportation Commission requires South Carolina counties and municipalities to make bicycling and pedestrian improvements an integral part of their transportation planning and programming where State or Federal Highway funding is utilized.

L. Morgan Martin, Chairman

Robert W. Harrell, First Congressional District

John N. Hardee, Second Congressional District

Eugene C. Stoddard, Third Congressional District

H. Howell Clyborne, Jr., Fourth Congressional District

B. Bayles Mack, Fifth Congressional District

John M. "Moot" Truluck, Sixth Congressional District

APPENDIX F

Complete Streets Policy Checklist

Pre-screen: Does the policy *require* that road projects be designed to accommodate all users? *If not, it does not qualify as a complete streets policy.*

☐ **1. Policy intent:**
Is the policy part of a broader goal of providing a complete transportation network for all modes such as through the current strategic plan, transportation system upgrades, new administration's goals, etc.?

2. Policy Coverage:
☐ **2a.** Does the policy cover motorists, bicyclists, pedestrians, transit users, and disabled users?

☐ **2b.** Does the policy cover:
-all roads, regardless of responsible agency? (best)
OR:
-roads managed by single agency or roads seeking a specific funding source?
AND/OR:
-roads installed by private developers?

☐ **2c.** Does the policy cover:
Construction? Reconstruction? Widenings? Other improvements? Repaving? Bridges? Stand-alone retrofit projects?

☐ **3. Policy requirements** (beyond pre-screen requirement above)**:**
When projects do not meet this standard, is there a formal process for approval of clearly stated exceptions placing the burden of proof on not accommodating all users?

☐ **4.** Does the policy direct the use of the latest and best design standards?

☐ **5.** Does the policy set performance standards?

☐ **6.** Does the policy including a funding mechanism?

☐ **7. Implementation**
Has the policy resulted in:
-restructured procedures?
-re-written design manuals or cross-sections?
-sessions for training planners and engineers?
-new data collection procedures?
-the creation of complete streets?

Complete Streets

In the last decade transportation planners and urban designers have made a significant shift in their approach to the design and intended function of streets. Conventional transportation planning was concerned primarily with the safe and efficient movement of cars. Today many transportation planners are working with land-use experts and urban designers to create what have been termed "complete streets."

WHAT ARE COMPLETE STREETS?

A complete street is a safe, accessible, and convenient street for all users regardless of transportation mode, age, or physical ability. Complete streets adequately provide for bicyclists, pedestrians, transit riders, and motorists. Complete streets promote healthy communities and reductions in traffic congestion by offering viable alternatives to driving.

Democratizing the Streets. Because streets and roads are the largest component of public space in every city, they should benefit the entire community. Improved design, a redefinition of function, and physical reorganization are the ways to achieve these benefits. Jurisdictions that adopt complete streets policies aim to create a comprehensive and integrated local and regional transportation network for all travel modes—driving, walking, and cycling.

Policy Considerations. Creating complete streets may mean changing the policies and practices of transportation agencies. Advocates argue that it will take new training, new procedures, and design manual changes to accommodate bicycling, walking, and transit to an equal degree with motor vehicles.

Different Approaches. The principle behind complete streets policy is that multimodal corridors should become the default design mode for streets—and a formal exception process must be followed when they are not. Many existing policies are based on the U.S. Department of Transportation's

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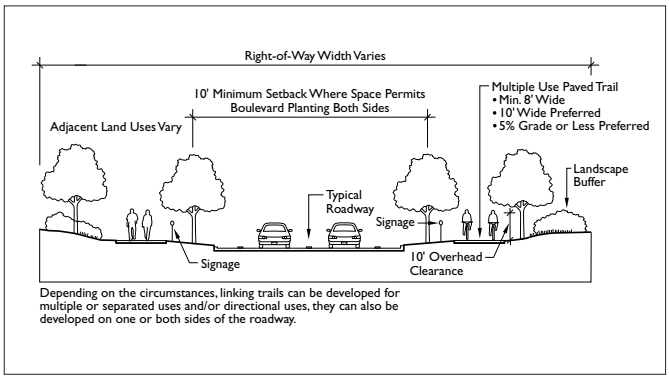
design guidance for Accommodating Bicycle and Pedestrian Travel: A Recommended Approach, which names only three exceptions where roads can lack facilities for all users: (1) excessive cost, (2) absence of need, and (3) roads where bicyclists and pedestrians are prohibited. More comprehensive policies include accommodation for people with disabilities and for transit vehicles and users.

COMPLETE STREETS DESIGN CONSIDERATIONS

Skinny Streets. Skinny, or narrow, streets complement complete streets policies. Narrower traffic lanes result in slower travel speeds that translate into safer, more accessible, and more pleasant thoroughfares for all users. A physical narrowing of the actual street may be unnecessary because on-street parking can also visually narrow the thoroughfare for drivers.

Street Connectivity. Street connectivity—meaning the directness and length of the street blocks and the density of connections within a street system— influences the accessibility of destinations in a community and holds important implications for modal choice. Complete streets in areas with higher levels of street connectivity will produce greater overall accessibility for all travelers, regardless of the mode they choose.

Context-Sensitive Streets. All streets are not alike. Streets in industrial areas have a much different character than streets in residential, commercial, and mixed use districts. Traffic engineers and urban designers are beginning to combine the functional classification of streets with their adjacent land uses to yield a more comprehensive array of street types. This approach takes into account land uses adjacent to the street and recommends five basic classes of street design: commercial streets,



Linking trails emphasize safe travel for pedestrians to and from parks and around the community.

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(Continued on back.)

mixed use streets, main streets, residential streets, and industrial streets. Streets in each class can be designed as complete streets.

Complete Streetscape Design Elements. Undertaking major construction projects to achieve complete streets is not always necessary. In fact, small projects can have a large impact. Examples include raised medians, pedestrian refuge islands within medians, bicycle lanes, bus pullouts, transit shelters, and street furniture.

www.pedbikeimages.org / ITE Pedestrian Bicycle Council

Multimodal streets like this one improve access and safety for drivers, pedestrians and cyclists.

COMPLETE STREETS ARE FOR EVERYONE

Pedestrian Safety. Communities with complete streets policies protect travelers from cars. Walkways should provide secure footing, pedestrian pathways should be clearly indicated, and signaling must consider the rights of all users of the road. Designing the street with pedestrians in mind—sidewalks, raised medians, better bus stop placement, traffic-calming measures—all improve pedestrian safety. One study found that designing for pedestrian travel by installing raised medians and redesigning intersections and sidewalks reduced pedestrian risk by 28 percent.

Public Health. Public health officials are calling for Americans to increase their physical activity. Officials argue that increased walking and bicycling will help to combat the current obesity epidemic. A 2002 report issued by the National Conference of State Legislators noted that the most effective policy for encouraging bicycling and walking is complete streets.

Vulnerable Populations. Truly complete streets go beyond accommodating bicycling and walking to consider children, the elderly, and people with a disability. More often than not, the elderly and people with disabilities rely on the pedestrian and transit infrastructure for access and mobility. Complete streets policies make it possible for vulnerable populations to better use transportation systems by equipping streets with the necessary infrastructure, including curb ramps, textured and varied pavement, audible crossing signals, countdown signals, and high-visibility crosswalks.

www.pedbikeimages.org / ITE Pedestrian Bicycle Council

Multimodal streets like this one improve access and safety for drivers, pedestrians and cyclists.

DEVELOPING WITH COMPLETE STREETS

Economic Development. Streets create marketable value for abutting private property by providing access. Complete streets can increase the economic viability of a city district by improving access for more people, thus increasing the potential number of customers to businesses.

Transit-Oriented Development. Complete streets policies go hand in hand with transit-oriented development (TOD). Traffic-calming measures, streetscape improvements, and transit have successfully been combined to revitalize entire commercial districts. Both residential and commercial projects near transit typically appreciate in value more rapidly than other projects. In a TOD land uses and infrastructure are arranged to encourage and to facilitate the use of transit while accommodating a range of travel modes and purposes. Transition points where travelers transfer easily from one mode of transportation to another are key features of both complete streets and TODs.

Challenges. One challenge to complete streets implementation is a lack of right-of-way in cramped thoroughfares. Another is the misconception that complete streets cost more to build than "normal" streets when, in fact, complete streets most often cost no more and many times can cost less. Current methodologies for studying traffic pose another problem. Many contemporary traffic studies fail to consider how the presence of transit and decreases in automobile use associated with mixed use neighborhoods may lower trip generation rates. Communities should reevaluate traffic studies based on antiquated trip generation models. *Patrick C. Smith*

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NCHRP

REPORT 616

NATIONAL
COOPERATIVE
HIGHWAY
RESEARCH
PROGRAM

Multimodal Level of Service Analysis for Urban Streets

TRANSPORTATION RESEARCH BOARD
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NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

NCHRP REPORT 616

Multimodal Level of Service Analysis for Urban Streets

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CHAPTER 6

Transit LOS Model

6.1 Model Development

The Transit Capacity and Quality of Service Manual (TCQSM) provides a family of LOS models for dealing with several dimensions of transit service at different levels of geographic aggregation. The TCQSM is oriented to the entire service area, the entire route, or the bus stop. It was necessary to extract a subset of these quality-of-service measures that were most appropriate for a single urban street. The urban street is at a level of aggregation that is greater than the bus stop level and incorporates multiple routes using the street, but it covers just the portion of the routes that actually use the street. Thus a different geographic focus was necessary in the development of the Urban Street transit level of service model.

Transit riders were surveyed on portions of routes using a specific urban street to determine what factors most significantly influenced their perceived quality of service. It was quickly discovered that passengers were basing their LOS ratings on their entire trip experience up to that point and not just the portion of their trip on a specific urban street. In addition, an on-board survey can survey only those that eventually chose to ride transit; it cannot take into account the opinions of those who chose not to ride that bus or selected a different route. Consequently, the surveys were used to identify the key factors influencing perceptions of quality of service, but LOS models were not fitted to the on-board survey levels of service.

An alternative source of data on traveler preferences was necessary to construct an urban street level of service model for transit. The working hypothesis of the research team was that "people vote with their feet." When confronted with a choice, people will pick the service that gives them more of what they value, in our case, quality of service. Thus, standard models of transit mode choice were consulted to identify the relationships between various service characteristics and the likely proportional increase in ridership.

LOS E was set for a hypothetical, base transit service on an urban street. A mode choice model would then be used to compare the ridership for the actual transit service to that for the hypothetical base case. An increase in ridership over the hypothetical base case would be interpreted as an indication of a preference for the actual service over the base case. The actual service would be assigned a level of service superior to E. Similarly, lesser ridership would be interpreted as an indication of poorer quality of service and would be assigned a level of service inferior to E.

The application of mode choice models at the urban street level was considered impractical, so mode choice models were replaced with elasticities derived from typical mode choice models. The elasticities predict the percent increase in ridership as a function of percent change in the transit service characteristics.

Selection of Explanatory Variables for LOS

The Phase 1 surveys asked passengers to rate their satisfaction with 17 specific aspects of their trip. A multiple linear regression model was developed that related individual factor ratings to the overall satisfaction rating. The factors that added significance to the model were

- Close to home rating;
- Close to destination rating;
- Frequency rating;
- Reliability rating;
- Driver friendliness rating;
- Seat availability rating; and
- Travel time rating.

Of these factors, "close to home" and "close to destination" relate to getting to the stop, "frequency" and "reliability" relate to waiting at the stop, and "driver friendliness," "seat availability," and "travel time" relate to the ride on the bus.

Other considerations also had to be taken into account during this factor selection process:

1. The factors included in the model should be under the control of either the transit operator or the roadway owner;
2. To the extent possible and warranted, the factors as a whole should reflect the influence of other modes on transit quality of service;
3. The factors should be readily measurable in the field;
4. The factors should reflect conditions existing within the urban street right-of-way; and
5. The factors should have a documented impact on some aspect of customer satisfaction.

Based on these criteria, "driver friendliness" was dropped from consideration. Although partially under the control of the transit operator, this factor can only be measured through a customer satisfaction survey, which we felt made it impractical to include. In addition, we are not aware of any research relating different levels of driver friendliness to some measurable aspect of satisfaction (for example, increased ridership).

The factors "close to home" and "close to destination" generated considerable discussion among the project team. Walking distance to the stop depends on a number of factors beyond the urban street right-of-way, including land use patterns, street connectivity, transit route structure, stop locations, and sidewalk provision on connecting streets, which would tend to suggest not including these factors. At the same time, there are known relationships that describe how bus patronage declines the farther one has to walk to a stop.

One potential surrogate measure identified through initial statistical modeling is "number of stops per mile"—the more stops per mile, the shorter the distance passengers may have to walk to get to a stop once they reach the street with transit service. However, there are two potential difficulties with this measure. First, the more stops per mile, the slower the bus travel time. Travel time is already identified as a potential factor, so adding stops per mile to the model would be redundant. Second, long stop spacing may or may not be inconvenient to passengers, depending on how convenient the stops are to where passengers actually want to go. Without knowing something about adjacent land development patterns (which takes the analyst beyond the urban street right-of-way), it is hard to make a judgment about the impact of stop spacing on customer access.

Another potential surrogate measure would be the distance of the bus stop from the nearest intersection. This is something that may be influenced by the auto mode—for example, traffic engineers frequently do not want far-side bus stops located adjacent to intersections, in situations where buses must stop in the travel lane, because of the potential for cars to stop behind the bus and block the intersection. Moving the stop farther from the intersection increases walking distances for passengers arriving from three of the four directions at the intersection, which can be related to walking time. On the other hand, near-side/far-side stop location trade-offs can be evaluated through changes in travel speed, using methodologies found in the TCQSM.

A third potential surrogate, and the one recommended by the project team, is pedestrian LOS. Pedestrian LOS relates to the ease of access to and from destinations along the urban street, the quality of pedestrian facilities serving the bus stop, and the difficulty of crossing the street. It will be a part of the multimodal urban street LOS methodology; therefore, no additional data collection will be required. It is a measure of the impact of another mode on the transit mode and can be impacted by roadway agency actions. In short, it meets all of the criteria set out above.

The TCQSM provides an areawide measure, "service coverage," that addresses the "close to home" and "close to destination" factors. This measure accounts for land use patterns, street connectivity, and street-crossing difficulty, at the cost of requiring more data than is desirable for an urban street analysis.

The four remaining candidate factors are travel time, reliability, seat availability, and frequency. All are impacted by conditions on the urban street, or by transit or roadway agency actions. All are related to TCQSM measures, which is important from a consistency standpoint. The first three factors can be related to travel time, which addresses a panel request to consider travel speed in the transit LOS model. The key remaining question is: Do relationships exist between passenger satisfaction and different values of these factors?

The answer to this question appears to be "yes." Considerable research has been conducted on traveler ridership responses to changes in service frequency and travel time. (Both *TCRP Report 95: Traveler Response to System Changes,* and the Victoria Transport Policy Institute's *Online TDM Encyclopedia* provide extensive summaries of the literature pertaining to ridership responses to transit system changes.) For example, as bus headways decrease from 60 minutes to 30 minutes, from 30 minutes to 15 minutes, and so on, ridership increases, although in an ever-decreasing proportion to the amount of added service. All other things being equal, the relative amount of ridership one would expect at a given headway, compared to a 60-minute headway, is reflective of the difference in customer satisfaction between the two headways.

There is comparatively little research on the impacts of reliability and crowding on ridership. However, reliability can be converted to an "excess wait time"—the average additional amount of time one would wait for a bus as a result of non-uniform headways. The excess wait time can, in turn, be

converted into a perceived wait time, with an impact greater than the actual wait time [**98**]. Time spent standing or even seated in a crowded transit vehicle is also perceived by passengers as being more onerous than the actual travel time (See, for example, Balcombe [**99**]). Thus, the level of crowding on a bus can be used to convert an actual in-vehicle travel time to a perceived in-vehicle travel time. Furthermore, variable headways result in uneven loadings on buses, with the result that late buses are more crowded than would be suggested by an average peak-hour or peak-15-minute load. Finally, research exists to document how certain kinds of stop amenities can help reduce the perceived waiting time at bus stops.

Therefore, the recommended factors to include in the transit LOS model are the following:

- Service frequency (headways);
- Travel time (speed);
- Crowding;
- Reliability (headway variability);
- Presence of stop amenities documented to reduce perceived wait time; and
- Pedestrian LOS.

Proposed General Model Form for Transit LOS

The proposed general form for the transit LOS model is a linear combination of the quality of service accessing the bus stop on foot and the quality of service involved in waiting for and riding the bus. It is similar to many transit mode choice models incorporating the factors of accessibility, wait time, and travel time to predict the probability of choosing transit. This model form varies slightly from traditional mode choice models in that it blends wait time and travel time into a single factor before adding the result to the accessibility. Only pedestrian accessibility is considered (as opposed to auto accessibility) because this model is designed for application in an urban street environment where park and ride is less likely a phenomenon.

$$\text{Transit LOS} = a1 * \text{Pedestrian Access} + a2 * \text{Transit Wait/Ride} \qquad \text{(Eq. 20)}$$

Where:

a1, a2 = calibration parameters
Pedestrian Access Score = A measure of the pedestrian level of service for the street.
Transit Wait/Ride Score = A measure of the quality of transit ride and waiting time.

The quality of the pedestrian access can be conveniently obtained by employing the pedestrian level of service score for the street.

The quality of the transit wait/ride experience would be measured based on the average wait time for a bus and the perceived travel time on the bus.

The ratio of transit patronage for the actual wait time divided by the patronage for a base wait time gives an indication of the perceived quality of the service provided relevant to the wait time.

The ratio of transit patronage for the perceived travel time rate (minutes per mile, the inverse of the speed) divided by the patronage for a base travel time rate gives an indication of the perceived quality of the service provided relevant to the travel time rate of service.

The patronage ratios are estimated based on patronage elasticities obtained from various research, as explained in the following sections.

Elasticity Concept

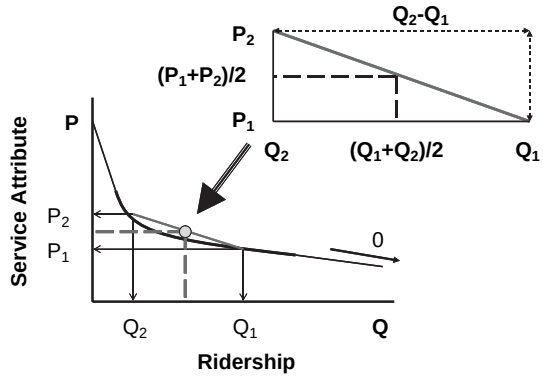
For practical purposes it is not feasible to apply full mode choice models to an isolated urban street (because the mode choice models are designed to consider the entire trip while the street is limited to portions of the trip). Elasticities were adopted instead since they can be used to predict changes in ridership without having to consider the full length of the trip.

A basic, hypothetical transit service for the urban street is assumed which would provide LOS E as far as transit patrons are concerned. The difference between the actual service and the hypothetical service is converted into an estimated percentage change in ridership to determine by how much the actual service LOS exceeds (or falls below) LOS E.

The two key components of the *TransitWaitRideScore* are the headway factor and the perceived travel time factor. These in turn, are related to documented traveler responses to changes in headway and changes in travel time. These responses are quantified in terms of elasticities.

Transit elasticities reflect the percent change in transit ridership resulting from a 1% change in an attribute of the service (e.g., fare, frequency, travel time, service hours, etc.). The relationship between demand and service attribute need not be linear. This is the case with service frequency: doubling the frequency from one bus to two buses an hour on a route has a much greater percentage impact on ridership than doubling the frequency from six buses to twelve buses an hour. Thus, the value of elasticity, *E,* may be different depending on where one starts from and where one ends up. *TCRP Report 95,* the source of many of the elasticity values used for the transit model, uses the concept of *mid-point arc elasticity* to approximate this relationship, based on average before-and-after values of the two variables, ridership and service attribute [**100**]. These relationships are illustrated in Exhibit 82 and expressed mathematically in the equation below.

Exhibit 82. Mid-Point Arc Elasticity.



$$E = \frac{\Delta Q}{(Q_1+Q_2)/2} \div \frac{\Delta P}{(P_1+P_2)/2} = \frac{\Delta Q(P_1+P_2)}{\Delta P(Q_1+Q_2)} = \frac{(Q_2-Q_1)(P_1+P_2)}{(Q_1+Q_2)(P_2-P_1)} \quad \text{(Eq. 21)}$$

Where
E = mid-point arc elasticity;
P = the before (P_1) and after (P_2) prices (e.g., fare, headway, travel time); and
Q = the before (Q_1) and after (Q_2) ridership demand.

Elasticity is relative—the actual ridership of a route is determined by many factors, including the type and density of adjacent land uses, the demographic characteristics of persons living near the route (e.g., age and vehicle ownership), and the ease of access to bus stops. However, given no changes in these external factors, one can estimate the change in a route's ridership resulting from a change in a single service attribute under the control of a transit or roadway agency. Whether the resulting change in ridership is from 100 to 150 riders, or from 1,000 to 1,500 riders makes no difference—one can still estimate how much more attractive (satisfactory) one level of a particular service attribute to passengers is compared to another.

Bus Frequency Elasticity

Elasticities related to how often bus service is provided can be expressed as frequency elasticities (using positive numbers—increased frequencies result in increased ridership) or as headway elasticities (using negative numbers—decreased headways result in increased ridership). Trends identified in *TCRP Report 95* suggest that frequency elasticities can be +1.0 or greater, in situations where the original service was very infrequent (60-minute headways or longer), that is, doubling the frequency may more than double the ridership in those situations. With more frequent service as a starting point, typical frequency elasticities are in the +0.3 to +0.5 range, dropping to as low as +0.2 with very frequent service (i.e., service every 10 minutes or better).

The recommended transit LOS model uses the following frequency elasticity values, based on typical values reported in *TCRP Report 95*: +1.0 for 1–2 buses/hour, +0.5 for 2–4 buses/hour, +0.3 for 4–6 buses/hour, and +0.2 for 6 or more buses/hour. Solving for Q_2 in Equation 1, one can estimate future ridership demand based on a given starting demand and an assumed elasticity, as shown Equation 22 below.

$$Q_2 = \frac{((E-1)P_1Q_1)-((E+1)P_2Q_1)}{((E-1)P_2)-((E+1)P_1)} \quad \text{(Eq. 22)}$$

Thus, with an elasticity of +1.0, a route with a ridership of 100 passengers at 60-minute headways (P_1 = 1 bus/hour) would be expected on average to have a ridership of 133 passengers if headways improved to 45 minutes (P_2 = 1.33 bus/hour), and a ridership of 200 passengers if headways improved to 30 minutes. With the decreased response to frequency changes assumed to begin at 30-minute headways, ridership would increase to 244 passengers at 20-minute headways (E = +0.5, Q_1 = 200 passengers, P_1 = 2 buses/hour, and P_2 = 3 buses/hour), 280 passengers at 15-minute headways, 316 passengers at 10-minute headways, and 379 passengers at 5-minute headways. For any given frequency or headway, one can estimate the ridership relative to a 60-minute headway and, thus, the relative attractiveness of the service. In this example, 10-minute headways produce 3.16 times the number of passengers compared to 60-minute headways, all other things being equal; therefore, the value of f_h that would be used for 10-minute headways would be 3.16.

If local data were available, local elasticities could be substituted for the typical national values used in the model.

Travel Time Elasticity

A review of transit travel time elasticities in the literature, conducted by TCRP Project A-23A (Cost and Effectiveness of Selected Bus Rapid Transit Components), found a typical range of -0.3 to -0.5 (that is, for every 1% decrease in travel time, ridership increases by approximately 0.3 to 0.5%) [**101**]. The *TCRP Report 95* chapter on Bus Rapid Transit, where travel time elasticities will probably be covered, has not yet been published.

Assuming some baseline travel time that passengers would be satisfied with, additional travel time above this baseline value would be less satisfactory, while a reduction in travel time would be more satisfactory. The relative satisfaction of passengers associated with a given travel time can be expressed in terms of the ridership expected at the actual travel time, relative to the ridership that would occur at the baseline travel time. For example, a route with

an average passenger travel time of 25 minutes would be expected to have 10% higher ridership than a route with an average passenger travel time of 30 minutes, all other things being equal, assuming an elasticity of -0.5. (This value is calculated using Equation 2, rather than by taking a 16.7% difference in travel times and multiplying by 0.5). Therefore, if a 30-minute travel time was set as the baseline, the value of f_{ptt} would be 1.10 for 25-minute travel times, assuming for the moment no other influences on perceived travel time.

Because urban street LOS focuses on the quality of urban street segments, rather than the bus trip as a whole, the alternative transit LOS model works with travel time rates (e.g., 6 minutes per mile) instead of travel times (e.g., 30 minutes) or travel speeds (e.g., 10 mph). Travel time rates are the inverse of speeds and, over a given distance, change at the same rate that travel times do. For example, if a bus' travel time to cover 2 miles decreases from 12 to 11 minutes, the travel time decreases by 8.3% and so does the travel time rate (from 6 minutes per mile to 5.5 minutes per mile). Because the rate of change is the same, travel time elasticities should also apply to changes in travel time rates.

The f_{ptt} factor serves to increase or decrease LOS when transit service is particularly fast or slow, compared with some neutral, baseline value. The f_{ptt} and f_h factors, in combination, produce a *TransitWaitRideScore* that represents the percent increase in ridership for a particular headway and perceived travel time rate, compared with a baseline of 60-minute service at a baseline speed.

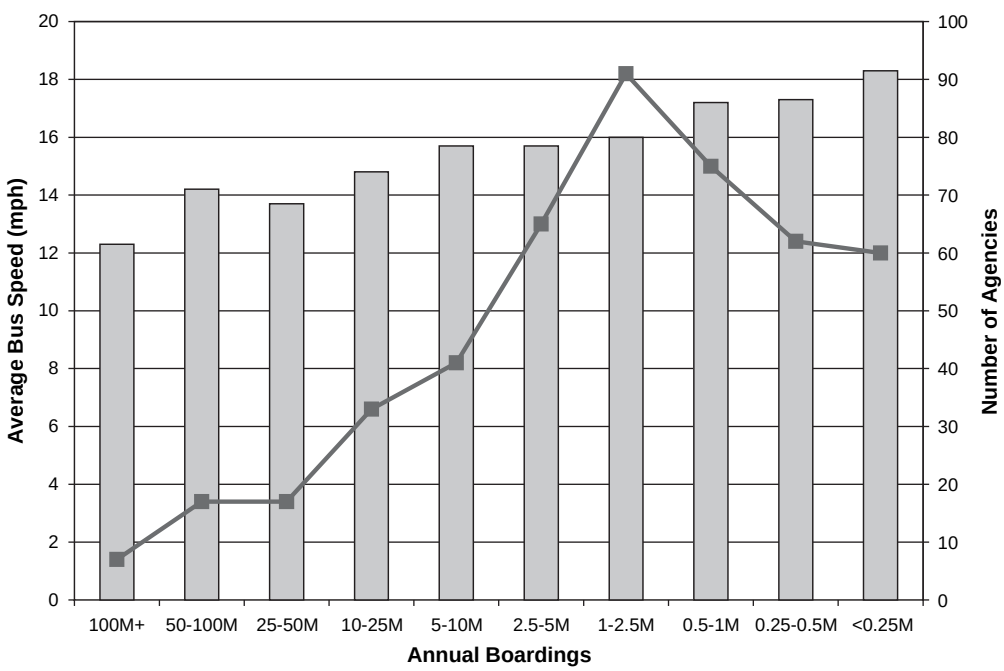
Selection of a Baseline Travel Time Rate

Originally 6 minutes/mile (10 mph) was proposed as a preliminary value for the baseline travel time rate, based on LOS ranges given in *TCRP Report 26* [**102**]. Testing of the preliminary model using real-world data for the entire TriMet bus system in Portland, Oregon, found that the travel time rate of 6 minutes/mile resulted in LOS ratings for Portland that were too high (62-69% of all street segments ended up as LOS A).

The National Transit Database (NTD) can be used to calculate a systemwide average bus speed, in terms of revenue miles operated divided by revenue hours operated. "Revenue service" consists of the time a bus is in passenger operation—it does not include travel to or from the bus garage, but does include driver layover time at the end of the route. To eliminate the effect of layover time on average speed, we assumed that layover time was 10% of total revenue hours, which is a typical transit industry standard, although local contracts with the bus drivers' union may specify a different value.

For all bus systems reporting to the NTD, the median speed is 15.2 mph. As shown in Exhibit 83, average speed is a function of city size: the larger the city, the lower the speed. For the seven largest bus operators (serving 100 million or more annual boardings), the mean speed was 12.3 mph; for the 60 smallest bus operators reporting to the NTD (10 or more buses in service and fewer than 250,000 annual boardings), the mean speed was 18.3 mph. The 33 bus operators in the 10 to 25 million boardings category (Montgomery

Exhibit 83. Average System Bus Speed by Number of Annual Boardings.



County, Maryland, and Cincinnati, Ohio are toward the top of this group) had a mean speed of 14.8 mph, while the 91 bus operators in the 1 to 2.5 million boardings category (Appleton, Wisconsin, and Pueblo, Colorado are toward the bottom of this group) had a mean speed of 16.0 mph. In total, 247 bus agencies out of 468 reporting (53%) are represented by groups with mean speeds within 1 mph of the median speed of 15.2 mph; thus, this median value is representative of most U.S. bus agencies.

When a baseline travel time rate of 4 minutes/mile (15 mph) was tested against the Portland data, a much better distribution of LOS grades was obtained, with only 30 to 39% of route segments receiving LOS A grades, depending on whether route-average or segment-specific speeds were used in the calculation.

However, a baseline travel time rate of 4 minutes/mile, when applied to the San Francisco surveys, results in LOS grades that were too low relative to the frequency of service provided. This suggests that a different baseline travel time rate may be appropriate for dense urban areas such as San Francisco or downtown Washington, DC. Further testing of the speed elasticity used in the model would also be appropriate.

Reliability

One way that the TCQSM measures transit reliability is through the *coefficient of variation of headway deviations*—the standard deviation of headway deviations divided by the mean scheduled headway. (A headway deviation of a given bus is the actual headway minus the scheduled headway. When buses arrive exactly on schedule every time, $cv_h = 0$; when two buses consistently arrive together, $cv_h = 1$.)

Some believe that a better reflection of headway reliability from a passenger point-of-view is given by *excess wait time* (e.g., Furth and Miller (previously cited) and Transport for London's transit performance standards), which is the average additional time a passenger must wait for a bus to arrive because of non-uniform headways. When passengers arrive randomly at a stop—the case when service is relatively frequent (the TCQSM suggests this occurs at headways of 10 to 12 minutes or less)—the average passenger will wait half a headway for a bus to arrive. When a bus is late, passengers will wait longer than half a headway on average. The difference in these two times is the excess wait time.

For random passenger arrivals, excess wait time is calculated as half the scheduled headway multiplied by the square of the coefficient of variation of headways (or headway deviations) [**103**, **104**]. For non-random arrivals (i.e., for longer headways, when passengers would be expected to be familiar with the schedule and arrive a few minutes before the scheduled departure time), excess wait time is the average number of minutes that buses are behind schedule. Buses more than a minute early can be treated as being one headway behind schedule, because passengers arriving near the scheduled departure time would have to wait for the next bus. Excess wait time adds to a passenger's overall wait time; it also affects a passenger's perceived wait time. A common value in the literature is that passengers perceive or value wait time approximately twice as much as in-vehicle time; Furth and Muller suggest a value of 1.5 and suggest accounting for "potential wait time," an allowance a rider makes to show up earlier for service known to be unreliable, with a value of 0.75 of in-vehicle time [**98**].

Excess wait time makes a passenger's trip take longer than intended (i.e., the perceived speed or travel time rate for the trip is slower). However, the effect of excess wait time on the travel time rate varies depending on the length of the trip: a 2-minute excess wait has a bigger proportional effect on a 10-minute trip than a 2-minute wait for a 20- or 30-minute trip. The difficulty is in determining what an appropriate trip length should be.

The recommended solution is to compare the excess wait time with the average trip time. The NTD provides information on weekday boardings and passenger miles by mode each year for most transit systems; an average trip length (miles/boarding) can be computed from these two variables. (This calculation assumes that trip lengths are consistent throughout the day, which may or may not be the case. Passenger miles are only available as daily values. Although the NTD allows agencies to report boardings in smaller time increments than a day (e.g., AM peak, midday, etc.), most choose not to.)

Dividing the excess wait time (minutes) by the computed average trip length (miles) provides the average effect on the overall travel time rate (minutes/mile), which can then be converted to a perceived travel time rate. For example, if the analysis were being performed in Portland, the average weekday passenger miles in 2003 were 765,100, while the average weekday boardings were 214,158, resulting in an average trip length of 3.57 miles. If the average excess wait time was 2 minutes, the additional travel time rate would be (2 / 3.57) = 0.56 minutes/mile. The *perceived* additional travel time rate could be up to twice this value, or 1.12 minutes/mile.

Effect of Stop Amenities on Perceived Waiting Time

Research presented in *TRL Report 593* suggests that certain stop amenities, including shelters, lighting, and seating, can reduce perceived journey time by providing a more comfortable waiting environment. Exhibit 84 presents these values, converted from pence to in-vehicle time, using an in-vehicle time value of 4.2 pence per minute.

Some authors have suggested that real-time displays at bus stops showing the number of minutes until the next bus arrival

Exhibit 84. In-Vehicle Time Value of Stop Amenities.

Amenity	In-Vehicle Time Value (min)
Shelter with roof and end panel	1.3
Shelter with roof	1.1
Lighting at bus stop	0.7
Molded seats	0.8
Flip seats	0.5
Bench seats	0.2

SOURCE: Calculated from Steer Davies Gleave, *Bus passenger preferences. For London Transport buses*. (1996) in Balcombe, R. (editor), [**105**].

should reduce, if not eliminate, the perceived travel time penalty. (In other words, perceived excess wait time would be the same as actual excess wait time when real-time bus-arrival information is provided.) Although this seems to be a reasonable hypothesis, to date, the project team has not seen any literature documenting such an effect.

Crowding

Perceived Travel Time Effects

In the same way that passengers perceive or value wait time more than in-vehicle time, passengers also perceive or value time spent in crowded conditions more than time spent in uncrowded conditions. Exhibit 85 presents values of train crowding used in Great Britain.

To demonstrate how the Exhibit 85 information could be applied, consider a situation where a train is operating with a passenger load that is 120% of its seating capacity (i.e., a load factor of 1.20). In the absence of crowding, rail commuters value in-vehicle time at 7.2 pence/minute. At a load factor of 1.20, seated commuters experience a penalty of 1.6 pence/minute due to the more crowded conditions, while standing commuters experience a penalty of 7.5 pence/minute (i.e., standees perceive their time spent standing as being more than twice as onerous as being seated in an uncrowded carriage). The weighted average penalty for all passengers in the train would be 2.58 pence/minute, corresponding to a value of time 36% higher than in uncrowded conditions. This value-of-time factor, 1.36, corresponds to factor a_1 in the perceived travel time rate equation. In application, the transit LOS model would provide a lookup table based on a similar calculation using bus passenger value-of-time to directly provide a_1. Section 6.10 provides an example of such a lookup table.

Exhibit 85. British Crowding Penalties for Rail Passengers.

	Crowding Penalty (pence/min)	
Load Factor (p/seat)	Seated Passengers	Standing Passengers
≤ 0.80	0.0	--
0.90	0.4	--
1.00	0.8	6.5
1.10	1.2	7.0
1.20	1.6	7.5
1.30	2.0	8.0
1.40	2.4	8.5
1.50	--	9.0
1.60	--	9.5

NOTE: The baseline value of in-vehicle time for rail passengers is 7.2 pence/minute, in 2000 prices. Intermediate values are obtained through linear interpolation. The baseline value of in-vehicle time for bus passengers is 4.2 pence/minute; no corresponding crowding penalties are available.
SOURCE: Derived from Balcombe [**106**].

No corresponding British values exist for bus crowding penalties and no American work was found that could be used to compare U.S. rail crowding perceptions to U.K. perceptions. Additional research would be needed to establish U.S. crowding penalty values. In the absence of other data, the recommended transit model uses a combination of U.K. bus value-of-time data and rail crowding penalties.

Load Variability Effects

Unreliable operations tend to result in higher levels of crowding on buses that are running late, because these buses pick up not only their own passengers, but passengers who have arrived early for the following bus. For existing-condition analyses, this crowding can be measured directly. For future-condition analyses, for frequent service (i.e., headways approximately 10 minutes or less), this additional crowding can be estimated as the mean load multiplied by $(1 + cv_h)$ (Derived from the TCQSM, Part 4, Appendix E, Equations 4-22 and 4-23). At long headways, a late bus will pick up its normal load, because passengers will have timed their arrival at the bus stop to the expected departure time (Furth and Miller, previously cited). There is also an intermediate range of headways with a mix of randomly and non-randomly arriving passengers [**107**]. This late-bus load can be used in the perceived travel time calculation described in the previous section, thus incorporating the effect of unreliable service's crowding into the LOS measure.

The literature review uncovered no information directly relating overcrowding and/or reliability to transit demand. In the United States, the San Francisco County Transportation Authority appears to be the only agency to have documented a test of reliability and crowding factors for use in a travel demand model. The tested values were based on a stated-preference telephone survey, but were not incorporated in the final model because the predicted number of boardings did not reasonably match the observed number of boardings [**108**].

6.2 Recommended Transit LOS Model

The recommended transit LOS model predicts the average quality of service rating that transit riders would give the bus service on an urban street. The model is as follows:

$$\text{Transit LOS Score} = 6.0 - 1.50 * \text{TransitWaitRideScore} + 0.15 * \text{PedLOS} \quad \text{(Eq. 23)}$$

Where

PedLOS = The pedestrian LOS numerical value for the facility (A=1, F=6).

TransitWaitRideScore = The transit ride and waiting time score, a function of the average headway between buses and the perceived travel time via bus.

The computed transit LOS score is converted to a letter LOS grade using the equivalencies given in Exhibit 86. These are the same thresholds as used for auto.

Estimation of the Pedestrian LOS

The pedestrian LOS for the urban street is estimated using the pedestrian LOS model described in a later chapter.

Estimation of the Transit Wait Ride Score

The transit wait and ride score is a function of the headway between buses and the perceived travel time via bus for the urban street.

$$\text{TransitWaitRideScore} = f_h * f_{ptt} \quad \text{(Eq. 24)}$$

Where

f_h = headway factor = the multiplicative change in ridership expected on a route at a headway *h*, relative to the ridership at 60-minute headways;

f_{ptt} = perceived travel time factor = the multiplicative change in ridership expected at a perceived travel time rate *PTTR*, relative to the ridership expected at a baseline travel time rate.

The baseline travel time rate is 4 minutes/mile except for central business districts of metropolitan areas with over 5 million population, in which case it is 6 min/mile.

Exhibit 87 provides f_h values for typical bus headways.

The perceived travel time factor is estimated based on the perceived travel time rate and the expected demand elasticity for a change in the perceived travel time rate.

$$F_{PTTR} = \frac{[(e-1)BTTR - (e+1)TTR]}{[(e-1)TTR - (e+1)BTTR]} \quad \text{(Eq. 25)}$$

Exhibit 86. Transit LOS Thresholds.

LOS	Numerical Score
A	≤ 2.00
B	>2.00 and ≤ 2.75
C	>2.75 and ≤ 3.50
D	>3.50 and ≤ 4.25
E	>4.25 and ≤ 5.00
F	> 5.00

Exhibit 87. Headway Factor Values.

Headway (min)	Frequency (bus/h)	f_h
60	1	1.00
45	1.33	1.33
40	1.5	1.50
30	2	2.00
20	3	2.44
15	4	2.80
12	5	2.99
10	6	3.16
7.5	8	3.37
6	10	3.58
5	12	3.79

NOTE: The following frequency elasticities are assumed: +1.0 for 1-2 buses/hour, +0.5 for 2-4 buses/hour, +0.3 for 4-6 buses/hour, and +0.2 for 6 or more buses/hour. Elasticities derived from data reported in *TCRP Report 95,* Chapter 9.

Where

F(PTTR) = Perceived Travel Time Factor

PTTR = Perceived Travel Time Rate (min/mi)

BTTR = Base Travel Time Rate (min/mi). Use 6 minutes per mile for the main central business district of metropolitan areas with population greater than or equal to 5 million. Use 4 minutes per mile for all other areas.

e = ridership elasticity with respect to changes in the travel time rate. The suggested default value is –0.40, but local values may be substituted.

Exhibit 88 below illustrates the application of this equation for selected perceived travel time rates and a selected elasticity.

The perceived travel time rate (PTTR) is estimated based on the mean speed of the bus service, the average excess wait time for the bus (due to late arrivals), the average trip length, the average load factor for the bus service, and the amenities at the bus stops.

Exhibit 88. Example Perceived Travel Time Factors (F(PTTR)).

	F(PTTR)	
BTTR:	4 min/mi	6 min/mi
PTTR (min/mi)		
2	1.31	1.50
2.4	1.22	1.41
3	1.12	1.31
4	1.00	1.17
6	0.85	1.00
12	0.67	0.76
30	0.53	0.58

Notes:
- *F*(PTTR) = Perceived Travel Time Factor
- PTTR = Perceived Travel Time Rate.
- BTTR = Base Travel Time Rate (default is 4 minutes per mile. 6 minutes per mile BTTR is used for the central business districts (CBDs) of metropolitan areas with 5 million or greater population).
- Based on default value of –0.40 for elasticity.

$$PTTR = a_1 * IVTTR + a_2 * EWTR - ATR \quad \text{(Eq. 26)}$$

Where

PTTR = perceived travel time rate.

IVTTR = actual in-vehicle travel time rate, in minutes per mile.

EWTR = excess wait time rate due to late arrivals = excess wait time (minutes) / average trip length (miles).

a_1 = passenger load weighting factor (a function of the average load on buses in the analysis segment during the peak 15 minutes).

a_2 = 2 = wait time factor, converting actual wait times into perceived wait times.

ATR = amenity time rate = perceived travel time rate reduction due to the provision of certain bus stop amenities = in-vehicle travel time value of stop amenities (minutes) / average trip length (miles).

Exhibit 89. Passenger Load Weighting Factor (a_1).

Load Factor (pass/seat)	a_1
≤0.80	1.00 default
1.00	1.19
1.10	1.41
1.20	1.62
1.30	1.81
1.40	1.99
1.50	2.16
1.60	2.32

Notes:
Load factor is the average ratio of passengers to seats for buses at the peak load point within the study section of the street.If bus load factor is not known, a default value of 1.00 can be assumed for the load weighting factor (a_1).

In-Vehicle Travel Time Rate

The in-vehicle travel time rate is equal to the inverse of the mean bus speed converted to minutes per mile.

$$IVTTR = \frac{60}{Speed} \quad \text{(Eq. 27)}$$

Where

IVTTR = In-Vehicle Travel Time Rate (min/mi)r.

Speed = Average speed of bus over study section of street (mph).

When field measurement of mean bus speed is not feasible, the mean schedule speed can be used. Identify two schedule points on the published schedule for the bus route(s). Measure the distance covered by the bus route(s) between the two points. Divide the measured distance by the scheduled travel time between the two schedule points. The bus speed estimation procedure given in Chapter 27 (Transit) may be used to estimate future bus speeds.

The in-vehicle travel time rate is multiplied by a passenger load weighting factor (a_1) to account for the increased discomfort when buses are crowded. Values of the passenger load weighting factor (a_1) are given in Exhibit 89.

Excess Wait Time Rate

The excess wait time is the sum of the differences between the scheduled and actual arrival times for buses within the study section of the street divided by the number of observations. Early arrival without a corresponding early departure is counted as being on-time. However, early arrival with an early departure is counted as being "one headway" late for the purposes of computing the average excess wait time for the street.

The excess wait time rate is the excess wait time (in minutes) divided by the mean passenger trip length for the bus route(s) within the study section of the street.

For average passenger trip length, a default value can be taken from national average data reported by the American Public Transit Association (APTA) http://www.apta.com/research/stats/ridership/trlength.cfm). In 2004, the mean trip length for bus passenger-trips nationwide was 3.7 miles.

More locally specific values of average trip length can be obtained from the NTD. Look up the annual passenger miles and annual unlinked trips in the transit agency profiles stored under NTD Annual Data Publications at http://www.ntdprogram.gov/ntdprogram/pubs.htm#profiles. The mean trip length is the annual passenger-miles divided by the annual unlinked trips.

Amenity Time Rate

The amenity time rate is the time value of various bus stop improvements divided by the mean passenger trip length. The mean passenger trip length is the same distance used to compute the Excess Wait Time Rate (described above).

$$ATR = \frac{1.3 * Shelter + 0.2 * Bench}{ATL} \quad \text{(Eq. 28)}$$

Where

ATR = Amenity Time Rate (min/mi)

Shelter = Proportion of bus stops in study section direction with shelters

Bench = Proportion of bus stops in study section direction with benches

ATL = Average passenger trip length (miles)

Notes:
1. Shelters with benches are counted twice—once as shelters, once as benches.
2. Coefficients adapted from Steer Davies Gleave, *Bus passenger preferences. For London Transport buses.* (1996) in Balcombe, R. (editor) [**109**].

6.3 Performance of Transit LOS Model

Exhibit 90 compares the ability of the existing TCQSM LOS models and the proposed transit LOS model to predict the mean LOS response for each bus route obtained from the field surveys.

None of the models reproduce the mean levels of service reported by passengers in the on-board surveys very well. Both the FDOT LOS and proposed LOS model match the passenger surveys about 21% of the time. Although a better match might have been desirable, the on-board survey results indicate a high degree of acceptance for a wide range of conditions. It is thought that passengers not satisfied with the service are less likely to ride the buses and thus were undersampled in the survey. Consequently, it was considered acceptable that the proposed transit LOS model should predict poorer levels of service than obtained in the on-board surveys.

The scope of the TCQSM LOS model is quite a bit different than the urban street. The TCQSM is designed to represent the entire trip, while this research is limited to transit service on a given street. Also, the TCQSM provides six different letter grade levels of service, depending on the geographic scope and aggregation of the analysis. Only the worst result is shown in the table.

Both the FDOT LOS model and the proposed transit LOS model predict a range of LOS A to E for the transit routes surveyed. All three LOS models, FDOT, TCQSM, and the proposed transit LOS model, tend to agree that WMATA Route 2B and AC Transit Route 218 are LOS D/E, which passengers rated as LOS A.

Exhibit 90. Evaluation of Proposed Transit Model and TCQSM against Field Survey Results.

Operator	Rte	Freq. (bus/h)	Spd (mph)	OTP %	Shelter (%)	Bench (%)	LF (p/seat)	Ped LOS	CBD	Survey LOS	FDOT LOS	TCQSM LOS	Model LOS
TriMet	14	8	11.8	75%	34%	47%	0.55	C	No	A	A	C	A
TriMet	44	4	14.8	76%	30%	41%	0.83	C	No	A	B	D	A
AC Transit	72R	5	15.7	66%	74%	75%	1.10	D	No	A	B	D	B
AC Transit	72	4	12.1	53%	39%	46%	1.10	D	No	A	B	D	B
WMATA	38B	4	10.1	46%	29%	26%	0.38	D	No	A	C	D	B
WMATA	2B	2	14.0	67%	13%	15%	1.10	D	No	A	E	D	D
AC Transit	218	1	15.1	72%	11%	15%	1.10	C	No	A	E	E	E
AC Transit	51	8	11.8	54%	28%	51%	1.10	D	No	B	A	C	A
SF Muni	14	10	9.2	57%	54%	56%	1.30	E	Yes	B	A	C	C
SF Muni	30	7	7.4	59%	44%	44%	1.30	E	Yes	B	A	C	D
SF Muni	1	20	8.8	63%	44%	44%	1.30	C	Yes	B	A	C	A
SF Muni	38	8	9.8	59%	68%	69%	1.30	F	Yes	B	B	C	D
SF Muni	38L	9	12.1	48%	84%	86%	1.10	F	No	B	B	C	A
Broward	18	4	13.6	65%	23%	75%	1.10	E	No	B	C	D	B
% Exact Match										100%	21%	0%	21%
% Within 1 LOS										100%	86%	43%	71%

Notes:
1. OTP = on time performance with 5 minutes late considered on-time.
2. LF = load factor
3. Shelter = percent of bus stops with shelters.
4. Bench = percent of bus stops with benches.
5. Survey = the mean level of service reported in the field survey.
6. FDOT = Florida Quality/Level of Service Handbook method.
7. TCQSM = Transit Capacity and Quality of Service Manual. The TCQSM does not produce a single letter grade LOS for transit routes. The letter grade reported here is an average, a grade point average (GPA) of the numerous LOS ratings that the TCQSM reports for any given transit route.
8. Model LOS = the letter grade predicted by the recommended transit LOS model.

CHAPTER 7

Bicycle LOS Model

7.1 Development

Two basic forms were considered for the bicycle LOS for arterials model. The first was an aggregate model using the outputs from existing segment and intersection LOS models to determine the arterial LOS. The other was an agglomerate model considering the independent characteristics of the roadway environment to calculate an arterial LOS for bicyclists directly. Both forms were preliminarily evaluated during model development.

The aggregate model was chosen for refinement for several reasons. The stepwise approach to an aggregate model is useful because it allows the practitioner to address concerns at individual intersections or along specific segments. The aggregate model also retains all the terms found both intuitively and mathematically to be significant to bicyclists riding along a roadway. The agglomerate model would not retain all the terms as significant. Consequently, we focused on the aggregate model in model development efforts.

We considered various functional techniques for model development, including linear regression and ordered probit. We performed linear regression modeling because it is more intuitive than probit modeling in practice and non-modelers better understand the sensitivity of the regression model. These reasons are particularly important in that these models are most frequently used: the development or analysis of specific design options or in the development of bicycle facility community master plans with presentations to interested citizens and public officials. To ensure the validity of the results of the linear regression modeling results, we evaluated the ordered probit model form as well. The results of both the linear regression and ordered probit modeling efforts are described below.

Before starting correlations analysis and modeling, we created two data subsets from the overall dataset. The total dataset was sorted by city and LOS grade responses. A random sampling of 20% of the data representing each city and LOS grade response was taken from the overall dataset for model validation. The balance of the data, 80% of the total dataset, was used for model development.

SPSS 14.0 was used to conduct Pearson correlation analysis on the extensive array of geometric and operational variables. Subsequently, we selected the following relevant variables for additional testing:

- Segment LOS—The bicycle LOS for roadway segments (see below).
- Intersection LOS—The bicycle LOS for signalized intersections (see below).
- Conflicts per mile—The total conflicts per mile represent the motor vehicle conflicts resulting from motorists turning across the bicycle facility at unsignalized locations.
- Size of the city in which the data collection took place—The Metropolitan Statistical Area (MSA) population was used to represent the size of each city.

At the panel's request, the MSA variable was dropped from further consideration. Other variables were dropped from further consideration because of their poor correlation with the dependent variable or because of their colinearity with more strongly correlated variables. After testing numerous combinations of variables and variable transformations, we determined the aggregate model using two constituent sub-models would be the most theoretically valid.

7.2 Recommended Bicycle LOS Model

The recommended bicycle LOS model is a weighted combination of the bicyclists' experiences at intersections and on street segments in between the intersections. Two models of the same form were evaluated, but with different parameters:

Bicycle LOS Model 1

$$\text{Bicycle LOS \#1} = 0.160*(\text{ABSeg}) + 0.011*(\exp(\text{ABInt})) + 0.035*(\text{Cflt}) + 2.85 \quad \text{(Eq. 29)}$$

Bicycle LOS Model 2

$$\text{Bicycle LOS \#2} = 0.20*(\text{ABSeg}) + 0.03*(\exp(\text{ABInt})) + 0.05*(\text{Cflt}) + 1.40 \quad \text{(Eq. 30)}$$

Where

ABSeg = The length weighted average segment bicycle score

Exp = The exponential function, where e is the base of natural logarithms.

ABInt = Average intersection bicycle score

Cflt = Number of unsignalized conflicts per mile, i.e., the sum of the number of unsignalized intersections per mile and the number of driveways per mile

The output of either model is a numerical value, which must be translated to a LOS letter grade.

Exhibit 91 provides the numerical ranges that coincide with each LOS letter grade.

The first model provides a better fit with the numerical scores given by the video lab participants to the video clips. This model was derived based on a statistical fitting process to the video clip data. However, this first model does not predict LOS A or B for the video clips. Consequently the second model was developed.

The second model has an inferior numerical fit with the video lab data (measured in terms of squared error) but produces the full range, LOS A through F, for the video clips. The second model was derived from the first model by reducing the constant so that the second model would predict LOS A for video clips #328 and #330. The other parameters in the model were then manually adjusted until the second model could produce LOS F for one or more of video clips #314, 317, 323, and 324 (which were rated LOS F by the video lab participants).

Both models use the same bicycle segment and bicycle intersection submodels.

Bicycle Segment LOS

The segment bicycle LOS is calculated according to the following equation:

Exhibit 91. Bicycle LOS Numerical Equivalents.

LOS	Numerical Score
A	≤ 2.00
B	>2.00 and ≤ 2.75
C	>2.75 and ≤ 3.50
D	>3.50 and ≤ 4.25
E	>4.25 and ≤ 5.00
F	> 5.00

$$\text{BSeg} = 0.507 \text{ Ln } (V/(4*PHF*L)) + 0.199Fs*(1 + 10.38HV)^2 + 7.066(1/PC)^2 - 0.005(We)^2 + 0.760 \quad \text{(Eq. 31)}$$

Where

BSeg = Bicycle score for directional segment of street.

Ln = Natural log

PHF = Peak Hour Factor (see Chapter 10 for default values)

L = Total number of directional through lanes

V = Directional motorized vehicle volume (vph). (Note: V > 4 *PHF * L)

Fs = Effective speed factor = 1.1199 In(S - 20) + 0.8103

S = Average running speed of motorized vehicles (mph) (Note: S >= 21)

HV = Proportion of heavy vehicles in motorized vehicle volume.
Note: if the auto volume is < 200 vph, the %HV used in this equation must be <= 50% to avoid unrealistically poor LOS results for low volume and high percent HV conditions.

PC = FHWA's five point pavement surface condition rating (5=Excellent, 1=Poor) (A default of 3 may be used for good to excellent pavement)

We = Average effective width of outside through lane (ft)
= Wv – (10ft × %OSP) (ft) ** If W1 < 4
= Wv + W1 – 2 (10 × %OSP) (ft) ** Otherwise

%OSP = Percentage of segment with occupied on-street parking

W1 = width of paving between the outside lane stripe and the edge of pavement (ft)

Wv = Effective width as a function of traffic volume (ft)
= Wt (ft) ** If V > 160 vph or street is divided
= Wt*(2 – (0.005 × V)) (ft) ** Otherwise

Wt = Width of outside through lane plus paved shoulder (including bike lane where present) (ft)
Note: parking lane can be counted as shoulder only if 0% occupied.

Bicycle Intersection LOS

The intersection bicycle LOS is calculated according to the following equation:

$$\text{IntBLOS} = -0.2144\text{Wt} + 0.0153CD + 0.0066\,(Vol15/L) + 4.1324 \quad \text{(Eq. 32)}$$

Where

IntBLOS = perceived hazard of shared-roadway environment through the intersection

Wt = total width of outside through lane and bike lane (if present)

CD = crossing distance, the width of the side street (including auxiliary lanes and median)

Vol15 = volume of directional traffic during a 15-minute period
L = total number of through lanes on the approach to the intersection

7.3 Performance of Bicycle LOS Model on Video Clips

Exhibit 92 compares the ability of the existing HCM speed-based LOS model and the proposed bicycle LOS models against the mean LOS response for each video clip. The HCM matched the video clips 15% of the time. The proposed LOS models matched the clips between 27% and 46% of the time. The second model had the highest percentage match because it can predict LOS A and B. The first model is better at predicting the poorer levels of service (E and F) than the second model.

Exhibit 92. Evaluation of Proposed Bike Models and HCM against Video Lab Results.

Clip	Location	Outside Lane (ft)	Bike/Shldr Lane (ft)	Through Lanes	Divided (D/UD)	Pk Hr. Vol. (vph)	Heavy Veh (%)	Spd Lim (mph)	Pavement Rate (1-5)	% OSP	Sig. Int X-Dist (ft)	Unsig. Conf Per Mile	Video LOS	HCM LOS	Model #1 LOS	Model #2 LOS
328	N Village, Cypress/S Vill.(N)	12	4	1	U	79	0%	30	4.0	0%	0	5.5	A	B	C	A
330	N Village, S Vill./Cypress (S)	12	4	1	U	136	0%	30	4.0	0%	0	6.7	A	B	C	A
306	Alumni at Magnolia (N)	11	4	2	U	717	0%	30	4.0	0%	72	0.0	B	B	C	B
305	Collins at Alumni (W)	12	3.5	2	D	813	8%	30	3.5	0%	65	0.0	B	C	D	B
307	Alumni at Magnolia (N)	11	4	2	U	757	0%	30	4.0	0%	72	0.0	B	D	C	B
304	Collins Blvd at Alumni (E)	12	3.5	2	D	428	0%	30	3.5	0%	65	0.0	B	E	C	B
303	Fowler Ave at North	12	5	3	D	1211	0%	50	4.0	0%	0	26.4	C	B	D	C
319	Fletcher, North Palm (S)	12	5	2	D	2961	0%	45	4.0	0%	53	0.0	C	B	D	D
311	15th St at 7th Ave, (W)	12	8	1	U	631	0%	25	3.5	70%	33	13.2	C	D	D	C
329	Ehrlich, Turner/S Village (S)	12	4	2	D	1261	0%	45	3.5	0%	61	8.8	D	B	D	C
302	Fowler Ave at North	12	5	3	D	2119	0%	50	4.0	0%	0	26.4	D	B	D	C
327	W University at 10th (S)	12	8	2	U	165	0%	30	3.0	40%	40	20.8	D	C	D	C
309	Holly at Laurel , (S)	10	0	2	U	134	0%	20	4.0	0%	52	0.0	D	D	C	B
313	21st St at 7th Ave, (W)	10	0	3	OW	536	0%	30	3.5	0%	33	24.0	D	D	E	D
308	Holly at Magnolia , (N)	10	0	2	U	407	0%	20	4.0	0%	86	0.0	D	D	D	C
320	Fletcher Ave at 50th (S)	12	5	2	D	1898	0%	45	4.0	0%	64	0.0	E	B	D	B
321	Fletcher, 50th to 56th (S)	12	5	2	D	2146	0%	45	4.0	0%	0	15.2	E	B	D	C
318	US 41 at 31st St, (W)	12	0	3	D	182	100%	55	3.5	0%	35	24.0	E	B	F	F
322	56th St at 98th Ave, (W)	12	0	3	D	1544	0%	45	3.5	0%	0	28.7	E	B	E	D
310	Fletcher at Sebring, (S)	11.5	0	2	D	1589	0%	40	4.0	0%	0	37.0	E	B	F	E
301	Fowler, River H./Gillette	12	5	3	D	2549	0%	50	4.0	0%	0	28.9	E	B	E	D
312	7th Ave, 17th to 14th (N)	12	0	1	U	631	0%	25	3.5	0%	49	5.0	E	C	D	C
317	US 41 at Dover St, (E)	12	0	2	D	495	17%	55	3.0	0%	0	11.5	F	B	E	D
314	56th St at Busch (W)	12	0	2	D	638	0%	45	3.5	0%	142	28.7	F	B	F	F
323	56th St at Busch (W)	12	0	3	D	357	0%	45	3.5	0%	142	28.7	F	E	E	F
324	Bullard at 56th St	12	4	3	D	636	0%	45	4.0	0%	87	19.6	F	E	D	C
	% Exact Match to Video												100%	15%	27%	46%
	% Within 1 LOS of Video												100%	50%	85%	77%

CHAPTER 8

Pedestrian LOS Model

8.1 Model Development

Two basic forms were considered for the pedestrian LOS for arterials model. The first was an aggregate model that used the outputs from existing segment and intersection LOS models to determine the arterial LOS. The other was an agglomerate model that considered the independent characteristics of the roadway/walkway environment to calculate an arterial LOS for pedestrians directly. Both were preliminarily evaluated during model development.

The aggregate model was chosen for refinement for several reasons. The stepwise approach to an aggregate model is useful because it allows the practitioner to evaluate the effect of improvements at individual intersections or along specific segments on the overall LOS of the facility. The aggregate model also retains all the terms found both intuitively and mathematically validated to be significant to pedestrians walking within an urban environment. The agglomerate models form was tested during our preliminary models and did not retain all the terms as significant. Consequently, we focused on the aggregate model in our model development efforts.

We considered various functional techniques for model development, including linear regression and ordered probit. We performed linear regression modeling because it is more intuitive than probit modeling in practice and non-modelers better understand the sensitivity of the regression model. These reasons are particularly important in that these models are most frequently used: the development or analysis of specific design options or in the development of pedestrian facility community master plans with presentations to interested citizens and public officials. To ensure the validity of the results of the linear regression modeling results, we evaluated the ordered probit model form as well. The results of both the linear regression and ordered probit modeling efforts are described below.

For both modeling efforts the dependent variable, Observed pedestrian LOS, was defined as the score that a participant assigned to a specific video clip. The scores were on a scale of A (best) through F (worst). For modeling purposes, the letter grades were converted to numerical scores: A=1, B=2, C=3, D=4, E=5, and F=6.

Before starting correlations analysis and modeling, we created two data subsets from the overall dataset. The total dataset was sorted by city and LOS grade responses. A random sampling of 20% of the data representing each city and LOS grade response was taken from the overall dataset for model validation. The balance of the data, 80% of the total dataset, was used for model development.

We used SPSS 14.0 to conduct Pearson correlation analysis on the extensive array of geometric and operational variables. Subsequently, we selected the following relevant variables for additional testing:

- Segment LOS—The pedestrian LOS for roadway segments (see below).
- Intersection LOS—The pedestrian LOS for signalized intersections (see below).
- Midblock Crossing LOS—The LOS associated with midblock crossings (see below).
- Total Pedestrians—The total number of pedestrians encountered in the video clip; a measure of pedestrian space, which is an input to the existing pedestrian LOS methodology in the HCM.
- Conflicts per mile—The total conflicts per mile represent the motor vehicle conflicts resulting from motorists turning across the pedestrian facility at unsignalized locations.
- Size of the city in which the data collection took place—The MSA population was used to represent the size of each city.

The panel asked that MSA be dropped from further consideration as a variable. Other variables were dropped from further consideration because of their poor correlation with

the dependent variable or because of their colinearity with more strongly correlated variables. Also, variables such as traffic volume, sidewalk width, and signal delay, are components of the segment LOS or the intersection LOS, so we did not model them independently.

Several variables were evaluated for inclusion as additional terms in the model. Frequency of unsignalized conflicts (intersections and driveways) per mile was tested for its correlation and significance to the arterial LOS for pedestrians and was not found to be a significant factor. Additionally, the density of pedestrians on the sidewalk (the current HCM measure of LOS) was not found to be significant for this model, within the low range of density values available in the video clips.

8.2 Recommended Pedestrian LOS Model

The proposed pedestrian level of service predicts the mean level of service that would be reported by pedestrians along or across the urban street. The average pedestrian LOS for the urban street facility is a function of the segment level of service, the intersection level of service, and the mid-block crossing difficulty.

Overall Pedestrian LOS Model

The overall pedestrian level of service for an urban street is based on a combination of pedestrian density and other factors. The level of service according to density is computed. Then the pedestrian LOS according to other factors is computed. The final level of service for the facility is the worse of the two computed levels of service.

Ped LOS = Worse of (Pedestrian Density LOS, Ped Other LOS) (Eq. 33)

Where

Ped LOS = The letter grade level of service for the urban street combining density and other factors.

Ped Density LOS = The letter grade level of service for sidewalks, walkways, and street corners based on density

Ped Other LOS = The letter grade level of service for the urban street based on factors other than density

Pedestrian Density LOS Model for Sidewalks, Walkways, Street Corners

The methods of Chapter 18 of the HCM are used to compute the pedestrian density for the sidewalks and the pedestrian waiting areas at signalized intersection street corners. The LOS thresholds given in that chapter for these facilities are used to determine the level of service. The thresholds for sidewalks and walkways are given in Exhibit 93.

Pedestrian Other LOS Model

The pedestrian LOS for the facility that is representative of non-density factors is computed according to either of the two models below:

Pedestrian Other LOS Model 1

OtherPLOS (#1) = (0.318 PSeg + 0.220 PInt + 1.606) * (RCDF) (Eq. 34)

Pedestrian Other LOS Model 2

OtherPLOS (#2) = (0.45 PSeg + 0.30 PInt + 1.30) * (RCDF) (Eq. 35)

Where

OtherPLOS = Pedestrian non-density (other factors) LOS
PSeg = Pedestrian segment LOS value
PInt = Pedestrian intersection LOS value
RCDF = Roadway crossing difficulty factor

The first model provides the better statistical fit with the video lab data. However, this model does not produce LOS F for the streets in the video clip data set. The second model is a manual modification of the parameters of the first model so that the second model will produce a full range of LOS A to F for the streets in the video clip data set. The constant was

Exhibit 93. Pedestrian Walkway LOS (Density).

LOS	Minimum Pedestrian Space Per Person	Equivalent Maximum Flow Rate per Unit Width of Sidewalk
A	> 60 SF per person	≤ 300 peds/hr/ft
B	>40	≤ 420
C	>24	≤ 600
D	>15	≤ 900
E	>8	≤ 1380
F	≤ 8 SF	> 1380

Source: Exhibit 18-3 HCM 2000 [**110**]

manually adjusted downward and the other parameters were adjusted upward until the second model produced LOS F for at least one of the streets in the data set.

Although none of the video clips actually produced a LOS A or F rating (on average) from the video lab participants, the second model was developed to address potential public agency acceptance issues that might arise with adopting the first LOS model for pedestrians that might not produce LOS A and LOS F for at least some streets in the jurisdiction. The second model produces a full range of LOS A to F results for a reasonable range of street conditions typical of urban areas of the United States.

The output of both of these models is a numerical value, which must be translated to a LOS letter grade. Exhibit 94 provides the numerical ranges that coincide with each LOS letter grade. These thresholds are the same as for the other modes.

Pedestrian Segment LOS

The segment pedestrian LOS is calculated according to the following widely used equation [**111**]:

$$\text{Ped Seg LOS}_S = -1.2276 \ln (W_{ol} + W_l + f_p \times \%OSP + f_b \times \times W_b + f_{sw} \times Ws) + 0.0091(Vol_{15}/L) + 0.0004\ SPD^2 + 6.0468 \quad \text{(Eq. 36)}$$

Where

Ped Seg LOS_S = Pedestrian level of service score for a segment
ln = Natural log
W_{ol} = Width of outside lane
W_l = Width of shoulder or bicycle lane
f_p = On-street parking effect coefficient (= 0.20)
%OSP = Percent of segment with on-street parking
f_b = Buffer area coefficient (= 5.37 for trees spaced 20 feet on center)
W_b = Buffer width (distance between edge of pavement and sidewalk, in feet)
f_{sw} = Sidewalk presence coefficient (= $6 - 0.3W_s$)
W_s = Width of sidewalk
Vol_{15} = Volume of motorized vehicles in the peak 15 minute period
L = Total number of directional through lanes
SPD = Average running speed of motorized vehicle traffic (mi/h)

Exhibit 94. Pedestrian "Other" Model LOS Categories.

LOS	Numerical Score
A	≤ 2.00
B	>2.00 and ≤ 2.75
C	>2.75 and ≤ 3.50
D	>3.50 and ≤ 4.25
E	>4.25 and ≤ 5.00
F	> 5.00

Pedestrian Intersection LOS

The intersection LOS for pedestrians is computed only for signalized intersections according to the following equation developed by Petritsch et al. [**112**]:

$$\text{Ped Int LOS (Signal)} = 0.00569(\text{RTOR+PermLefts}) + 0.00013(\text{PerpTrafVol*PerpTrafSpeed}) + 0.0681(\text{LanesCrossed}^{0.514}) + 0.0401\ln(\text{PedDelay}) - \text{RTCI}(0.0027\text{PerpTrafVol} - 0.1946) + 1.7806 \quad \text{(Eq. 37)}$$

Where

RTOR+PermLefts = Sum of the number of right-turn-on-red vehicles and the number of motorists making a permitted left turn in a 15-minute period
PerpTrafVol*PerpTrafSpeed = Product of the traffic in the outside through lane of the street being crossed and the midblock 85th percentile speed of traffic on the street being crossed in a 15-minute period
LanesCrossed = The number of lanes being crossed by the pedestrian
PedDelay = Average number of seconds the pedestrian is delayed before being able to cross the intersection
RTCI = Number of right turn channelization islands on the crossing.

Pedestrian Midblock Crossing Factor

The pedestrian Roadway Crossing Difficulty Factor (RCDF) measures the difficulty of crossing the street between signalized intersections. The RCDF worsens the pedestrian LOS if the crossing difficulty is worse than the non-crossing LOS for the facility. It improves the pedestrian LOS if the crossing difficulty LOS is better than the non-crossing difficulty LOS. The factor is based on the numerical difference between the crossing LOS and the non-crossing LOS. The pedestrian RCDF is limited to a maximum of 1.20 and a minimum of 0.80.

$$\text{RCDF} = \text{Max}[0.80, \text{Min}\{[(\text{XLOS\#-NXLOS\#})/7.5 + 1.00], 1.20\}] \quad \text{(Eq. 38)}$$

Where

RCDF = Roadway crossing difficulty factor
XLOS# = Roadway crossing difficulty LOS Number
NXLOS# = Non-crossing Pedestrian LOS number = (0.318 PSeg + 0.220 PInt + 1.606)

Pseg = Ped. Segment LOS number (computed per equation #20)
Pint = Ped. Intersection LOS number (computed per equation #21)

The crossing difficulty LOS number is computed based on the minimum of the waiting-for-a-gap LOS number and diverting-to-a-signal LOS number.

XLOS = Min [WaitForGap, DivertToSignal] (Eq. 39)

Where
XLOS = Crossing LOS score (based on Exhibit 96)
WaitForGap = Delay waiting for safe gap to cross.
DivertToSignal = Delay diverting to nearest signalized intersection to cross.

The delay is converted into a LOS numerical score based on the minimum of the mean delay waiting for a gap or diverting to a signal, according to the values given in Exhibit 95.

Wait-For-Gap LOS Calculation

The Wait-For-Gap LOS is computed based on the expected waiting time required to find an acceptable gap in the traffic to cross the street. The acceptable gap is computed as a function of the number of lanes, their width, and the average pedestrian walking speed, with 2 seconds added.

Acceptable Gap = (Number of Lanes * 12 feet/lane) / 3.5 feet/second + 2 seconds (Eq. 40)

The expected waiting time until an acceptable gap becomes available is computed as follows:

$$MeanWait = \frac{1}{\lambda}\left[\exp(\lambda t) - 1\right] - t \quad \text{(Eq. 41)}$$

Where
t = The acceptable gap plus the time it takes for a vehicle to pass by the pedestrian.
The average pass-by time = Average Vehicle Length/ Average Speed, converted to seconds.
λ = The average vehicle flow rate in vehicles per second.
Exp = The exponential function

Exhibit 95. Pedestrian Crossing LOS Score.

Minimum of Wait or Divert Delay (Seconds)	XLOS Score
10	1
20	2
30	3
40	4
60	5
> 60	6

Using the numerical cutoffs shown in Exhibit 96 the final numerical score is then interpolated between the cutoff values based on the probability of obtaining an adequate gap within the allowed time.

For this calculation, the increasing LOS numerical score is assumed to become logarithmic beyond LOS F.

Divert To Signal LOS

The LOS rating for diverting to the nearest traffic signal to cross the street is computed as a function of the extra delay involved in walking to and from the mid-block crossing point to the nearest signal and the delay waiting to cross at the signal.

The geometric delay associated with a pedestrian deviation is the amount of time it takes the pedestrian to walk to a controlled crossing and back. To calculate this delay, one must first determine the distance to the nearest crossing. For this methodology, this was assumed as one third of the block length. This distance is then divided by the pedestrian's walking speed (assumed to be 3.5 feet/second) to obtain the geometric delay:

Ped Geometric Delay = 2/3 * (Block Length)/ Ped Walking Speed (Eq. 42)

The control delay at the intersection is calculated as shown in the HCM [**113**]:

Ped Control Delay = (Cycle Length − Green Time)^2/ (2*Cycle Length) (Eq. 43)

The total delay is the sum of the two:

Total Ped Deviation Delay = Ped Geometric Delay + Ped Cycle Delay (Eq. 44)

Exhibit 96. Pedestrian LOS and Delay Thresholds.

Pedestrian LOS	Delay Threshold Seconds	Equivalent LOS Numerical Score Range	Equivalent LOS Midpoint Score
A	10	≤ 1.5	1
B	20	>1.5 and ≤ 2.5	2
C	30	> 2.5 and ≤ 3.5	3
D	40	> 3.5 and ≤ 4.5	4
E	60	> 4.5 and ≤ 5.5	5
F	> 60	> 5.5	6

For this calculation, the increasing LOS numerical score is assumed to become logarithmic beyond LOS F.

Exhibit 97. Evaluation of Proposed Pedestrian Model and HCM Against Video Lab Results.

Clip	Location	Sidewalk Width (ft)	Pedestrian Flow Rate (pph)	Outside Lane (ft)	Shoulder Width (ft)	On-Street Parking (%)	Barrier (Y/N)	Buffer Width (ft)	Dir. Vol. (vph)	Traffic Lanes (lanes)	Traffic Speed (mph)	Video LOS	HCM LOS	Model #1 LOS	Model #2 LOS
215	7th Ave at 15th St, N side	8	60	12	0	50%	Yes	7	170	1	25	B	E	B	B
227	Grant Ave at California St, E side	6	200	16	0	0%	Yes	4	630	2	30	B	B	C	C
230	3rd St at Mission St, E side	6	220	12	0	0%	No	5	220	2	30	B	D	C	D
221	Stockton St at Washington St, E side	4	640	16	0	0%	Yes	3	0	1	30	B	E	B	B
224	Grant Ave at Jackson St, E side	4	1320	12	0	100%	Yes	2	80	1	30	B	E	B	B
228	Post St at Stockton St, S side	6	180	10	0	40%	Yes	1	370	1	30	B	D	B	C
226	Geary Blvd at Divisadero St, S side	9	190	20	0	50%	Yes	5	1180	2	40	B	D	D	D
232	Hillsborough, Arm. to Tamp., N side	6	0	16	4	0%	No	0	540	1	45	B	B	D	D
229	Post St at Stockton St, S side	6	280	10	0	40%	Yes	0	310	1	30	B	D	B	B
205	Alumni Dr at Magnolia Dr, N side	10	0	12	4	0%	No	10	200	2	30	C	B	C	C
211	Bearss Ave at North Blvd, N side	4	0	12	0	0%	No	5	570	1	45	C	A	B	C
214	Dale Mabry at Tampa Bay, E side	9.5	0	12	5	0%	No	35	2030	3	45	C	E	D	E
225	Geary Blvd at Divisadero St, S side	9	280	20	0	50%	Yes	5	1050	2	40	C	C	D	D
218	Market St at Kearney St, N side	15	340	12	0	0%	No	12	60	1	30	C	C	B	B
222	Stockton St at Broadway St, E side	6	610	16	0	50%	Yes	3	220	2	30	C	E	C	C
219	Stockton St at Clay St, E side	7	640	16	0	100%	Yes	4	150	1	30	C	E	B	B
220	Stockton St at Clay St, E side	7	820	16	0	100%	Yes	4	150	1	30	C	D	B	B
223	Stockton St at Broadway St, E side	6	1600	16	0	50%	Yes	3	0	2	30	C	D	A	A
210	Magnolia Dr at Holly Dr, W side	0	0	12	0	0%	No	0	160	2	30	C	C	C	C
216	21st St at 7th Ave, W side	6	0	12	0	0%	No	0	360	1	30	C	A	C	C
217	21st St at 7th Ave, W side	6	0	12	0	0%	No	0	300	1	30	C	E	B	C
203	Collins Blvd at Alumni Dr, E side	10	0	12	4	0%	No	15	270	2	30	D	D	C	C
204	Collins Blvd at Alumni Dr, E side	10	0	12	4	0%	No	15	160	2	30	D	E	B	C
231	Dale Mabry, State to Carmen, W side	5	0	12	0	0%	No	6	570	1	35	D	B	D	D
201	Holly Dr at Magnolia Dr, N side	0	0	10	0	0%	No	0	270	2	20	D	E	D	E
209	Fletcher at Bruce B Downs, S side	0	0	12	4	0%	No	0	2170	4	45	D	A	E	F
206	Fowler Ave at 56th St, S side	5	0	12	5	0%	No	23	1690	4	50	E	E	D	E
208	Fletcher at Bruce B Downs, S side	0	30	12	4	0%	No	0	1750	4	45	E	C	E	F
	% Exact Match to Video Rating											100%	25%	43%	43%
	% Within 1 LOS of Video Rating											100%	43%	86%	79%

Notes:

- On-Street Parking = Percent of on-street parking lane occupied by parked vehicles.
- Barrier is presence of trees, or other barrier between pedestrian sidewalk and street.
- Traffic lanes is number of lanes in direction of travel closest to pedestrian.
- Video LOS is the mean of the letter grade LOS ratings reported by subjects in video lab.
- Model LOS is the LOS grade predicted by the proposed pedestrian LOS model.

The total delay is then converted into a numerical LOS score by linearly interpolating numerical scores on the scale provided in Exhibit 96.

8.3 Performance Evaluation of Pedestrian LOS Model

Exhibit 97 compares the performance of the proposed pedestrian LOS model (with the mid-block crossing factor) to the mean LOS rating for each pedestrian video clip. The video clips did not expose lab subjects to any arterial mid-block crossing situations. Although the HCM reproduces the mean video lab ratings for each video clip 25% of the time, the two proposed pedestrian LOS models (1 and 2) both reproduce the mean video clip ratings 43% of the time. The difference is that Model 2 produces LOS A to F results for the streets in the video clip data set. Model 1 produces LOS A to E results for the same streets.

CHAPTER 9

Integrated Multimodal LOS Model Framework

This section provides an overview of the proposed urban street LOS framework and the proposed LOS modeling system.

9.1 The Framework

The proposed multimodal LOS framework for urban streets reports a single average level of service for each of four modal users of the urban street:

1. Auto drivers,
2. Bus passengers,
3. Bicycle riders, and
4. Pedestrians.

The individual modal levels of service are NOT combined into a single comprehensive level of service for the facility because this would disguise the disparities in the perceptions of quality of service for the four modes.

The urban street LOS for a given mode is defined as the *average* degree of satisfaction with the urban street that would be reported by a large group of travelers using that mode of travel *if they had traveled the full length* of the study section of the street. The video lab research showed that the degree of satisfaction experienced by an individual traveler for a given situation varies widely across individuals. Consequently, this framework focuses on predicting the average degree of satisfaction of a large group of people exposed to the same urban street experience. Due to fatigue effects, travelers actually traveling the full length of the facility would forget key aspects of their experience and report a different level of service than would several travelers traveling short lengths of the facility. This framework takes the LOS perceptions of travelers on short sections of urban street and compiles them into an estimate of LOS for the full length of the street.

The six-letter grade A-F LOS structure of the HCM has been preserved. Many of the statistical results suggest that people can actually distinguish only two to three levels of service. However, public agency planners and engineers need to be able to predict how close a facility is to an unacceptable level of service. So the six levels have been retained for agency planning purposes, rather than because people actually can distinguish among them.

Level of service is defined for each mode as shown in Exhibit 98.

9.2 The Integrated LOS Modeling System

The proposed LOS modeling system relies on 37 variables to predict the perceived degree of satisfaction experienced by travelers on the urban street. These variables consist of four basic types: facility design, facility control, transit service characteristics, and the volume of vehicle traffic on the facility.

Input Variable Interactions Among Modes

Exhibit 99 lists the input variables and their major interactions. Minor interactions are not shown in this exhibit, but are discussed below.

The Auto LOS Model 1 uses two variables: Auto Stops Per Mile, and Presence of Left-Turn Lanes.

- The presence of a left-turn lane is a facility design feature.
- The stops per mile are directly influenced by the intersection control type and the settings of the traffic signal. High auto and transit volumes can increase the probability of stopping. Pedestrian and bicycle volumes at intersections reduce the saturation flow rate, which reduces speed and increases stops.

The Auto LOS Model 2 uses two variables: Percent of Posted Speed Limit, and Median Type.

Exhibit 98. Definition of LOS by Mode.

Level of Service	Auto	Transit	Bicycle	Pedestrian
A	Best Performance	Very Satisfied	Best Performance	Best Performance
B				
C				
D				
E				
F	Worst Performance	Very Dissatisfied	Worst Performance	Worst Performance

Exhibit 99. Interaction of Modal LOS Model Inputs.

Inputs to LOS Models	Facility Design	Facility Control	Transit Service	Auto Volume	Transit Volume	Bicycle Volume	Pedestrian Volume
Auto LOS Model #1							
Auto Stops (or Delay)		XXX		XXX	XXX	XXX	XXX
Left Turn Lanes	XXX						
Auto LOS Model #2							
Mean Speed		XXX		XXX	XXX	XXX	XXX
Median Type	XXX						
Transit LOS Model							
Pedestrian LOS	XXX	XXX		XXX	XXX		XXX
Bus Headway			XXX				
Bus Speed		XXX		XXX	XXX	XXX	XXX
Bus Schedule Adherence			XXX	XXX	XXX	XXX	XXX
Passenger Load					XXX		
Bus Stop Amenities	XXX						
Bicycle LOS Models							
Bike-Pedestrian Conflicts*	XXX					XXX	XXX
Driveway Conflicts/Mile	XXX						
Vehicles Per Hour				XXX	XXX		
Vehicle Through Lanes	XXX						
Auto Speed	XXX	XXX		XXX	XXX		
Percent Heavy Vehicles				XXX	XXX		
Pavement Condition	XXX			XXX	XXX		
Width of Outside Lane	XXX						
On-Street Parking Occupancy	XXX	XXX					
Cross Street Width	XXX						
Pedestrian LOS Models							
Pedestrian Density	XXX						XXX
Pedestrian-Bike Conflicts*	XXX					XXX	XXX
Width of Shoulder	XXX						
Width of Outside Lane	XXX						
On-Street Parking Occupancy	XXX						
Presence of Trees	XXX						
Sidewalk Width	XXX						
Distance To Travel Lane	XXX						
Vehicles Per Hour				XXX	XXX		
Vehicle Through Lanes	XXX						
Average Vehicle Speed	XXX	XXX		XXX	XXX	XXX	XXX
Right Turns On Red	XXX	XXX		XXX			XXX
Cross Street Speed	XXX	XXX					
Cross Street Vehicles/Hour				XXX	XXX		
Cross Street Lanes	XXX						
Crossing Delay		XXX					
Right-Turn Channelization	XXX						
Block Length	XXX						
Signal Cycle Length		XXX		XXX	XXX		XXX
Signal Green Time		XXX		XXX	XXX		XXX

"XXX" indicates that input variable is influenced by that factor.
* Ped/bike conflicts come into play only for paths outside of roadway but within right-of-way of street.

- The Median Type is a facility design feature.
- The percent of posted speed limit that traffic is able to travel the full length of the street is directly influenced by the intersection control type and the settings of the traffic signal. High auto and transit volumes can reduce the mean speed. Pedestrian and bicycle volumes at intersections reduce the saturation flow rate, which reduces mean auto speed.

The Transit LOS Model uses 6 variables: Pedestrian LOS, Bus Headway, Bus Speed, Bus On-Time Performance, Passenger Load, and Bus Stop Amenities.

- The pedestrian LOS is determined by the facility design, intersection controls, the volume of auto and transit traffic, and the pedestrian volume (pedestrian volumes influence signal timing, which affects signal delay for pedestrians, which affects pedestrian LOS).
- The bus headway is determined by the transit service provider, which is related to the passenger loads.
- Bus speed is determined by the facility controls (signal settings), the amount of auto and transit traffic, and the number of boarding passengers at each stop. Bicycles in the travel lanes may delay buses. Heavy pedestrian volumes at intersections (or mid-block) may delay buses.
- Bus on-time performance is determined by the service provider (e.g., number of back up buses, and maintenance to prevent breakdowns). It is also influenced by the auto, bicycle, and pedestrian volumes on the street.
- Passenger load is determined by the density of development in the area, the relative convenience of other modes of travel, and the bus headways provided by the transit operator.
- Bus stop amenities are a design feature of the facility.

The Bicycle LOS Model uses the following variables: Driveway Conflicts/Mile, Vehicles Per Hour, Vehicle Through Lanes, Speed Limit, Percent Heavy Vehicles, Pavement Condition, Width of Outside Lane, On-Street Parking Occupancy, and Cross Street Width.

- Bicycle-Pedestrian Conflicts (only if bicycles share the pedestrian facility).
- Driveway Conflicts/Mile are a design feature.
- Vehicles Per Hour is determined by the auto, truck, and transit volumes.
- Vehicle Through Lanes is a design feature of the facility.
- Speed Limit is a control feature of the facility. It is influenced by the facility design.
- Percent Heavy Vehicles is influenced by the auto, truck, and transit volumes.
- Pavement Condition is a facility maintenance feature. It is influenced by auto, truck, and transit volumes and the pavement design.
- Width Of Outside Lane is a design feature.
- On-Street Parking Occupancy is determined by the parking controls, available off-street parking, and the density of land uses in the area. Facility design determines whether a parking lane is provided and whether or not parking is prohibited during peak hours.
- Cross Street Width is determined by the facility design.

The Pedestrian LOS Model uses the following variables: Pedestrian Density, Bicycle-Pedestrian Conflicts (if facility is shared), Width of Shoulder, Width of Outside Lane, On-Street Parking Occupancy, Presence of Trees, Sidewalk Width, Distance To Travel Lane, Vehicles Per Hour, Vehicle Through Lanes, Average Vehicle Speed, Right-Turns on Red, Cross Street Speed, Cross Street Vehicles/Hour, Cross Street Lanes, Crossing Delay, Right-Turn Channelization, Block Length, Signal Cycle Length, Signal Green Time

- Pedestrian Density (Computed according to HCM).
- Bicycle-Pedestrian Conflicts (only if bicycles share the pedestrian facility).
- Width of Shoulder is a design feature.
- Width of Outside Lane is a design feature
- On-Street Parking Occupancy is determined by the parking controls, available off-street parking, and the density of land uses in the area. Facility design determines whether a parking lane is provided and whether or not parking is prohibited during peak hours.
- Presence of Trees is a design feature.
- Sidewalk Width is a design feature.
- Distance to Travel Lane is a design feature.
- Vehicles Per Hour is determined by the auto, truck, and transit volumes.
- Vehicle Through Lanes is a design feature of the facility.
- Average Vehicle Speed is determined by the facility design, the facility control (speed limit), and the auto, bus, bicycle, and pedestrian volumes on the facility, to the extent that bicycles and pedestrians share (or cross) the traveled way used by motor vehicles.
- Right-Turns on Red are determined by the facility control (are they allowed?). They are influenced by the auto and transit volumes. Heavy pedestrian volumes may reduce the ability of autos or buses to turn right on red.
- Cross Street Speed is determined by the design and control of the cross street. It is influenced by cross-street volumes. Heavy pedestrian or bicycle volumes may reduce the cross street speed.
- Cross Street Vehicles/Hour is determined by the auto and transit volume.
- Cross Street Lanes is a design feature. It is influenced by the auto and transit volumes.
- Crossing Delay is determined by the intersection control (signal timing), which in turn is influenced by auto, bus, and pedestrian volumes.

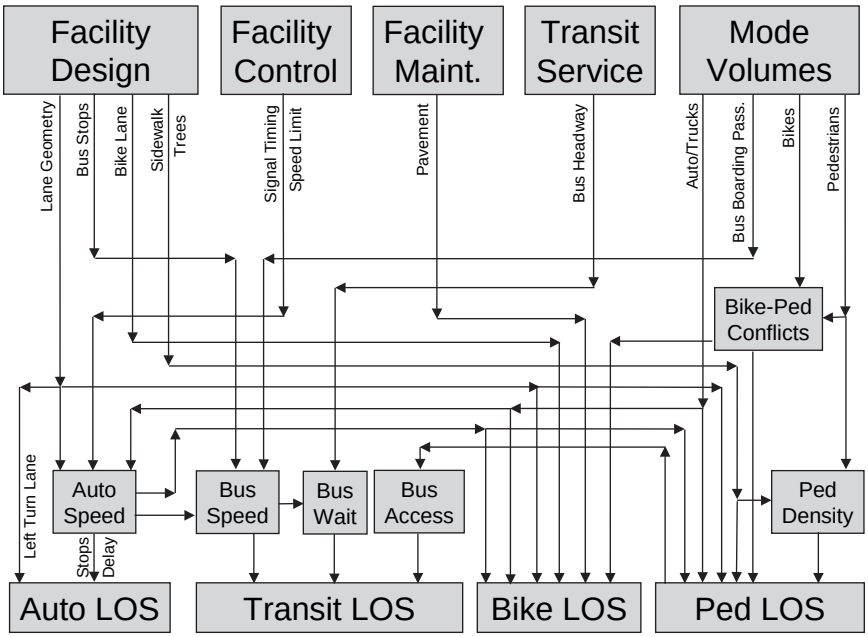
- Right-Turn Channelization is a design feature.
- Block Length is a design feature
- Signal Cycle Length is a facility control feature. It is influenced by the facility design, auto and transit volumes, and the pedestrian volumes.
- Signal Green Time is a facility control feature. It is influenced by the facility design, auto and transit volumes, and the pedestrian volumes.

Interactions Among Modal LOS Results

Exhibit 100 shows the major interactions among the input variable types, the modal LOS models, and the modal LOS model results.

To estimate the variables required by the LOS models, the analyst first collects data on facility design, facility control, facility maintenance, transit service, and the volume for each mode. The analyst uses these data to estimate various modal performance characteristics (auto speed, bus speed, bus wait, bus access, bicycle-pedestrian conflicts if a shared facility is present, and pedestrian density). Once the modal performance characteristics are known, then the methods of NCHRP 3-70 are used to estimate auto LOS, transit LOS, bicycle LOS, and pedestrian LOS for the urban street. The bicycle-pedestrian conflict LOS is estimated using procedures in Chapters 18 and 19 of the HCM.

Exhibit 100. LOS Model Interactions.



Safe Streets, Livable Streets

Eric Dumbaugh

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Transportation safety is a highly contentious issue in the design of cities and communities. While urban designers, architects, and planners often encourage the use of aesthetic streetscape treatments to enhance the livability of urban streets, conventional transportation safety practice regards roadside features such as street trees as fixed-object hazards and strongly discourages their use. In this study, I examine the subject of livable streetscape treatments and find compelling evidence that suggests they may actually enhance the safety of urban roadways. Concerns about their safety effects do not appear to be founded on empirical observations of crash performance, but instead on a design philosophy that discounts the important relationship between driver behavior and safety. This study traces the origin and evolution of this philosophy, and proposes an alternative that may better account for the dynamic relationships between road design, driver behavior, and transportation safety.

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> The danger in supplanting the real measure of safety (i.e., crash frequency and severity) by surrogates arises when the link between the two is conjectural, when the link remains unproven for long, and when the use of unproven surrogates becomes so habitual that the need to eventually speak in terms of crashes is forgotten. (Hauer, 1999a, p. 17)

Beyond simply acting as thoroughfares for motor vehicles, urban streets often double as public spaces. Urban streets are places where people walk, shop, meet, and generally engage in the diverse array of social and recreational activities that, for many, are what makes urban living enjoyable. And beyond even these quality-of-life benefits, pedestrian-friendly urban streets have been increasingly linked to a host of highly desirable social outcomes, including economic growth and innovation (Florida, 2002), improvements in air quality (Frank et al., 2000), and increased physical fitness and health (Frank et al., 2003), to name only a few. For these reasons, many groups and individuals encourage the design of "livable" streets, or streets that seek to better integrate the needs of pedestrians and local developmental objectives into a roadway's design.

There has been a great deal of work describing the characteristics of livable streets (see Duany et al., 2000; Ewing, 1996; Jacobs, 1961), and there is general consensus on their characteristics: livable streets, at a minimum, seek to enhance the pedestrian character of the street by providing a continuous sidewalk network and incorporating design features that minimize the negative impacts of motor vehicle use on pedestrians. Of particular importance is the role played by roadside features such as street trees and on-street parking, which serve to buffer the pedestrian realm from potentially hazardous oncoming traffic, and to provide spatial definition to the public right-of-way. Indeed, many livability advocates assert that trees, as much as any other single feature, can play a central role in enhancing a roadway's livability (Duany et al., 2000; Jacobs, 1993).

While most would agree that the inclusion of trees and other streetscape features enhances the aesthetic quality of a roadway, there is substantive disagreement about their safety effects (see Figure 1). Conventional engineering practice encourages the design of roadsides that will allow a vehicle leaving the travelway to safely recover before encountering a potentially hazardous fixed object. When one considers the aggregate statistics on run-off-roadway crashes, there is indeed

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cause for concern. In 2003 alone, there were over 8,500 fatalities involving roadside objects such as trees and utility poles on U.S. roadways, accounting for more than 20% of the total fatalities for that year (National Highway Traffic Safety Administration [NHTSA], n. d.). Correspondingly, designing livable streets is often more difficult than simply counterbalancing the needs of motorists with those of pedestrians. How is the transportation designer to conscientiously incorporate design elements that may result in the loss of life?

This study details existing design guidance and literature, as well as the historical evolution of contemporary safety practice, and reports the results of an empirical test of the professional assumptions that guide the current approach to addressing safety through design. It concludes by outlining an approach to urban roadway design that may better address the twin goals of safety and livability.

Considering the Literature on Roadside Safety

The initial motivation behind this research effort was an attempt to understand the safety impacts of livable streetscape treatments on urban roadways. On this issue, the design guidance is clear: "for all types of highway projects,[1] clear zones should be determined or identified and forgiving roadsides established" (American Association of State Highway and Transportation Officials [AASHTO], 1997, p. 14). In practice, this entails providing a clear roadside adjacent to the vehicle travelway, with a preferred width of 30 feet.[2] In terms of how to best accomplish this goal, AASHTO's (2002) *Roadside Design Guide*, the central authority on the design of safe roadsides, is also clear:

> Through decades of experience and research, the application of the forgiving roadside concept has been refined to the point where roadside design is an integral part of transportation design criteria. Design options for reducing roadside obstacles, in order of preference, are as follows:
>
> 1. Remove the obstacle.
> 2. Redesign the obstacle so it can be safely traversed.
> 3. Relocate the obstacle to a point where it is less likely to be struck.
> 4. Reduce impact severity by using an appropriate breakaway device.
> 5. Shield the obstacle with a longitudinal traffic barrier designed for redirection or use a crash cushion.
> 6. Delineate the obstacle if the above alternatives are not appropriate. (pp. 1–2)

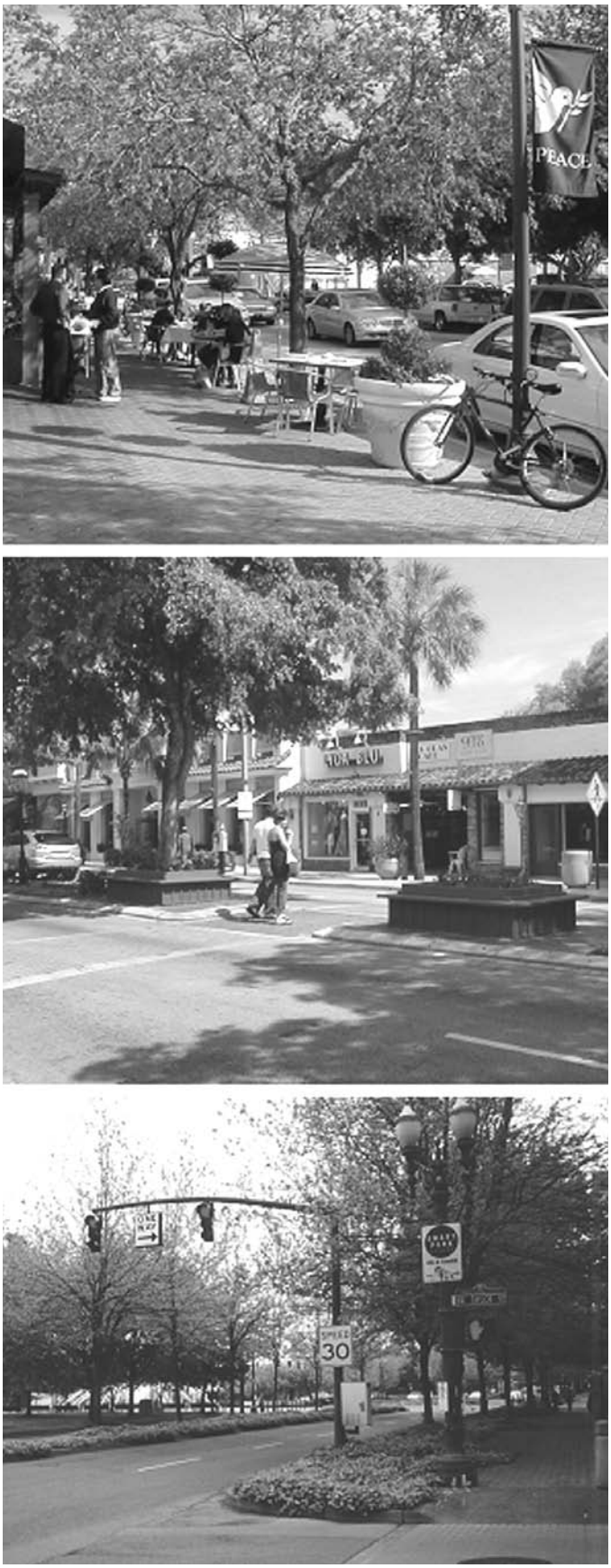

Figure 1. Livable streetscape treatments: urban amenities or roadside hazards?

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While the *Roadside Design Guide* cites "decades of experience and research," there is very little information on the use of aesthetic streetscape features, and much of the existing literature on the application of clear zone policies in urban environments is problematic, at best. The definitive work on the subject is a study that describes the physical characteristics of trees involved in crashes within the City limits of Huntsville, Alabama (Turner & Mansfield, 1990). This study found that most crashes involving trees occur within 20 feet of the roadway, that 75% of the reported crashes involved trees with a caliper width 12 inches or more, and that almost 60% occurred on a horizontal curve.[3] While such information is useful for understanding the characteristics of tree-related crashes, it does not lead to the conclusion that eliminating trees with any or even all of these characteristics will have any effect on a roadway's safety. Such conclusions can only be made by examining the actual crash performance of eliminating trees in urban areas, as measured by changes in crash frequency and severity.

Indeed, there is a growing body of evidence suggesting that the inclusion of trees and other streetscape features in the roadside environment may actually reduce crashes and injuries on urban roadways. Naderi (2003) examined the safety impacts of aesthetic streetscape enhancements placed along the roadside and medians of five arterial roadways in downtown Toronto. Using a quasi-experimental design, the author found that the inclusion of features such as trees and concrete planters along the roadside resulted in statistically significant reductions in the number of mid-block crashes along all five roadways, with the number of crashes decreasing from between 5 and 20% as a result of the streetscape improvements. While the cause for these reductions is not clear, the author suggests that the presence of a well defined roadside edge may be leading drivers to exercise greater caution.

Ossenbruggen, Pendharkar, and Ivan (2001) examined sites with urban, suburban, and residential characteristics in New Hampshire and hypothesized that the urban "village" areas, with greater traffic volumes and more pedestrian activity, would be associated with higher numbers of crashes and injuries. Instead, they found the opposite: the village areas, which had on-street parking and pedestrian-friendly roadside treatments, were two times less likely to experience a crash event than the comparison sites. The authors associate these crash reductions with the characteristics of the roadside environment, which included sidewalks, mixed land uses, and other "pedestrian-friendly" roadside features. The authors also attributed the safety performance to reduced speeds, noting that "since no speed limit signs are erected at village sites, it suggests [speeds] are self regulating" (p. 496).

A study of two-lane roadways by Ivan, Pasupathy, and Ossenbruggen (1999) found that while shoulder widths were associated with reductions in single-vehicle, fixed-object crashes, they were also associated with a statistically significant *increase* in total crashes, with multiple-vehicle crashes offsetting safety gains achieved through reductions in fixed-object crashes. The authors comment that "the positive coefficient on right shoulder width is troubling; one normally expects a wider shoulder to be a safety feature" (p. 702).

Finally, Lee and Mannering (1999) examined run-off-roadway crashes along a 100-km section of an arterial roadway in Washington State that traveled through both urban and rural environments. Using a negative binomial model, the authors sought to associate crash frequencies with the characteristics of the roadside environment. While their model for rural areas performed as expected, with trees and other features being associated with a statistically significant increase in the number of roadside crashes, their model for urban areas produced radically different results (see Table 1). Not only were trees not associated with crash increases, but the model coefficients entered negatively at a statistically significant level, indicating that the presence of trees in urban areas was associated with a decrease in the probability that a run-off-roadway crash would occur.

The authors attribute these unexpected crash reductions to the fact that there are fewer trees in urban areas than in rural ones, but this begs the question: even if there are fewer trees in urban areas, which suggests that their presence would violate driver expectancy, why are they associated with statistically significant crash reductions?

Other roadside features proved to be statistically related to crash reductions as well. The number of sign supports was associated with crash reductions, as was the presence of miscellaneous fixed objects, a variable that included such roadside features as mailboxes. Further, wider lanes and shoulders were associated with statistically significant *increases* in crash frequencies.

Interestingly, clear zones are not the only design feature for which such safety anomalies appear. Hauer (1999a) reexamined the literature on lane widths and found that there was little evidence to support the assertion that widening lanes beyond 11 feet enhances safety. Instead, the literature has almost uniformly reported that the safety benefit of widening lanes stops once lanes reach a width of roughly 11 feet, with crash frequencies increasing as lanes approach and exceed the more common 12-foot standard.[4] Further, in a series of broad-sweeping and profoundly important studies, Noland (2001, 2003) and Noland and Oh (2004) consistently found that when one controls for intervening factors such as time-series effects, seat belt use,

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Variable	Estimated coefficients	*t*-statistic
Constant	−1.983	
Roadway characteristics		
Broad lane indicator (1 if lane is greater than 3.69 meters, 0 otherwise)	1.684	3.984
Median width (meters)	−0.017	−3.781
Roadside characteristics		
Bridge length (meters)	4.610	2.145
Distance from outside shoulder edge to guardrail (meters)	0.113	3.655
Fence length (meters)	5.781	2.870
Number of isolated trees in a section	−0.093	−1.857
Number of miscellaneous fixed objects in a section	−0.094	−2.140
Number of sign supports in a section	−0.080	−3.515
Shoulder length (meters)	−1.042	−1.461
Dispersion parameter	0.661	2.680
Restricted log likelihood	−686.57	
Log likelihood at convergence	−681.53	
Number of observations	1,584	

Table 1. Negative binomial estimation results for crash frequencies in urban areas (Lee & Mannering, 1999; reprinted by permission).

and the demographic characteristics of the population, conventional design "improvements" result in increases in crashes and fatalities.

Indeed, there are a host of safety anomalies in the existing design literature, but as Noland and Oh (2004) stated, the problem is that

> Studies that find unexpected or unconventional results tend to dismiss these results as aberrations and have not examined them in further detail. . . . The results of many of these studies lead us to conclude that the impact of various infrastructure and geometric design elements on safety are inconclusive. Most studies using sophisticated statistical techniques either find no association, or an unexpected association from infrastructure changes assumed to be beneficial. (p. 527)[5]

Thus, a key question emerges: why does contemporary design guidance recommend practices that the best available evidence suggests may have an ambiguous or even negative impact on safety, and paradoxically, to do so under the auspices that they constitute a safety enhancement?

The Passive Safety Paradigm

While safety has been a concern for the transportation design profession throughout its history, the current approach to addressing transportation safety received its philosophical basis as part of the transportation safety movement of the 1960s, a movement that resulted in the National Highway Safety Act, the creation of the National Highway Traffic Safety Administration (NHTSA), the adoption of the *Roadside Design Guide*, crash testing, and the development of air bags, among other features of the contemporary transportation safety landscape. This movement, led by William Haddon and promoted by figures such as Daniel Patrick Moynihan and Ralph Nader, sought to apply the principles of epidemiology to transportation safety issues (Gladwell, 2001; Kratzke, 1995; McLean, 2002; Viano, 2002; Weingroff, 2003).[6]

As a profession, epidemiology is based on the work of John Snow, an English physician who sought to address an outbreak of cholera that plagued London in the 1850s. While current medical theory asserted that the spread of cholera was associated with "vapors," Snow hypothesized that cholera was not airborne, but was instead transmitted through polluted water supplies. Using what was at the time a highly elaborate, data-driven analysis, Snow mapped out the locations of affected households, and determined that these households were indeed sharing a common water source. In an episode that has since become legendary, Snow sought to resolve this problem in one particularly hard-hit neighborhood by implementing a strategy that was both simple and radical: rather than encouraging residents to adopt behavioral modifications, such as boiling infected water or using an alternative water supply, Snow simply removed the handle from the pump of the affected well, thereby neutralizing the environmental cause of the hazard (Rosenberg, 1962).

William Haddon, an epidemiologist trained at the Harvard School of Public Health during the 1950s, likewise believed that it was difficult, if not impossible, to prevent people from engaging in behaviors that lead to traffic injuries and fatalities. Instead, Haddon proposed a *passive* approach: rather than relying on behavioral modifications to prevent crashes from occurring, Haddon believed the design objective should be to enable a "crash without an injury" by physically engineering safety features into vehicles and their environments (Gladwell, 2001). The idea was compelling: what if transportation professionals could

design vehicles and roadways to eliminate the injuries associated with a crash event?

Clear Zones, Highways, and Passive Safety

The life safety implications of the passive approach were not lost on Ralph Nader. In 1965, Nader published *Unsafe At Any Speed*, a critique of the auto industry based on Haddon's passive safety philosophy. Nader's book generated a public outcry to address the "designed-in" dangers of the nation's automobiles and transportation system, leading both congress and AASHO (later AASHTO) to hold special hearings on the subject in 1966. Figures such as Nader and Haddon reported to these committees, but testimony by Kenneth Stonex played perhaps the central role in formulating the contemporary perspective on safe roadway design.

One of the key problems identified by the AASHO committee was the large number of fatalities associated with single-vehicle, run-off-roadway crashes. To address this issue, they heard testimony from Stonex, a General Motors employee responsible for designing the "Proving Ground," an experimental "crashproof" highway that had 100-foot clearances on either side of the travelway (McLean, 2002; Weingroff, 2003). Based on the test performance of the Proving Ground, Stonex was of the opinion that "What we must do is to operate the 90% or more of our surface streets just as we do our freeways . . . [converting] the surface highway and street network to freeway and Proving Ground road and roadside conditions" (Weingroff, 2003, p. 147).

With respect to fixed-object crashes specifically, Stonex reported that most vehicles on the Proving Ground came to a stop within 30 feet after leaving the roadway. Thus, the committee concluded that eliminating fixed objects within 30 feet of the travelway would eliminate most fixed-object crashes and, in a conjectural leap, that the roadway would therefore be safer as a result. The 30-foot clear zone standard (with adjustments for sideslope) was thus incorporated into AASHO's 1967 publication *Highway Design and Operational Practices Related to Highway Safety*, as well as the revised 1974 edition, and remains in the subsequent editions of the *Roadside Design Guide* (AASHTO, 1974, 2002; McLean, 2002; Weingroff, 2003).

Side Effects of the Passive Treatment

Prior to the 1960s, transportation safety had been addressed primarily through strategies aimed at encouraging drivers to engage in safe behavior, an approach that led to the development and codification of the nation's signing practices and motor vehicle laws. Yet, as Nader testified, focusing on behavior was not an adequate solution to the problem:

> Even if people have accidents, even if they make mistakes, even if they are looking out the window, or they are drunk,[7] we should have a second line of defense for these people . . . the sequence of events that leads to an accident injury can be broken by engineering measures even before there is a complete understanding of the causal chain. (quoted in Weingroff, 2003, p. 154)

Following the 1966 hearings, contemporary safety practice thus became principally concerned with how to engineer this second line of defense, shifting the profession's focus away from driver behavior and towards the design of vehicles and roadside hardware.[8] Passive safety begins from the perspective that drivers will err, combined with the observation that there are fewer crashes on Interstates than on other roadways. Collectively, this resulted in the conclusion that "Highways built with high design standards put the traveler in an environment which is fundamentally safer because it is more likely to compensate for the driving errors he *will* eventually make" [emphasis added] (AASHTO, 1974, p. 15).

This perspective is still evident in the most recent edition (2001) of AASHTO's *A Policy on the Geometric Design of Highways and Streets* (the "Green Book"), which states:

> The objective in design of any engineered facility used by the public is to satisfy the public's demand for service in a safe and economical manner. The [highway] facility should, therefore, accommodate nearly all demands with reasonable adequacy and also should not fail under severe or extreme traffic demands . . . every effort should be made to use as high a design speed[9] as practical to attain a desired degree of safety. (pp. 66–67)

Thus, the passive approach attempts to enhance a roadway's safety by designing it to accommodate the safety needs of high-speed, "extreme" driving behavior. This approach hinges on a critical assumption, however: it assumes that drivers who already drive safely will continue to do so when forgiving design values are used, thereby enhancing the overall safety of a roadway by making it safe for not only "average" drivers, but also extreme drivers as well.

While the logic behind the passive approach has a high degree of face validity, it overlooks several important questions: how do average drivers adjust their behavior to forgiving design values? What about specific at-risk subpopulations?[10] Is it possible that by widening lanes and shoulders and eliminating roadside objects, designers are

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encouraging "non-design drivers" to adopt behaviors that result in crashes and injuries?

A Simple Empirical Test

With respect to determining the appropriate clear zone for a roadway, the most recent guidance states that "the wider the clear zone, the safer it will be" (Transportation Research Board [TRB], 2003, p. V-43). If this is true, then one would expect livable streetscape treatments to be less safe, in terms of crash frequency and severity, than roadways adopting more forgiving values for lane widths and clear zones. To test this assertion, as well as to build an understanding of the safety effects of livable streets more generally, I examined 5 years (1999–2003) of crash data for Colonial Drive (State Road 50), a state-owned arterial that connects the north end of downtown Orlando, Florida, to its eastern and western suburbs.

While none of Colonial Drive would be regarded as a particularly representative example of a livable street, the 0.9-mile segment that constitutes the northern edge of downtown Orlando (between Orange Avenue and Mills Avenue) includes many of the design features desired by livable streets advocates. Roadside development abuts the sidewalk, which is often uncomfortably narrow at points, but continuous throughout the section. Lane widths are narrower here (11 feet) than on much of the remainder of the roadway, and the segment includes on-street parking and roadside objects that buffer the pedestrian environment. The cross section, curb-to-curb, is roughly 68 feet, including four 11-foot travel lanes, a 10-foot painted median, and two 6.5-foot parking lanes. Roadside objects are offset by 1.5 to 2 feet from the curb (see Figure 2).

To evaluate the safety performance of this segment, it was matched with the nearest 0.9-mile section of Colonial Drive that was similar in terms of cross-sectional characteristics (four lanes and a painted median), posted speed limit, and average daily traffic (ADT) but which used more forgiving values for lane widths and clear zones.

The nearest comparison length was located slightly less than 4 miles east of the livable section described above. As shown in Table 2, the roadways are almost identical in all relevant characteristics of interest—section length, ADT, number of lanes, and median width—while differing principally in terms of lane widths and roadside object offsets. It should be observed that the posted speed limit is slightly higher for the comparison section (45 mph vs. 40 mph), but not substantially so. There is little difference in the average number of crashes per intersection or the mean age of at-fault drivers. Further, the use of a nearby comparison section on the same roadway helps control for the unique characteristics of the driver population, which in this case will include many of the exact same drivers. Holding all of these features constant, if the passive safety assumption holds, there should be fewer mid-block injuries and fatalities on this comparison section.

Comparing Crash Performance

As shown in Table 3, the livable section is safer in all respects. By any meaningful safety benchmark—total mid-block crashes, injuries, or fatalities—there can be little doubt that the livable section is the safer roadway.

A second area of interest for this study is the specific distribution of crash types across the roadways. What are the types of crashes that result in mid-block fatalities and injuries? There were no fatal mid-block crashes on the livable section during the 5-year evaluation period, while 6 occurred along the comparison length of the roadway, 3 of which involved pedestrians. Harmful event data were not provided on the other 3 fatalities.

Pedestrian and bicyclist injuries were likewise higher on the comparison section (see Table 4), which may be partly attributable to the fact that the livable section provides parked cars and fixed objects to buffer pedestrians from oncoming traffic. But do the benefits in pedestrian safety outweigh the hazards these features may pose to errant motorists?

For the livable section, there were 2 injurious crashes involving roadside objects, one involving a tree, and a second involving a parked car. Comparatively, there were 5 injurious crashes involving pedestrians and bicyclists on the comparison section, 3 of which were fatal.

What about the relative roadside hazards these designs might pose? From a passive safety perspective, the comparison section, with a 20-foot clear zone, should be the safer of the two in terms of total injurious collisions with fixed objects. Yet this is also not the case. Not counting pedestrians and bicyclists, there were 3 roadside object-related injuries on the comparison section, versus 2 in the livable section.

Finally, what about motor vehicle collisions? The average number of crashes per intersection were similar between the two study sections. Might the comparison section be at least as safe in terms of two-vehicle mid-block crashes? Again, the answer is no. For rear-end crashes, the crash type most likely to be associated with on-street parking, there were fewer injuries for the livable section. Likewise with injuries associated with head-on crashes, turn-related crashes, and sideswipe crashes. Only angle crashes were comparable, with both sections reporting 6 such injurious crashes during the 5-year evaluation period. In

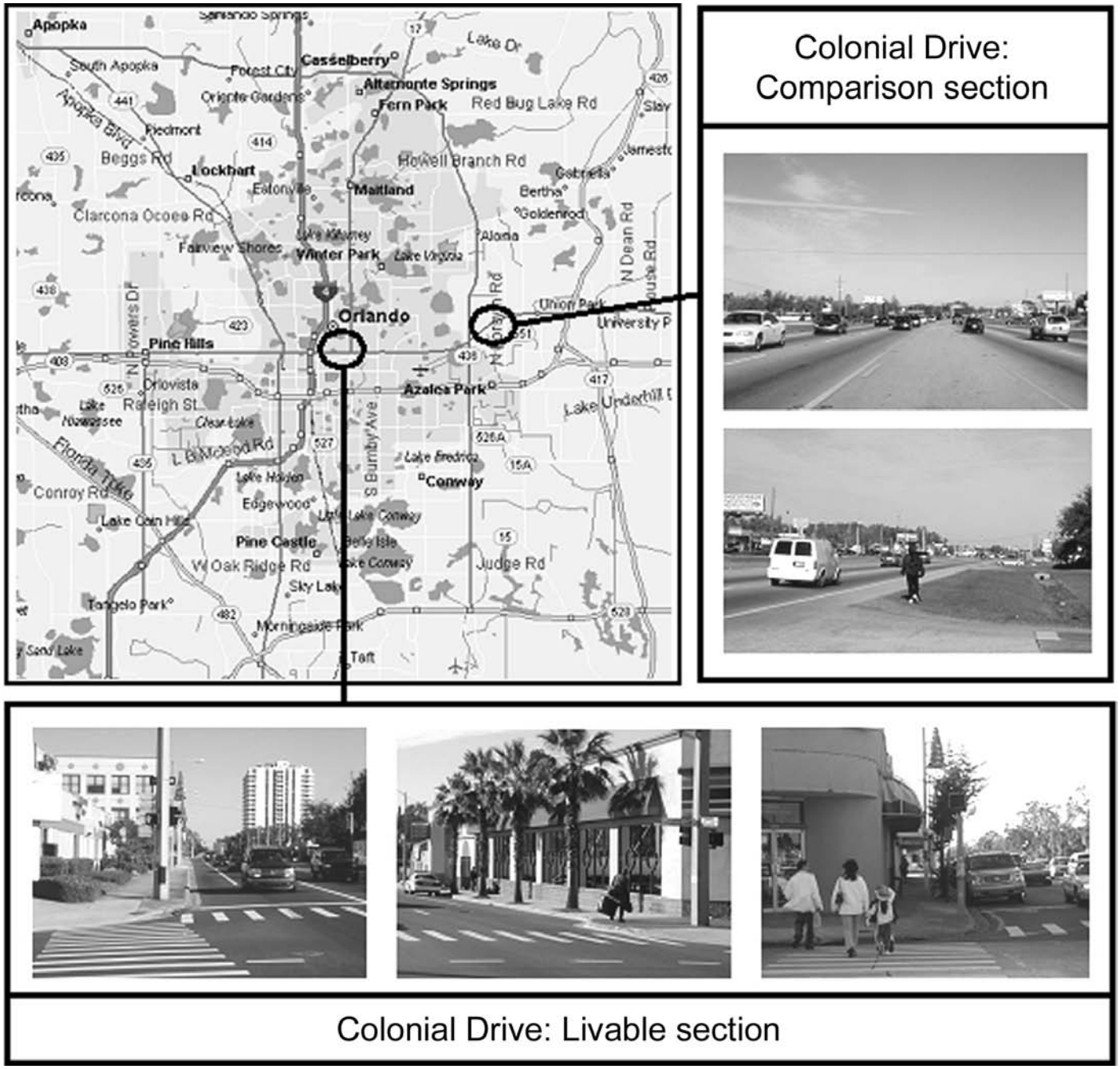

Figure 2. Colonial Drive: livable and comparison sections.

total, 9 more multiple-vehicle mid-block injurious crashes occurred on the comparison section than the livable one.

Comparing the Livable Section to Baseline Roadway Safety Performance

To understand how the livable section of Colonial Drive performed against urban operating conditions along State Route 50, I further compared its crash performance to 5-mile sections of Colonial Drive located on either side of the livable section, thereby capturing the majority of urban and suburban travel along this roadway. While this approach does not control for specific design variations along individual roadway segments, it is useful for determining whether the livable section is more or less safe than one would expect, on average, from the urbanized portion of the roadway as a whole.

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Characteristic	Livable section	Comparison section
Length (miles)	0.9	0.9
Average daily traffic (vehicles)	47,000	46,000
Posted speed limit (mph)	40	45
Lanes	4 x 11 ft.	4 x 12.5 ft.
Median	10 ft. painted	10 ft. painted
Shoulder	6.5 ft. parking lane	5 ft. paved shoulder ± 15 ft. runout zone
Avg. crashes per intersection	21	19
Mean age of at-fault driver	28	27

Table 2. Design characteristics of livable and comparison sections of Colonial Drive.

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Mid-block crashes	Livable section	Comparison section	Difference (%)
Total	73	82	−11%
Injurious	42	61	−31%
Fatal	0	6	−100%

Table 3. Mid-block crashes on Colonial Drive, 1999–2003.

Crash type	Livable section	Comparison section	Difference
Rear-end	29	35	−6
Head-on	0	1	−1
Angle	6	6	0
Left-turn	1	2	−1
Sideswipe	1	2	−1
Parked car	1	0	1
Pedestrian	0	4	−4
Bicyclist	0	1	−1
Tree/shrubbery	1	0	1
Other fixed object	0	1	−1
Ditch/culvert	0	2	−2
Other/unreported	3	7	−4
Total	42	61	−19

Table 4. Injurious mid-block crashes on Colonial Drive, 1999–2003.

Crashes were normalized by determining the number of crashes per 100 million vehicle miles traveled (VMT), [11] thereby developing a measure of exposure that could be used to directly compare safety performance. Nevertheless, a problem with VMT-based measures is that the relationship between VMT and crashes is not linear (Ivan et al., 1999). This finding may be attributable to the fact that high levels of congestion occurring during peak periods can have the dual effect of increasing the denominator of the measure while simultaneously reducing free-flow travel speeds, the combination of which may result in underestimates of a roadway's actual hazard during low-volume, free-flow operating conditions, such as late-night travel. To address this concern, I also evaluated safety performance based on the number of mid-block crashes per mile, a measure that makes no assumption about the relationship between traffic volumes and crash performance.

As shown in Table 5, the livable section of Colonial Drive is safer, by either measure, than one would expect when examining the 10-mile urban and suburban comparison section as a whole, reporting fewer total mid-block crashes than the comparison length of Colonial Drive, and substantially fewer injurious and fatal crashes.

Trend Identification

To determine whether the safety performance of Colonial Drive might perhaps be part of a broader safety trend, I further examined the crash performance of state arterial roadways traveling through the National Register–designated historic districts of DeLand and Ocala, Florida. Each city has two 0.5-mile sections of state roadways entering its historic district, with all four roadways having dense development adjacent to the travelway, minimum (1.5–2 feet) fixed-object offsets, and, for the two DeLand roadways, on-street parking as well.

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These roadways also included posted speed limit reductions of 10 mph or more, thus preventing one-to-one comparisons with adjacent sections. Nevertheless, understanding their safety performance with respect to the urban sections of these roadways as a whole does allow one to evaluate whether such treatments are safer than one would expect from baseline roadway averages, and is extremely useful for determining whether the safety performance of the livable section of Colonial Drive is anomalous, or whether it might perhaps be part of a broader safety trend.

In the absence of detailed field observations, the historic district boundaries were used to determine the boundaries of the livable sections of these roadways, and these sections were then compared against the crash performance of 5-mile sections of the same roadway located on either side of the historic district,[12] thereby permitting a consistent comparison of these roadways both against each other and against Colonial Drive. The individual performance of these roadways, as well as their averages, are reported in Table 6.

Like Colonial Drive, the livable sections were generally safer than their comparison roadways. On average, the historic roadway sections reported somewhat fewer total crashes and substantially fewer injurious crashes. Perhaps most notably, not a single fatal crash was reported for any of these historic roadway sections during the 5-year analysis period.

Individually, two specific results warrant noting. First, while the historic section of Woodland Avenue shows reductions in total and injurious crashes on a per-mile basis, it reports substantially higher crashes and injuries when using a VMT-based metric. In this case, the relatively low level of VMT observed for the historic section when compared to its comparison roadway (17,000 vs. 31,000 ADT) may overestimate its relative hazard. In absolute terms, the number of mid-block injurious crashes on the historic section of Woodland Avenue is identical to that for the other three roadways, with all of the historic sections reporting *exactly* 4 injury crashes over the 5-year analysis period, or 8 injurious crashes per mile.

Pine Avenue, while safer than the comparison roadway overall in terms of injuries and fatalities, nevertheless reports a higher number of total mid-block crashes than the roadway as a whole, although this may in part be attributable to cross-sectional differences. While the majority of State Route 25, of which Pine Avenue is a part, is a four-lane roadway, the 0.5-mile section that travels through Ocala's historic district briefly switches to a six-lane cross section, a factor that has been shown to result in higher numbers of crashes and injuries (Noland & Oh, 2004). The fact that higher total crash rates were not accompanied by higher rates of injurious or fatal crashes is an interesting and potentially important finding.

Reconsidering the Relationship Between Safety and Design

> To reject one paradigm without simultaneously substituting another is to reject science itself. (Kuhn, 1962, p. 79)

While these results seem to contradict conventional design practice, they confirm a trend that many researchers and practicing engineers have observed for some time, but which has received little substantive elaboration: specifically, that clear zones and other forgiving design practices often have an ambiguous relationship to safety in urban environments, and may be associated with declines in safety performance. The best possible explanation for the enhanced safety performance of the livable sections considered in this study is that drivers are "reading" the potential hazards of the road environment and adjusting their behavior in response.

	Mid-block crashes per 100 million VMT			Mid-block crashes per mile		
	Livable section	10-mile comparison	Difference (%)	Livable section	10-mile comparison	Difference (%)
Mid-block crashes						
Total	95	102.0	−6.9%	66	88.0	−25.0%
Injurious	54	69.0	−21.7%	38	59.0	−35.6%
Fatal	0	2.1	−100.0%	0	1.8	−100.0%

Table 5. Mid-block crash performance of Colonial Drive, livable section vs. 10-mile urban comparison section, 1999–2003.

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The reason why this subject has not received greater attention in design literature and guidance appears to be that it contradicts the prevailing paradigm of what constitutes safe roadway design. Nevertheless, a behavior-based understanding of safety performance is supported by research and literature in the field of psychology, which has focused on the subject of traffic safety as a means for understanding how individuals adapt their behavior to perceived risks and hazards.

Risk homeostasis theory, as developed by Wilde (1982, 1988, 1994), asserts that individuals make decisions on whether to engage in specific behaviors or activities by weighing the relative utility of an action against its perceived risk. While all actions involve some risk, risk homeostasis theory asserts that individuals will adjust their behavior to maintain a static level of minimum exposure to perceived hazard or harm. With respect to driving behavior, risk homeostasis theory posits that drivers intuitively balance the relative benefits of traveling at higher speeds or engaging in other higher-risk driving behavior against their individual perceptions of how hazardous engaging in such behavior might be. Where hazards are present and visible, such as in the case of livable streetscape treatments, risk homeostasis theory would expect drivers to compensate for this perceived environmental hazard by adjusting their behavior to minimize their exposure to risk.

Nevertheless, risk homeostasis theory would also assert that, *ceteris paribus*, the relative crash performance of a roadway should remain constant along its length, regardless of specific design variations, since any change in perceived hazard will be offset by corresponding adjustments in behavior. Thus, according to risk homeostasis theory, the livable street sections should be no more or less safe than their comparison roadways overall.

Yet as Hauer (1999b) describes, there is an important distinction between *safety*, which is (or should be) an em-

	Mid-block crashes per 100 million VMT			Mid-block crashes per mile		
Roadway	**Historic district**	**10-mile comparison**	**Difference (%)**	**Historic district**	**10-mile comparison**	**Difference (%)**
Pine Ave., Ocala (SR 25)						
Total	36.0	33.6	7.1%	24.0	18.4	30.4%
Injurious	12.0	23.2	−48.3%	8.0	12.7	−37.0%
Fatal	0.0	0.9	−100.0%	0.0	0.5	−100.0%
Silver Springs Blvd., Ocala (SR 40)						
Total	28.7	42.1	−31.8%	16.0	20.0	−20.0%
Injurious	14.4	24.2	−40.5%	8.0	11.5	−30.4%
Fatal	0.0	0.4	−100.0%	0.0	0.2	−100.0%
New York Ave., DeLand (SR 44)						
Total	44.7	68.9	−35.1%	10.0	14.9	−32.9%
Injurious	35.8	52.7	−32.1%	8.0	11.4	−29.8%
Fatal	0.0	4.2	−100.0%	0.0	0.9	−100.0%
Woodland Ave., DeLand (SR 15)						
Total	43.1	26.6	62.0%	12.0	14.3	−16.1%
Injurious	28.7	18.8	52.7%	8.0	10.1	−20.8%
Fatal	0.0	0.7	−100.0%	0.0	0.4	−100.0%
Average						
Total	38.2	42.8	**−10.7%**	15.5	16.9	**−8.3%**
Injurious	22.7	29.7	**−23.6%**	8.0	11.4	−29.8%
Fatal	0.0	1.6	**−100.0%**	0.0	0.5	−100.0%

Table 6. Mid-block crash performance of roadways in historic districts and 10-mile comparison sections, 1999–2003.

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pirical measure of crash performance, and *security*, which is an individual's subjective perception of safety (or conversely, perceived exposure to harm). The presence of features such as wider lanes and clear zones would appear to reduce the driver's perception of risk, giving them an increased but false sense of security, and thereby encouraging them to engage in behaviors that increase their likelihood of being involved in a crash event. If so, this explains why the livable streetscape treatments examined in this study resulted in not only fewer fixed-object crashes, but fewer multiple vehicle and pedestrian crashes as well. Such treatments appear to help balance drivers' sense of security with the real levels of risk in their environment, providing them with more accurate information on the appropriate level of caution, and resulting in behavioral adjustments that better prepare them for the potentially hazardous vehicle and pedestrian conflicts that one encounters in urban environments. From the perspective of risk homeostasis theory, the use of high design values is not "forgiving," but is instead "permissive."

Researchers attempting to understand safety anomalies emerging in their work have implicitly suggested a driver's risk perception accounts for their findings. Ossenbruggen et al. (2001) speculated that the better safety performance of urban villages may be attributable to the fact that the roadside environment "warn[s] drivers that they must maintain a low speed and use caution" (p. 496). In explaining why new roadway improvements were shown to result in an increase in crashes and injuries, Noland (2001) suggested that "higher design standards [allow] drivers to increase their speeds on roads and reduce their levels of caution" (p. 24).

Towards a Theory of Positive Design

> . . . competent drivers can be given appropriate information about hazards and inefficiencies to avoid errors. (Federal Highway Administration, 1990, p. 1-1)

The idea that safety can be addressed by focusing on a driver's perception of risk, rather than relying solely on passive engineering principles, is not without precedent in the engineering community. Two important byproducts of the passive safety approach are the related concepts of positive guidance and driver expectancy, which first emerged in the Appendix to the second edition of AASHTO's *Highway Design and Operational Practices Related to Highway Safety* (1974) as a means to address crashes associated with narrow bridges. While emphasizing that the consistent[13] application of freeway standards is the preferred solution for addressing safety at narrow bridges, the guide remarks that "it would take years and billions of dollars to effect such a program" (p. 83).

In an attempt to satisfice a lower-cost, more implementable solution, the guidance proposes that "highway safety can be considerably improved by restructuring the driver's expectancies so that he is prepared for the narrow bridge situation [and] the narrowing of the shoulder and/or roadside . . ." (p. 83). The guidance then proceeds to detail how to adequately sign and mark the approach to the "restricted" condition of a narrow bridge.

To date, positive guidance has focused largely on the use of pavement markings and signs to convey safety information, and there has been relatively little advancement in this area since 1990, when the most recent edition of the Federal Highway Administration's (FHWA's) *A Users Guide to Positive Guidance* was published.[14] Nevertheless, it may be time to resurrect this concept, particularly as it may relate to the physical design of highways and streets.

A positive approach to transportation design would seem to explain the emerging safety anomalies the passive approach simply cannot account for, such as Naderi's (2003) findings on aesthetic streetscape treatments or the livable street examples included in this study. It also explains why narrowings and chicanes, two traffic calming applications that modify the roadside in a manner that passive safety suggests should increase crashes and injuries, have been shown to result in substantial (74%–82%) crash reductions (Zein et al., 1997). Indeed, all traffic calming measures appear to reduce accidents by slowing traffic and/or increasing driver caution (Ewing, 1999), leading European designers to view them not as "livability" features but as safety countermeasures (Skene, 1999).

A Positive Approach to the Design of Urban Streets

The passive approach promotes designs intended to support high-speed operating behavior, and then attempts to mitigate a roadway's hazards through the use of signs and pavement markings. The problem that emerges, however, is that signs and roadways are often communicating contradictory information. The result is that the majority of drivers in urban areas disregard posted speed limits, and seem to learn to disregard road signs altogether, even when they display information that is essential to their safety (Chowdhury et al., 1998; Fitzpatrick, Carlson, et al., 2003; Fitzpatrick, Shamburger, et al., 1996; Kubilins, 2000; Tarris et al., 2000). Further, even when drivers are deliberately attempting to obey speed restrictions, they instinctively increase their operating speed to their perception of a roadway's safe speed when their concentration is focused on something other than actively monitoring their vehicle's

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speedometer (Recarte & Nunes, 2002). This latter finding suggests that even conscientious drivers may be unable to comply with posted speed limits when roadways are designed for higher-speed operation.

A key point of departure for positive design is that it openly recognizes that drivers use the total information provided by their environment—not just posted speed limits—and strives to take advantage of these opportunities to provide drivers with the information they need to operate their vehicles safely and appropriately. On this subject, Our European counterparts, with markedly safer roadways than the United States,[15] have developed a potentially valuable alternative.

European designers use an "environmental reference speed" when designing a roadway, beginning the design process by tightly specifying the desired operating speed of a roadway, and then using this intended operating speed as the roadway's design speed, providing posted speed limits that match (FHWA, 2001; Lamm et al., 1999). Roadways are thus designed to be self-explaining and self-enforcing, conveying a single and consistent message to the driver on safe operating behavior.

Further, European designers view high-speed driving as incompatible with the safe operation of urban roadways. For all streets with any concentration of roadside development or anticipated pedestrian activity, design speeds are severely restricted, rarely exceeding 50 km/h (31 mph). As a 2001 FHWA scan of European design practice concluded:

> [European] countries have very high safety goals (ranging from zero fatalities to reduction of more than 40 percent for all crashes) that guide the design approach and philosophy. To achieve these goals, planners are willing to provide roadways that self-enforce speed reductions, potentially increase levels of congestion and promote alternative forms of transportation. This approach contrasts with the U.S. design philosophy, in which wider roads are deemed safer, there is a heavier reliance on signs to communicate the intended message, and there is a lower tolerance for congestion and speed reduction. (FHWA, 2001, p. viii)

The European approach is achievable because designers explicitly recognize that a roadway's environmental context plays a key role in determining its safe design and operation, and they have developed design practices aimed at linking specific design values to their corresponding physical and operational contexts. German designers, for example, use a 30-celled functional classification system that accounts for not only mobility and access, but also variations in a roadway's design environment and the needs of a diverse set of user groups (Lamm et al., 1999). Thus, practicing designers are provided with clear guidance on the safe and appropriate design of roadways that address design needs for a range of physical and environmental contexts.

Conversely, U.S. practice applies an extremely coarse, three-tiered functional classification system that categorizes roadways exclusively according to their vehicle access or mobility functions (AASHTO, 2001), resulting in the problem that many of the urban roadways classified as minor arterials serve a variety of purposes other than higher-speed mobility functions. Roadways designated as minor arterials cover a wide range of physical environments, and there is little guidance detailing which design values are most appropriate in each context (see Figure 3). Indeed, the lowest recommended design speed for an urban minor arterial in the United States (30 mph) is simultaneously the *highest* design speed that would be applied on a similar roadway in a European city (AAHSTO, 2001; Lamm et al., 1999).

Despite a host of problems associated with applying the U.S. functional classification system in an urban environment (de Cerreno & Pierson, 2004; Forbes, 2000; Kubilins, 2000; Meyer & Dumbaugh, 2004), many design engineers have made notable strides in this area through the use of context-sensitive solutions, an approach that incorporates stakeholders in the project design and development process (FHWA, 1997; TRB, 2002). One problem that emerges, however, is that determining whether a specific design approach is appropriately safe is ultimately a matter of professional engineering judgment, not an outcome of public involvement activities. On this subject, designers are forced to navigate the uncharted waters of urban road safety alone.

And increasingly, many practicing designers are doing so. There are a growing number of examples of design engineers who have chosen to thoughtfully strike out on their own, moving beyond the conventional definition of "safe" design practice to develop new strategies for addressing the twin goals of safety and livability. Five such examples are included in this study alone. Yet any success in this area has occurred in spite of passive safety practices, not because of them. It is the obligation of future researchers to begin to more fully develop our understanding of how to safely design urban roadways, and to ensure that this information is better disseminated throughout the profession. A positive approach to transportation design would appear to be a key means of doing so.

Finally, this study does not suggest that certain urban roadways can not or should not be designed to address mobility needs. But it does suggest that we must move

beyond the assumption that the use of "forgiving" design values necessarily equates to enhanced safety, and to begin reconsidering the role that driver behavior may have on a roadway's safety performance, particularly in urban environments. Substantial opportunities for enhancing both safety and livability remain to be explored.

Safe Streets, Livable Streets

At the most fundamental level, the major tension in the design of urban roadways does not appear to be a matter of balancing safety and livability objectives. There is little evidence to support the claim that "livable" streetscape treatments are less safe than their more conventional counterparts, and the weight of the evidence suggests that they can possibly enhance a roadway's safety performance. Instead, the more basic problem appears to be that safety and livability objectives are often in direct conflict with the overarching objective of mobility, and its proxy—speed.

The passive approach to transportation safety began with the observation that the Interstate Highway System produced fewer crashes and injuries than other roadway classes, and attributed this safety performance to the use of higher-speed, more "forgiving" design values. Yet it must be recognized that the safety performance of the Interstate system is probably better explained by the fact that these roadways physically restrict access, channel vehicle movements, and limit their use to a single user type—motorists—than because they permit higher operating speeds.

Conventional safety practice attempts to superimpose these high-speed, limited-access design characteristics on other roadway types, but it is not at all clear that these designs are either safe or appropriate in an urban context. At the most basic level, the primary function of cities, and thus the streets that serve them, is to concentrate compatible developments and activities together and to encourage a high degree of access between them, traditionally through nonmotorized modes. High-speed, limited-access roadways are inherently antithetical to these purposes.

I have argued that many of the safety concerns that emerge on urban streets result from design practices that fail to link a roadway's design to its environmental context, thereby providing motorists in urban environments with a false sense of security and increasing their potential exposure to crashes and injuries. I have further provided a theoretical framework that better accounts for the safety anomalies one observes when examining the literature and data on the crash performance of urban roadways. Yet theory is only the first step. There is a clear and demonstrated need to better develop our professional understanding of the relationship between driver behavior and transportation safety, as well as to enhance our overall approach to the design of urban roadways. This study thus concludes with the hope that by better understanding the relationship between design, driver behavior, and safety, we can design roadways that are not only safe, but also livable.

Figure 3. Three urban minor arterials.

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Notes

1. In conventional engineering parlance, all roadways are referred to as *highways*. Conventional, high-speed highways are referred to as *freeways*.

2. While the AASHTO (2001) Green Book permits the use of a 1.5-foot "operational offset" on urban arterials, it is important to recognize that this is intended only to prevent motor vehicles from hitting their mirrors on roadside objects during normal operating conditions, and is not intended or perceived as having a meaningful relationship to safety. As stated in the Green Book: "Clear roadside design is recommended for urban arterials wherever practical" (p. 485).

3. The finding with the potentially most profound influence on roadside safety is also the one that receives the least attention. The authors noted that "curves were highly over-represented in tree accidents. Almost 59% of tree accidents were related to a curve. This is startlingly high considering that probably no more than 5% of all street mileage in the city of Huntsville is curved" (Turner & Mansfield, 1990, p. 97). In response to this finding, the authors recommended prioritizing tree eliminations at curves. While such an approach may go a long way towards reducing injuries in run-off-road events, it fails to ask the potentially more important question: why are run-off-roadway events more likely to occur at curves in the first place? It would seem unlikely that this remedial action—eliminating the tree—will have any effect on eliminating the run-off-roadway event, which may nevertheless result in an injurious crash, such as a rollover, regardless of whether a tree is present. As evidenced in Milton and Mannering (1998), the problem is not the curve itself, but a curve that it is preceded by a straight (high-speed) approach.

4. Hauer (2000) does note that "I am not convinced that if research was done on current data, that 12-foot lanes would be found to be less safe than 11-foot lanes. Much has changed since then; trucks grew to be larger and research methods improved. However, at the time the Policy was written, the aforementioned findings by respected researchers should have sounded alarm" (p. 12).

5. While Noland and Oh's (2004) study focused primarily on rural observations, two specific findings bear mentioning. Shoulders had an ambiguous relationship to safety, with wider shoulders being associated with a decrease in total crashes but increases in fatal ones. While these findings do not directly address safety in urban environments, they do suggest that increasing shoulder widths may increase vehicle speeds, thereby increasing crash severity, if not frequency.

6. My treatment of this topic skirts over a rich and interesting history that deserves a more thorough treatment than can be given here. Interested readers should are encouraged to see Weingroff (2003) and Gladwell (2001), both of which are not only highly informative, but surprisingly compelling.

7. Practicing engineers will undoubtedly recognize the similarity between Nader's hypothetical "drunk looking out the window" and the definition of the "design driver" used in contemporary design practice.

8. This is evidenced in the fact that while our methods for the crash testing of vehicles and roadside hardware have become increasingly elaborate in the past 40 years (see Transportation Research Board, 1993, for current test standards), there has been little advancement in our understanding of the behavioral factors that cause crashes to occur (Kanellaidis, 1996; Noland, 2001).

9. While a full treatment of the subject of design speed is beyond the scope of this study, the important fact is that a roadway's design speed is the controlling element in its design. Once a design speed is selected, all other geometric features, such as lane widths and clear zones, are designed to conform to the adopted design speed. Thus, higher design speeds encourage the use of higher minimum values for all other geometric features as well.

10. Examining Fatality Analysis Reporting System (FARS) data for minor arterials, collectors, and local roadways is revealing. In 2002, for example, half of all individuals killed in a fixed-object crash on these road classes were between the ages of 16 and 25, and fully 40% of the total crashes involved males in this age group. Females account for less than a third of the fatalities in all age brackets except the 71 and older group, where male and female fatalities equalize, undoubtedly the result of the fact that at these ages, personal motor functions and reaction times begin to decline. When one considers this information holistically, it suggests that fixed-object fatalities may not be a design problem as much as they are a reflection of broader demographic and sociocultural factors, such as a propensity of young males to engage in higher-risk behavior.

11. To calculate a roadway's VMT for the 5-year study period, I determined average ADT for each roadway milepost, and then used the median ADT to derive an overall estimate of VMT for the road segment. The median was selected as a better measure of central tendency than the average because several small roadway segments had unusually high ADTs, thus skewing the overall averages. Once median ADT was determined, VMT was calculated as: VMT = Median ADT $\times$ 365 $\times$ 5 $\times$ Section Length.

12. The exception is Pine Avenue (State Road 25) in Ocala. Only 2.1 miles of roadway were available for the northern comparison section because a substantial (14-mile) segment is currently off the state system. To acquire 10 miles of comparison roadway data, I used averages for a 2.1-mile section to the north and a 7.9-mile section to the south.

13. *Design consistency*, a phrase often used by designers to discuss how they address safety through design, also emerged in the 1974 guide, which states: "consistency in design standards is desirable on any section of road, because problem locations are generally at the point where minimum design treatment is used" (p. 15). Restated another way, design consistency, as it was originally conceived, encourages the consistent adoption of high design values.

14. In the 1994 and 2001 editions of AASHTO's Green Book, the sections dealing with these subjects contain no data, nor has a word been changed.

15. A few statistics bear mentioning. In 1966, the year that passive safety principles first became embedded in contemporary practice, the U.S. had fewer transportation-related fatalities per capita (26 per 100,000 population) than all other countries except Great Britain (15 per 100,000). By 2000, the U.S. (15 fatalities per 100,000) remained behind Great Britain (6 per 100,000), but had also fallen behind the entirety of the European Union (11 per 100,000), Australia (10 per 100,000), Japan (8 per 100,000), and, indeed, the rest of the developed world (NHTSA, n. d.; World Health Organization, 2004). While these statistics are alarming, they also suggest that promising new opportunities for enhancing transportation safety remain to be explored.

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Counterpoint

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It has taken many decades for roadway designers to begin to recognize that how road and road environments are designed affects safety, and to identify what particular features enhance or detract from safety in a given environment. This process is still evolving. Historically, there has been a tendency for those funding research to focus on rural or high-speed environments, and on pavements and structures. One outcome of the resulting underemphasis on safety and urban design concerns, as author Eric Dumbaugh identified in this article, is the problem with the published research about urban roadside design in the U.S.: it is limited in both scope and quantity. With these limitations, it is understandable that city street designers extrapolate from principles learned in a rural highway environment. They may not be standing on the firmest ground when they do this, but they judge that it is the best ground they have.

While the author's initial focus is on urban roadside design, he eventually broadens the scope of the article to consider underlying philosophies and assumptions of why drivers choose a certain speed or exhibit other behaviors. He and I agree on certain points, such as that current research is inadequate and a better understanding of urban roadway design and driver behavior interactions is needed, and that other paradigms may bear consideration. However, I question some of his statements in the article:

- In discussing the Huntsville study (Turner & Mansfield, 1990), the author states ". . . it does not lead to the conclusion that eliminating trees . . . will have any effect on a roadway's safety. Such conclusions can only be made by examining the actual crash performance of eliminating trees in urban areas. . . ." Would not a comparison of roadways similar except for the absence or presence of roadside objects such as trees constitute a valid comparison?
- Does the Toronto study (Naderi, 2003) actually show that trees in concrete planters resulted in crash reduction, or that they were instead *associated* with a reduction? While inferences from association can be valid, they do not always equate with causality.
- Contrary to the author's claims, I believe that growing awareness of the need to engineer safety into roadways did not necessarily shift the focus away from driver behavior, but rather expanded the focus to be more inclusive.
- The author suggests that an active approach to safety —constraining the roadway to communicate the need to slow down—might be more effective than the passive approach, which accommodates and perhaps encourages "extreme driving behavior." It is misleading to state that the passive approach attempts to accommodate high-speed, extreme behavior. Speed studies typically reveal that most drivers on a given roadway fall within a rather narrow band of speeds. When roadway designers design for the 85th or 90th percentile speed, they are designing for a speed that is within a few miles per hour of what most drivers choose to drive at, which is hardly extreme. For example, refer

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to the accompanying graph, showing the plotted cumulative speed distribution from five city streets in Fayetteville, Ft. Smith, and Little Rock, Arkansas. There is approximately a 3- to 4-mph difference between the 85th percentile speed and the mean speed, which means there is very little difference between designing for the 85th percentile driver and designing for the average driver.

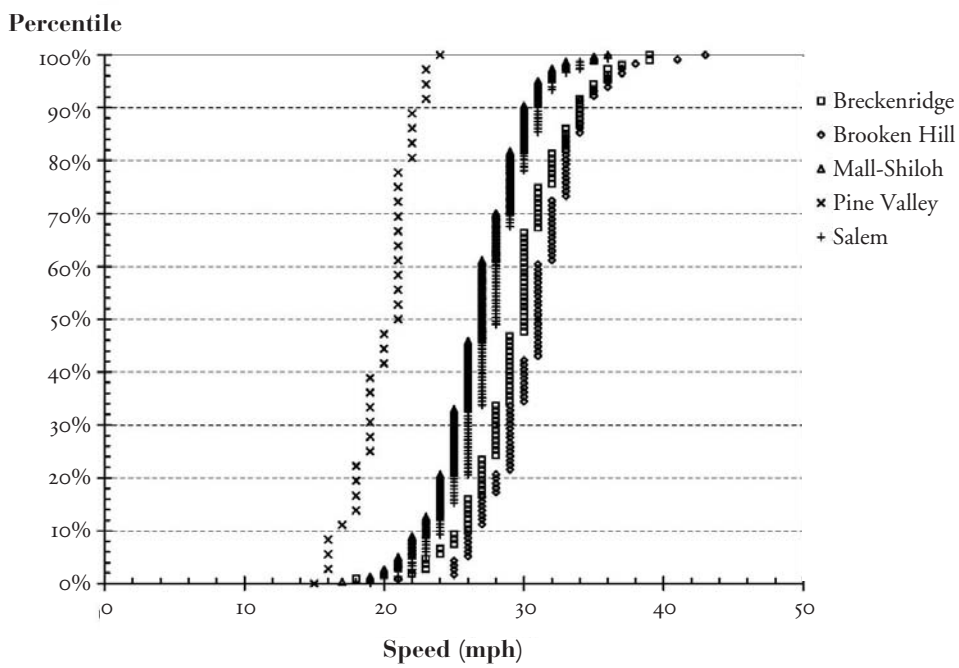
- The author's appeal to risk homeostasis theory employs an *a priori* assumption. First, we need to question whether this theory applies to driving behavior. Observation would suggest there is elasticity in the amount of risk drivers accept, since drivers seem to be willing to increase risk to achieve some reward, such as saving time. Used in this context, this theory almost suggests purposefully increasing the driving hazard in order to improve safety. If we wanted to discourage people from running in grocery store aisles, would we throw down more banana peels?

It should be noted that some recent American research has tried to examine why drivers choose a certain speed in an urban environment, and what factors might communicate to them that they should slow down, but this is a difficult issue to study, much less to resolve. For the present, we are left with conflicting concepts about what effects certain design features will have on the safety of a given urban street. To better understand where and under what conditions various urban aesthetic streetscape treatments are benign or even helpful, resources must be reallocated to improve both urban roadway data systems and safety analysis.

A problem one has with trying to draw conclusions from limited and sometimes seemingly contradictory studies is that of comparing apples to oranges. Research suggests that crash rates are affected by multiple factors, such as traffic volume, width, speed, presence of parking, type of roadside development, and access frequency. Crash studies do not always consider these nuances, but due to the effort needed to have a suitable sample size, it is certainly understandable that only some factors are accounted for. Even in the author's own data, there were somewhat mixed results (e.g., Woodland Avenue in DeLand, Florida). If access frequency for these roadways were to be factored in, still a different finding could have appeared. In short, more context-sensitive research is a prerequisite for context-sensitive design.

Also not to be overlooked in a discussion of the author's initial issue is the fact that there can be other problems with roadway landscaping. Motorists pulling out of side streets and driveways encounter landscaping that has been installed in such a way that it obstructs their view of oncoming traffic. Also, landscaping in the wrong place can restrict motorists' ability to see pedestrians or traffic-control devices.

Perhaps there is another lesson to learn from the Stonex report. What is most often referenced from the



Cumulative speed distribution for five city streets in Arkansas.

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report of GM Proving Ground experience is the 30-foot clear zone, but what is overlooked is perhaps more significant. Stonex reported that even with professional drivers on a closed course, with a statistical probability drivers would sooner or later lose control and have an accident. A society that understands this lesson recognizes that drivers are human and sooner or later make mistakes, and tries to incorporate safeguards into roadway design.

Livable streets advocates sometimes ignore the fact that mobility is also a part of quality of life. In the American cities I am familiar with, only a small fraction of the streets (the major and minor arterials) are intended for higher volumes and speeds, while the great majority of the street miles are for lower volumes and speeds. This small percentage of arterial streets is all that people have to rely on to get to their jobs, schools, and other destinations safely and without delay. Policies and design features that impede travel on the few available corridors of mobility, or make travel more dangerous, adversely affect the quality of life for all people.

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Introduction

The desire for safe streets that function well for all users is a timeless idea. Since the early part of the last century, street design has been an inter-disciplinary affair, often occurring in the context of a larger vision for the neighborhood, community, or city. Designs were guided by the uses planned along the street, the needs of pedestrians, horse drawn carriages, bicycles, and even streetcars. In urban environments, conflicts between these street users were commonplace and various design solutions were devised to address these challenges.

With the mid-20th century rise of the automobile, however, the focus on street design shifted; driven by new physical and safety considerations related to the size, weight, and speed of the automobile. Specialists in traffic engineering emerged. A new professional language was created. Roadway standards were developed, and attention was increasingly focused on moving vehicles quickly, minimizing delay for motorists, and increasing the personal freedom, access, and mobility afforded by the automobile.

The sustainability implications of this narrow focus on the automobile are widespread. At the community scale, land uses have become increasingly segregated and separated by larger distances, requiring more time and more energy to meet daily needs. At the neighborhood scale, higher traffic speeds and higher traffic volumes increasingly conflict with pedestrian and bicycle uses that once shared the same streets. At the roadway intersection level, improvements constructed to meet vehicular delay standards have the unintended consequence of also creating wide and unfriendly barriers to pedestrian crossing.

As a result, there is a growing public desire for a return to more walkable and bikable streets that support livable communities. Increasingly, local and regional agencies are working in support of street and transportation network design that encourages walking, bicycling, transit use by all users, including children, seniors, and disabled. The public is calling for a renewed attention to the context

and adjacent land uses, focusing on streets and the access they provide to the destinations they are meant to serve.

The two concepts that have galvanized this growing interest are “Complete Streets,” with an emphasis on routinely designing for all street users, and “Context Sensitive Design,” with an emphasis on an inter-disciplinary approach to design and increased consideration of the surrounding context.

Complete Streets

A complete street is safe, comfortable, and convenient for travel via automobile, foot, bicycle, and transit. This concept was initially championed by cycling advocacy groups seeking increased accommodation of cyclist needs in roadway design. What their initial research revealed was a changing attitude among the majority of Americans. For the first time in decades, surveys are showing a preference for expanding existing public transportation and building new bikeways and sidewalks over expanding existing highways and building new highways.[1]

Despite the increasingly segregated land use pattern changes over the last century, the potential for increasing bicycle and walking trips is high and the need is growing:

- There are an estimate 35.3 billion walking trips nationwide every year in the U.S.
- Walking is not just for recreation. Over 50% of all walking trips serve a functional purpose other than exercise and recreation[2]
- Nearly a third of Americans do not drive, and the non-driving senior population will grow even larger in the near future with the aging Boomer generation
- 55% of Americans say they would rather drive less and walk more[3]
- The top pedestrian complaint is simply that there are too few sidewalks[4]
- The top bicyclist complaint is simply that there are too few bikeways[5]

Incomplete street design may also result in continued safety problems. Streets designed exclusively for the automobile have been associated with disproportionately high crashes rates and fatalities for pedestrians and bicyclists. While pedestrian and bicycle trips account for roughly 9% of all trips, 13% of all traffic related fatalities involve pedestrians and bicyclists[6].

States and local jurisdictions are responding to these changes with new policies and changes to internal design processes and transportation planning to

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[1] Federal Highway Administration Infrastructure Survey, 2000.
[2] Natl. Survey of Pedestrian and Bicyclist Attitudes and Behaviors, 2002
[3] Surface Transportation Policy Project Survey, 2002
[4] National Transportation Availability & Use survey, 2002
[5] National Transportation Availability & Use survey, 2002
[6] 2005 NHTSA Traffic Safety Facts

routinely accommodate all modes of travel. Examples of agencies with complete streets policies include:

	State	County	Metropolitan Planning Organization	City
Legislative: Legislation, Ordinances, Resolutions	OR, FL, RI, NC, SC, MA	DuPage, IL Sacramento, CA San Diego, CA Jackson, MI	Columbus, OH Bay Area, CA	Columbia, MO Sacramento, CA Aurora, CO Spartanburg, SC
Procedural: Policies, Plans, Manuals	TN, CA, KY, VA, PA, MA		Cleveland, OH Bay Area, CA Knoxville, TN Gulf Coast, FL Austin, TX	Chicago, IL Charlotte, NC Aurora, CO Boulder, CO Colorado Springs, CO Fort Collins, CO Santa Barbara, CA San Diego, CA W. Palm Beach, FL

Source: Completestreets.org

Context Sensitive Design

Also referred to as Context Sensitive Solutions (CSS), this idea has become an accepted approach to designing or re-designing streets to be more compatible with adjoining uses and more accommodating to all modes of travel. The broader scale design approach often incorporates complete streets concepts into a larger discussion of the street and its function in relationship to land use. There is strong support for CSS at the Federal level. States such as New Jersey, Maryland, Washington, and California have adopted context sensitive design policies that consider the impact of state highway designs decisions on abutting land uses, community character, and the comfort and convenience of pedestrians, cyclists, and transit users as well as automobiles. The design process is also changing with this concept, shifting the focus from the motorist to include consideration of safety, operations, community and aesthetics, natural and built environments, and the jurisdiction interests.

Techniques include more rigorous management of traffic speeds, narrowing the traffic realm while expanding the pedestrian realm, accommodating bikes and transit, using curb parking as a buffer between moving traffic and sidewalk activities, and improving the sidewalk environment and ability of pedestrians to cross the street. Land use related policies include specific policies for transit oriented development locations, urban centers, and pedestrian priority zones such as Downtown area. A compilation of many such techniques can be found in the Context Sensitive Solutions for Major Urban Thoroughfares in Walkable

Communities document, which was jointly prepared by the Institute of Transportation Engineers and the Congress for New Urbanism.

Examples at the local level of context sensitive design are often expressed in flexible street standards or typologies that vary with the type of adjacent land use. Blueprint Denver in Colorado and the Sacramento Area Council of Governments Blueprint in Sacramento, California represent examples where street design considerations were integrated into the larger community land use planning effort.

Sustainability Benefits

In addition to responding to an increasing desire from the traveling public for more walkable and bikable communities, complete streets and context sensitive solutions can provide the following sustainability benefits:

- Increased safety for bicyclists and pedestrians
- Energy savings related to more fuel efficient modes of travel
- Infrastructure cost savings with coordinated land use and transportation planning
- Reduced vehicle miles traveled (VMT) resulting in:
    - CO2 emission reduction
    - Improved traffic flow
    - Decreased maintenance and repair costs
- Improved Public health
    - Increased physical activity levels
    - Improved air quality

Principles for Sustainable Transportation

The body of research and literature surrounding both Complete Streets and Context Sensitive Solutions is growing and focusing attention to design at the street level. This work fits into a larger framework of transportation planning at a range of scales that also considers regional accessibility, network design, and integrated land use and transportation planning to provide a sustainable transportation system.

At the regional scale, highly interconnected vehicle, transit, bicycle, and trail networks increase accessibility and provide a variety of transportation choices. The focus at this scale should be on incorporating all modes into travel modeling and planning, increasing accessibility and mobility through land use and multimodal network planning, and working to minimize the average length of vehicle trips in the region through compact growth and a balanced mix of jobs and housing. Ideally, the roadway, transit, and trail networks should be serving trips throughout the day in both directions to maximize the utility of these investments.

The best work at the local scale or street level should consider the following Principles for Sustainable Transportation Design:

1. **Land Use Context –** sustainable street design reflects and enhances the adjacent land uses and the surrounding context
2. **Multimodal Design –** sustainable street design operates safely at all times for all modes of travel and all users, including the young, old, able and disabled
3. **Aesthetic Quality –** sustainable street design reflects a commitment to aesthetic quality in the public realm and a sense of civic art, increasing economic value and the desire to use the space
4. **Interdisciplinary Approach –** sustainable street design includes consideration of safety, operations, community and aesthetics, natural and built environments, and the agency interests
5. **Community Input –** sustainable street design reflects community values, needs, and ideas

Potential Sustainability Measures:

- Percent of streets with accommodation for all modes
- Regional accessibility
- Quality of transit service
- Percent of population within walking distance of transit
- Percent of jobs within walking distance of transit
- Percent of population served by bicycle facilities
- Percent of jobs served by bicycle facilities
- Average vehicle trip length (shorter is better)
- Increased bicycling mode share
- Increased walking mode share
- Increased transit mode share
- Person throughput (corridor or intersection)
- Energy (fuel) savings due to mode shift
- Safer streets (reduction in bicycle & pedestrian crash severity and frequency)
- Emissions metrics related to vehicle use

Land Use Code Strategies

Removing Obstacles

- Eliminate “one size fits all” approach to roadway design process and standards
- Include all users in safety and design discussions
- Remove or reduce auto-centric peak hour level of service (LOS) standards on certain streets or in certain locations
- Remove or reduce vehicle parking supply requirements

Incentives

- Increased development intensity
- Reduced contribution to development related roadway infrastructure costs
- Provide funding for all elements of the right of way, not just curb to curb vehicular improvements
- Increased maintenance funding for enhanced design treatments
- Allocate a minimum percentage of agency funding for bicycle, pedestrian, and transit improvements
- Link parking pricing to street improvements

Regulations

- Regional Transportation Plans
- Adequate Transportation Facilities Ordinances
- Transportation Demand Management Programs
- Transportation Impact Fees
- Vehicle Miles Traveled Fees
- Context Sensitive Design Standards
- Complete Streets Policies
- Multimodal Level of Service Policies
- LEED ND Standards

Please feel free to contact Jeremy R. Klop, AICP with comments, questions, or suggestions at 303.296.4300 or j.klop@fehrandpeers.com

Complete Streets: We Can Get There from Here

THIS FEATURE EXPLAINS THE COMPLETE STREETS MOVEMENT AND EXPLORES WAYS TO MAKE URBAN THOROUGHFARES MORE PEDESTRIAN AND BICYCLE FRIENDLY AND RESPECTFUL OF THE SURROUNDING COMMUNITY WHILE NOT UNDULY COMPROMISING MOTOR VEHICLE TRAVEL. TECHNIQUES FOR DESIGNING AN ARTERIAL STREET THAT CAN CONTROL TRAFFIC SPEEDS AND PERMIT MORE COMFORTABLE AND SAFE PEDESTRIAN AND BICYCLE ACCESS ARE DESCRIBED.

BY JOHN LAPLANTE, P.E., PTOE AND BARBARA McCANN

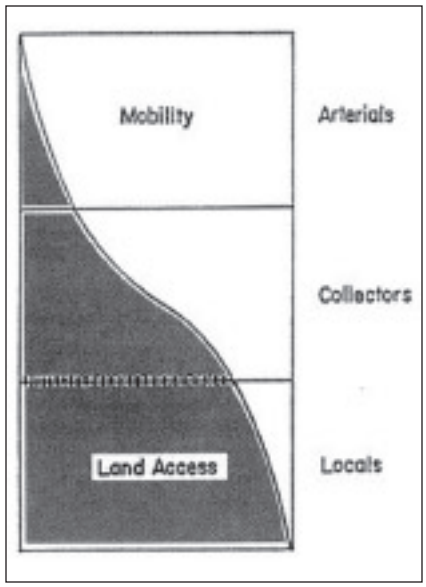
A COMPLETE STREET IS A ROAD that is designed to be safe for drivers; bicyclists; transit vehicles and users; and pedestrians of all ages and abilities. The complete streets concept focuses not just on individual roads but on changing the decision-making and design process so that all users are routinely considered during the planning, designing, building and operating of all roadways. It is about policy and institutional change.

This may seem simple enough. Over the last 30 years, a lot of planning and engineering energy have gone into learning to create beautiful streets that work well for everyone. Standards from *A Policy on Geometric Design of Highways and Streets* have been changed to reflect a multimodal approach, but many roads continue to be built as if private motor vehicles and freight are the only users.[1] Too many urban arterials feature a well engineered place for cars to travel next to a homemade pedestrian facility—a "goat track" tramped in the grass—with a bus stop that is no more than a pole in the ground uncomfortably close to high-speed traffic.

This stems in large part from entrenched planning and design practices. Transportation projects typically begin with an automobile-oriented problem—increasing average daily traffic or deteriorating level of service (LOS). The performance of the right of way for bicyclists, pedestrians and transit riders or transit vehicles often is not measured. Roadway classification is similarly oriented toward auto mobility.

THE FUNCTIONAL CLASSIFICATION TRAP

Using the standard functional classification system, streets designated as arterials are, by definition, intended primarily to provide mobility, with emphasis placed on operating speed and traffic-carrying capacity (see Figure 1). This leads to other design requirements that stress access management, wider lane widths, increased turning radii and minimum interference with traffic movements. This, in turn, often leads to urban roadways dividing neighborhoods, destroying local businesses in established communities and creating sterile, inhospitable streetscapes in developing suburbs.



Source: *A Policy on Geometric Design of Highways and Streets*. Washington, DC, USA: American Association of State Highway and Transportation Officials, 2001, pp. 1–7.

Figure 1. Proportion of service.

CONTEXT-SENSITIVE SOLUTIONS (CSS)

As a reaction to this unhealthy trend, context-sensitive design concepts and techniques have developed. Within ITE, a new arterial street design paradigm for urban areas is being adopted in the Recommended Practice entitled *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities*. The document is being developed in conjunction with the Congress for New Urbanism and the Federal Highway Administration.[2]

How do complete streets initiatives relate to CSS? CSS is a project-oriented and location-specific process and is aimed at making sure a road project fits into its context. Early projects tended to be large roadway improvements and featured extensive public meetings, stakeholder out-

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reach and plenty of extra work. More recently, CSS practitioners have recognized that this process can be applied to every project and that early public involvement does not necessarily lead to expensive and time-consuming outreach efforts.

Complete streets focuses more on road users and is about making multimodal accommodation routine so that multimodal roads do not require extra funds or extra time to achieve. The intent is to change the everyday practice of transportation agencies so that every mode should be part of every stage of the design process in just about every road project—whether a minor traffic signal rehabilitation or a major road widening. The ultimate aim is to create a complete and safe transportation network for all modes. CSS and complete streets can be seen as complementary, not competitive movements.

NATIONAL COMPLETE STREETS COALITION

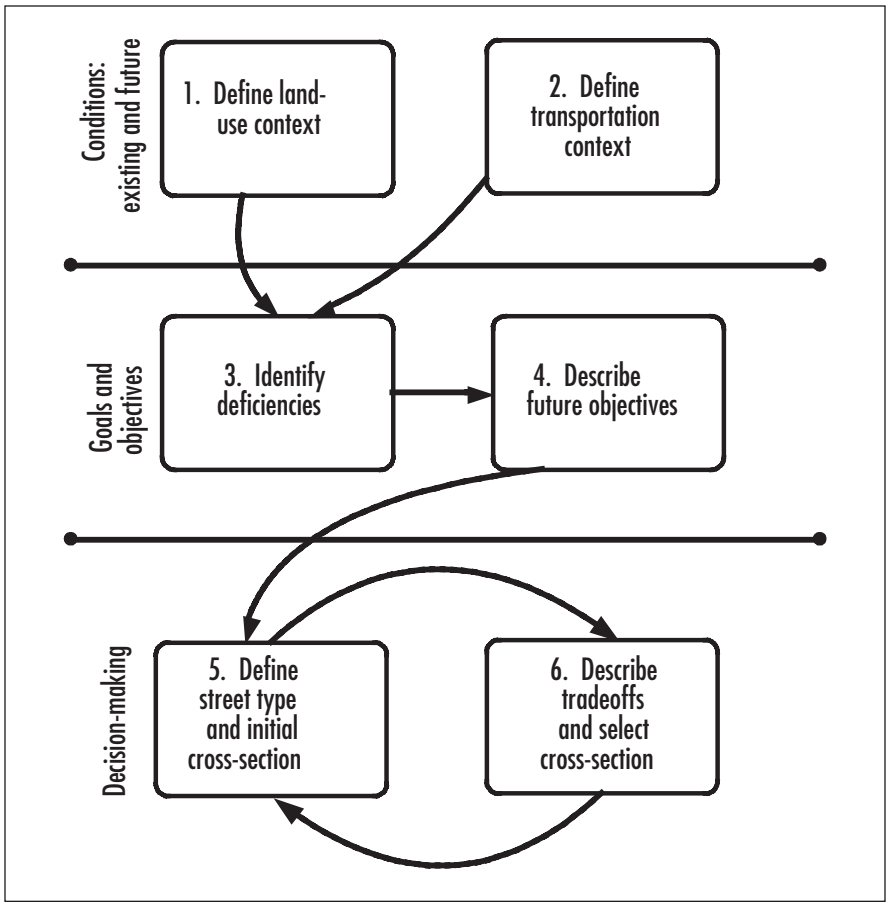
The National Complete Streets Coalition has been working for three years to promote policy and procedural changes at the federal, state and local levels. In addition to ITE, the coalition includes the American Public Transportation Association, the American Planning Association, AARP and many others.[3]

The coalition has succeeded in gaining national media attention and policy adoption across the country. More than 50 jurisdictions, from states to small towns, have adopted some type of complete streets policy, most over the last few years. In 2007, several cities adopted notable policies, including Salt Lake City, UT, USA, through a simple executive order; Seattle, WA, USA, through a comprehensive ordinance; and Charlotte, NC, USA, through adoption of its *Urban Street Design Guidelines*.

At the state level, a new law in Illinois requires the state department of transportation to accommodate bicycle and pedestrian travel on all its roads in urbanized areas. It is effective immediately for project planning and required in construction beginning in August 2008. Other places have been building complete streets for a while, including Oregon; Florida; Arlington, VA, USA; and Boulder, CO, USA.

A new complete streets policy adopted by a legislature or city council is likely to make any engineer nervous. If well written, the impact should be gradual and reasonable. These policies are not prescriptive. Complete streets will look different in different places. They must be appropriate to their context and to the modes expected on that corridor.

A bustling street in an urban area may include features for buses, bicycles and pedestrians as well as private cars; in a more rural area with some walkers, a paved shoulder may suffice. Low-traffic streets need few treatments. Places with existing complete streets policies are successfully building a variety of roads that meet the varied needs of children, commuters and other users while creating an overall network that serves all modes.



Source: *Urban Street Design Guidelines*. Charlotte, NC, USA: Charlotte Department of Transportation, October 2007. Accessible via www.charmeck.org/departments/transportation/urban+street+design+guidelines.htm.

Figure 2. Charlotte, NC, USA, street design standards: A six-step process for considering and balancing the needs of all users.

IMPLEMENTATION CHALLENGES

In order for complete streets to be truly effective, the following implementation measures should be considered:

- Rewrite and/or refocus agency policies and procedures to serve all modes.
- Rewrite and/or adapt design guidelines.
- Train and develop staff skills in serving all modes.
- Collect data on all users and modes for performance improvements.

The policy change should result in an institutionalization of the complete streets approach in all aspects of the transportation agency and beyond and often means a restructuring of everyday procedures, beginning with scoping. For example, in Charlotte, transportation planners are using a new six-step complete streets planning process that systematically evaluates the needs of all modes (see Figure 2).[4] The National Complete Streets Coalition is offering a Local Implementation Assistance Program to help jurisdictions with this task.

An effective policy should lead to the rewriting of design manuals. The best example of this in the United States is Massachusetts. A complete streets policy statement became one of three guiding principles for the new award-winning design guide—context-sensitivity is another. The new manual has no chapters for bicycling, walking, transit,

or disabled users. Every mode is integrated into every chapter, with new tools to help engineers make decisions about balancing the modes.[5]

The third of the four implementation steps is the need for additional training for planners and engineers. Balancing the needs of all users is a challenge, and doing so with every project requires new tools and skills. For example, South Carolina has used its policy to launch a comprehensive training program.

Complete streets policies also should result in new ways to track the success of the road network in serving all users. Florida; Ft. Collins, CO; and other jurisdictions have adopted multimodal level of service standards to do that.

SPEED MATTERS

Complete streets is about more than simple allocation of street space. One of the major components of this new design paradigm is selecting a design speed that is appropriate to the actual street typology and location and that allows safe movement by all road users, including more vulnerable pedestrians and bicyclists. From a safety and community livability standpoint, speed does matter.

Everyone should be familiar with the chart that shows that a pedestrian hit by a car traveling at 20 miles per hour (mph) (32 kilometers per hour [km/hr.]) has an 85-percent survivability rate. That same collision with a car going twice as fast, 40 mph (65 km/hr.), will lower the survivability likelihood to 15 percent (see Figure 3).

Current practice is to use a design speed based on a somewhat arbitrary functional classification and then post a speed limit based on the 85th-percentile of speeds engendered by this artificial street designation. This practice is based on the conventional wisdom that to maintain mobility to and through communities, some arterial streets have to be designated as major traffic carriers or the entire regional economy will grind to a halt. Travel speed has always been equated as a necessary component of this mobility.

Source: *Guide to Recommended Pedestrian Safety Planning*. Washington, DC, USA: Federal Highway Administration, 1989.

Figure 3. Vehicle speed versus injury and death.

REDEFINING MOBILITY

Given that speeds much over 30 mph (50 km/hr.) in urban areas are incompatible with pedestrians (including transit passengers) and bicyclists, if not downright dangerous, is the only choice to sacrifice mobility for community livability? The answer to this question depends on how mobility is defined. One aspect of mobility is travel speed or, more accurately, total travel time.

For a 5-mile (8 km) trip along an arterial corridor with a 45 mph (70 km/hr.) travel speed, the added travel time for a reduced speed of 30 mph (50 km/hr.) would be 2.5 minutes. In the overall scheme of things, how important is this potential delay compared to the proven safety benefits and the city livability advantages that come with the slower traffic speeds?

Some will quote the standard benefit-cost travel-time delay litany that multiplies these 2.5 minutes times an average daily traffic of 30,000 vehicles times 365 days per year times $20 per hour in time costs, equaling $600,000 in lost wages to the economy. However, in reality, the loss is still under 3 minutes per individual for this one trip, for which he or she is probably not being paid and which is less than the time he or she willingly will spend in line for morning coffee.

Take this scenario one step further, to the all-too-common suburban arterial traffic experience of driving 45 mph (70 km/hr.), stopping for up to 2 minutes at a traffic signal, accelerating back up to 45 mph (70 km/hr.), only to stop and wait again one-half-mile (0.8 km) down the road. This uncoordinated signal system wastes time and fuel, and the many stops increase crash rates. If these signals can be coordinated to permit two-way progression at a constant speed of 25 or 30 mph (40 or 50 km/hr.), the total travel time ends up being roughly the same.

The other part of the mobility equation is capacity, with the number of lanes acting as the primary surrogate measurement. It should be recognized by now that LOS D is a reasonable peak period LOS in an urban area, provided the above-mentioned signal progression can be maintained. However, some state departments of transportation or regional planning organizations still recommend LOS C (or even B) in an urban setting whenever possible.

Not only is this a waste of tax dollars constructing unneeded pavement, it also increases pedestrian crossing distances (and thus pedestrian crossing times, which impact negatively on signal timing for vehicular traffic) and encourages faster vehicular speeds during the other 22 hours of the day in each direction.

ARTERIAL TRAFFIC CALMING MEASURES

The remainder of this feature deals with specific design measures that may be used to retrofit urban arterials into complete streets. These roads present one of the biggest challenges to engineers in that they tend to be the most hostile to bicyclists, pedestrians and transit riders, but all of these modes are usually present in significant numbers.

Arterial traffic calming first must deal with controlling vehicular speeds. In addition to timing the traffic signals for a 25 or 30 mph (40 or 50 km/hr.) operating speed, other possible speed control measures include:

- Narrower travel lanes: Based on the results of a recent National Cooperative Highway Research Program study, 11-foot (3.3-meter [m]) or 10-foot (3.0-m) lanes in urban areas are just as safe as 12-foot (3.6-m) lanes for posted speeds of 45 mph (70 km/hr.) or less.[6]
- Road diets: A four-lane to three-lane road diet can work for average daily traffic volumes as high as 20,000. This makes the more prudent driver the "pace" car for that roadway and greatly improves left turning safety.
- Tightening corner curb radii: Selecting the appropriate design vehicle and using the minimum needed to provide the "effective" turning radius from the closest approach lane into

any lane in the departure roadway will slow down turning vehicle speeds.

- Elimination of any free-flow right-turn lanes: This specifically includes freeway entry and exit ramp connections. Encouraging freeway speeds onto or off arterial streets is particularly dangerous for both pedestrians and bicyclists.
- Raised medians: Raised medians visually narrow the roadway and provide a median refuge for mid-block crossings.
- Median and parkway landscaping: Appropriate low-maintenance landscaping further visually narrows the roadway and provides a calming effect.
- Curb parking: Retaining curb parking provides for community access while creating a significant traffic calming effect.
- Curb bulb-outs: Where on-street parking exists, curb bulb-outs shorten pedestrian crossing distances, improve sight lines and help control parking.

Source: Ben Miller, Charlotte Department of Transportation.

Figure 4. Redesigned intersection of Kenilworth and Romany in Charlotte, NC, USA.

PEDESTRIAN CROSSINGS

The other important element in creating a pedestrian-friendly arterial street is making pedestrian crossing locations safe, comfortable and more frequent. On any road where there is transit service, a pedestrian will cross wherever there is a transit stop, whether it is provided for or not. In a dense downtown case with signals spaced every 300 to 600 feet (90 to 180 m), crossing at a traffic signal is a reasonable expectation. However, along most urban and suburban arterials, these signals usually are spaced no closer than every one-quarter mile.

Requiring travel just 1,200 feet (360 m) or more out of the way to cross a street will add 5 minutes to the travel time of a pedestrian walking at the average 4.0 feet per second (1.2 m per second) walking speed. If a 5-minute detour for all automobile traffic were suggested, this would be the equivalent of adding a distance of 2.5 miles (4 km) for a car traveling at 30 mph (50 km/hr.). The outrage would be loud and instantaneous.

Many of the suggested pedestrian crossing improvements flow directly out of the traffic speed control measures noted above. They include:

- Narrower travel lanes: Shorten the pedestrian crossing distance and roadway exposure time.
- Road diets: Reduce the number of lanes to be crossed.
- Tighter corner curb radii: Shorten pedestrian crossing distances and provide space for perpendicular curb ramps.
- Adding corner "pork chop" islands where design vehicle turning radii do not permit a small corner radius: Also shorten pedestrian crossing distances.
- Raised medians: Provide pedestrian refuge and allow pedestrians to cross half the street at a time.
- Curb bulb-outs: Shorten pedestrian crossing distances, improve sight lines and provide space for curb ramps.
- Continental-style crosswalks and pedestrian crossing warning signs: Effective for lightly-traveled arterials posted for urban speed limits.
- Pedestrian-actuated crosswalk warning signs: For heavier traffic flows.
- Pedestrian-actuated HAWK-style signals: Will be in the new *Manual on Uniform Traffic Control Devices* (MUTCD).
- Full signalization: All pedestrian signals should now be timed using the new MUTCD pedestrian walking speed of 3.5 feet per second (1.05 m per second) to set the Flashing Don't Walk pedestrian clearance time and 3.0 feet per second (0.9 m per second) to determine the total Walk/Flashing Don't Walk time.
- Countdown clocks: The new MUTCD will not only require countdown clocks at all new pedestrian signal installations, but there will be a 10-year compliance date for retrofitting all existing pedestrian signal locations, finally correcting the longstanding confusion surrounding the traditional but counter-intuitive Flashing Don't Walk.

TRAFFIC "TAMING"

In conclusion, instead of the concept of traffic calming used in discussing the design of residential streets, the term "traffic taming" should describe the concept of making arterial streets more pedestrian, bicycle and community friendly. This compilation of suggestions for retrofitting arterial streets into complete streets is not meant to be all-inclusive. Many more solutions are available once the task of designing arterial roadways for community livability while retaining a reasonable level of mobility along the most important travel corridors is taken seriously.

Complete streets is both evolutionary and revolutionary. A growing awareness of other transportation modes has led to a trend toward accommodating a wider

variety of users. Complete streets is simply the latest evolutionary step in this process. At the same time, stepping beyond how design typically is done today by greatly increasing travel options, flexibility and usability, a revolutionary new network of travel can be created for all modes.

Largely through the work of the transportation industry, the United States has succeeded brilliantly over the last century in building better roads for farmers, national security and economic growth. It is now time to achieve the same success in the challenge of completing U.S. streets for everyone. ■

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Introduction to Multi-Modal Transportation Planning

Principles and Practices

17 September 2009

By Todd Litman
Victoria Transport Policy Institute

Abstract

This paper summarizes basic principles for transportation planning. It describes conventional transport planning, which tends to focus on motor vehicle traffic conditions, and newer methods for more multi-modal planning and evaluation.

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Conventional Transportation Planning

Conventional (also called *traditional* or *business as usual*) transportation planning refers to current practices for making transport policy, program and investment decisions. *Multi-modal* planning refers to decision making that considers various modes (walking, cycling, automobile, public transit, etc.) and connections among modes so each can fill its optimal role in the overall transport system. There are several specific types of transport planning for reflecting different scales and objectives:

- *Traffic impact studies* evaluate traffic impacts and mitigation strategies for a particular development or project.
- *Local transport planning* develops municipal and neighborhood transport plans.
- *Regional transportation planning* develops plans for a metropolitan region.
- *State, provincial and national transportation planning* develops plans for a large jurisdiction, to be implemented by a transportation agency.
- *Strategic transportation plans* develop long-range plans, typically 20-40 years into the future.
- *Transportation improvement plans (TIPs)* or *action plans* identify specific projects and programs to be implemented within a few years.
- *Corridor transportation plans* identify projects and programs to be implemented on a specific corridor, such as along a particular highway, bridge or route.
- *Mode- or area-specific transport plans* identify ways to improve a particular mode (walking, cycling, public transit, etc.) or area (a campus, downtown, industrial park, etc.).

Figure 1 **Transport Planning Process**
(FHWA and FTA, 2007)

A transport planning process typically includes the following steps:

- Monitor existing conditions.
- Forecast future population and employment growth, and identify major growth corridors.
- Identify current and projected future transport problems and needs, and various projects and strategies to address those needs.
- Evaluate and prioritize potential improvement projects and strategies.
- Develop long-range plans and short-range programs identifying specific capital projects and operational strategies.
- Develop a financial plan for implementing the selected projects and strategies.

Conventional transportation planning tends to focus on a specific set of options (primarily automobile travel) and impacts (summarized in Table 1). Commonly-used transportation economic evaluation models, such as *MicroBenCost*, were designed for highway project evaluation, assuming that total vehicle travel is unaffected and is unsuitable for evaluating projects that include alternative modes or demand management strategies.

Table 1 **Impacts Considered and Overlooked**

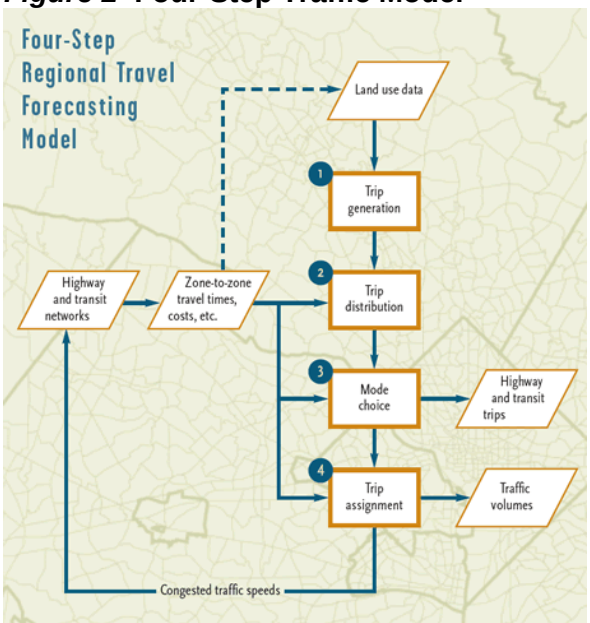
Usually Considered	Often Overlooked
Financial costs to governments	Generated traffic and induced travel impacts
Vehicle operating costs (fuel, tolls, tire wear)	Downstream congestion
Travel time (reduced congestion)	Impacts on non-motorized travel (barrier effects)
Per-mile crash risk	Parking costs
Project construction environmental impacts	Vehicle ownership and mileage-based depreciation costs.
	Project construction traffic delays
	Indirect environmental impacts
	Strategic land use impacts (sprawl versus smart growth)
	Transportation diversity and equity impacts
	Per-capita crash risk
	Public fitness and health impacts
	Travelers' preferences (e.g., for walking and cycling)

Conventional transportation planning tends to focus on a limited set of impacts. Other impacts tend to be overlooked because they are relatively difficult to quantify (e.g., equity, indirect environmental impacts), or simply out of tradition (e.g., parking costs, vehicle ownership costs, construction delays).

Conventional transportation planning strives to maximize traffic speeds, minimize congestion and reduce crash rates (generally measured per vehicle-mile) using a well developed set of engineering, modeling and financing tools. Many jurisdictions codify these objectives in *concurrency requirements* and *traffic impact fees*, which require developers to finance roadway capacity expansion to offset any increase in local traffic. Alternatives to roadway expansion, such as *transportation demand management* and *multi-modal* transport planning, are newer and so have fewer analysis tools. As a result, conventional planning practices support *automobile dependency*, which refers to transport and land use patterns favoring automobile travel over alternative modes (in this case, *automobile* includes cars, vans, light trucks, SUVs and motorcycles).

In recent years transportation planning has expanded to include more emphasis on non-automobile modes and more consideration of factors such as environmental impacts and mobility for non-drivers. One indication of this shift is that over the last two decades, many *highway agencies* have been renamed *transportation agencies*, and have added departments and experts related to environmental analysis, community involvement and nonmotorized planning. Transportation modeling techniques are improving to account for a wider range of options (such as alternative modes and pricing incentives) and impacts (such as pollution emissions and land use effects). In addition, an increasing portion of transport funds are flexible, meaning that they can be spent on a variety of types of programs and projects rather than just roadways.

Figure 2 **Four-Step Traffic Model**



www.mwcog.org/transportation/activities/models/4_step.asp

Most regions use *four-step models* to predict future transport conditions (see Figure 2). The region is divided into numerous *transportation analysis zones* (TAZs) each containing a few hundred to a few thousand residents. *Trip generation* (the number and types of trips originating from each TAZ) is predicted based on generic values adjusted based on local travel surveys that count zone-to-zone peak-period trips. These trips are assigned destinations, modes and routes based on their *generalized costs* (combined time and financial costs), with more trips assigned to relatively cheaper routes and modes, taking into account factors such as travel speeds, congestion delays and parking costs. Transport models are being improved in various ways to better predict future travel activity, including the effects of various transport and land use management strategies.

This predicts future peak-period traffic volumes on each route, and identifies where volumes will exceed capacity (based on the *volume/capacity ratio* or *V/C*) of specific roadway links and intersections. The intensity of congestion on major roadways is evaluated using *level-of-service* (LOS) ratings, a grade from *A* (best) to *F* (worst).

Table 2 summarizes highway LOS ratings. Similar ratings are defined for arterial streets and intersections. Roadway level-of-service is widely used to identify traffic problems and evaluate potential roadway improvements. Figure 3 illustrates a typical model output: a map showing LOS ratings of major regional roadways.

Figure 3 **Highway LOS Map** (PSRC, 2008)

Table 2 **Highway Level-Of-Service (LOS) Ratings** (Wikipedia)

LOS	Description	Speed (mph)	Flow (veh./hour/lane)	Density (veh./mile)
A	Traffic flows at or above posted speed limit. Motorists have complete mobility between lanes.	Over 60	Under 700	Under 12
B	Slightly congested, with some impingement of maneuverability. Two motorists might be forced to drive side by side, limiting lane changes.	57-60	700-1,100	12-20
C	Ability to pass or change lanes is not assured. Most experienced drivers are comfortable and posted speed is maintained but roads are close to capacity. This is the target LOS for most urban highways.	54-57	1,100-1,550	20-30
D	Typical of an urban highway during commuting hours. Speeds are somewhat reduced, motorists are hemmed in by other cars and trucks.	46-54	1,550-1,850	30-42
E	Flow becomes irregular and speed varies rapidly, but rarely reaches the posted limit. On highways this is consistent with a road over its designed capacity.	30-46	1,850-2,000	42-67
F	Flow is forced, with frequent drops in speed to nearly zero mph. Travel time is unpredictable.	Under 30	Unstable	67-Maximum

This table summarizes highway Level of Service (LOS) rating, an indicator of congestion intensity.

Under optimal conditions a *grade separated highway* (no cross traffic) can carry up to 2,200 vehicles per hour (VPH) per lane. An arterial with intersections can carry about half that. Table 3 indicates units commonly used to measure traffic. These are generally measured during *peak hours*. Speed is generally based on the *85th percentile* (the speed below which 85% of vehicles travel). Traffic volumes are also sometimes measured as *Annual Average Daily Traffic* (AADT), indicating traffic volumes averaged over a year.

Table 3 **Basic Traffic Units**

Parameter	Typical Units	Reciprocal	Typical Units
Flow	Vehicles per hour (Veh/h)	Headway	Seconds per vehicle (s/veh)
Speed	Kilometers or miles per hour (Km/h)	Travel time	Seconds per km or mi (s/km)
Density	Vehicles per lane-km or mi (veh/lane-km)	Spacing	Feet or meters per vehicle (m/veh)

This table summarizes units commonly used to measure vehicle traffic.

Terms and Concepts

- Traffic congestion can be *recurrent* (occurs daily, weekly or annually, making it easier to manage) or *non-recurrent* (typically due to accidents, special events or road closures).
- *Design vehicle* refers to the largest and heaviest vehicle a roadway is designed to accommodate. *Passenger Car Equivalents* (PCE) indicate the traffic impacts of larger vehicles compared with a typical car.
- A *queue* is a line of waiting vehicles (for example, at an intersection). A *platoon* is group of vehicles moving together (such as after traffic signals turn green).
- *Capacity* refers to the number of people or vehicles that could be accommodated. *Load factor* refers to the portion of capacity that is actually used. For example, a load factor of 0.85 indicates that 85% of the maximum capacity is actually occupied.

A typical transport planning process defines the minimum level-of-service considered acceptable (typically LOS C or D). Roads that exceed this are considered to *fail* and so deserve expansion or other interventions. This approach is criticized on these grounds:

- It focuses primarily on motor vehicle travel conditions. It assumes that transportation generally consists of automobile travel, often giving little consideration to travel conditions experienced by other modes. As a result, it tends to result in automobile dependency, reducing modal diversity.
- It defines transportation problems primarily as traffic congestion, ignoring other types of problems such as inadequate mobility for non-drivers, the cost burden of vehicle ownership to consumers and parking costs to businesses, accident risk, and undesirable social and environmental impacts.
- It ignores the tendency of traffic congestion to maintain equilibrium (as congestion increases, traffic demand on a corridor stops growing), and the impacts of *generated traffic* (additional peak-period vehicle travel that results from expanded congested roadways) and *induced travel* (total increases in vehicle travel that result from expanded congested roadways). As a result, it exaggerates the degree of future traffic congestion problems, the congestion reduction benefits of expanding roads, and the increased external costs that can result from expanding congested roadways.
- It can create a self-fulfilling prophecy by directing resources primarily toward roadway expansion at the expense of other modes (widening roads and increasing traffic speeds and volumes tends to degrade walking and cycling conditions, and often leaves little money or road space for improving other modes).
- Short trips (within TAZs), travel by children, off-peak travel and recreational travel are often ignored or undercounted in travel surveys and other statistics, resulting in walking and cycling being undervalued in planning.

In recent years transportation planning has become more multi-modal and comprehensive, considering a wider range of options and impacts. Transport planners have started to apply Level-of-Service ratings to walking, cycling and public transit, and to consider demand management strategies as alternatives to roadway capacity expansion.

Green Transportation Hierarchy

1. Pedestrians
2. Bicycles
3. Public Transportation
4. Service and Freight Vehicles
5. Taxis
6. Multiple Occupant Vehicles
7. Single Occupant Vehicles

The Green Transportation Hierarchy favors more efficient (in terms of space, energy and other costs) modes.

Some urban areas have established a transportation hierarchy which states that more resource efficient modes will be given priority over single occupant automobile travel, particularly on congested urban corridors. This provides a basis for shifting emphasis in transport planning, road space allocation, funding and pricing to favor more efficient modes.

Table 4 Mode Profiles

Mode	Availability	Speed	Density	Loads	Costs	Potential Users			Limitations	Appropriate Uses
	Portion of locations and times served	typical speeds	space requirements	ability to carry baggage	user costs	Non-Drivers	Poor	Handi-capped		
Walking	Wide (nearly universal)	2-5 mph	High	Small	Low	Yes	Yes	Varies	Requires physical ability. Limited distance and carrying capacity. Sometimes difficult or unsafe.	Short trips by physically able people.
Wheelchair	Limited (requires suitable facilities)	2-5 mph	Medium	Small	Med.	Yes	Yes	Yes	Requires suitable sidewalk or path. Limited distance and carrying capacity.	Short urban trips by people with specific physical disabilities.
Bicycle	Wide (feasible on most roads and some paths)	5-15 mph	Medium	Small to medium	Med.	Yes	Yes	Varies	Requires bicycle and physical ability. Limited distance and carrying capacity.	Short to medium length trips by physically able people on suitable routes.
Taxi	Moderate (in most urban areas)	20-60 mph	Low	Medium	High	Yes	Limited	Yes	High costs and limited availability.	Infrequent trips, short and medium distance trips.
Fixed Route Transit	Limited (major urban areas)	20-40 mph	High	Small	Med.	Yes	Yes	Yes	Limited availability. Sometimes difficult to use.	Short to medium distance trips along busy corridors.
Paratransit	Limited	10-30 mph	Medium	Small	High	Yes	Yes	Yes	High cost and limited service.	Travel for disabled people.
Auto driver	Wide (nearly universal)	20-60 mph	Low	Medium to large	High	No	Limited	Varies	Requires driving ability and automobile. Large space requirements. High costs.	Travel by people who can drive and afford an automobile.
Ridesharing (auto passenger)	Limited (requires motorist, matching services)	20-60 mph	High	Medium	Low	Yes	Yes	Yes	Requires cooperative motorist. Consumes driver's time if a special trip (chauffeuring).	Trips that the driver would take anyway (ridesharing). Occasional special trips (chauffeuring).
Carsharing (vehicle rentals)	Limited (requires nearby services)	20-60 mph	Low	Medium to large	Med.	No	Limited	Varies	Requires convenient and affordable vehicle rentals services.	Occasional use by drivers who don't own an automobile.
Motorcycle	Wide (nearly universal)	20-60 mph	Medium	Medium	High	No	Limited	No	Requires riding ability and motorcycle. High fixed costs.	Travel by people who can ride and afford a motorcycle.
Telecommute	Wide (nearly universal)	NA	NA	NA	Med.	Yes	Varies	Varies	Requires equipment and skill.	Alternative to some types of trips.

This table summarizes the performance of various transportation modes.

Multi-modal transportation planning is complicated because modes differ in various ways, including their availability, speed, density, costs, limitations, and most appropriate uses (Table 4). They are not equal substitutes; each is only appropriate for specific users and uses.

Such analysis is even more complex because each mode includes various subcategories with unique characteristics. For example, "pedestrians" include people standing, walking alone and in groups, using canes and walkers, jogging and running, playing, walking pets, carrying loads, and pushing hand carts. Their actual needs, abilities, impacts and value to society can vary significantly, as indicated in Table 5.

Table 5 **Nonmotorized Facility Uses Compared**

Mode or Activity	Facility Requirements	Risk to Others	Basic Mobility
	Quality and quantity of pedestrian facilities	Danger these users impose on others	Whether the mode provides basic mobility benefits)
People standing	Minimal	None	NA
People sitting at benches or tables	Seats or benches	None	NA
Individual walkers	Minimal	Low	High
Walkers in groups	Medium	Low	High
Walkers with children	Medium	Low	High
Children playing	Medium to large	Medium	Medium
Walkers with pets	Medium to large	Low	Medium
Human powered wheelchairs	Medium	Low	Very High
Motor powered wheelchairs	Medium to large	Medium to high	Very High
Joggers and runners	Medium to large	Medium	Medium
Skates and push-scooters	Large	Medium	Low
Powered scooters and Segways	Large	Medium	Low to high
Human powered bicycle	Medium to large	Medium to high	Medium
Motorized bicycle	Large	High	Low
People with handcarts or wagons	Medium to large	Low to medium	Medium
Vendors with carts and wagons	Medium to large	Low	Sometime (if the goods sold are considered 'basic').

This table compares various nonmotorized facility users.

Similarly, *public transit* (also called *public transportation* or *mass transit*) includes various types of services and vehicles. Table 6 summarizes the performance of various types of public transit. Actual performance depends on specific circumstances; for example costs per trip can vary depending on which costs are included (for example, whether major new road or rail improvements are required, whether Park-and-Ride facilities are included in transit budgets, construction and operating costs, load factors and types of trips.

Table 6 **Transit Modes Compared**

Name	Description	Availability	Speed	Density	Costs
		Destinations served	Passenger travel speeds	Passenger volumes	Cost per trip
Heavy rail	Relatively large, higher-speed trains, operating entirely on separate rights-of-way, with infrequent stops, providing service between communities.	Limited to major corridors in large cities	High	Very high	Very high
Light Rail Transit (LRT)	Moderate size, medium-speed trains, operating mainly on separate rights-of-way, with variable distances between stations, providing service between urban neighborhoods and commercial centers.	Limited to major corridors	Medium	High	High
Streetcars (also called trams or trolleys)	Relatively small, lower-speed trains, operating primarily on urban streets, with frequent stops which provide service along major urban corridors.	Limited to major corridors	Medium	High	High
Fixed route bus transit	Buses on scheduled routes.	Widely available in urban areas	Low to medium	High	Low to medium
Bus Rapid Transit (BRT)	A bus system with features that provide a high quality of service.	Limited to major corridors	Medium to high	High	Low to medium
Express bus	Limited stop bus service designed for commuters and special events.	Limited to major corridors	High	High	Low to medium
Ferry services	Boats used to transport people and vehicles.	Limited to major corridors	Low to medium	Low to medium	Medium to high
Paratransit	Small buses or vans that provide door-to-door, demand-response service.	Widely available	Low	Low	High
Personal Rapid Transit (PRT)	Small, automated vehicles that provide transit service, generally on tracks.	Limited to major corridors	Low to medium	Low to medium	Medium to high
Vanpool	Vans used for ridesharing.	Widely available	Medium to high	High	Low
Shared taxi.	Private taxis that carry multiple customers.	Limited to busy corridors	Medium to high	Low to medium	Medium to high
Taxi	Conventional taxi service.	Widely available	Medium to high	Low	High

This table summarizes different types of public transit and their performance attributes.

Multi-modal transport planning requires tools for evaluating the quality of each mode, such as Level-of-Service standards which can be used to indicate problems and ways to improve each mode. Tables 7 and 8 indicate factors that can be considered when evaluating different modes.

Table 7 **Nonmotorized Level-Of-Service Rating Factors**

Feature	Definition	Indicators
Network continuity	Whether sidewalks and paths exist, and connect throughout an area.	• Portion of streets with nonmotorized facilities. • Length of path per capita. • Network connectivity and density (kilometers of sidewalks and paths per square kilometer).
Network quality	Whether sidewalks and paths are properly designed and maintained.	• Sidewalk and path functional width. • Portion of sidewalks and paths that meet current design standards. • Portion of sidewalks and paths in good repair.
Road crossing	Safety and speed of road crossings	• Road crossing widths. • Motor vehicle traffic volumes and speeds. • Average pedestrian crossing time. • Quantity and quality of crosswalks, signals and crossing guards.
Traffic protection	Separation of nonmotorized traffic from motorized traffic, particularly high traffic volumes and speeds.	• Distance between traffic lanes and sidewalks or paths. • Presence of physical separators, such as trees and bollards. • Speed control.
Congestion and user conflicts	Whether sidewalks and paths are crowded or experience other conflicts.	• Functional width of sidewalk and paths. • Peak-period density (people per square meter) • Clearance from hazards, such as street furniture and performers within the right-of-way. • Number of reported conflicts among users. • Facility management to minimize user conflicts.
Topography	Presence of steep inclines.	• Portion of sidewalks and paths with steep inclines.
Sense of Security	Perceived threats of accidents, assault, theft or abuse.	• Reported security incidents. • Quality of visibility and lighting.
Wayfinding	Guidance for navigating within the station and to nearby destinations.	• Availability and quality of signs, maps and visitor information services.
Weather protection	User protected from sun and rain.	• Presence of shade trees and awnings.
Cleanliness	Cleanliness of facilities and nearby areas.	• Litter, particularly potentially dangerous objects. • Graffiti on facilities and nearby areas. • Effectiveness of sidewalk and path cleaning programs.
Attractiveness	The attractiveness of the facility, nearby areas and destinations.	• Quality of facility design. • Quality of nearby buildings and landscaping. • Area Livability (environmental and social quality of an area). • Community cohesion (quantity and quality of positive interactions among people in an area). • Number of parks and recreational areas accessible by nonmotorized facilities.
Marketing	Effectiveness of efforts to encourage nonmotorized transportation.	• Quality of nonmotorized education and promotion programs. • Nonmotorized transport included in Commute Trip Reduction programs.

This table summarizes factors to consider when evaluating walking and cycling conditions.

Table 8 **Transit Level-of-Service Rating Factors**

Feature	Description	Indicators
Availability	Where and when transit service is available.	• Annual service-kilometers per capita. • Daily hours of service. • Portion of destinations located within 500 meters of transit service. • Hours of service.
Frequency	Frequency of service and average wait time.	• Trips per hour or day. • Headways (time between trips). • Average waiting times.
Travel Speed	Transit travel speed.	• Average vehicle speeds. • Transit travel speed relative to driving the same trip. • Door-to-door travel time.
Reliability	How well service actually follows published schedules.	• On-time operation. • Portion of transfer connections made. • Mechanical failure frequency.
Boarding speed	Vehicle loading and unloading speed.	• Dwell time. • Boarding and alighting speeds.
Safety and security	Users perceived safety and security.	• Perceived transit passenger security. • Accidents and injuries. • Reported security incidents. • Visibility and lighting. • Absence of vandalism.
Price and affordability	Fare prices, structure, payment options, ease of purchase.	• Fares relative to average incomes. • Fares relative to other travel mode costs. • Payment options (cash, credit cards, etc.). • Ticket availability (stations, stores, Internet, etc.).
Integration	Ease of transferring between transit and other modes.	• Quality of connections between transit routes. • Quality of connections between transit and other modes (train stations, airports, ferry terminals, etc.).
Comfort	Passenger comfort	• Seating availability and quality. • Space (lack of crowding). • Quiet (lack of excessive noise). • Fresh air (lack of unpleasant smells). • Temperature (neither too hot or cold). • Cleanliness. • Washrooms and refreshments (for longer trips).
Accessibility	Ease of reaching stations and stops.	• Distance from transit stations and stops to destinations. • Walkability (quality of walking conditions) in areas serviced by transit.
Baggage capacity	Accommodation of baggage.	• Ability, ease and cost of carrying baggage, including special items such as pets.
Universal design	Accommodation of diverse users including special needs.	• Accessible design for transit vehicles, stations and nearby areas. • Ability to carry baggage. • Accommodation of people who cannot read or understand the local language.
User information	Ease of obtaining user information.	• Availability and accuracy of route, schedule and fare information. • Real-time transit vehicle arrival information. • Information available to service people with special needs (audio or visual disabilities, inability to read or understand the local language, etc.).
Courtesy and responsiveness	Courtesy with which passengers are treated.	• How passengers are treated by transit staff. • Ease of filing a complaint. • Speed and responsiveness with which complaints are treated.
Attractiveness	The attractiveness of transit facilities.	• Attractiveness of vehicles and facilities. • Attractiveness of documents and websites.
Marketing	Effectiveness of efforts to encourage public transport.	• Popularity of promotion programs. • Effectiveness at raising the social status of transit travel. • Increases in public transit ridership in response to marketing efforts.

This table summarizes factors that can be considered when evaluating public transit services.

Automobile Dependency and Multi-Modalism

Automobile dependency refers to transportation and land use patterns that favor automobile travel and provide relatively inferior alternatives. Its opposite, *multi-modalism*, refers to a transport system that offers users diverse transport options that are effectively integrated, in order to provide a high degree of accessibility even for non-drivers. Table 9 compares automobile dependency and multi-modal transport systems.

Table 9 **Auto Dependency and Multi-Modal Transportation Compared**

Factor	Automobile Dependency	Multi-modal Transportation
Motor vehicle ownership	High per capita motor vehicle ownership.	Medium per capita motor vehicle ownership.
Vehicle travel	High per capita motor vehicle mileage.	Medium to low vehicle mileage.
Land use density	Low. Common destinations are dispersed.	Medium. Destinations are clustered
Land use mix	Single-use development patterns.	More mixed-use development.
Land for transport	Large amounts of land devoted to roads and parking.	Medium amounts devoted to roads and parking.
Road design	Emphasizes automobile traffic.	Supports multiple modes and users.
Street scale	Large scale streets and blocks.	Small to medium streets and blocks.
Traffic speeds	Maximum traffic speeds.	Lower traffic speeds.
Walking	Mainly in private malls.	Mainly on public streets.
Signage	Large scale, for high speed traffic.	Medium scale, for lower-speed traffic.
Parking	Generous supply, free.	Moderate supply, some pricing.
Site design	Parking paramount, in front of buildings.	Parking sometimes behind buildings.
Planning Practices	Non-drivers are a small minority with little political influence.	Planning places are high value on modal diversity.
Social expectations	Non-drivers are stigmatized and their needs given little consideration.	Non-drivers are not stigmatized and their needs are considered.

This table compares automobile dependency and multi-modal transport systems.

Automobile dependency is a matter of degree. Few places are totally automobile dependent (that is, driving is the *only* form of transport). Many relatively automobile dependent areas often have significant amounts of walking, cycling, and transit travel among certain groups or situations. Even 'car free' areas usually have some automobile travel by emergency, delivery and service vehicles.

Automobile dependency has many impacts. It increases total mobility (per capita travel), vehicle traffic, and associated costs. It makes non-drivers economically and socially disadvantaged, since they have higher financial and time costs or less ability to access activities. This tends to reduce opportunities, for example, for education, employment and recreation. In an automobile dependent community virtually every adult is expected to have a personal automobile (as opposed to a *household* automobile shared by multiple drivers), non-drivers require frequent chauffeuring, and it is difficult to withdraw driving privileges from unfit people since alternatives are inferior. Automobile dependency reduces the range of solutions that can be used to address problems such as traffic congestion, road and parking facility costs, crashes, and pollution.

Summary of Factors Affecting Accessibility

The table below lists factors that affect accessibility and the degree to which they are considered in current transport planning. Multi-modal transportation planning requires consideration of all of these factors.

Table 10 **Summary of Factors Affecting Accessibility** (Litman 2006)

Name	Description	Current Consideration
Transport Demand	The amount of mobility and access that people and businesses would choose under various conditions (times, prices, levels of service, etc).	Motorized travel demand is well studied, but nonmotorized demand is not. Travel demand is often considered exogenous rather than affected by planning decisions.
Mobility	The distance and speed of travel, including *personal mobility* (measured as person-miles) and *vehicle mobility* (measured as vehicle-miles).	Conventional transport planning primarily evaluates mobility, particularly vehicle mobility.
Transportation Options	The quantity and quality of access options, including walking, cycling, ridesharing, transit, taxi, delivery services, and telecommunications. Qualitative factors include availability, speed, frequency, convenience, comfort, safety, price and prestige.	Motor vehicle options and quality are usually considered, using indicators such as roadway level-of-service, but other modes lack such indicators and some important service quality factors are often overlooked.
User information	The quality (convenience and reliability) of information available to users on their mobility and accessibility options.	Frequently considered when dealing with a particular mode or location, but often not comprehensive.
Integration	The degree of integration among transport system links and modes, including terminals and parking facilities.	Automobile transport is generally well integrated, but connections between other modes are often poorly evaluated.
Affordability	The cost to users of transport and location options relative to incomes.	Automobile operating costs and transit fares are usually considered.
Mobility Substitutes	The quality of telecommunications and delivery services that substitute for physical travel.	Not usually considered in transport planning.
Land Use Factors	Degree that factors such as land use density and mix affect accessibility.	Considered in land use planning, but less in transport planning.
Transport Network Connectivity	The density of connections between roads and paths, and therefore the directness by which people can travel between destinations.	Conventional planning seldom considers the effects of roadway connectivity on accessibility.
Roadway Design and Management	How road design and management practices affect vehicle traffic, mobility and accessibility.	Some factors are generally considered, but others are not.
Prioritization	Various strategies that increase transport system efficiency.	Often overlooked or undervalued in conventional planning.
Inaccessibility	The value of inaccessibility and external costs of increased mobility.	Not generally considered in transport planning.

This table indicates factors that affect accessibility and whether they are currently considered in planning.

Best Practices

The following are recommendations for multi-modal transportation planning:

- Consider a variety of transportation improvement options, including improvements to various modes, and mobility management strategies such as pricing reforms and smart growth land use policies. Consider various combinations of these options, such as public transport improvements plus supportive mobility management strategies.
- Consider all significant impacts, including long-term, indirect and non-market impacts such as equity and land use changes. This should at least include:
  - Congestion
  - Roadway costs
  - Parking costs
  - Consumer costs
  - Traffic accidents
  - Quality of access for non-drivers
  - Energy consumption
  - Pollution emissions
  - Equity impacts
  - Physical fitness and health
  - Land use development impacts
  - Community livability
- Impacts that cannot be quantified and monetized (measured in monetary values) should be described.
- Multi-modal comparisons should be comprehensive and marginal, and should account for factors such as transit system economies of scale and scope.
- Special consideration should be given to transport system connectivity, particularly connections between modes, such as the quality of pedestrian and cycling access to transit stops and stations.
- Special consideration should be given to the quality of mobility options available to people who are physically or economically disadvantaged, taking into account universal design (the ability of transport systems to accommodate people with special needs such as wheelchair users and people with wheeled luggage) and affordability.
- Indicate impacts with regard to strategic objectives, such as long-range land use and economic development.
- Use comprehensive transportation models that consider multiple modes, generated traffic impacts (the additional vehicle traffic caused by expansion of congested roadways), and the effects of various mobility management strategies such as price changes, public transit service quality improvements and land use changes.
- People involved in transportation decision-making (public officials, planning professionals and community members) should live without using a personal automobile for at least two typical weeks each year that involve normal travel activities (commuting, shopping, social events, etc.) in order to experience the non-automobile transportation system.

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AARP Public Policy Institute

PLANNING COMPLETE STREETS FOR AN AGING AMERICA

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Research Report

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AARP's Public Policy Institute (PPI) informs and stimulates public debate on the issues we face as we age. Through research, analysis, and dialogue with the nation's leading experts, PPI promotes development of sound, creative policies to address our common need for economic security, health care, and quality of life.

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PLANNING COMPLETE STREETS FOR AN AGING AMERICA

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CHAPTER 4

BEST PRACTICES - MAKING STREETS WORK FOR OLDER TRAVELERS

PLANNING AND DESIGN PROCESS

Complete Streets planning processes usually begin with an assessment of the community context and the type of road users expected along a corridor. An analysis is conducted of the gaps in the system for different users—such as a lack of sidewalks. Planners and roadway designers then seek to make improvements that increase mobility and accessibility for all anticipated roadway users. *See Figure 10*.

By definition, a Complete Streets planning process should also address the needs of people in different stages of life and at different levels of ability. The need to expand transportation options has particular relevance for older Americans who need alternatives to driving. An AARP survey of Americans over 50 conducted in part for this study found that almost 40 percent of those polled reported inadequate sidewalks in their neighborhoods, while 55 percent do not have bike lanes or paths, and 48 percent say there is not a comfortable place to wait for the bus. Most sobering, almost half (47 percent) of poll responders say they cannot cross the main roads in their community safely. Half of those who reported such problems said they would walk, bicycle, or take the bus more if these problems were fixed (Skufca, 2008).

The Complete Streets planning and design approach provides an opportunity to address the needs of older road users.

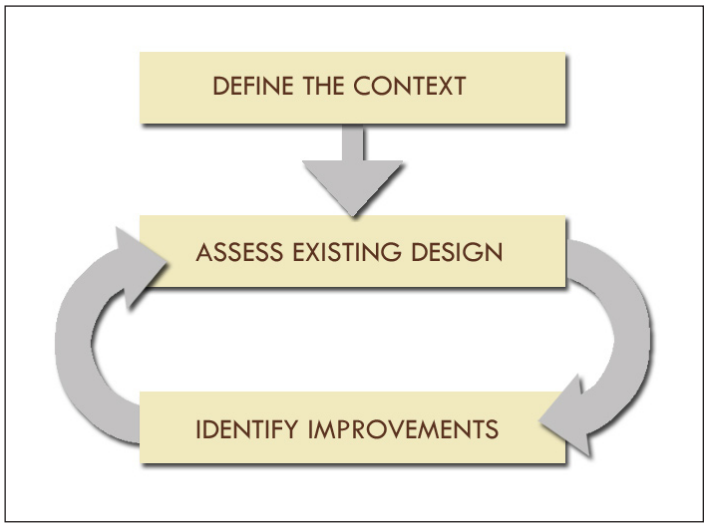

Figure 10. The Complete Streets Planning and Design Approach

A Complete Streets approach should also balance the needs of older drivers with those of older pedestrians. The wide lanes and gentle curves that may make travel easier for older drivers can make crossing the street a much bigger challenge for older pedestrians. Complete Streets planning processes should help transportation planners take the needs of both constituencies into account, consistent with the community's vision for the mobility outcomes it wishes to achieve.

PLANNING & DESIGN PRINCIPLES

As discussed in the section on the effects of physical limitations on mobility, the issues that commonly affect the safety and comfort of older drivers and pedestrians include declining vision, decreased physical fitness and flexibility, decreased ability to focus attention, and increased reaction time. Strategies to address these core issues can be organized around three basic planning and design principles explained below: Slow Down, Make it Easy, and Enjoy the View. Together these principles can aid designers in simplifying the road environment and increase its safety for all users. They can be applied to transportation project improvements at all stages, from initial planning to final design and construction, as noted below.

Slow Down

Reduce vehicle travel speeds in areas where vehicles and pedestrians interact and where older drivers and pedestrians need more time to make decisions and execute changes.

As discussed earlier, pedestrian injuries and deaths increase with increasing vehicular speed. In addition, older drivers who need more time to absorb information and make decisions may feel pressured in high-speed environments. This is especially true at intersections where 41 percent of fatal crashes involving drivers over the age of 64 take place (Eby, 2009). Older pedestrian deaths are also more likely to take place at intersections than are those involving pedestrians under the age of 65.[9]

To apply this principle in the planning realm, agencies and policy makers can establish goals and performance measures that seek to achieve optimal vehicle throughput at speeds that accommodate the needs of older drivers and pedestrians. For example, a traditional response to congestion problems along a suburban corridor is to maintain or increase vehicle capacity (measured principally by LOS and travel time or intersection delay) by widening the roadway or adding turn lanes. This can lead to increased vehicular speed.

An alternative approach would be to maintain or reduce overall corridor travel times and congestion levels while improving vehicle and pedestrian safety through strategies that aid in maintaining a desired target speed. These strategies include visual cues or physical changes that reduce real or perceived lane widths, in conjunction with improving operational efficiency through strategies such as access management and signal coordination.

Planning strategies such as these could be further strengthened by roadway design techniques aimed at keeping intersection size to a minimum and allowing sufficient signal timing for pedestrians to cross the street. Tighter curb radii at intersections require all drivers to navigate turns more slowly and serve to shorten pedestrian crossing

9 Calculated using 2006 FARS Encyclopedia.

distances. Roundabouts offer this "traffic calming" benefit plus an additional advantage to maneuverability by allowing drivers and pedestrians to monitor oncoming traffic from only one direction at a time.

Make It Easy

Make the physical layout of transportation systems easy to navigate for older drivers and pedestrians who have lost some of their dexterity.

Planning and design principles that can support better maneuverability focus on integrating transportation plans with land use policies and urban design standards in order to provide interconnected roadway networks, offering travelers a variety of multimodal routes to key destinations. Many of today's transportation networks, particularly in suburban areas, funnel virtually all travelers—drivers and pedestrians—onto a few large-scale arterials, which are typically designed for large vehicles moving at relatively high speeds. In addition to improving the design of these larger roadways in order to support the needs of older drivers and pedestrians, adding complementary grid networks of local streets provides travelers the option of lower-speed routes with smaller intersections that are easier to maneuver. These networks also shorten walking distances. *See Figure 11.*

Design treatments that improve maneuverability for pedestrians include strategies such as placing two curb ramps at each corner that lead directly into the crosswalks instead of one ramp in the middle that leads directly into the street. The latter design requires

Networks designed for proximity better accommodate older drivers and pedestrians

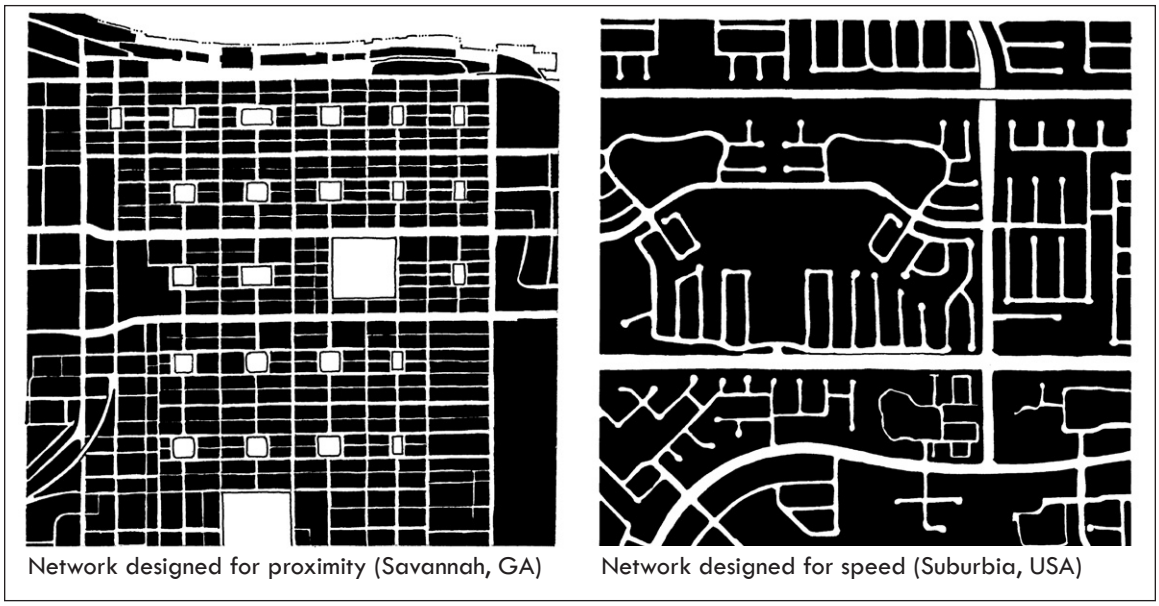

Figure 11. Speed vs. Proximity

Source: © MIT Press, 1993. Reprinted with permission from MIT Press.

people using wheelchairs, walkers, or strollers to quickly "zig-zag" over to the crosswalk after entering the street.

Another strategy is to avoid channelized free-flow right-turn lanes and/or use tighter angles for right turns in order to improve maneuverability for older drivers who have difficulty turning their heads. While more generous curb radii assist an older driver with limited upper body dexterity, slower intersection speed resulting from tighter curb radii benefits older drivers, while at the same time providing benefits to pedestrians as described above. The avoidance of channelized free-flow right-turn lanes allows older drivers with stiff necks from looking over their shoulders at an uncomfortable angle.

Enjoy the View

Make it easy for older drivers and pedestrians to notice, read, understand, and respond to visual cues and information.

Planners and policy makers can improve roadway visibility by adopting corridor design standards that reduce visual "clutter," such as oversized store signs and landscaping that make it hard for drivers to see important elements such as directional signs and pedestrians entering the roadway. They can also establish economic development policies and programs that support streetscape improvements such as burying overhead utility lines, further improving intersection visibility. Access management is another policy strategy that can improve corridor visibility by reducing the number of driveways and roadway signs that drivers and pedestrians must monitor.

Large-sized pedestrian countdown signals that can be seen easily from across the intersection or the median refuge improve visibility for pedestrians. For older drivers, visibility improvements can include retro-reflective signs, curb markings, and improved intersection signage and sight distance (both at and in advance of the intersection). Crosswalks painted with zebra stripes make pedestrians more noticeable to drivers.

Enriching Complete Streets policies and roadway planning and design methods to more specifically address these principles of speed, ease of navigation, and visibility will advance safety and mobility not only for older drivers and pedestrians, but for roadway users of all ages and travel modes. In addition, by adopting policies and practices that address these elements at each stage of project development—from policy to planning and design—the multitude of agencies and individuals involved in the process can communicate more clearly and consistently, so that the improvements envisioned in the plan are ultimately realized on the ground.

KEY DESIGN ELEMENTS FOR OLDER DRIVER AND PEDESTRIAN SAFETY

Older Drivers

Vertical and Horizontal Alignment

Vertical curvature can impede a driver's ability to see in the distance. Horizontal curvature can reduce a driver's peripheral vision. Roadway designers should avoid creating situations in which drivers may suddenly come upon a pedestrian or turning driver at the bottom or the crest of a steep hill (vertical alignment) or after rounding a sharp curve (horizontal alignment).

Pavement Markings

All drivers, but especially older drivers, can have trouble seeing poorly designed or maintained pavement markings, especially at night or in wet or foggy conditions. Longitudinal pavement markings that delineate the edge of the lane should be six to eight inches, rather than the four inch minimum. Retroreflective treatments, enhanced with other technologies such as oversized glass beads or raised pavement markings, improve wet-night recognition on edge and centerline markings. These treatments are is especially important for poorly lit and fast roads. The front and sides of median curb islands should be treated with retroreflective paint and/or reflectors.

Crosswalk markings can be invisible to drivers moving quickly and/or people with declining vision. Crosswalks should be designed to correspond to vehicle speeds, and made highly visible by means such as retro-reflective paint. Zebra striping draws greater driver attention to the crosswalk than two parallel lines. Alternatively, a combination style crosswalk with no paint inside the parallel lines, but with zebra striping outside the parallel lines can be used. This type of crosswalk may lessen the chance of falling from paint that gets slippery in rainy conditions. *See Figure 12*.

Combination crosswalks use zebra stripes to grab drivers' attention but keep the walking surface free of paint, which can become slippery when wet

Figure 12. Combination Crosswalk

Visual Clutter

Sign clutter is distracting and confusing to an older driver. A delayed or late reaction to an upcoming turn can be unsafe for all roadway users. Important directional signs and markings, particularly at decision points such as intersections, must be highly visible, not lost within a jumble of other signs or vegetation.

Designers should create a visual clearance zone at intersections and near crosswalks, including only those signs necessary for traffic safety.

Continuous Center-Turn Lanes

Continuous center-turn lanes (colloquially referred to as "suicide lanes") increase the chances for vehicular conflict among all drivers because turning movements become less predictable along the length of the roadway. While this issue affects drivers of all ages, older drivers are particularly challenged if they have lower visual acuity and increased reaction times. Confusion over their use can cause older drivers to stop in the through lane, leading to rear-end collisions. Roadway designers should limit vehicular turning movements to defined locations, using measures such as raised grassy medians to control these movements and increase roadway predictability. *See Figure 13.*

Watch out for "Suicide lanes!"

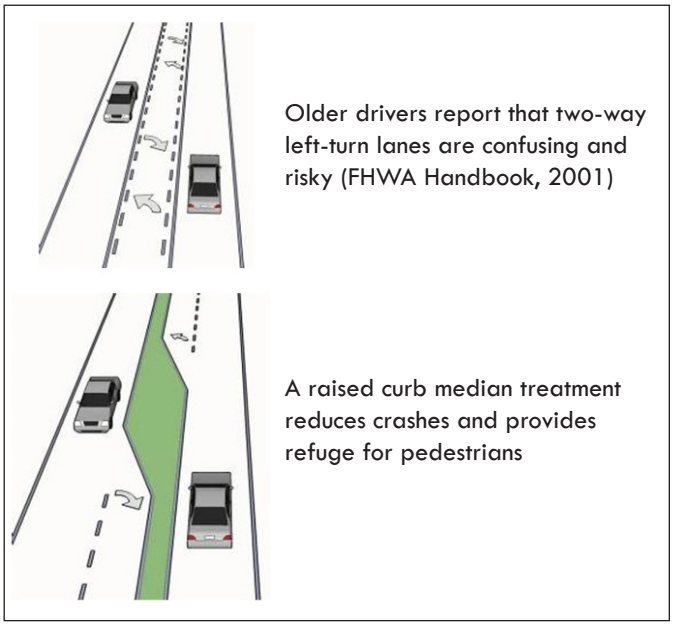

Figure 13. Comparison of a two-way left-turn lane and raised curb median treatment

Older Pedestrians

Pavement Maintenance and Materials

Road designers need to be concerned not only with the risks to pedestrians from motor vehicles, but also from falls. For those aged 65 and older, falls are the leading cause of death from injuries among older persons (Kochera, 2002). Uneven pavement can be difficult to navigate in a wheelchair, with a walker, or with a walking aid. Declining physical fitness and flexibility can make a bump feel like a mountain. Roadway designers should select smooth, strong materials for sidewalks and crosswalks such as concrete or asphalt rather than textured materials such as cobblestones or bricks. Paint can be used to highlight pedestrian areas, rather than elevating them or using knobby textures. Sidewalks should be maintained to ensure uneven pavement does not pose a hazard to pedestrians. Street trees should be chosen from species whose roots will not lift or break the pavement.

Curb Ramps

ADA standards require that curb ramps be included at all intersections; however, the

design of ramps can be accomplished in a variety of ways. A single central curb ramp at an intersection can "dump" the pedestrian into the center of the intersection and to the side of either crosswalk. People using wheelchairs or walkers in these situations may have a particularly hard time navigating to the crosswalk quickly and can become stranded in the roadway. Designers should provide a separate curb ramp directly aligned with the crosswalk and sidewalk approach at each leg of the intersection. Alternatively, designers can choose a single, continuous ramp that wraps around the corner from one crosswalk to the other.

Median Refuges

Older pedestrians need more time to cross streets, which presents a particular challenge for crosswalks on multilane and/or wide-lane highways. Small or complex crossing signal icons are hard to read from across the entire roadway for those who suffer from declining vision. Designers should break up the crossing distance on wider roadways with one or more median refuge islands that allow pedestrians to cross a single direction of traffic at a time for increased predictability and safety. Simple, highly visible crosswalk signs should be placed within the median if necessary.

Pedestrian Crossing Signals

Pedestrian crossing signals are a useful part of a complete street network. However, signals placed across a wide roadway may not be visible to older pedestrians with declining vision. In addition, complex placards can be confusing. Designers should provide pedestrian countdown signals rather than placards. For wider crosswalks, visual signals should be combined with audible signals, and crossing signals in the median may be warranted. Regardless of the width of the intersection, designers should set the walk signal time for a crossing speed of 3.5'/second plus 7 seconds to leave the curb, consistent with the proposed changes to the MUTCD.

Other Pedestrian Amenities

A lack of attention to streetscape detail discourages pedestrian activity and can even pose hazards to older travelers. Street lights scaled for automobiles can leave pedestrians in the shadows. A lack of benches and trees or awnings at transit stops can force pedestrians to stand for a long time in the hot sun. Narrow sidewalks with obstructions such as mailboxes, light posts, and fire hydrants leave no room for wheelchairs and walkers. Sidewalk amenities are important for all users; the following are especially critical for older people:

- Include pedestrian-scaled lighting to focus light onto the sidewalk, activating the sidewalk into the evening and improving visibility.
- Provide a wide sidewalk for wheelchair access and create room for outdoor cafes with awnings, benches, etc., transforming an uncomfortable, lonely pathway into a pleasant, visually interesting public plaza.

- Provide benches for sitting, resting, or gathering.
- Plant street trees for shade, enhanced aesthetics, and as a buffer between the sidewalk and roadway.

Balancing the Needs of Older Drivers and Pedestrians

Access Management

Strategies to consolidate multiple driveways into a few well-designed intersections address the needs of many different roadway users. Frequent driveways on main roads interrupt the pedestrian and bicycle network and create potential conflict points among turning vehicles, bicyclists, pedestrians, and oncoming traffic. Closing or limiting driveways along major roadways creates clearer pathways for all roadway users and less potential for conflict. Designers and planners should work together to create parallel access roads and shared driveways to improve access management.

Right Turn on Red

When a crossing signal reads "Walk," pedestrians begin crossing the street with the belief that it is safe to cross. Vehicles making right turns on red, however, may place the pedestrian in sudden, unexpected danger. Where pedestrian activity is high, designers should prohibit right turns on red and/or consider a roundabout as an alternative. Roundabouts keep traffic moving at a consistent but low speed and provide pedestrians with crosswalks that are set back from turning vehicles.

Protected Left Turns

Left-turn movements without the benefit of a turn arrow can put all road users in danger. Older drivers as a group experience difficulties when making left turns, as they do not position themselves within the intersection before initiating a left turn and they have more difficulty judging the speed of oncoming traffic to find a safe gap (Staplin, 1998). When focused on judging gaps in oncoming traffic, drivers of any age may fail to notice pedestrians in the crosswalk. To reduce the risk to drivers and pedestrians, a protected left-turn phase should be provided.

Protected left turn arrows become even more important at intersections with a pedestrian refuge island or median. The median creates a negative offset—pushing the drivers' line of site away from oncoming traffic and making it more difficult to judge gaps in traffic. See Figure 19, page 44.

Curb Radius

Curb radius describes the curvature of the curb between two legs of an intersection. Wide curb radii allow faster turning speeds and wider turning movements, lessening intersection congestion and facilitating vehicle mobility. However, higher speeds allow less time for drivers to look for other vehicles or pedestrians, and less time to make and

execute decisions. These conditions are problematic for older drivers. Higher vehicle speeds also increase the risk of serious injuries or fatalities to pedestrians, particularly among older adults. Wide curb radii also lengthen the crossing distance for pedestrians and make it more difficult to align the curb cut with the sidewalk approach. Roadway designers should use a 10'–15' maximum curb radius wherever possible, particularly in urban and suburban locations. The addition of parallel parking and bike lanes can increase the effective turning radius.

AN ASSESSMENT OF FHWA DESIGN RECOMMENDATIONS

One of the objectives of this research project was to review the FHWA's *Highway Design Handbook for Older Drivers and Pedestrians* through the lens of Complete Streets. The FHWA Handbook presents cost-effective solutions backed up by human factors and highway safety research. Given the increasing funding difficulties faced by state DOTs, the FHWA Handbook's emphasis is on providing solutions for new construction and reconstruction that have measurable safety results, rather than a systemwide retrofit. This is a positive and pragmatic approach.

The FHWA Handbook's design solutions go beyond mere policy. They offer engineers detailed recommendations that can be incorporated to "real-life" roadway design problems. The FHWA Handbook also offers a process for engineers to use in prioritizing strategies, based on safety issues specific to the community and relative cost benefit.

The great majority of the 31 recommendations in the FHWA Handbook are mode neutral. If states wholeheartedly implemented the mode-neutral recommendations, the safety of the U.S. road system would be greatly enhanced—for drivers in particular, yet without detriment to other road users. Thus, it is not the objective of this research to discard the FHWA Handbook recommendations, but to examine them through the lens of Complete Streets and offer refinements to better address the simultaneous needs of all road users.

General Issues and Opportunities for Refinement

Focusing Equally on Pedestrians and Drivers

While the FHWA Handbook is titled *Highway Design Handbook for Older Drivers and Pedestrians*, the discussions and recommendations are primarily focused on the older driver. For example, the introduction provides only one mention of the older pedestrian compared to 18 references made to the driver. The preponderance of research on drivers versus pedestrians dictates this outcome, because the FHWA Handbook presents only empirically based recommendations. Still, while it may not be possible to give equal weight to pedestrians throughout the FHWA Handbook, more discussion about the design

considerations for the older pedestrian would greatly enhance the document.[10]

The scope of the FHWA Handbook does not permit discussion of the growing debates among research, planning, and engineering communities on how to design roads for safety. Increasingly, planners and engineers challenge traditional highway design practice that tends to promote suburban roadways designed to provide mobility for the personal vehicle, often at the expense of other road users. The human cost of this traditional roadway engineering approach is significant. It exacerbates the social and physical isolation of nondrivers, not to mention the dangers imposed upon pedestrians and bicyclists.

Addressing Different Land Use Contexts

Understanding land use context is critical to balancing the needs of different users. Many suburban communities, small towns, and cities are seeking to build walkable, mixed-use places modeled upon the traditional city streetscape, and to expand public transportation options by creating a safe and comfortable walking environment around transit stops. Communities such as these would need to carefully consider whether the FHWA Handbook recommendations are appropriate for their situation. For example, the FHWA Handbook's recommendation to build acceleration lanes when applying channelization treatments (discussed below) may be appropriate for rural highways, but not for urban and suburban roadways with a mix of modes.

This emphasis on context, central to new approaches such as Context Sensitive Solutions and Complete Streets, is largely absent from the FHWA Handbook. Readers should understand that the FHWA Handbook's recommendations are appropriate primarily for rural highways and new, suburban higher-speed roads.

In a few instances the FHWA Handbook mentions the need to consider the surrounding land use when designing for improved mobility of older adults, but there is room for much more information on this topic. For example, adding several design iterations for each of the intersection recommendations could demonstrate ways in which the needs of older drivers and pedestrians can be addressed, given the functional classification of the road (residential, collector, arterial) as well as the land use context (urban, suburban, rural). The CSS framework could serve as a structure to present the FHWA Handbook recommendations.

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10 The FHWA Handbook bases its recommendations on a solid understanding of the available research on human factors and highway safety. Unfortunately, there is much less research on older pedestrians and other road users than on older drivers, and most studies lack a multimodal analysis of safety. Furthermore, the current practice of highway safety research is largely based on the use of safety surrogates rather than actual observances of safety outcomes, such as crash frequency and severity (Hauer, 2007). When field or laboratory studies of driver behavior were not available, the research referenced in the FHWA Handbook relied upon these surrogates (driver reporting of comfort levels, observations of curb and lane encroachment, change in speed, etc.). This weakness in the current state of road safety research makes it difficult to fully consider the interrelated issues of older drivers and pedestrians.

Considering the Effects of Vehicle Speed

Guidelines for many roadway design elements, from lane widths to intersection treatments, vary depending upon the assumed design speed. Traditional engineering practice is to establish a design speed of 5–10 mph above the intended posted speed. Yet, research has shown that the speed at which traffic is moving has a significant impact on pedestrian safety. The risks of fatalities and severe injuries, particularly for older pedestrians, rise exponentially with driver speeds. The literature on context sensitive solutions emphasizes the importance—and the difficulty—of establishing design speeds that balance pedestrian safety with driver mobility in different land use contexts.

The FHWA Handbook recommendations do not indicate an assumed design speed, and the supporting research in the appendix does not clearly address the question of whether treatments apply equally to roads designed for varying speeds. This lack of information indicates a need for more research on this topic. In the meantime, the FHWA Handbook could benefit from discussions and, where appropriate, design iterations to address a variety of design speeds.

Intersection Design Assessment

Intersections are complex locations that pose many safety risks, particularly for older drivers and pedestrians. Different road users must make many individual decisions rapidly at intersections, while simultaneously anticipating or reacting to the decisions of others. These decisions are harder to make with reduced visual acuity, physical dexterity, and reaction times.

The FHWA Handbook recommendations on interchanges, roadway curvature, and passing zones (presumably for rural highways); construction/work zones; and highway-rail grade crossings present comparatively few potential conflicts among bicyclists, pedestrians, and older road users. In many cases, the recommended treatments to aid older drivers, such as larger sign fonts and retro-reflectivity, can benefit all travelers.

However, a few of the intersection recommendations could have the unintended consequence of benefiting one type of roadway user at the expense of others. For example, wide lanes and sweeping curves may make it easier for older drivers to navigate an intersection. But the increased crossing widths and potentially higher vehicle speeds associated with these types of design treatments can make conditions more difficult for older pedestrians.

These design conflicts are not unique to the FHWA Handbook. An energetic debate has been going on for some time among planners and engineers on how to balance the needs for roadway capacity and vehicle mobility with the needs of nonmotorized road users at intersections, specifically when designing elements such as lane widths and curb radii.

The following analysis identifies five types of potential older driver/pedestrian conflicts presented by the FHWA Handbook's "Intersection Design Element" recommendations,

and offers supplemental urban and suburban intersection refinements intended to reduce these conflicts and achieve greater compatibility with Complete Streets goals.[11] The design assessment elements described in this section are as follows:

- Receiving lane (throat) width for turning operations
- Channelization
- Offset (single) left-turn lane geometry, signing, and delineation
- Curb radius
- Pedestrian crossing design, operations, and control

Receiving Lane (Throat) Width for Turning Operations

FHWA Recommendation

A minimum receiving lane width of 3.6 m (12') is recommended, accompanied, wherever practical, by a shoulder of 1.2 m (4') minimum width.

As explained in the FHWA Handbook, older drivers have more difficulties maneuvering their vehicles through smaller areas. Narrow (10'–11') receiving lanes with no shoulder could provide insufficient width for turning vehicles, causing conflicts as left-turning vehicles cut the corner of the turn lane on the receiving street.[12] At the same time, the FHWA Handbook acknowledges that lane widths beyond 12' may result in "unacceptable increases in older pedestrian crossing times." The recommendation (minimum receiving lane width of 12' with a 4' shoulder) is intended as a compromise to accommodate the needs of older drivers and pedestrians, as well as larger turning vehicles. *See Figure 14.*

Discussion

The AASHTO Green Book provides substantial flexibility on whether lane widths

11 The project team's suggested design refinements focus on intersection design appropriate for urban and suburban areas where pedestrians are present and more multimodal transportation travel is desired. The authors' goal is to show examples of how designers could approach a particular intersection treatment through the lens of Complete Streets. The intent is not to exhaust the myriad design possibilities that inevitably depend on an engineer's understanding of the particular context in which the road is situated. The design refinements that follow build upon accepted engineering design guidelines, such as those offered by AASHTO, ITE, FHWA, and the U.S. Access Board. Appendix A cross-references the project team's recommendations with those very documents to show how their guidelines can be used in the actual implementation of more universal road design.

12 Several factors that can compromise an older driver's ability to remain within the boundaries of the turning lane include a diminished ability to view and process activity at the intersection and lack of strength needed to turn the wheel sharply enough given the travel speed to properly complete the turning movement (FHWA Handbook reference of McKnight & Stewart, 1990; and Staplin, Harkey, Lococo, & Tarawheh, 1997).

A wide receiving lane and shoulder increase pedestrian crossing distance and may encourage faster driving

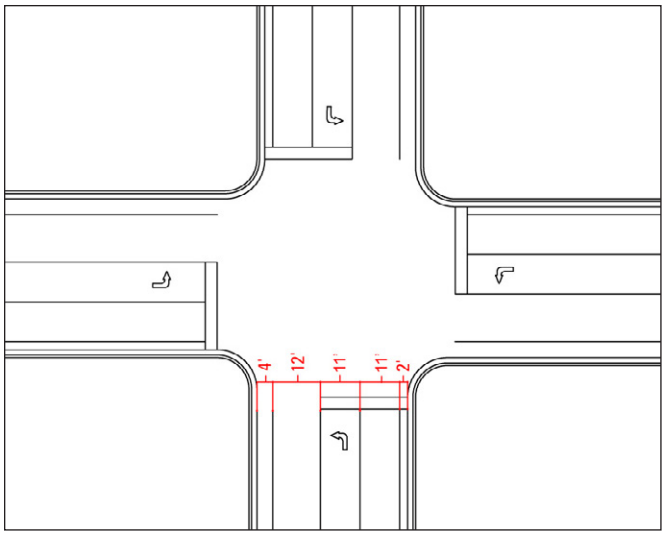

Figure 14. Authors' Illustration of Enhanced FHWA Handbook Recommendation

narrower than 12' are appropriate for urban and suburban arterials.[13] While narrow lanes (less than 12') may be difficult for the older driver to maneuver in some cases, they are ideal for pedestrians, especially older pedestrians. Not only do they reduce crossing distance, they also tend to encourage drivers to drive more slowly and carefully.[14] Conversely, studies show that the safety benefit of wider lanes effectively stops once lanes reach a width of 11'; after that point, crash rates increase on lanes that approach or exceed the more common 12' standard.[15]

Narrower lanes are one element of roadway design that can contribute to lower speeds. Other factors such as roadway markings and landscaping can change the drivers' perception of their maneuvering area, causing them to feel as if they are traveling faster than they actually are and slowing

13 "The use of narrower lanes in appropriate locations can provide other benefits to users and the surrounding community, including shorter pedestrian crossing distances and space for additional through lanes, buffer areas between travel lanes and sidewalks, and placement of roadside hardware." I.B. Potts, D.W. Harwood, and K.R. Richard, "Relationship of Lane Width to Safety on Urban and Suburban Arterials," *Transportation Research Record: Journal of the Transportation Research Board*, no. 2023 (2007): 63–82.

14 As pointed out by Ewing (1999), narrow streets contribute to calmer traffic and less aggressive driving because drivers sense that there is a greater risk of traveling outside the lane and colliding with objects on either boundary of the lane. Several studies have found that reduced lane widths lower vehicular speeds. Yagar and Van Aerde "found a reduction in speed of 1.1 mph for every foot of reduction in lane width beyond 13 feet" (cited in Martens et al., 1997). Heimbach and colleagues found that on four-lane undivided urban roadways, during off-peak hours a foot reduction in lane width would result in traffic moving 0.6 mph slower. A 1.0 mph reduction in speed would occur during peak hours (Heimbach et al., 1983). Another study, titled "Design Factors that Affect Driver Speed on Suburban Arterials," suggested that on four-lane urban arterials for every foot the width of a travel lane increased, traffic traveled 2.9 mph faster (Fitzpatrick et al., 2000).

15 Recent studies indicate that increased lane widths and overall street widths are linked to increased crash rates and severity (Dumbaugh, 2005; King, 2003; Swift, 2006). Dumbaugh (2005) references Hauer (1999), whose examination of the literature found that there was "little evidence to support the assertion that widening lanes beyond 11 feet enhances safety. Instead, the literature has almost uniformly reported that the safety benefit of widening lanes stops once lanes reach a width of roughly 11 feet, with crash frequencies increasing as lanes approach and exceed the more common 12-foot standard." Similarly Potts and colleagues (2007) concluded that there is "no indication of an increase in crash frequencies as lane width decreased for arterial roadway segments or arterial intersection approaches."

down as a result (Massachusetts Highway Department Project Development and Design Guide [MassSAFE], 2004).

Suggested Refinements

In most urban areas, the FHWA recommendation to widen the receiving lane can be accomplished through the provision of bike lanes. Additional travel lanes also provide the indirect benefit of additional throat width for a left-turning vehicle. In these areas, the FHWA Handbook standard should be refined to accommodate a 10'–11' receiving lane, ideally with an adjacent 5' bicycle lane. Bike lanes can increase the effective maneuvering space while still keeping speeds down, as drivers will adjust to the marked lane width. *See Figure 15*.

Bike lanes increase the effective maneuvering space without encouraging higher speeds and help to "complete the street"

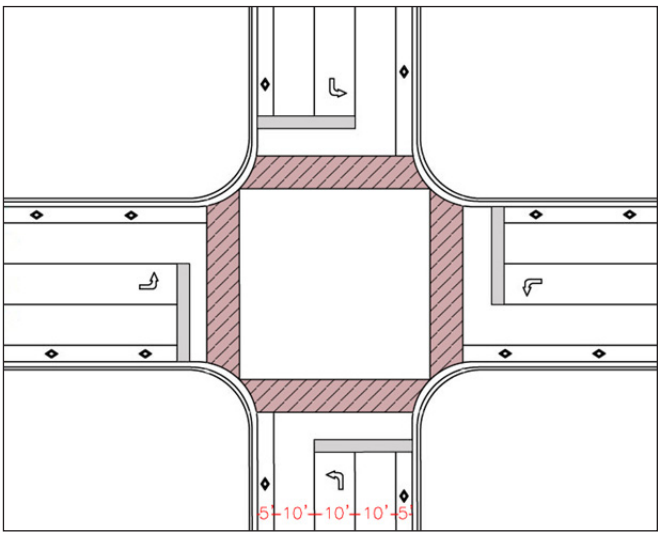

Figure 15. Authors' Refinement of Receiving Lane Treatment Appropriate for Urban Areas.

At intersections where it is necessary to accommodate heavy vehicles or other vehicles with a wider turning radius, it may be appropriate to move the stop bar on the receiving side back to accommodate a wider radius, as long as the recommended sight distance is not compromised.

It may also be useful for the FHWA Handbook to specify that the 12' receiving lane with 4' shoulder recommendation is a rural standard and may be accompanied by "share the road" signage where bicycle activity is expected. Lanes of 12' or greater should be applied, if necessary, on parkways, rural highways, and other types of throughways where traffic movement is the primary objective of the roadway.

Channelization

FHWA Recommendation

The FHWA Handbook does not endorse channelization but, rather, describes how it should be designed. For right-turn channelization where pedestrian traffic may be expected based on surrounding land use, it is recommended that an adjacent pedestrian refuge island conforming to the MUTCD and AASHTO design guidelines be provided. The crosswalk should be located as close as possible to the approach leg to maximize the visibility of pedestrians before drivers are focused on scanning for gaps in traffic on the

intersecting roadway.[16] The channel should be raised and treated with retro-reflectorized marking and maintained at a minimum luminance contrast level. The FHWA Handbook also discussed the need to provide an acceleration lane providing for the acceleration characteristics of passenger cars as delineated in AASHTO specifications.

Discussion

Channelization is used to separate and define travel paths. It directs drivers and pedestrians to the correct location when they are navigating through traffic medians or pavement markings. By providing a protected turning area with a large radius, channelized right turns allow all vehicles to turn more quickly and large vehicles to turn more easily. Some channelized right turns exit into a dedicated acceleration lane before having to merge into traffic (free right turn), while others require the merge to occur when exiting the turn itself.

The study team does not have concerns with the content of FHWA Handbook recommendation but, instead, with the issues left unstated. The FHWA Handbook does not discuss the physical fitness issues that may be at play for older drivers when they navigate channelized right turns. Furthermore, it fails to caution designers against using right-turn channelization in urban and suburban areas where pedestrians are present.

The FHWA Handbook discusses the decline of older driver's head and neck mobility and the difficulty in seeing and judging oncoming traffic at skewed intersections (Design Element A) but it does not discuss limited range of motion in the context of channelization. A channelized right turn requires a larger range of motion for a driver's head and neck, for which older drivers may be unable to compensate.[17]

In addition, since channelized turns are designed to keep traffic moving quickly around a curve, they present a short window of time for drivers to make merging or yielding decisions when exiting the channelized turn, which can be an issue for older drivers with slowed reaction times. As the angle at which the two roads intersect diverges from 90 degrees, the sight distance for turns diminishes, making it increasingly difficult for persons with reduced neck mobility to identify gaps. ITE's recent publication on context sensitive solutions (2006) justifies a low-angle turn to "slow down the speed of right-turning vehicles and improve driver visibility of pedestrians within and approaching the crosswalk." [18] While the FHWA Handbook does cite research pointing to increased

16 Found in FHWA Handbook Design Element P: Pedestrian Crossing Design, Operations, and Control.

17 The movement of neck rotation used to perform turns at skewed intersections is similar to the motion required for navigating a channelized right turn. In a study by Staplin and colleagues (1997) to determine whether older drivers used outside mirrors to help perform a right turn on red at a skewed intersection, 30 percent of drivers ages 25–45 and 65–74 used their mirrors, and none of the drivers over 75 used outside mirrors to help (FHWA, 2001). Channelization could be problematic for older drivers who are less physically capable of looking over their shoulder, and arguably less likely to use outside mirrors.

18 The AASHTO Green Book design calculations for sight distance are relevant for intersections

Channelized intersections designed for high speed place pedestrians outside the driver's cone of vision.

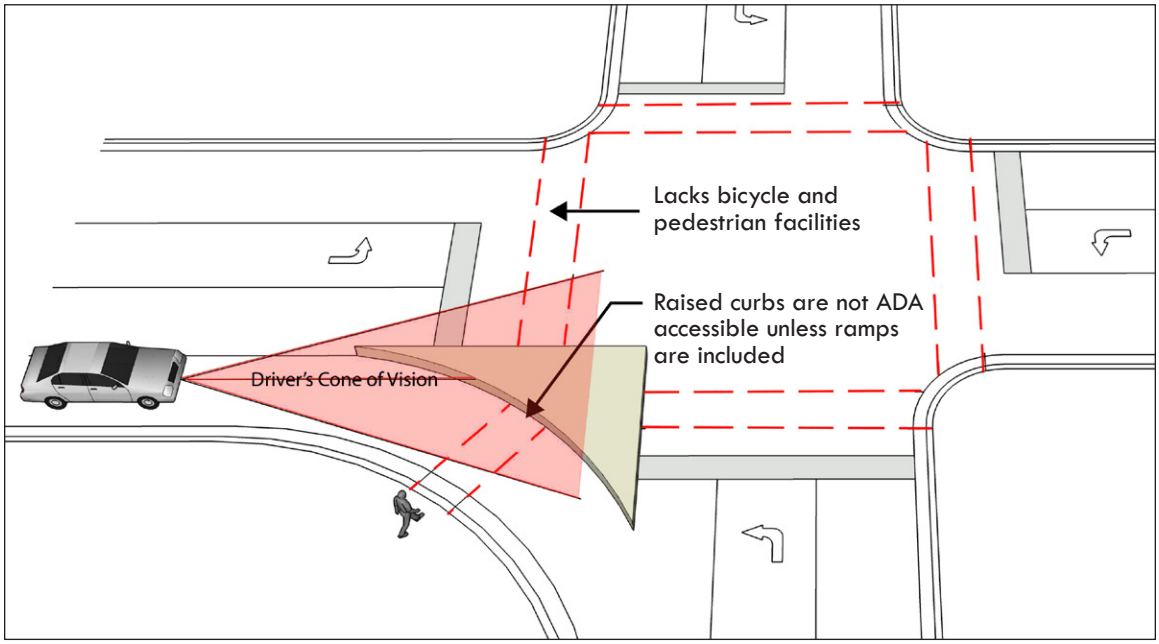

Figure 16. Illustration Showing the Challenges Faced by Pedestrians at Channelized Intersections.

older driver comfort with channelized right turns when acceleration lanes are provided, these lanes are undesirable for pedestrians as they increase pedestrian crossing distance and facilitate increased vehicle speed.

The FHWA Handbook references the benefits of the pedestrian refuge, as well as the fact that channelization can help clarify an ambiguous or complex intersection. However, it also notes that the presence of islands is unlikely to offset the pedestrian disadvantage at a large intersection (Hauer, 1988).

It also references studies that indicate vehicles move faster, are less likely to stop, and exhibit higher crash rates at channelized intersections with longer curb radii.[19] As the risk of pedestrian death in crashes with motor vehicles rises with speed, it can be assumed that higher vehicle crash rates and longer pedestrian crossing distances also contribute to a more dangerous situation for pedestrians.

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where roads intersect at an angle not less than 60 degrees. ITE's publication *Recommended Guidelines for Subdivision Streets* advises using a minimum of 75 degrees for the intersecting angle (ITE, 1984). The FHWA Handbook endorses this "75-degree minimum as a practice to accommodate age-related performance deficits" (FHWA, 2001).

19 A study by Staplin and colleagues (1997) found that higher turn speeds (3–5 mi/h) are common among younger drivers on intersection approaches with channelized right-turn lanes. The study also indicated that younger drivers were less likely to stop before making a right turn on red at channelized intersections. Additional recent research indicates that vehicle turning speed increases as the turn radius increases and, in most cases, vehicular crash rates are higher at channelized right turns than at right turns without channelization (Bauer, 2000; Fitzpatrick, 2005).

A tighter turn makes it easier for drivers with stiff necks to merge with traffic

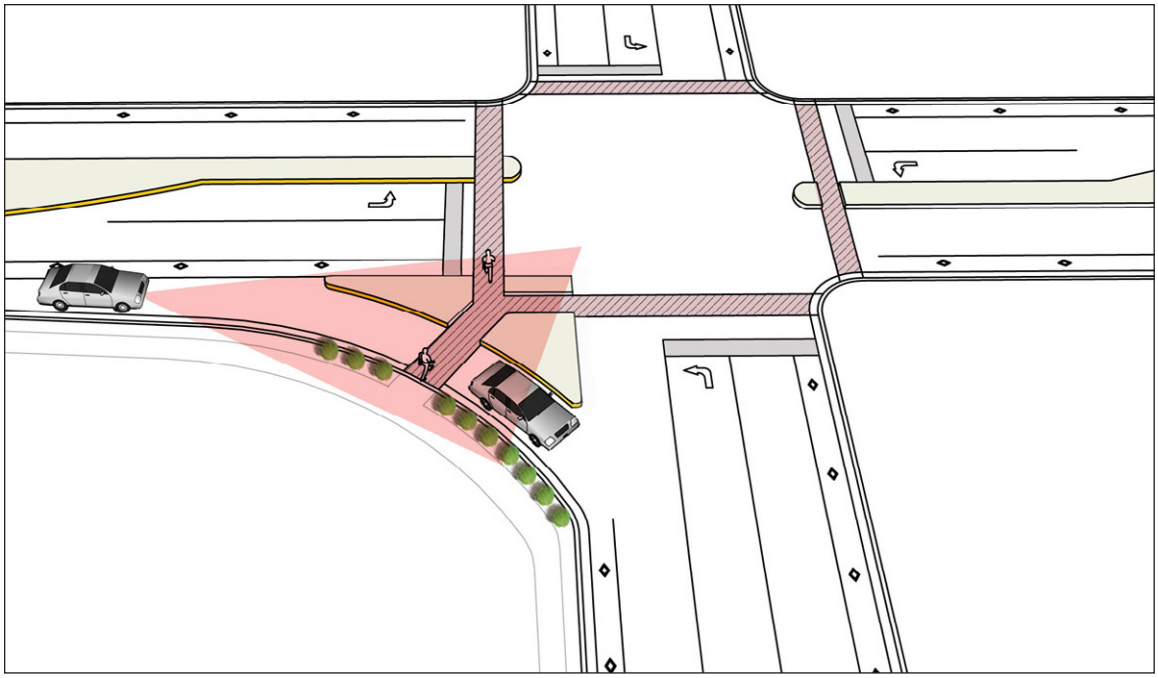

Figure 17. Illustration of Authors' Refinement Showing Pedestrian and Driver Improvements at Channelized Intersections.

Unmarked or improperly marked paths for pedestrians crossing from the curb to the channelized island refuge can cause dangerous situations. *See Figure 16.* Pedestrians at channelized intersections must cross from the curb to the island and then cross the lanes of traffic.

Research shows that poorer contrast sensitivity makes the painted channel marking less visible to older drivers. Without a visibly marked crossing path, drivers may not be aware of the presence of pedestrians at the intersection. Drivers may be unable to stop for pedestrians who cross too close to the approach, and are less likely to see pedestrians who cross too close to the receiving side. A clearly marked crossing alerts drivers to the possibility of pedestrians, and provides pedestrians with a clear safe path to follow. Advance warning signs would also remind drivers to be aware of crossing pedestrians. Installing "Yield to Pedestrian" signs reduces pedestrian crashes by 10 percent (ITE, 2004).

Suggested Refinements

As with all suggested refinements in this report, the first priority is to make sure the design treatment is appropriate for the context of the road and surrounding area. Channelization in urban and suburban settings should be discouraged, because of the potentially dangerous obstacles it can present to pedestrians. A non-channelized, 90-degree intersection accompanied by a prohibition of right turn on red (RTOR) is suggested to reduce conflicts between motorized vehicles and pedestrians and bicyclists. If RTOR

prohibitions are not used, yield to pedestrian signs should be used.

Where channelization is warranted, the older driver's cone of vision should be considered in designing the angle of a channelized turn. Pedestrian visibility to drivers should be the top priority. Tighter turn angles can reduce driver speeds and open the driver's vision to the potential presence of a crossing pedestrian. In addition, tighter angled channelized turns reduce the degree to which the driver's head must turn left in order to look for oncoming traffic. These attributes are particularly important for older drivers, who may have stiff neck issues. *See Figure 17.* Minimizing the curb radius can help increase pedestrian safety while reducing the width of the approach lane for the channelized turn can help reduce vehicle speed.

Crosswalks should be located 15'–20' behind the merge point of the channelized island to allow adequate space for a vehicle to stop and look left for oncoming traffic without blocking the path of pedestrians. This placement also enables drivers to scan the intersection for the presence of pedestrians in advance of needing to merge with traffic.

Landscaping treatments such as low prickly shrubs along the curb will confine pedestrians to crossing at the safest location. Other treatments such as rumble strips and raised crosswalks help to slow traffic and improve pedestrian safety. Signalizing the channelized right turn with an actuated pedestrian button further increases pedestrian safety, as right-turning vehicles are stopped by a red light while pedestrians are crossing.

As recommended by FHWA, if a channelized right turn is present in a pedestrian-oriented area, a raised curb is recommended with an at-grade crosswalk to provide refuge for crossing pedestrians, rather than demarcating the channel with surface paint alone. Contrast paint should be added to the curb side to make it more visible at all times of the day and under all driving conditions. The surface and sides of the median refuge should also be reflectively painted to increase visibility.

Participants in the online survey and the Innovation Roundtable assembled for this study mostly agreed with these suggested refinements. In general, survey participants discouraged channelization, encouraged raised islands especially in pedestrian-heavy areas,

Positive offsets improve the line-of-sight for drivers making left turns.

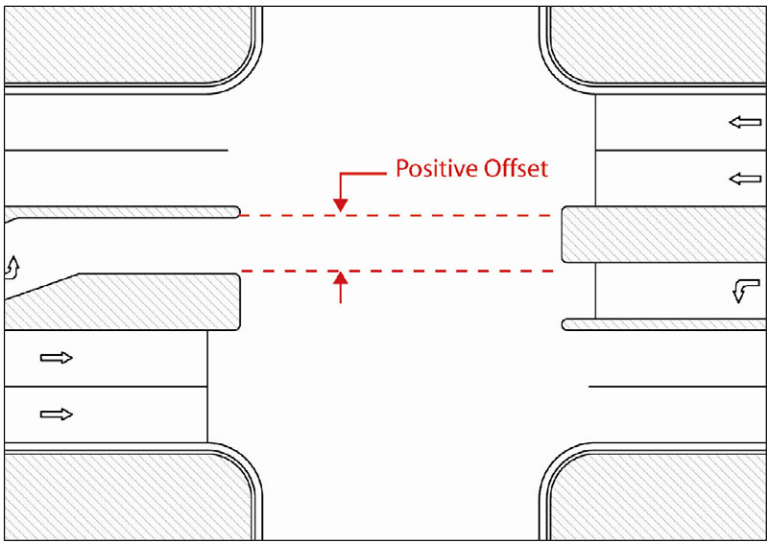

Figure 18. FHWA Handbook Illustration Refined to Show Positive Offset.

supported a tighter angle for easier perception of approaching traffic, and opposed free-flow turns. To further improve the safety of pedestrians at intersections, Roundtable attendees recommended that right-turn channelization be replaced by right-angle turns in combination with a right turn on red (RTOR) prohibition. When a RTOR crash occurs, a pedestrian or bicyclist is frequently involved, and these types of crashes usually result in injury (Compton & Milton, 1994).

Offset (Single) Left-Turn Lane Geometry, Signing, and Delineation

FHWA Recommendation

Unrestricted sight distance (achieved through positive offset of opposing left-turn lanes) is recommended whenever possible, for new or reconstructed facilities. *See Figure 18*. This will provide a margin of safety for older drivers who, as a group, do not position themselves within the intersection before initiating a left turn

Discussion

Older drivers are overrepresented in left-turn crashes where failure to yield to the right-of-way is the movement violation. Typical underlying causes of these crashes include the misjudgment of oncoming vehicle speed, misjudgment of available gap, assuming the oncoming vehicle was going to stop or turn, and simply not seeing the other vehicle (Council & Zegeer, 1992, as discussed in FHWA Handbook, 2001). Older drivers as a group experience inordinate difficulties when making left turns, as they do not position themselves within the intersection before initiating a left turn. This can block the sight line to oncoming traffic for drivers waiting to make left turns from the opposite direction.

Attempting to make a left turn at an intersection where there is no protected phase can be difficult and dangerous to the older driver. Making a left turn during a permissive (unprotected) phase requires the driver to judge the speed of oncoming through traffic, identify an adequate gap, and execute the turn within the space allowed by the gap. When the oncoming traffic consists of two or more lanes, judging the speed and identifying a gap becomes considerably more difficult. In areas with pedestrian activity, left-turning drivers must also make sure that there are no pedestrians in the crosswalk that would block the vehicle from finishing the turn and proceeding safely out of the way of opposing through vehicles. Attendees at AARP's Innovation Roundtable asserted that permissive left turns with two or more lanes of oncoming traffic have very high pedestrian crash rates, and that permissive-only left turns are one of the leading causes for crashes in urban areas.

Obstructed lines of sight caused by queued vehicles in opposing left-turn lanes (i.e., negative offsets) can pose safety and capacity deficiencies for all drivers, particularly for those making unprotected left-turn movements. Older drivers may experience additional difficulties in completing left turns as a result of diminished ability to properly perceive

depth and speed of oncoming traffic.[20] Positive offsets are associated with larger sight distances (Joshua & Saka, 1992), which helps older drivers to judge gaps in opposing traffic, and they are associated with a reduction in crashes relative to permissive left turns without a positive offset.[21]

Positive offset treatments can, however, pose problems for pedestrians. Ideally, multilane roads would provide a median refuge for pedestrians unable to cross in the allotted signal time. However, this median introduces a negative offset, and an attempt to compensate for this by providing a positive offset for left-turning drivers creates an awkward location for a pedestrian to wait and is especially disorienting for visually impaired persons. *See Figures 19 and 20.*

Inclusion of a pedestrian refuge island creates a negative offset and blind spot for drivers turning left

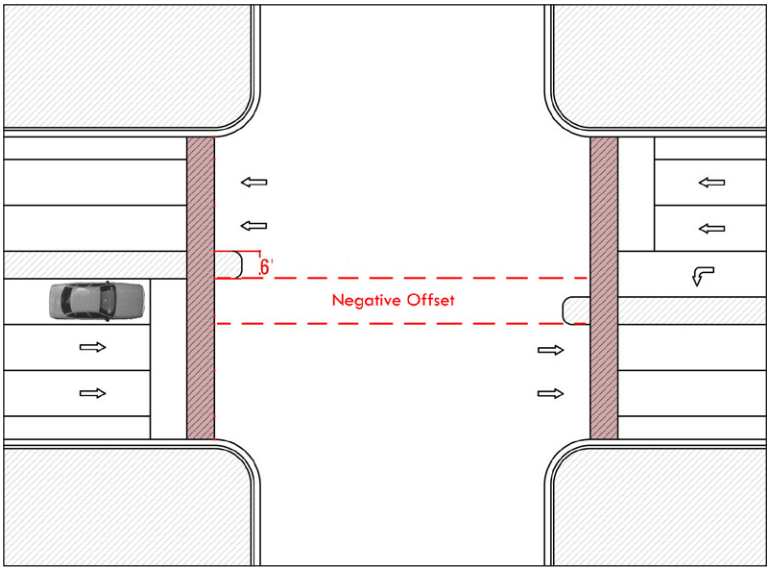

Figure 19. Illustration of Negative Offset Exacerbated by a Pedestrian Refuge Island

The additional space needed to provide the median also increases the total pedestrian crossing distance and required green time. Respondents to the online survey remarked that a pedestrian refuge must be at least 6' wide, which requires more right-of-way and increases crossing distance, while also failing to provide accommodations for bicycles.

Instead of addressing problems of restricted sight distance through geometric changes, a more affordable solution may be to make operational improvements such as traffic

20 Older drivers are found to require double the angle of stereopsis to perceive depth than is required for younger drivers (Staplin et al., 1993, as discussed in FHWA Handbook 2001). Additionally, older drivers require twice the rate of movement to perceive approaching objects as compared to younger drivers (Hills, 1975, as discussed in FHWA Handbook, 2001). These factors result in difficulty perceiving oncoming traffic and judging its speed while completing left turns.

21 Perception reaction time (PRT) also diminishes with age, which is an important factor in considering intersection sight-distance requirements for turning vehicles. Conclusions from several studies cited in the AASHTO Green Book report reaction times of 0.2 to 0.3 seconds for drivers under alerted conditions and 1.5 seconds under normal conditions (AASHTO, 2004b). To account for complexities beyond laboratory and road tests, AASHTO recommends a reaction time of 2.5 seconds, which is the minimum perception reaction time recommended by the FHWA Handbook. This amount of time is recommended in addition to the typical time needed to stop based on the road design speed.

signals with a protected left-turn phase (oncoming traffic is stopped, denoted by a green arrow). Left-turning drivers are protected from opposing drivers who are stopped at a red light, and from opposing pedestrians who have a "Don't Walk" light during the protected phase. When left turns are only allowed during a protected phase (thus prohibited during the general green phase), pedestrians are protected as they will not conflict with left-

This attempt to balance older driver and pedestrian needs by providing both a pedestrian refuge median and negative offset was rejected by engineers and planners.

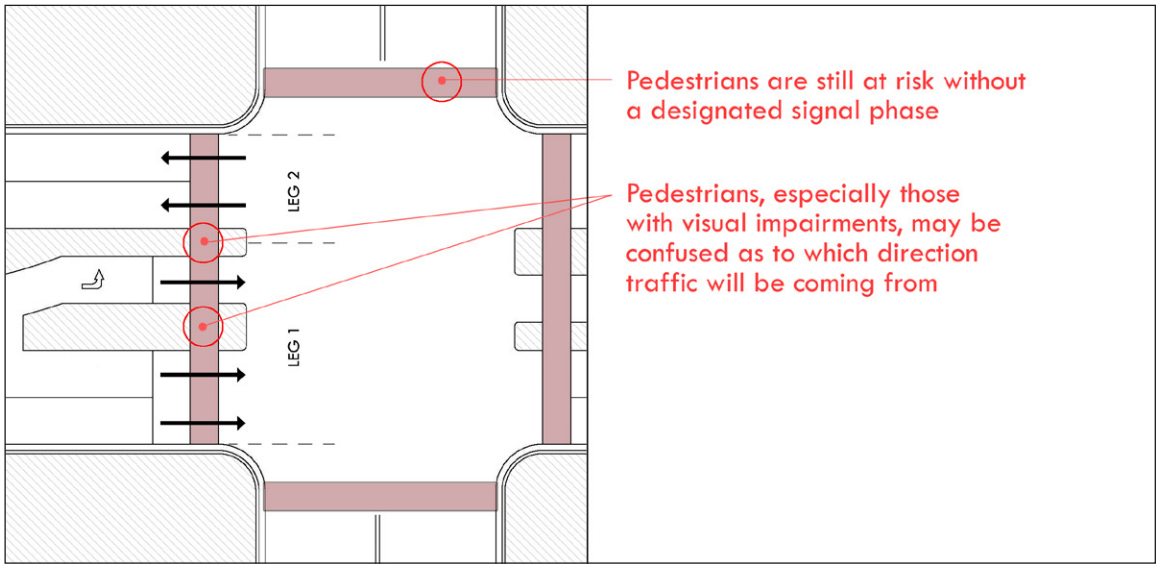

Figure 20. Intersection showing both a negative offset and pedestrian refuge median.

turning vehicles during the "Walk" phase.

A protected-only mode works best when the average daily traffic (ADT) is heavy, the use of through lanes is heavy, and the permissive left turn would result in a high frequency of crashes. The protected-only mode reduces left-turn crashes by 63–70 percent and has a particular safety benefit to the older driver (ITE, 2004).[22]

In spite of the safety benefits of protected-only left-turn phases, they present some drawbacks that can discourage an agency from universally implementing them. Providing protected phases requires green time from other phases that could decrease intersection capacity, especially on wide roads with long pedestrian crossing distances. In addition, protected-only left turns can frustrate left-turning drivers who are forced to wait even when there is no oncoming traffic.

22 Basha (2007) found collision rates at intersections with lagging left-turn arrows to be less than those at intersections with leading left-turn arrows. Left-turn head-on (LTHO) collisions make up 33 percent of all collisions at intersections in a city with leading left-turn arrows, while 21 percent of collisions are LTHO collisions in a city with lagging left-turn arrows (Basha, 2007).

Employing a phasing plan with a permissive left turn during the general phase and a lagging protected left-turn phase (solid green light, followed by a green arrow) is a comprehensive solution in most cases. Allowing left turns to process during the permitted phase reduces the queue of vehicles during the protected phase, which can give green time back to other movements. For older drivers who are less likely to position themselves within an intersection, a protected lag phase allows them time to execute the turn during the green arrow, while drivers behind them, who may normally become impatient, will have the opportunity to turn at the end of the general phase.[23]

Suggested Refinements

Depending upon the context of the intersection, a signal phasing plan with a protected left-turn lag phase will often provide more comprehensive benefits to older drivers and pedestrians than positive offset for the left-turn lane. This strategy provides an exclusive phase for drivers to make a left turn without risking conflicts with opposing traffic or pedestrians. It requires no additional pavement and does not increase pedestrian crossing distances.

Generally, if opposing through vehicular traffic is heavy, or if opposing pedestrian volumes are high, it may be best to restrict left turns to the protected-only phase. The presence of marked crosswalks between all quadrants of the intersection becomes more essential if a lagging left-term phase is permitted in order to draw the attention of turning drivers to the possible presence of pedestrians in the intersection.

In urban and suburban settings, which warrant a median refuge of 6' between directions of traffic, it becomes more important to limit the turn to a protected left-turn phase, as the refuge creates a negative offset and reduces the line of sight for drivers turning left.

As with any change in intersection design and operation, it is of utmost importance to consider the context of the road and the character of the surrounding area when deciding if a design treatment or phasing change is appropriate. The design presented here is most appropriate for urban and suburban roadways. The wider offset recommended by the FHWA Handbook may be more appropriate in limited rural settings where pedestrian traffic is not expected.

The FHWA Handbook recommends a 25' curb radius

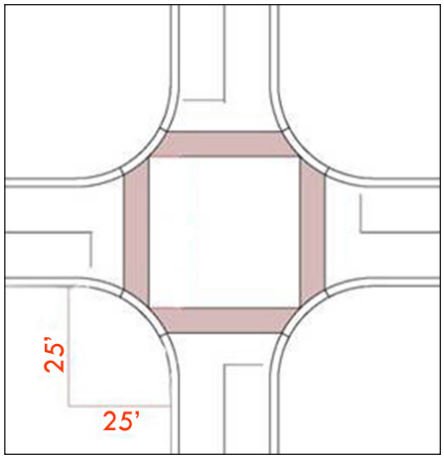

Figure 21. Authors' Illustrative of FHWA Handbook recommendation

23 It should be noted that older drivers have more difficulty understanding left turn signal relative to younger drivers. Ullman (1993) found the protected left-turn signal to be the best understood while the protected/permissive the least (Eby, 2009).

Curb Radius

FHWA Recommendation

(1) Where roadways intersect at 90 degrees and are joined with a simple radius curve, a corner curb radius in the range of 7.5 m to 9 m (25'–30') is recommended as a trade-off to (a) facilitate vehicle turning movements, (b) moderate the speed of turning vehicles, and (c) avoid unnecessary lengthening of pedestrian crossing distances, except where precluded by high volumes of heavy vehicles. *See Figure 21.*

(2) When it is necessary to accommodate turning movements by heavy vehicles, the use of offsets, tapers, and compound curves is recommended to minimize pedestrian crossing distances.

Older pedestrians may find intersections with longer curb radii more difficult to cross due to increased crossing distance and vehicle turning speeds.

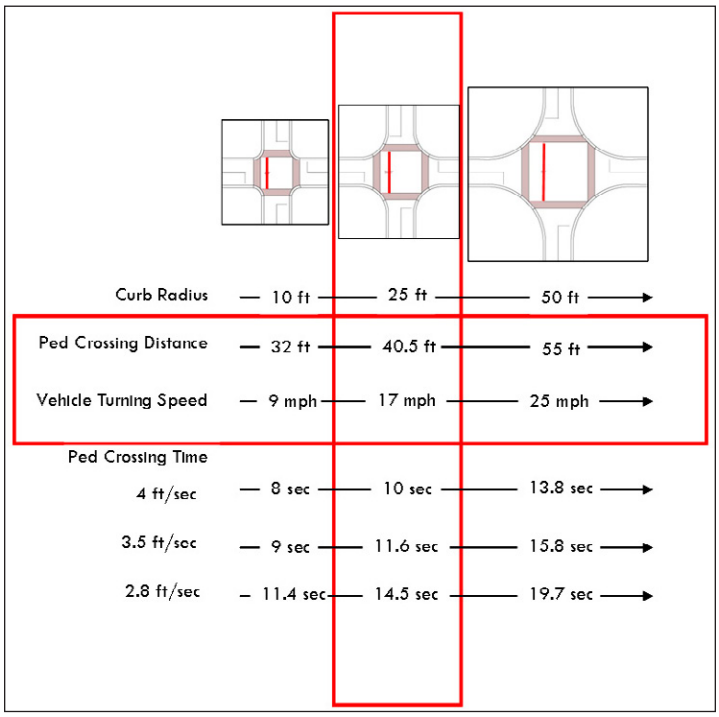

Figure 22. A comparison of the crossing distance and turning speed for 10', 25', and 50' curb radii.

Discussion

Curb radius is a measure of the sharpness of a corner: smaller radii equal sharper turns suitable for automobiles and pedestrians, while larger radii facilitate the turning of large trucks and buses. One of the common pedestrian crash types involves a pedestrian who is struck by a right-turning vehicle at an intersection. Therefore, the design of the curb radius is an important consideration at an intersection where the paths of turning cars and crossing pedestrians overlap.

When curb radii are too small, older drivers who have physical conditions that make it difficult for them to maneuver turns may attempt to increase their turning radius in order to decrease steering wheel rotation, which results in cutting the corner or encroaching into other lanes of traffic (Staplin et al., 1994, as discussed in FHWA Handbook, 2001).[24] While large curb radii are preferred by older drivers, they

24 In a design preference survey both young and old drivers preferred larger curb radii (48') over smaller curb radii (18' or 40'). Preference was given to the 48' radius curb for ease of turning and maneuverability. Tight intersections with smaller curb radii were disliked because of difficulty in maneuver-

pose significant challenges for all pedestrians. Studies have shown that wide turns at intersections extend the crossing distance and encourage higher speeds among turning vehicles, putting the pedestrian at greater risk of vehicular conflict even when a pedestrian refuge island is provided (Hauer, 1988; Fitzpatrick, 2005; Wolfe, 2000). *See Figure 22.* Participants at the AARP Innovation Roundtable also pointed out that a large radius creates difficulties with the geometry of lining up the sidewalk, crosswalk and curb ramp, a design detail of particular importance to people who use wheelchairs and those with visual impairments.

The FHWA Handbook recommends a corner curb radius between 25' and 30' at 90- degree intersections to assist with the challenge of steering wheel rotation needed for older drivers, but provides little discussion of the most appropriate context for the standard. This type of radius is appropriate on streets with high volumes of large vehicles, and it is often applied in auto-oriented suburban areas where less emphasis is placed on pedestrian activity and safety.

The AASHTO Green Book gives an acceptable range of 15'–25' as the design curb radius for passenger vehicles, appropriate for streets with fewer turning trucks or buses. The book recommends a minimum of 25' where space permits, but notes that urban areas can function with curb radii of 10'–15' given space limitations, presence of pedestrians, and generally lower operating speeds (AASHTO, 2004b). ITE's *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities* recommends a curb radius of 10'–15' in several situations: where pedestrian activity is expected, where occasional encroachment into the opposing lane is acceptable and/or it is possible for larger vehicles to encroach on the corner of a curb, or where bike lanes or on-street parking increase the effective turning radius. Even 5' curb radii are common in older cities.

Suggested Refinements

In all cases, the context of the roadway and appropriate vehicle speed should be considered in determining the appropriate size of the curb radius for the particular condition where it is located. Smaller curb radii in the 10'–15' range, combined with lower vehicle speeds, are useful traffic calming devices and are most appropriate in urbanized areas where there is a greater mixture of users sharing the roadway. This is true for small towns, suburban mixed-use areas, and any other places where communities wish to encourage pedestrian and bicycle travel.

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ability, visibility of oncoming traffic, and likelihood of hitting a curb or median while completing a right turn (Staplin et al., 1997, as discussed in FHWA Handbook, 2001). Another study further supported these difficulties. For older persons who are more likely to suffer from rheumatoid arthritis or other arthritic conditions that make gripping and turning the steering wheel difficult and painful, these conditions result in less control over vehicle movement when completing turns (Roberts & Roberts, 1993, as discussed in FHWA Handbook, 2001).

The addition of bike lanes and parallel parking increases the effective radius making it easier for older drivers to turn.

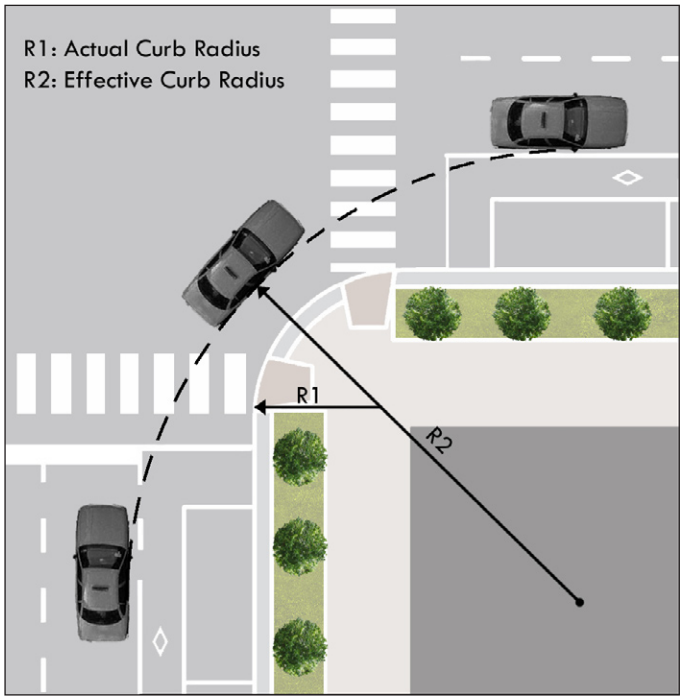

Figure 23: Comparison of Actual and Effective Curb Radii

Crosswalks do not line up with curb cuts and sidewalks

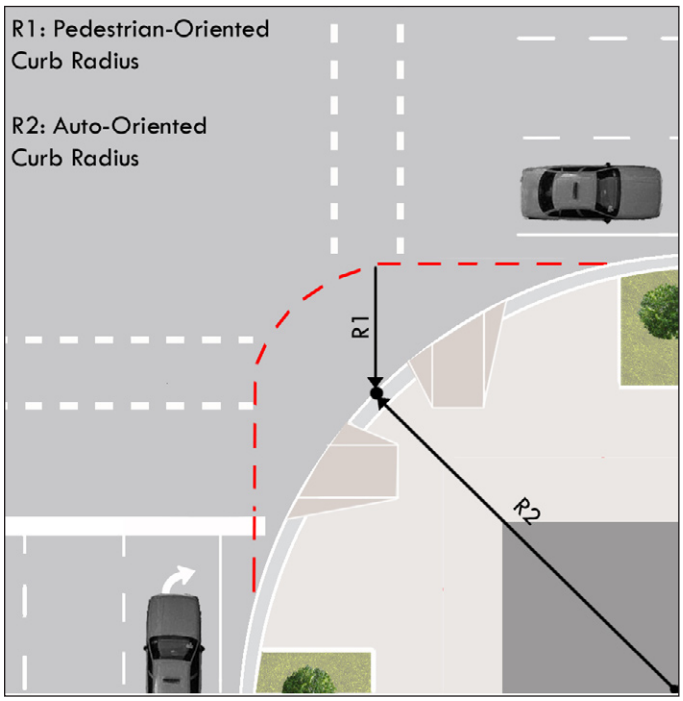

Fig. 24: Illustration of how R2 in figure 23 would appear if it were the actual radius.

A 25' curb radius may be appropriate, however, for urban boulevards, parkways, and less urbanized areas where the dominant form of mobility is the automobile, or where larger vehicles use the facility on a regular basis. In all cases, the designer should aim for the smallest curb radius possible with consideration given to the nearby land uses, design speed, and types of road users.

To ensure pedestrian safety, designers should aim for the smallest curb radius that works for the particular context, design speed, and vehicle. Smaller curb radii can both shorten the crossing distance and force drivers to slow down as they make a tighter radius turn. Participants at the Innovation Roundtable offered the following recommendations to make a tighter curb radius work in a variety of contexts:

- Choose the appropriate design vehicle. Curb radii should be designed to accommodate the largest vehicle type that will *frequently* turn the corner. For example, a bus may use a make a certain turn several times an hour, but a moving van, once or twice a year. Do not choose a larger design vehicle than necessary.

- Calculate the curb radius for each corner individually. Curb radius design is not a one-size-fits-all approach. For example, on one-way streets, a corner with

no turns can have a very tight (5') radius, while another corner may require a longer radius.

- Calculate curb radii to reflect the "effective" turning radius of the corner. The effective turning radius takes into account the wheel tracking of the design vehicle utilizing the width of parking and bicycle lanes, and location of the stop bar. This allows a smaller curb return radius while retaining the ability to accommodate larger design vehicles.
- Allow trucks and other large vehicles to encroach into second lane at large signalized intersections.
- Use a lower-speed setting on truck-turning software. Occasional turns by vehicles that are larger than the design vehicle could be accomplished by turning more slowly.

Comments from the online survey varied on this design refinement. There was general consensus that 10'–15' radii work well for pedestrians particularly in urban areas, as evidenced by the 80 percent approval that the suggested refinement resolved potential conflicts well or somewhat well as compared to the original FHWA Handbook design. Many respondents also acknowledged that small radii would be difficult for large trucks and buses, and may cause problems for pedestrians if the corner, curb, or sidewalk is damaged by heavy vehicles. These responses prove the importance of considering the context of the road, as different types of roadway users and activities will influence transportation needs and priorities.

Pedestrian Crossing Design, Operations, and Control

FHWA Recommendation

To accommodate the shorter stride and slower gait of less capable (15th percentile) older pedestrians, and their exaggerated start-up time before leaving the curb, pedestrian control-signal timing based on an assumed walking speed of 0.85 m/second (2.8'/second) is recommended.

Discussion

Assumed Walking Speeds - The walking speed set for signal operations is by far one of the most important design and operational parameters that can affect pedestrian-vehicular conflicts, pedestrian safety, and crashes at signalized intersections. Older pedestrians may have physical limitations that make it difficult to cross a street in the time allotted by a crossing signal. Additionally, older pedestrians may have physical or visual disabilities that impair their ability to safely navigate a crossing.

Current standards from the *Manual on Uniform Traffic Control Devices for Streets and Highways* (MUTCD) base the length of the pedestrian clearance phase (the flashing

"Don't Walk" segment) on the "normal" pedestrian walking speed of 4' (1.2 m) per second. However, the length of time it takes to cross a street varies by an individual's age, gender, physical abilities, etc. Nearly 90 percent of older pedestrians using walkers or canes would be unable to cross the street in the time allotted (Arango, 2008). Because of this, older pedestrians often find themselves caught in the right-of-way after the walking signal has already expired. To account for this discrepancy, the FHWA Handbook recommends that crossing signals be based on an assumed walking speed of 2.8'/second (Staplin et al., 2001).

In 2004, LaPlante and Kaeser summarized the research on pedestrian walking speeds, citing average crossing times for normal adults at 4.0'/second and crossing speeds for older adults ranging from 2.2'/second to 3.8'/second. Based on their research, they recommended a maximum walking speed of 3.5'/second be used to determine the pedestrian clearance interval (PCI) from curb to curb, and a maximum walking speed of 3.0'/second be used to determine the entire "Walk" plus PCI (considering signal phasing of the total crossing from the top of the ramp to the far curb).

More recent research from ITE and AAA supports these findings, recommending a 7-second walk signal, in addition to a pedestrian clearance interval based on a walking speed of 3.5'/second (Stollof, 2007). The recommendations also include options to increase or decrease the pedestrian walking speed based on specific pedestrian characteristics and available pedestrian signal hardware at intersections. In 2006, the National Committee on Uniform Traffic Control Devices (NCUTCD) Signals Technical Committee voted to recommend these changes for the next edition of MUTCD.

Signal Design - Another important crosswalk safety factor for older pedestrians is the design of the pedestrian crossing signal. Traditional pedestrian signals consist of illuminated symbols such as a walking person (symbolizing "Walk"), a flashing upraised hand during the pedestrian clearance interval (symbolizing that it is okay to continue walking if one has already begun crossing), and an upraised hand (symbolizing "Don't Walk"). Research shows that such signals can be confusing to the pedestrian if used without any explanation (Stollof, 2007). The FHWA Handbook recommends a placard that explains pedestrian control-signal operations and presents a warning to watch for turning vehicles to be posted at the near corner of all intersections with a pedestrian crosswalk.

A tested strategy to reduce confusion at crosswalks is the use of pedestrian countdown (PCD) signals, which are more easily understood than the traditional pedestrian signal (Eccles, Tao, & Mangum, 2004; Mahach, Nedzesky, Atwater, & Saunders, 2002; Allsbrook, 1999; Chester & Hammond, 1998). One study recommended the use of PCD signals at intersections frequented by an older adult population because of the value of the added information about the time available for crossing (Huang & Zegeer, 2000). The proposed amendments for the next edition of the MUTCD require all new pedestrian signal heads to include a PCD, except on the narrowest of streets.

Curb Ramp Design - The 2005 draft Public Rights-of-Way Accessibility Guidelines (PROWAG) serves as the current best practice for accessible pedestrian design (as identified by the USDOT). It provides guidance on all types of public rights-of-way, and contains a useful summary of ADA and ADA Accessibility Guidelines (ADAAG) regulations as well as industry design practices on bus stops, curb ramps, pedestrian crossings, and street furniture relevant to bus stop accessibility. A whole chapter is dedicated to providing examples of curb ramp designs for 10' and 30' radius curb returns.

Suggested Refinements

Assumed Walking Speeds - The FHWA Handbook should recommend a 7-second walk signal, in addition to a pedestrian clearance interval based on a walking speed of 3.5'/second. According to the research conducted by ITE, reducing signal timing so that the PCI accommodates a walk speed of 3.5'/second would have minimal operational impacts in most cases. Increased vehicle delays would occur most often on the major street approaches, which tend to be wider and, thus, have longer crossing distances, requiring a longer PCI. A careful balance between the needs of pedestrians and drivers is necessary; attention to the context and operational capacity of the intersection is critical in determining pedestrian crossing time.

Signal Design - Pedestrian signals should be designed simply (without complex placards) and include a pedestrian countdown (PCD). The signals should be large enough to be clearly visible from the opposite side of the street and may be best when combined with an audible signal to assist pedestrians with visual impairments. The use of backplates surrounding the signal housing would further increase signal visibility to older drivers, especially where the lights are viewed against a bright sky or confusing background.[25]

Curb Ramps - The FHWA Handbook should include a section on ADA accessibility and compliance, referring to PROWAG for the design and layout of curb ramps. While there is no standard layout for a curb ramp, there are a number of factors that need to be achieved to construct a curb ramp that will be usable by all pedestrians. These include:

1. Curb ramp slope should be aligned with the sidewalk and crosswalk to help citizens with visual disabilities or those using a wheelchair to navigate safely.

2. Where a curb ramp is present on one side of a roadway, another curb cut or at-grade sidewalk must provided on the other side of the roadway.

3. So as not impede the progress or safety of pedestrians with disabilities, sidewalks should be designed with no more than a 2 percent cross-slope, which is sufficient for proper drainage of rainwater (and snowmelt).

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25 The FHWA Handbook cites studies that show backplates can increase the intensity of the signal face by 33 percent. However, backplates increase wind loading on signal suspension systems and therefore are appropriate when used with wind-resistant suspension systems (Amparano, 2006).

ADDITIONAL RESEARCH NEEDED

Several issues were raised during the course of this study that could not be adequately addressed and are recommended for further research. These include the need for better multimodal safety research and the effects of speed on safety and urban roadway design.

Multimodal Safety Research

Current literature is deficient for fully understanding the safety implications of design on the pedestrian and bicyclist, especially the older pedestrian. More research projects need to be tailored to look at the effects of a particular treatment on more than one mode at the same time. For instance, research studies supporting the FHWA Handbook recommendations for curb radius reference focus groups of drivers, older and younger, where participants reported factors such as ease of turning, better maneuverability, and less chance of hitting the curb. Based on these studies and a desire to moderate the negative impact of a long radius on pedestrians, FHWA recommends a 25' curb radius. More recent research to test the effectiveness of the FHWA guidelines uses kinematics measures such as acceleration forces, yaw, and speed as surrogates for safe driving performance (Classen, 2007). Older drivers' ability to maintain their speed through the intersection is seen as a positive benefit of the FHWA Handbook treatment.

While the FHWA Handbook recognizes that wider radii would increase speed and compromise pedestrian safety, a 25' radius is nonetheless challenged by many engineers as still too fast and wide to "Complete the Street" in many urban and suburban settings. More rigorous research should be done to test actual safety for different road users for varying curb radii. The same is true for testing other intersection design treatments. Safety surrogates provide an inconclusive basis for design guidelines.

Effects of Speed on Safety and Urban Roadway Design

Current research related to the effects of speed on the safety of all road users, including older adults, is inadequate. A better understanding of urban roadway design and driver behavior is needed. Gattis (2005) notes that current research predominantly focuses on rural or high-speed environments, which results in urban roadway engineers' extrapolating from the principles learned in a rural highway environment to the urban environment. The current research on older driver safety fails to adequately address the effect of speed. Questions worth looking at would include:

- How could the effects of traffic calming impact the recommendations offered for older driver safety?
- What particular challenges does the older driver have in slow urban environments compared to fast rural or fast suburban environments? How would treatment recommendations vary under these different conditions?
- Treatments should be tested against the safety and traffic operations effects for each

mode. What is gained by lowering the speed? What is lost?

Road design is a both a science and an art. It requires designers to balance and prioritize the needs of diverse users. Planners, engineers, policy makers, developers, and all other stakeholders, including residents, must work together in support of a new paradigm. Approaching road planning and design through the lens of a Complete Streets framework offers designers the opportunity to assess community context and goals. The results of such an approach will never be perfect, but they will come closer to realizing solutions that work for everyone.

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Streets to Live By

How livable street design can bring economic, health and quality-of-life benefits to New York City

August 2008

Lindsey Lusher, Mark Seaman, Shin-pei Tsay

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Executive Summary

Many critical issues faced by New York City, including public health, environmental sustainability and long-term economic viability are best addressed at street level. Following the lead of cities across the globe, the City is now employing livable streets as a central strategy to nurture a healthy population and support local economies in all five boroughs. This report analyzes the potential economic and quality-of-life benefits that an expanded livable streets initiative could bring New York City.

A livable street prioritizes people and all their activities – sitting, strolling, resting, shopping and observing city life. Cities such as San Francisco and London have embarked on large-scale livable streets initiatives to encourage people to walk, ride a bike or hop on the train rather than get behind the wheel of a private automobile. In turn, livable street improvements are bringing striking economic and quality-of-life benefits to those cities. For example, pedestrian-friendly retail zones are drawing large numbers of new shoppers and quiet and traffic-calmed streets are bringing higher property values, less crime and greater social cohesion among neighbors.

Livable streets have demonstrated the following effects on local economies:

- Pedestrian zones in city centers have boosted foot traffic by 20-40% and retail sales by 10-25%.[1]
- Property values have increased by nearly one-third after traffic calming measures were installed.[2]
- Property values on quiet streets are generally higher than those on noisy streets. In the extreme, the value of a house on a quiet street would be 8-10% higher than the same house on a noisy street.[3]
- Public recreational and gathering space increases property values. Apartment prices near community gardens in New York City are 7% higher than comparable apartments in the same neighborhood.[4]

Many important quality-of-life benefits also arise with livable streets. Increased outdoor activity and reduced air pollution translate into better public health. More people walking about and enjoying sidewalk space creates a livelier city and is the first step towards stronger neighborhoods. Demonstrable progress toward these goals can be measured: lower obesity and diabetes rates, lower noise and air pollution levels, and increases in the size of residents' social networks.

In New York City, where most residents have a retail district within walking distance and everyone has a favorite store just a train ride away, livability initiatives have a high chance of success. In the last year,

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[1] University of Oxford, 2003.
[2] Bagby, 1980.
[3] Nelson, 1982.
[4] Voicu and Been, 2006.

new livability pilot programs by the Department of Transportation (DOT) – such as Broadway Boulevard, the 9th Avenue Cycle Track, and the Public Plaza Initiative – have revealed highly positive results.

But there is more to be done. To make the city's streets more livable and achieve the economic, health and quality-of-life benefits that other cities have experienced, leadership and coordination are required. Unlike most policies that fall within the jurisdiction of only one City agency, livable streets policies require agency staff to work together in completely new ways.

To this end, we offer the following recommendations:

1. **Make livable streets the rule.** The Mayor should mandate livable streets as the overarching goal for all city streets. Improvements that support livable streets, whether through new construction, street rebuilding or zoning amendments, should be the standard, not the exception.

2. **Increase the amount of walking in NYC.** A walking city is a healthy, livable city. The DOT should set a citywide goal to increase the share of city travel taken on foot by 10% by 2015.

3. **Promote livable streets on the basis of public health.** The Department of Health and Mental Hygiene (DOHMH) should continue conducting research on the connection of livable streets to better public health and stand beside DOT in explaining the benefits to the public.

4. **Promote livable streets in business districts.** The Department of Small Business Services (SBS) should develop educational materials for Business Improvement Districts (BIDs) to help local businesses understand the connection between livable street designs and economic vitality.

5. **Put livable streets on the agenda of all New York City Community Boards.** Community Boards with livable streets champion received the most livability improvements. Organizations like Transportation Alternatives should create a Community Board training program to educate board members on the value of livable streets and encourage board members to make them a top priority.

6. **Create Parking Benefit Districts.** The City should create Parking Benefit Districts like the ones adopted by Washington. D.C. In a Parking Benefit District, meter prices in commercial corridors are increased on the basis of demand (to achieve 85% occupancy) and a portion of the new revenue generated by the higher meter rates is directed back to the districts in the form of pedestrian, cycling and surface transit improvements.

7. **Reduce congestion in neighborhoods.** A residential parking permit program, similar to the program developed by the DOT during the congestion pricing proposal, would reduce park-and-ride congestion in transit-rich neighborhoods.

8. **Promote car sharing.** The DOT should partner with the New York City Economic Development Corporation (EDC) to incentivize car-sharing in the city and track its effect on travel behavior.

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Introduction

Building on the experiences of cities around the world, this report examines the costs and benefits of a wide-ranging livable streets program in New York City. Other cities have launched similar initiatives, all with a common set of objectives:

- Environmental sustainability
- Public transit use
- Street life
- Social interaction
- Public health
- Economic vitality

The Brooklyn Promenade

On a neighborhood level, a subset of livable street benefits is particularly relevant – street life, social interaction, public health, and the local economy. This is our focus. This report is divided into three sections: The Livable Streets Movement; Streets for a Strong Community; Streets for a Strong Economy; and Making New York City Livable. Part One defines the current livable streets movement and presents the model outcomes of livability. Part Two examines the goals and outcomes of livable streets programs in other cities aimed at public health and environmental goals. Part Three focuses on the relationship between livable streets and local economies. Finally, action steps for making New York City healthier and more livable are introduced.

The Livable Streets Movement

The livable streets movement is changing the way cities around the world work. From Paris to Melbourne, cities are dedicating increasing amounts of public space to pedestrians, bicyclists, and public transit: London pedestrianized part of Trafalgar Square; Vienna closed its central streets to vehicle traffic; Copenhagen built an extensive bicycle network; Bogotá chose busses over highways. In the United States, cities, states and now Congress have either passed or are considering legislation that would require transportation planners to consider the needs of all users – not just those in motor vehicles. As New York sets out to fulfill PlaNYC's promise of dozens of new pedestrian plazas and hundreds of miles of bike lanes, the city is poised to be at the forefront of this historic movement.

Bogotá, Colombia

In the U.S., the livability movement is nothing short of a sea change in government transportation policies that have been singularly focused on motor vehicles for decades. The driving force of this movement continues to be a growing recognition of the economic and environmental costs of existing policy and a search for alternatives. Livable streets encourage walking, cycling and transit trips, cut into these costs and also advance important societal goals. London's Walking Plan, for example, argues that walking contributes to "health and well-being" and to the "vibrancy" of the city, while other programs point to benefits such as a stronger sense of community. [5]

The economic benefits of livable streets, despite their growing importance in transportation policy planning, are presently not well understood. This is due in part to a paucity of research: there have been almost no published studies in the U.S. on economic impacts, and only a handful in Europe. In addition, it has been difficult to untangle the specific impact of measures such as new pedestrian amenities or parking regulations from other civic improvements put in place simultaneously.

What are livable streets?

In New York City, streets represent one quarter of land area. The majority of this space is dedicated to only one use – private motorized vehicular transportation. People who walk are pushed off to the edges, and bicyclists are, in most places, given no space at all.[6] In the Central Business District as well as many other neighborhoods throughout the city, sidewalks are only wide enough to accommodate forward motion. As the Danish planner Jan Gehl noted, New Yorkers are always heading from Point A to Point B.[7]

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[5] Transport for London, 2004a, p. 2.

[6] By law, bicycles are allowed to ride along with vehicles on New York City roadways; however, high levels of traffic congestion in addition to the speed and generally aggressive behavior of drivers creates an inhospitable environment for the average cyclist.

[7] Gehl is a leading urban designer and has consulted for Copenhagen, Melbourne, London, and New York (currently), Gehl 2007.

Pedestrians on 42nd Street in Manhattan

Cities that have embraced livable streets, on the other hand, seek to create engaging public spaces that draw people in.[8] Cities achieve this, as one author writes, "by increasing [the street's] aesthetic appeal, as well as minimizing the negative impacts of automobile use on pedestrians."[9]

Creating a place where residents want to walk and ride a bike is critical. Design measures that enhance the pedestrian environment include expanding sidewalks, planting trees and installing benches or other seating. The impacts of automobiles can be directly addressed by cutting traffic speeds and volumes – for example, by removing or narrowing traffic lanes. Other important safety improvements include the adjustment of signal timing to provide adequate time for pedestrians to cross a street and building separated lanes for bicyclists. Providing alternatives to the automobile with improved transit facilities is also a necessity. As a planner from Gehl Architects pointed out, building livable streets is a "self-enforcing process." As a city enhances its public transportation and pedestrian environment, traffic will naturally lessen, "experience from around the world proves that when you provide invitations [for people to walk and enjoy their streets], people make wonderful use of them."[10]

Melbourne, Australia (population 3.8 million) is a prime example of a city that has made livability a top priority. In the 1990s, that city embarked on an ambitious program to improve its public spaces and attract people downtown.[11] The city center faced competition from attractions on its outskirts and was regarded no more than "a daytime destination for commuting office workers who could not get home quickly enough."[12] In response, the city expanded and improved sidewalks on the main commercial streets, turned some side streets into permanent or part-time (e.g., lunch hour only) pedestrian zones and added new public plazas. Over ten years, public space for pedestrians grew by 71%. Hundreds of new trees, major public art works and a consistent and elegant suite of street furniture – newsstands, drinking fountains, information pillars, public toilets – improved the aesthetic appeal of downtown. The result was a huge upsurge in street life. In ten years, pedestrian volume on the main street jumped 50% and surpassed that of London's busiest commercial street, Regent Street. The number of outdoor cafes nearly quadrupled, and the number of cafe seats nearly tripled. In 2004, *The Economist* ranked Melbourne first among the world's most livable cities. [13]

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[8] Project for Public Spaces, 2006.
[9] Dumbaugh, 2005.
[10] Jeff Risom, 2008.
[11] City of Melbourne and Gehl Architects, 2004.
[12] Millar, 2003 .
[13] "Melbourne 'World's Top City,'", 2004.

Melbourne, Australia

On a smaller scale, cities in Europe and the U.S. have redesigned streets to allow pedestrians and bicyclists to share space with motor vehicles. One such design, known as a "living street", or *woonerf* in Dutch,[14] is tailored for urban residential areas. This design, called a "home zone" in the United Kingdom, gives pedestrians and motor vehicles equal rights to the street by eliminating the curb boundary between a sidewalk and the vehicle right-of-way. Narrow travel lanes, landscaping and trees, intermittent parking spaces (i.e., parking that is not continuous), and other traffic calming features force drivers to travel slowly – around 10 miles per hour – and be aware of people walking, playing or riding a bike. This design is also appealing because it preserves vehicle access and parking for residents and businesses. Case studies suggest that *woonerven* are transformative. In one residential neighborhood in Manchester, UK vehicles speeds dropped from 17 mph to 11 mph, traffic volume fell 29% and residents reported feeling safer. Another example in Goteborg, Sweden turned a dull back alley into a vibrant mixed-use district and a popular local destination.[15]

A woonerf in Amsterdam, Holland

The economic, social and public health successes of these measures and the urgency of addressing environmental and public health concerns have led governments to encourage the wider application of livable streets improvements. London has set a goal of becoming "one of the world's most walking-friendly cities" by 2015, with specific targets for increasing the proportion of trips that are taken on foot. Its plan supports context-sensitive designs such as *woonerven*, and commits specific funds to improving walkability.[16]
New York recently joined the list of cities and states adopting "complete streets" policies that consider the needs of all users, not just motorists. "Complete Streets" are streets that incorporate the needs of all users by design.

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[14] Other names for these streets: "home zone in the United Kingdom, "shared zone" in Australia, Verkehrs-beruhigter Bereich in Germany.
[15] Nelson-Nygaard, 2007.
[16] Transport for London, 2004a.

How do you measure livable streets?

The success of a livable street does not necessarily arise from one particular design or policy, but is rather measured by its outcomes, with public health and environmental sustainability at the forefront. Although good street design and policy reforms are necessary to achieve livability, they do not guarantee it. It is important to distinguish outcomes from techniques when discussing the benefits of livable streets. For instance, traffic calming measures such as narrow traffic lanes, wide sidewalks and rows of trees are among the tools that planners use in designing streets, but are not ends in and of themselves. These techniques are discussed at length in other forums, such as the compendium of traffic calming measure published by the Institute for Transportation Engineers.

Outcomes are, of course, what inspire major cities to embark on such ambitious and far-reaching livability reforms. For example, the street design guidelines set out by Portland, Oregon, point to increased community activity and greater use of walking, bicycling and transit as key outcomes. Table 1 identifies the desired outcomes from the citywide livability initiatives of London, Melbourne, Portland and Oxford.

Table 1.
Goals of Selected Livable Streets Programs

Program	Goals or benefits cited
London's Walking Plan (2004)	Greater use of public transport; A better environment; Healthier lifestyles; Social inclusion; An improved economy.
Melbourne, Australia (1994, 2004)	Economic revitalization; Attracting more people to the city center.
Portland, Oregon street design guidelines (2002)	Greater use of walking, bicycling, transit; Community activity.
Oxford (England) Integrated Transport Strategy (1993)	Reduce congestion; Reduce pollution; Improve general quality of life; Improve relative attractiveness of car alternatives; Improve safety; Improve economic vitality; Provide access for mobility-impaired people.

Are New York City Streets "livable"?

New York City is perfectly primed to be one of the most livable cities in the world: it has high density, relatively well-mixed land uses, a world class transit system, and large population already accustomed to walking to the store and taking transit to work. These amenities and cultural norms set New York City ahead of other city in the U.S., but there is still much room for improvement. New York still suffers from the Robert Moses-era reconstruction that wholly reconfigured city streets for the quick and efficient movement of cars. With 4-lane avenues, lights perfectly timed for uninterrupted movement, free bridge access and plenty of parking, Manhattan couldn't be more welcoming to the private automobile. In other boroughs the situation is no better: where semi-trucks rumble through residential streets, zoning accommodates more and more car-friendly box stores, traffic calming projects are put on hold, and ever important shipping docks are paved over for parking.

New public plaza at 9th Avenue and 14th Street, Manhattan

A city built for cars isn't just inhospitable: it's also dangerous and unhealthy. The number of pedestrians and cyclists that have been injured or killed by cars in New York is tragic – in 2007, 136 pedestrians and 23 cyclists were killed by cars and, in 2006, 14,161 pedestrians and cyclists were injured by cars. These statistics do not characterize a livable place.

The good news is that New York City is finally making a turnaround. Greater public awareness and increased action over the last two decades have brought traffic reduction and pedestrian and cyclist safety to the forefront of New York City's agenda. In the past year, this trend has become even more pronounced, with new leadership at the Department of Transportation introducing new programs and projects with livability at their core:

- DOT's Strategic Plan, released in Spring 2008, commits to the development of Complete Street design standards.

- Under Local Law 23 (Intro 199), DOT will issue an annual report to monitor and evaluate volumes of traffic, bike, and ferries in addition to multimodal travel data on key corridors where DOT has undertaken changes in street design and/or operations. This report will thus demonstrate the effectiveness and impacts of DOT projects including complete streets, road diets, new bike facilities, new plazas, bus rapid transit, bus priority, and curb pricing.

- The City has made many striking new efforts to reclaim street space for pedestrians. In Summer 2008, the DOT introduced two temporary pedestrian street pilot programs in Brooklyn, a new model for neighborhood play streets in Queens and the ambitious "Summer Streets" program that will create a pedestrian corridor on city streets from the Brooklyn Bridge to Central Park.

- The DOT has also introduced parking protected bike lanes or "cycle track" bike lanes on 9th Avenue in Manhattan. This new street programming has been a resounding success for the safety and comfort of pedestrians and cyclists. It has brought a 50% decline in traffic related injuries, a 41% decrease in total crashes and a 36% decline in crashes involving pedestrians. The new cycle track has also spurred a 57% increase in cyclists on 9th Avenue. Plans have been unveiled for future lanes on 8th Avenue and Grand Street, also in Manhattan.

- Under PlaNYC, the DOT has initiated a comprehensive program to build public plazas in all city Community Districts. This initiative follows successful pedestrian plaza reclamations in DUMBO, the Meatpacking District and Willoughby Street that offer safe, attractive and comfortable places for people to sit and gather.

- The DOT will start a trial "Peak Rate Parking" proram in Fall 2008 to test the effect of meter prices on local traffic congestion and turnover.

- On the iconic stretch of Broadway in Midtown Manhattan, DOT has begun to reclaim the roadbed for pedestrian and cyclist use with a protected bike lane and pedestrian amenities such as café tables, chairs and umbrellas. These projects are slated to be complete by the end of summer 2008.

Streets for Strong Communities

Livable streets lay the groundwork for a healthy community – they bring people outside and keep them there. They provide amenities like seating, play areas, good sidewalks and trees that make children, adults and seniors feel safe and comfortable. The extent to which any street is livable can be measured by its street life, social contacts between neighbors and public health indicators. The following section breaks down these three important characteristics and how they each define a great street and a happy community.

Street Life

The most fundamental measure of success is street life, and the simplest benchmark of this outcome is the number of pedestrians on the street during a given period of time. The most radical street treatment, in which streets are closed to vehicular traffic, has generally had a significant and positive impact on pedestrian counts. New pedestrian districts in Germany in the 1960s and 1970s were shown to boost pedestrian counts by 20-40% in the first four years, with some cities seeing growth of as much as 92%. Some cities have seen continuing growth over longer periods; for example, Munich's core saw the number of pedestrians grow from 72,000 in 1967 to 175,000 in 1978, six years after the creation of a pedestrian zone.

Bedford Ave., Brooklyn

The simple number of pedestrians, however, may not indicate whether a place is livable. Times Square attracts hundreds of thousands of visitors every day, but with its congested streets and sidewalks overcrowded with pedestrians fighting over precious space, few would call it is livable. Many local residents purposely avoid this area because it is simply too uncomfortable. In an area with such a high pedestrian volume, a complimentary indication of livability is whether the place allows a diverse range of people to voluntarily engage in a wide variety of activities. Times Square fails this test. On most evenings, there are thousands and thousands of people, but space is so limited that it is impossible to stop, rest or do anything but keep going. Times Square would be an ideal location for a New York City pedestrian zone.

Simply eradicating cars does not guarantee a livable street. The success of pedestrian-only streets also depends on programming and the presence of popular destinations. Model pedestrian streets have several popular destinations, or "public life magnets" anchoring either end and are integrated into a wider network of attractive and pedestrian-friendly public spaces. Successful pedestrian zones are generally not larger than ½ square mile.[19]

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[18] Hass-Klau, 1993, p. 22.
[19] Jeff Risom, 2008.

The Lively Street

Planners have developed several methods to measure livability based on street life : who is walking, who is talking, who is shopping, and who is playing. Jan Gehl has developed sophisticated measures of street life that have been used in the planning and design of many cities including, most recently, New York. The following outlines three measures of street life including pedestrian volume, stationary activities and pedestrian diversity that characterize a livable street.

Pedestrian volume

Streets that are more attractive to pedestrians should draw more people for discretionary trips in the middle of the day, in the evening and on weekends. Thus, counts should be taken at various times of the day and night, and on weekends as well as weekdays. Gehl has also suggested calculating the ratio between summer and winter pedestrian volumes. He theorizes that if the street is only a conduit, and not a place for activity, these counts should not be significantly different. But a street that is a destination in itself is likely to attract more people when the weather is good.[20]

Crowded pedestrians on Prince Street, Manhattan

At a certain point, high pedestrian volumes exceed sidewalk capacity, thereby degrading a street's livability, similar to the Times Square experience. In his work *Great Streets*, University of California Professor Allan Jacobs demonstrates that there is an ideal rate of pedestrian activity where sidewalks are neither too crowded nor too sparse. Based on this target, Jacobs suggests volume guidelines, measured in pedestrians-per-minute-per-meter (of sidewalk) width (ppm). From his measurements, at volumes above 13 ppm pedestrians are unable to walk at their own pace, but must rather walk within flow and speed of existing pedestrian traffic. Jacobs finds that a volume of 7-9 ppm is the most comfortable rate of pedestrian traffic, allowing people to occasionally stop, increase speed and vary their pace as needed. A sidewalk with less than 2 ppm seems empty.[21] Based on this metric, cities can easily use pedestrian counts to determine where sidewalks need to be widened to better manage pedestrian traffic.

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[20] Gehl Architects, 2004.
[21] Jacobs, 1993.

Simple benches encourage street life, Manhattan

The Transportation Research Board's (TRB) Highway Capacity Manual provides some guidance, where it rates the performance of sidewalks with Levels of Service (LOS) from A to F based on numbers of pedestrian-per-minute-per-foot. LOS A is "unrestricted flow" and LOS F is described as "no movement is possible within the queue." This potentially leads to the misconception of equating no foot traffic with a highly successful sidewalk because there are no restrictions in the flow of pedestrians. The TRB method of determining the success of sidewalks fails to incorporate the fact that successful sidewalks are busy sidewalks. Within TRB's metric, Jacobs' Great Streets – among the world's most timeless and successful – would get a low grade. Although pedestrian activity on these streets is lively, they would only be rated LOS C, just bearable, "within the range of personal comfort." It would behoove transportation planners to recognize the LOS of lively sidewalks and not adhere to convention.

Shopping,Brooklyn

Stationary activities

When people enjoy spending time on the street, they will generally engage in a variety of activities. Gehl's study of New York streets counted people standing, waiting for transport, sitting on benches, sitting on cafe chairs, sitting on secondary sitting-possibilities, sitting on folding chairs, lying down, children playing and people engaged in commercial, cultural, and physical activities.

Pedestrian diversity

Women, children and the elderly may be more sensitive than others to street qualities such as comfort, safety and accessibility. For this reason, streets that attract a diverse cross-section of the population – including women, children and the elderly – are more likely to be livable. Project for Public Spaces, a non-profit firm that specializes in helping communities create vibrant public places, suggests measuring livability by comparing the population distribution of pedestrians by age and gender on a particular street against neighborhood or city distributions. [22]

[22] Ethan Kent, 2008.

Social interaction

When people spend time on streets, they have the opportunity to interact. The United Kingdom's walking and cycling plan notes that "both modes allow us to stop and chat or just say 'hello' in a way which it is difficult to do when closeted in the car. As such, they improve our sense of community." On the best residential streets, these contacts can be repeated over time and relationships can develop. In a 1970s study in San Francisco, Donald Appleyard found that on streets with lower levels of traffic, residents had more friends and acquaintances in the neighborhood than on higher-traffic streets. More recent studies in New York have confirmed these findings.

Community interactions are an important contributor to individual well-being. John Helliwell, an economist at the University of British Columbia, argues that the eye contact that people make when biking or on foot increases individuals' sense of trust. That trust translates into higher levels of happiness and civic-mindedness.[25] With this in mind, it's probably no accident that Denmark, one of the most livable places on Earth is also considered the happiest.[26] Emmanuel Mongon, designer of the Parc Astérix theme park in France, argues that "the best cities guide people to intersecting moments." Driving, on the other hand, creates a physical barrier between individuals, and drivers stuck in traffic are likely to feel animosity rather than trust. [27]

Neighbors redesign an intersection in Portland, Oregon

The Friendly Street

The degree to which a given street supports a strong social network has been measured in the number of friends people have on a given street. Another potential method is taking note of residents' ownership of a street.

Social contacts

In a Transportation Alternatives' (T.A.) survey of New York streets, residents were asked how many friends and acquaintances they had in their neighborhood. While the T.A. study compared results across streets, residents' number of friends and acquaintances could also be useful for determining the effect of improvements on a single street. These effects likely develop slowly, so a post-improvement survey could be done several years later.

Ownership

Especially within the context of the United States, the feeling of ownership and pride one exhibits towards a neighborhood may be another indicator of livability. As seen in many New York neighborhoods, neighbors build local livability on their own with the construction of community gardens, benches and the hosting of block parties and public gatherings right on their own street. In Portland, Oregon neighbors even engage in "intersection repair," street murals that calm traffic in addition to the construction of community gathering areas around the particular intersection. These types of interventions on a local block are an excellent indicator of a strong social network and a developing or high level of livability.

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[23] UK Ministry of Transport, 2004, p. 3.
[24] Bosselman, 1999; Transportation Alternatives, 2006. The Bosselman study looked specifically at Eastern Parkway and Ocean Parkway in Brooklyn, as well as a boulevard in Chico, California. The Transportation Alternatives study looked at streets in three New York City neighborhoods.
[25] Cited in Montgomery, 2008.
[26] White, A., 2007
[27] Ibid.
[28] Transportation Alternatives, 2006.

Public Health

A number of recent studies have established a connection between the built environment and public health. Several studies have shown that people are less likely to be overweight if they live in more walkable areas. Other studies have shown that people who live in walkable areas are less likely to drive and thus less likely to contribute to harmful air pollution.[29] New York's PlaNYC argues that open space improvements such as public plazas can help lower obesity and asthma rates.[30] Livable streets that maximize the comfort, ease and practicality of walking (including the availability of transit) promote physical activity.

Bogotá, Colombia

Livable streets also influence public health by reducing traffic injury and fatality rates, cutting noise levels and reducing air pollution. All of these are significant hazards in New York City. In 2007, 136 pedestrians and 23 bicyclists were killed in traffic crashes. Noise is the number one complaint of callers to the City's 311 hotline, and chronic exposure to high levels of noise has been linked to elevated stress and poorer memory recall in children.[31] Air pollution from traffic is a major contributor to health problems throughout the city, with some neighborhoods suffering the highest asthma hospitalization rates in the country.[32] These same hazards not only directly endanger the health of New Yorkers, but they discourage residents from spending time outdoors.

The Healthy Street

There are many ways to measure public health, but only a few are directly relevant to street conditions. Furthermore, the street environment is only one factor affecting physical activity, and physical activity is only one factor affecting conditions such as obesity. Still, improvements in the street environment that promote physical activity could lower the incidence of obesity. The following are easily accessible public health indicators that are linked with good street design:

Traffic injuries

Tracking traffic injuries and fatalities is the simplest metric for livable streets. Data on traffic injuries and fatalities, with the date and location of the crash, is available from the state and is currently used in Transportation Alternatives' CrashStat application (crashstat.org). While crash statistics can speak to pedestrian and cycling safety, they do not always capture the nuances of street design and conflict, especially in New York City, where crash reports are written manually (unlike much of the rest of the country and state, where crash reports are entered into a computerized system that can then be used to analyze sites and identify potential problems).

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[29] Frank, 2006.
[30] City of New York, 2007, p. 30.
[31] Evans, 1995.
[32] Environmental Defense, 2007.

Obesity

Data on obesity, diabetes, and other health conditions related to physical activity are available from the DOHMH by Community District. Given the large size of city Community Districts, it may be necessary to collect data in specific areas to determine the benefits of localized livability improvements.

In Salt Lake, Utah researchers found that more walkable neighborhoods decreased the risk of obesity. People who walked to work were found to decrease their risk of obesity by up to 10%. Pedestrian-friendly street networks, defined by neighborhoods with intersections within .25 miles of each address, were related to lower risks of obesity in three of four models. A short distance from an intersection generally implies that a person's walking trips are more direct and convenient, and that traffic is slower because cars have more stopping points.[33]

9th Avenue, Manhattan

While modal splits are not typically a measure of public health, they do measure physical activity that can contribute to public health.[34] The census collects information on the mode people use in commuting to work, but this data is collected infrequently (every 10 years) and does not capture how residents travel to retail and recreational districts. More detailed household surveys are important to accurately capture the activity level of a given neighborhood.

Noise and air pollution

Noise levels and air pollution can be measured for an entire day, week or longer period. Air pollution, of course, is not a single quantity: there are many pollutants with different consequences for human health. The most important for the sake of livability may be those such as ozone that restrict breathing and make it difficult for people to spend time outdoors. Truck noise and honking are among New Yorkers' constant complaints about the street environment.

Vehicle speeds

While speed is not a public health outcome, it is a prime factor affecting injury and fatality rates, and the effects of traffic calming on speed are visible before injury accidents occur. The speed of vehicles has a direct impact on the ability of a pedestrian to survive a crash: at every 10 miles per hour increase in speed, the risk of a fatality from a crash doubles. Furthermore, crashes with seniors disproportionately result in a fatality.

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[33] Smith, 2008.
[34] Frank, 2006.

Traffic Volume

The volume of automobile traffic strongly affects livability, but is a less useful measure of the success of a street. The ideal traffic volume, clearly dependant on the purpose of the street, is such that cyclists and pedestrians feel safe riding a bike on the street and crossing at intersections. When traffic volumes are too high, there may be excessive road noise and air pollution, and social networks may deteriorate. On the other hand, the absence of automobile traffic from Main Streets in the U.S. frequently signals their decline. Rather than a quantitative measure of livability, the appropriate level of automobile traffic is a precondition of a livable street.

Practical Considerations and Caveats

In selecting and applying the above measures of any street's success, a few caveats apply. First, some outcomes such as obesity rates are determined by a wide range of factors beyond the control of transportation planners, such as diet and education. This complicates the process of comparing outcomes across streets, since the outcomes may vary for reasons not related to street conditions.

Second, some data are clearly more difficult to measure than others. Obesity rates, social contacts and mode splits cannot be easily observed in the same way as, for example, pedestrian counts. One technique for addressing this is to collect all of this information in a single household survey. The survey requires a significant effort but can yield valuable information.

Finally, the same behaviors that are difficult to measure also tend to change slowly. Social contacts, for example, can take years to develop and obesity may be difficult to reverse. Thus, while it is important to take baseline measurements before a street improvement is made, the post-improvement survey can probably be put off for at least a year and maybe much longer. On the other hand, pedestrian behavior, vehicle speeds, and noise and air pollution, which are likely to change quickly, can be measured more easily.

Streets for a Strong Economy

Beyond improving quality of life, livable streets also support strong local economies. For instance, traffic calming improvements that increase safety, reduce road noise and make being outside more pleasant and safe can increase home values. In commercial districts, pedestrian street amenities draw more foot traffic, new shoppers and higher retail sales.

Stone Street, Manhattan

This section reviews existing research on the impact of livable streets on local economies. In the United States, very little research exists on the economic impacts of traffic calming and pedestrianization, reflecting the long dominance of the automobile in American planning. Somewhat more research has been conducted in Europe, where pedestrianization and traffic calming have a longer history. To supplement these studies, this section also looks at research into the economic impacts of related neighborhood characteristics, such as noise and open space. This research presents the range and magnitude of impacts that have been seen. Full results are presented in Table 2.

Table 2. Economic Outcomes of Livable Street Improvements

Measure	Range of outcomes
Residential property values	• 85% reduction in traffic translated to 5% increase after one year and 30% after 13 years (Bagby) • Streets with no through traffic command 9% price premium (Hughes) • Quiet streets command 8-10% premium over noisy streets (Nelson) • Community gardens boost nearby apartment prices 7% (Voicu and Been)
Retail sales	• Pedestrianization boosts sales 10-25% in first year (University of Oxford)
Pedestrian volumes	• Pedestrianization boosts pedestrian traffic 20-40% in first year (University of Oxford)

Researchers of potential economic outcomes face numerous challenges. First, any infrastructure renewal project – resurfacing a street, for example – might improve economic outcomes, regardless of its impact on livability, because people tend to place a higher value on places that are updated and perceived to be well-maintained. Second, it is conceivable that neighborhoods with rising property values or retail sales are more likely than others to demand and receive street improvements. A comparison of economic indicators before and after the project may show a strong gain, but this gain might have occurred anyway due to the changing character of a neighborhood. Finally, the results of some studies may not be generalizable, if there were unique conditions driving the economic gains. For example, outcomes in smaller cities, suburbs, and in new developments may not be relevant to conditions in New York and particularly Manhattan, where walking accounts for an unusually high relative share of travel.

Controlling these variables is clearly the biggest challenge in researching livability. Like the oft-cited milestone study of traffic calming in Grand Rapids, Michigan, the ideal study compares two very similar streets over time, one with traffic calming and one without.[35] The difficulty, of course, is finding two streets inhabited by similar communities, where similar physical and land use characteristics exist, and yet where only one street receives traffic improvements.

A more likely approach, a hedonic pricing study, would look at a large number of streets with widely varying characteristics.[36] Multiple regression analysis would estimate the relationship between each characteristic and property values or rents. This type of study might demonstrate that rents are $10 per square foot higher for every foot of sidewalk beyond the standard sidewalk width. That said, it's quite unlikely that any one particular characteristic would produce such a clear effect on rent. More likely, a package of changes that includes, for example, more trees, wide sidewalks, seating areas, and programming may have an effect.

Property values

The difficulty of carrying out such studies – and in the U.S., the scarcity of examples – has meant that most researchers have used less robust methodologies to analyze livable streets improvements. More rigorous techniques, however, have been applied in studies linking property values to environmental attributes that are outcomes of livable streets, such as noise, traffic volume and the provision of open space. These case studies provide indicators for real property value in U.S. cities, and therefore infer the type of value that livable streets, in general, provide to all neighborhoods.

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[35] Bagby, 1980.

[36] A hedonic pricing study calculates the influence of each of an item's characteristics on its value. For example, a housing pricing study estimates the extent to which factors such as size, quality, appearance, and school quality determine the price of a house.

Traffic diverters (Grand Rapids)
The earliest research on property values looked at the effects of traffic diversion in Grand Rapids, Michigan. In the early 1950s, the adjacent Dickinson and Burton Heights neighborhoods suffered high crash rates from through traffic. When a six-year old boy was killed by a speeding truck in the Dickinson neighborhood, the city responded by installing diverters to discourage through traffic.

As a result of these diverters, through traffic on neighborhood streets dropped by as much as 85%, and the accident rate dropped 95% over four years. Home prices were also affected by traffic reduction. Homes prices in Dickinson increased more quickly than in Burton Heights. Before the installation of the diverters, prices in Dickinson were about seven percent higher than in Burton Heights. One year later, the gap in the average sales price had grown by another five percent and by 1965, the gap had grown to 30%.[37]

Traffic volume (Baton Rouge)
A 1992 study in Baton Rouge, Louisiana, estimated the relationship between housing prices and traffic volumes. The researchers gathered data on home sales and traffic levels in two neighborhoods. Data was gathered from two different sites, one from an urban area and one from a suburban neighborhood. Traffic on these streets ranged from 1,000 to as high as 18,000 cars per day. Using a hedonic pricing model, the researchers estimated that home prices increased by 1.05% for every reduction in traffic of 1,000 cars. They also found that homes on streets with exclusively local traffic, such as cul-de-sacs, were worth 8.8% more than other homes.[38]

Road noise (U.S.)
A number of researchers have studied the impact of noise, and especially road noise, on property values. Noise levels as perceived by humans are measured on the A-weighted decibel (dB) scale, where a ten dB increase in sound corresponds to a sound level that is ten times louder. Daytime background levels in U.S. residential neighborhoods are typically 45-55 dB, and the noisiest streets are about 25 db louder.[39]

A 1982 review of this research found a statistically significant relationship between noise levels and property values. Houses further away from a noisy highway sold for more than those nearby, with prices increasing by 0.4% for every decibel reduction in noise. In the extreme, the value of a house on a quiet street would be 8-10% higher than the same house on a noisy street.

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[37] Bagby,1980.
[38] Hughes, 1992.
[39] Nelson, 1982.

Red Shed Community Garden, Brooklyn

Community gardens (New York)
A 2006 study by New York University researchers looked at the relationship between housing prices and the development of community gardens. The researchers examined apartment prices near 636 gardens that were developed mostly on vacant lots in New York City between 1977 and 2000. Before the gardens were established, the vacant lots had depressed nearby property values, such that apartments adjacent to the lots sold for 11% less than comparable apartments 1000 feet away. Development of the community gardens boosted the adjacent property values, and after five years the gap in prices relative to the more distant properties had shrunk to less than 4%. [40]

Pedestrian environment (London)
In the United Kingdom, the Commission for Architecture and the Built Environment (CABE) measured the quality of the pedestrian environment in 10 London commercial districts, and attempted to link this measure to apartment prices and retail rents. The pedestrian environment on the main streets in these districts was ranked on a scale of -3 to +3. Regression analysis hinted at a relationship between an improved environment and higher property values and rents, although the results were not statistically significant.[41]

Neal Street, London

The results of these studies suggest that homebuyers are willing to pay a premium for some of the outcomes that livable streets provide: reduced noise, improved public spaces and improved street safety. For the New York City, increases in property values suggest a possible means for financing such improvements. In the case of the community gardens, for example, the estimated increase in property tax revenues would have more than paid for the capital outlays and maintenance for the 636 gardens. At the same time, a rapid rise in property values could drive out renters – a distinctly negative livability outcome.

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[40] Voicu and Been, 2006.
[41] Commission for Architecture and the Built Environment, 2007.

Retail sales

In commercial districts, both the nature of the improvements and the outcomes that have been studied are different from those in residential areas. First, while most of the studies of housing prices looked at the value of reduced traffic or noise, many studies of retail impacts have looked at pedestrianization programs, where traffic has been entirely eliminated. The following briefly reviews the effect of traffic calming on retail sales within U.S. cities and then tracks the mixed results of pedestrian zones in the U.S. and Europe as illustrative of the potential and requirements of a successful – and profitable – pedestrian environment.

U.S. Commercial Districts

U.S. cities have found that reducing traffic volume and speed has a positive effect on commercial districts. Although the studies are few, anecdotal evidence is positive:[42]

South Street Seaport, Manhattan

- Mountain View, California, widened sidewalks on its main street, removed parking spaces and planted trees. The street has since drawn $150 million in private investment in residential and office units, and has become a regional attraction with its restaurants, bookstores, and cafes.
- West Palm Beach, Florida, converted its one-way main street to two-way operation, narrowed the street at points and raised intersections. In five years, vacancy rates fell from 70% to 20%, while commercial rents increased from $6 to $30 per square foot.
- Removing traffic lanes in Orlando, Florida, helped transform a commercial street into a popular dining destination.

With many of these projects, it is not possible to say that street changes alone were responsible for the economic improvements, since they were often part of a larger package of civic improvements. For example, Mountain View's upgrades to its pedestrian environment were accompanied by development of a new city hall and performing arts center, which themselves have likely drawn new business downtown. Yet in all of these cases, street changes were likely integral to the success of the schemes. If the cities had not expanded sidewalks and slowed down traffic, outdoor dining would have been much less attractive and the retail and restaurant booms might have been much weaker.

European Pedestrian Zones

The U.S. and Europe have had very different experiences with pedestrianization efforts. In the U.S. in the 1960s and 1970s, about 200

[42] Local Government Commission Center for Livable Communities (2005); McCann, 2007.

cities converted their downtown streets into pedestrian zones in a last-ditch attempt to slow the flight of shoppers to suburban malls. But most of these conversions failed – the exodus of shoppers and stores continued – and only thirty or so pedestrian zones remain. In most cases, there simply were not enough people living within walking distance of the downtowns to support those districts, and the cities did not have high quality transit to bring in customers from outside. The few places in the U.S. where pedestrianization has succeeded appear to have a large number of captive users, such as residents, students or workers; have good public transit links; are actively managed and programmed by solid leadership; and have strong attractions such as cultural establishments, retail anchors and public events.[43]

In Europe, on the other hand, pedestrian zones have found success. By the end of the 1970s, Germany alone had about 500 pedestrian zones in 300 towns.[44] Focus on pedestrian programs and amenities has continued to rise in recent decades, so that large parts of many city centers are entirely or mostly car-free. Munich, for example, has 7 kilometers of car-free streets.[45]

A comprehensive review in 1993 of studies on pedestrianization projects in Germany and the United Kingdom found that these projects generally brought positive results for retailers. A 2003 review confirmed these findings based on more recent studies in the United Kingdom. These studies found an average 32% increase in the number of visitors to stores in the first year after pedestrian zones were created, and a jump in sales of 10-25%.[46] London's business leaders see improving the pedestrian environment as critical to sustaining the capital's international status.[47]

A survey of retailers in eleven German cities that created pedestrian zones in the 1970s found that 83% of retailers inside the zones reported higher sales, while retailers outside the zone on balance saw essentially no change. A study in Leicester, England, found a statistically significant relationship between lower traffic volumes and reduced store vacancies. These results are not conclusive, since it may be that pedestrian zones tend to be built where retail sales are already strongest. Yet the same review found a 20-40% increase in pedestrian traffic in the first year after a pedestrian zone was created; this increased traffic could represent potential new customers. [48]

New York Opportunities

With its high density, mixed land use, and extensive transit network, New York already has in place many of the key ingredients for successful pedestrian zones. Unlike America's main streets thirty years ago, New York City's retail districts are generally flourishing. Its transit system provides good access to most parts of the city and especially to the Manhattan core. At the same time, in many parts of the city, retailers can draw on thousands of customers who live, work, or study within walking distance.

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[43] Flisram, 2000.
[44] Hass-Klau, 1993, p. 23.
[45] Cameron et al, 2004.
[46] Transport Studies Unit, 2003.
[47] Central London Partnership, 2003
[48] Hass-Klau, 1993.

The prevalence of pedestrian shopping in New York, and especially Manhattan, is borne out in several surveys. A 2007 study of pedestrians on SoHo's Prince Street, for example, found that 30% lived or worked in the neighborhood. Of those who traveled to SoHo, 78% took transit, biked, or walked and only ten percent arrived in their own car.[48] On Columbus Avenue on the Upper West Side, a 2007 survey of people on the street found that only two percent had driven there.[50] For Manhattan, this low share for auto trips is not unusual. The 1997-1998 household travel survey by the New York Metropolitan Transportation Council showed that six percent of Manhattan shopping trips are by auto, and 70% are by foot or bike. In the boroughs, the auto share is higher but varies significantly across boroughs (see Figure 2). On average, 50% of shopping trips in New York City are by foot or bike, and 36% are by car. [51]

By these measures, the experience of European cities is much more relevant for New York than for most of the United States. In Amsterdam in 1994, for example, 75% of shopping trips in the historical core and the inner city were on foot or by bike.[52] In Vienna, 30% of all trips are on foot or by bike; for Munich, the comparable figure is 35%.[52] In New York, 37% of all trips are on foot, while in the United States as a whole, walking accounts for fewer than 9% of all trips. [54]

In summer 2008, New York City is experimenting with temporary pedestrian streets in Brooklyn, Queens and Manhattan. Although the retail impact of these closures has yet to be evaluated, the preliminary findings are encouraging. Bedford Avenue, in Williamsburg, Brooklyn, is now closed to pedestrians from 12pm-7pm for 4 consecutive Saturdays. The street closure was inspired by a request by a local business owner and support from community leaders, the local community board and the DOT. Called "Williamsburg Walks," the closure has little programming other than a few additional tables and chairs on the street, free valet bicycle parking, and extended use of the sidewalk by local stores. On the first Saturday alone, Transportation Alternatives recorded a 50% increase in foot traffic.

[49] Schaller, 2006. Twelve percent traveled by taxi or livery.
[50] Project for Public Spaces, 2007, p. 10.
[51] Analysis of New York Metropolitan Transportation Council's Regional Travel-Household Interview Survey, 1998.
[52] Amsterdam Jaarboek, 1994.
[53] Federal Highway Administration, 2003; Winkler, 2006.
[54] Hu and Reuscher, 2004a and 2004b.

Figure 1. Mode Share for Soho Pedestrians on Saturdays

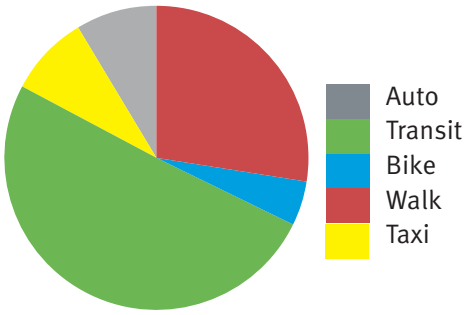
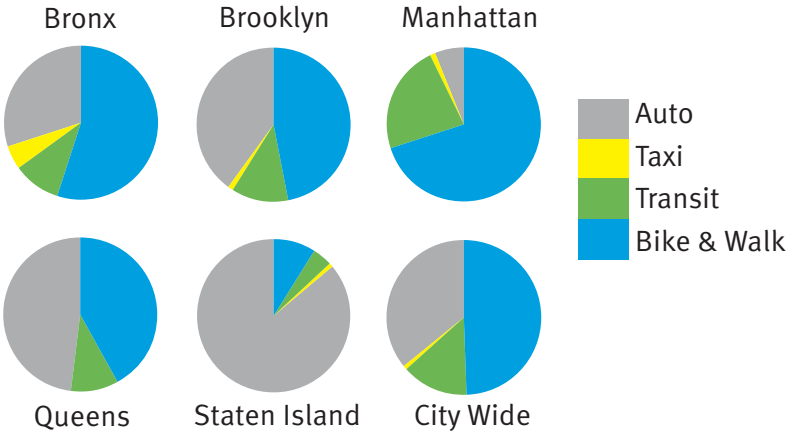


Figure 2. Mode Share for Shopping Trips, by Borough



Making New York City Livable

Worldwide experience suggests that the adoption of livable streets principles in New York would enliven the city and give a significant boost to local retailers. As can be seen from the experiences of other cities, New York could use pedestrian zones and traffic calming to attract new customers to retail districts. Most significantly, the prioritization of pedestrians through traffic calming, wider sidewalks, lower speed limits, and spatial restrictions on vehicle use (such as closing the street to vehicular traffic during specific times of the day) would engender many of the benefits of the completely pedestrianized streets in Europe. With thousands of residents a short walk or bike ride away from most retail districts and millions more with good transit access, the city is ideally suited to these improvements.

Williamsburg Walks, Brooklyn

In developing a livable streets program, the city can additionally expect a wide range of quality of life benefits – the very benefits that end up making neighborhoods more attractive and boosting property values. These outcomes – more children playing outside, cleaner air, stronger neighborhood social networks – can be measured and tracked over time. Citywide data gathering and the development of a livability index that combines several measures could pinpoint neighborhoods and streets with the greatest needs. Finally, setting livability outcomes as the program's goals, instead of using traditional technical goals, would ensure the program's success in improving the quality of life.

The real/tangible economic benefits that flow from livable streets can positively affect the City's budget. To the extent that street improvements translate into higher real estate values and retail sales, the City would collect more property and sales taxes. For example, community gardens, another type of neighborhood improvement, are estimated to have increased property values by a total of $1.3 billion and property tax collections by $503 million over twenty years.[55] It is certainly conceivable that the incremental tax collections from livable streets could meet or exceed the initial capital investment and operational expenses.

Neighborhood Concerns and Policy Options

Because only half of New York City households own automobiles and many of those households still depend on public transit for commuting and other trips, New Yorkers generally support improvements that make walking and cycling more pleasant. Nevertheless, perceptions that new traffic calming or the removal of traffic lanes and parking will increase traffic congestion are still strong. The following are a set of frequent questions from community members and how to address them.

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[55] Voicu and Been, 2006. Estimate a net present value of $503 million in increased tax revenues over twenty years. They estimate that capital costs and twenty years' maintenance, mostly privately provided, have a net present value of $177 million.

Won't this just create more traffic?

While traffic calming or pedestrianization may shift some traffic to alternate routes, experience shows that overall traffic levels are not necessarily impacted significantly, and can even be reduced. For years, traffic planners assumed that "nothing will make people get out of their cars – they'll always try and find another way round, and, if necessary, they'll just sit and wait in the traffic."[56] But the evidence from dozens of cities around the world has shown the contrary. Some of the traffic displaced by traffic calming or pedestrianization actually disappears, and the remaining traffic is typically dispersed and does not create a long-term disruption.

For example, after two streets in the center of Cambridge, England, were closed to through traffic, daily traffic levels in the core fell from 77,119 vehicles to 69,792, with no apparent effect on retail trade.[57] New York City has had its own experience with disappearing traffic. When the West Side Highway collapsed in 1972, overall traffic on the highway and on parallel routes fell by 40,000 vehicles per day.[58] In general, the evidence suggests that some traffic will move to parallel routes when a street is closed, but that careful planning can minimize the impacts.[59]

Where will I park?

In some instances, pedestrian improvements may require the removal of on-street parking spaces in residential areas. Residential parking permits may alleviate this concern by reducing park-and-ride pressure in transit-rich neighborhoods and car sharing is emerging as an innovative method to help urban residents actually get rid of their cars.

Residential parking permits (RPP) are a tool to reduce parking demand. These programs restrict neighborhood parking to local residents and their guests (who must display a permit in their vehicle). Several cities in the U.S. and internationally have implemented RPP. These programs, which would require State approval, could complement any proposals to raise metered parking rates on commercial streets, since they would prevent shoppers from hunting for free parking on nearby residential streets.

Car sharing is a relatively new strategy for reducing parking demand. Members of car sharing programs can reserve a nearby vehicle by the hour for a fee that covers gas, insurance and maintenance (cars are typically parked in nearby garages or in reserved spaces on the street, so members do not spend time hunting for a space when they return the car). In cities such as Philadelphia and San Francisco, each car share vehicle replaces as many as 22 new and existing cars, as members typically sell their existing car or forego the purchase of a new car, thereby reducing the number of sources for additional vehicle trips or for traffic generated by parking searches.[60] The City could encourage this shift by dedicating space for car share vehicles when it eliminates parking as part of livable street improvements. In new residential and commercial developments, the City could follow the example of cities such as San Francisco and Boston by requiring developers to dedicate spaces to car sharing vehicles.

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[56] Cairns, 2001.
[57] European Commission, 2004, pp. 42-45.
[58] Cairns, 2001.
[59] Cairns, 2001.
[60] Millard-Ball et al, 2005.

Where will my customers park?

When pedestrianization or traffic calming schemes are proposed, retailers are frequently among the most vocal opponents. Traffic calming and pedestrianization might result in drivers shopping elsewhere, and retailers may believe that these customers are the largest fraction of their customers. Even if there is an upsurge in pedestrian traffic, retailers may fear that pedestrians spend less than drivers.

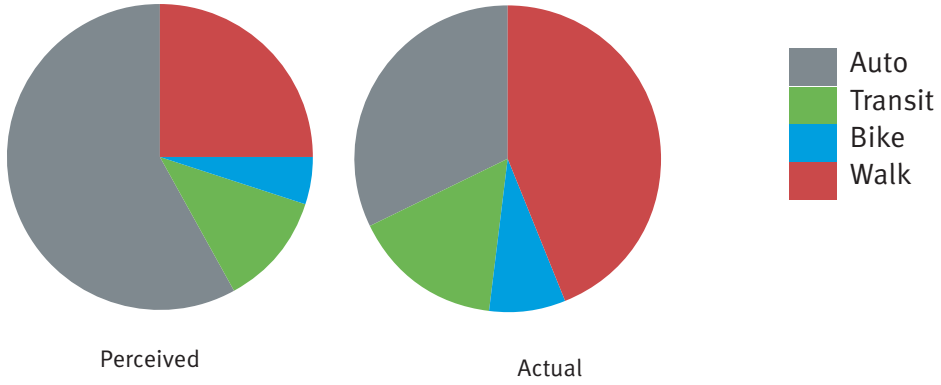
Evidence from London and other cities suggests that these fears are unfounded. As the research cited above suggests, where business is already thriving, traffic calming and pedestrianization have tended to boost sales. Some customers undoubtedly take their business elsewhere, but those losses are more than offset by the increase in pedestrian traffic.

Two surveys in Europe suggest that some of retailers' fears are based on a poor understanding of their customers' travel choices. A 1991 study in Graz, Austria, found that retailers thought that a majority of their customers arrived by car, and only 25% on foot. In fact, 32% arrived by car and 44% on foot. Sustrans (2004) found a similar discrepancy in Bristol, UK. This misperception may fuel anxiety about changes that increase pedestrian access at the expense of drivers.

Studies in London also suggest that pedestrians spend more than drivers. A survey of shoppers in central London shopping districts found that those who walked to the store spent about the same (£41) as those who drove (£43), but that over the course of a week, those who walked spent much more (£104) than those who drove (£73).[62] These findings were confirmed in a study on London's Kensington High Street, which found that walkers shopped more frequently than drivers and accounted for 35% of retail spending, compared with 10% for drivers.[63] The ability of customers to take home heavy or bulky goods – another possible concern of retailers – is apparently a minor issue for central London shoppers, at least: only one percent chose their travel mode because they had to carry heavy bags.

[60] Hass-Klau, 1993.
[62] Transport for London, 2004b.
[63] Transport for London, 2004a, p. 19.

Figure 3. Perceived and actual mode shares for shopping trips in Graz, Austria



Market-rate parking pricing, or performance parking, is a key strategy used by several U.S. cities to alleviate parking problems in commercial districts. At $1 to $1.50 per hour, curbside parking in New York is underpriced and far less expensive than garage parking in much of the city. Increasing this price would encourage some drivers to use other means of transportation, freeing up spaces and making it easier for the remaining drivers to find parking.

Getting there

Making New York City streets livable is no small challenge. More than just making select improvements, it is shifting the longstanding paradigm that city streets are meant for the quick and efficient movement of automobiles. This paradigm is still pervasive within City leadership, many City agencies and, most distressingly, the public mind.

Queens volunteers talk to neighbors about congestion pricing

Pilot projects, like those initiated by the DOT over the last year, have begun to change this. Experimentation with temporary street closures, including the Bedford Avenue and Montague Street commercial districts in Brooklyn and the new play street model initiated in Jackson Heights, Queens, offer New Yorkers the opportunity to inhabit and travel in public space that is normally reserved for cars. These street closures are also the first, critical step to subverting the existing paradigm that streets are for cars by showing New Yorkers that people can have priority and that it's fun and comfortable to have more room.

With the benefits of projects like the 9th Avenue Cycle Track, Broadway Boulevard and the Public Plaza Initiative already clear, an expansion is justified. These pilots have required an enormous amount of effort and political will because they are the exception. To get beyond individual pilot projects and capture the benefits of livable streets more broadly, a holistic and interagency livable streets policy is necessary.

To this end, we offer the following recommendations:

1. **Make livable streets the rule.** The Mayor should mandate livable streets as the overarching goal for all city streets. Improvements that support livable streets, whether through new construction, street rebuilding or zoning amendments, should be the standard. Coordination and creative problem solving between City agencies, including the Department of City Planning (DCP), Office of Management and Budget (OMB), Department of Design and Construction (DDC), Economic Development Corporation (EDC), Department of Environmental Protection (DEP), and Department of Sanitation (DOS) would be best led by the DOT and the Mayor's Office of Planning and Sustainability.

2. **Increase the amount of walking in NYC.** A walking city is a healthy, livable city. Similar to DOT's goal to double the number of bicycle commuters by 2015, the DOT should set a citywide goal for the share of city travel taken on foot. In 2004, Transport for London set a goal of increasing both the share of walking for trips less than two miles and the average number of trips made on foot each year by 10% by the year 2015. In 2002, a survey conducted by the New York Metropolitan Transportation Council found that one-third of trips made by New Yorkers included walking or bicycling. As a starting point for discussion, we recommend that agency match London's targets by 2020. The greatest gains can be made in neighborhoods that lack safe and well-maintained pedestrian facilities, such as the neighborhoods with Department of Health and Mental Hygene's (DOHMH) District Public Health Offices.

3. **Promote livable streets on the basis of public health.** The DOHMH should continue conducting research on the connection of livable streets to better public health and stand beside DOT in explaining the benefits to the public: testify at hearings; monitor the health impacts; and provide general context to support DOT implementation of livable streets.

4. **Promote livable streets in business districts.** The Department of Small Business Services (SBS) should promote livable street design as a driver of local economic development. To do so, we encourage SBS, in collaboration with DOT, to develop educational materials for Business Improvement Districts (BIDs) to help local businesses understand the connection between livable streets designs and economic vitality. Livability improvements could also be successfully integrated into existing economic development programs (e.g. Avenue NYC) and would be complemented by BID metrics, such as shoppers' mode share (how shoppers travel to and from business districts) and the age and gender composition of shoppers at different times of day.

5. **Put livable streets on the agenda of all New York City Community Boards.** Community Boards that have a livable streets champion have received the most livability improvements. These champions organize their neighbors and fellow Community Board members to bring new bike lanes, public plazas, and traffic calming improvements to their neighborhoods. Building on this model, organizations like Transportation Alternatives should create a Community Board training program to educate Community Board members on the value of livable streets and inspire Community Board members to make livable streets a top priority. Furthermore, Borough Presidents and Council Members who want livable street improvements should make a particular effort to recruit enthusiastic and proactive Community Board members.

6. **Create Parking Benefit Districts.** In the U.S., parking reform is most successful when coupled with a program to return meter revenue (or other benefits) to the community. The City should create Parking Benefit Districts such as the ones that has been adopted by Washington. D.C. In a Parking Benefit District, meter prices in commercial corridors are increased on the basis of demand (to achieve 85% occupancy) and a portion of the new revenue generated by the higher meter rates is directed back to the districts in the form of pedestrian, cycling and surface transit improvements. Community Boards and local City Council Members would have an opportunity to comment on and prioritize these improvements. The DOT has already begun to study the effect of pricing on cruising and demand with two "Peak Rate Parking" pilots in the West Village, Manhattan and Kings Highway, Brooklyn.

7. **Reduce congestion in neighborhoods.** A residential parking permit program would reduce park-and-ride congestion in transit-rich neighborhoods, as would commercial district pricing reform (see 6). Similar to the robust program developed by the DOT during the congestion pricing proposal, the City should create an opt-in program for interested Community Districts.

8. **Promote car sharing.** Car-sharing is rapidly emerging as an effective tool to reduce the length and frequency of car trips as well as the number of cars owned by an average household.[64] The DOT should partner with the EDC to incentivize car-sharing in New York and track its effect on travel behavior.

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[64] Millard-Ball et al, 2005.

Block party, Manhattan

This report is written at a time when leadership at the DOT and the Mayor's Office have made significant strides to show the promise of livable streets. To move this agenda beyond 2009, the next Mayor must select agency commissioners who embrace the potential of a livable streets policy and will lead their staff towards making it a reality. With a strong foundation set, New York City is now presented with the historic opportunity to be the global standard for a livable streets transformation.

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Planning — May 2005

Complete the Streets!

New state and local policies require that virtually all roads be built to serve all types of users.

By Barbara McCann

In many communities, designating a bicycle route or pouring a few new sidewalks is no longer enough. In the college town of Columbia, Missouri, the city adopted new street standards last June calling for wider sidewalks and narrower lanes. The governing commission of the South Carolina Department of Transportation recently passed a resolution declaring that "bicycling and walking accommodations should be a routine part of the department's planning, design, construction, and operating activities."

In San Diego last November, voters approved a sales tax measure that is expected to generate $14 billion over 40 years. It specifies that any roads built or improved with these funds must have room for cyclists and pedestrians.

All of these jurisdictions are part of a new trend: creating complete streets.

For everyone

A complete street is defined as a street that works for motorists, for bus riders, for bicyclists, and for pedestrians, including people with disabilities. A complete streets policy is aimed at producing roads that are safe and convenient for all users.

Complete streets are not limited to a few designated corridors. Many communities have launched main street initiatives, adopted bicycle plans, or undertaken special planning processes for nonmotorized travel in specific places. In contrast, complete streets policies strive for diversity on just about every thoroughfare. And the process of creating complete streets is leading planners and engineers across the country to approach street design in fundamentally new ways.

Most U.S. roadways are not "complete streets." According to a national survey conducted in 2002 by the federal Bureau of Transportation Statistics, about one quarter of all walking trips take place on roads without sidewalks or shoulders, and bike lanes are available for only about five percent of bicycle trips. Another BTS poll, the 2003 National Transportation Availability and Use Survey, found that the top complaint among both able-bodied and disabled pedestrians and cyclists was that there were too few usable sidewalks and bikeways — essentially, too many incomplete streets.

A new name

For advocates of bicycling and walking, this state of affairs demanded a whole new paradigm — and a name to go with it. The term "complete streets" was coined in early 2003 by bicycle advocates as a way to describe — and sell — what had until then been referred to as routine accommodation.

For years, advocates of this approach had lobbied to get a provision inserted in federal law that would require roads built using federal highway funds to accommodate people on foot and bicycle. While the Transportation Equity Act of 1998 (TEA-21) included language asking states to consider bicycle and pedestrian travel, it is still not a requirement.

Creating complete streets is a key goal of America Bikes, a group formed by eight national bicycling organizations to lobby for bicycle-friendly provisions in the next federal transportation bill. "We saw how the name Safe Routes to School opened doors for bicycle and pedestrian safety for children," says Martha Roskowski, former campaign manager for America Bikes. "Finally we have a name that describes the current vision of a network that is complete for everyone using the roads."

Today's policies

More than two dozen jurisdictions have adopted laws or policies requiring that all roads be routinely built and reconstructed to accommodate pedestrians and bicyclists, including disabled travelers, according to a recent national survey conducted for the Thunderhead Alliance, a coalition of state and local advocacy groups.

These policies differ from typical bicycle and pedestrian plans in that they are not limited to roads that are part of designated bicycle or pedestrian networks, but cover all roads, or at least all major roads, in the system. The idea is that multimodal corridors would become the default mode — and justification must be given when they are not.

Most of these policies have been put in place since 2001, when the U.S. Department of Transportation issued design guidance in response to the new language in TEA-21. The guidance document, "Accommodating Bicycle and Pedestrian Travel," states that "bicycling and walking facilities will be incorporated into all transportation projects unless exceptional circumstances exist."

Exceptions include roads where bicyclists or pedestrians are prohibited by law; where the costs are excessive (more than 20 percent of project costs); and where there is clearly no need. The document also calls for paved shoulders on rural roads and designs that are accessible for disabled people.

Some states, including South Carolina, Tennessee, California, Kentucky, and Virginia, have adopted resolutions or directives enacting some variation of the federal policy.

At the urging of bicycle advocates, Caltrans, California's transportation agency, adopted Deputy Directive 64 in 2001, calling for full consideration of the needs of bicyclists and pedestrians. The directive has been criticized for its vague wording, but the policy has spurred training programs in bicycle and pedestrian planning for both planners and engineers.

In March 2004, Virginia Transportation Secretary Whitt Clement announced "a broader and more enlightened approach to highway construction." The new policy requires the commonwealth to "initiate all highway construction projects with the presumption" that they will accommodate bicycling and walking.

Elsewhere, metropolitan planning organizations, counties, and cities have also used the federal guidance as a model, or in some cases, have crafted their own policies.

Santa Barbara's general plan, adopted almost three years before California's statewide 2001 directive, calls for "achieving equality of choice and convenience among modes." In Columbia, Missouri, new street standards calling for narrower roads and wider sidewalks were pushed by public health advocates and by Mayor Darwin Hindman, who firmly believes in the health benefits of walking and bicycling.

Many local policies have been adopted through internal directives or revised planning documents, but at least two local governments — in Illinois and California — have passed broadly worded council resolutions or ordinances, and MPOs in Ohio and California are requiring local governments using MPO-administered funds to meet complete street standards. In California, Sacramento has joined San Diego in requiring that roads built with funds raised through voter-approved bonds accommodate pedestrians and cyclists.

Farthest along

For a vision of the future of complete streets, visit Oregon. The state adopted the idea long before anyone else and codified it into state law. Legislators passed a "Bike Bill" in 1971, about the same time as the state's innovative land-use planning laws were taking shape.

The bill, which required bicycle and pedestrian facilities on all new roads, streets, and highways, was considered a tough sell, recalls Michael Ronkin, head of the Oregon DOT's bicycle and pedestrian program. The measure was sponsored by a conservative Republican from the southern part of the state, who at the same time was promoting bills to regulate dynamite and to tax church property.

"Of the three," says Ronkin, the legislator "was told the bike bill was least likely to pass." But pass it did. The measure, which allows highway funds to be used to retrofit all roads, also requires that at least one percent of the state's highway fund be spent on bicycle and pedestrian ways.

The impact of the law is obvious across the state. In Corvallis, 95 percent of arterial roads include bike lanes. In Portland, the rapid growth of the bike lane network since 1990 has been linked to dramatic increases in bicycle commuting. And even in suburban and rural areas, bike lanes and sidewalks are common.

But Oregon's work is far from done. Early implementation ignored pedestrians, and design standards were poor. It took years to make transportation engineers and designers aware of the requirement. Now, in the state's fourth decade of building for all modes, state and local bicycle and pedestrian planners are working on the thorniest design problems. "We've already gotten the low-hanging fruit; now we have to get out the big ladder," says Ronkin.

Bigger issues of land use and street connectivity still play a huge role in decisions to walk or cycle. In Oregon's experience, adding bike lanes and sidewalks to roads that are being widened from two to five lanes is not enough to mitigate the increased traffic volumes: Walking and cycling are still likely to decline.

Nonetheless, Ronkin says, roads must make these accommodations. "It is all a part of rethinking how roads function and whom they serve," he says.

Unique streets

While the idea of complete streets is based on consistency — every time you build or reconstruct a road, make it multimodal — in practice, every project is unique. In a rural area, a complete street may be a two-lane road with a paved shoulder. In a congested urban area, it may feature an extra-wide sidewalk and refuge islands for pedestrians. It does not necessarily have to include bike lanes, however, because cyclists can travel safely with the slow-moving automobile traffic.

Truly complete streets expand beyond bicycling and walking to consider disabled users and transit riders. Every street cross section requires balancing the needs of many users in a way not considered in typical highway design manuals.

"For pedestrians who have disabilities, the weak link is the sidewalk," says Lois Thibault of the U.S. Access Board, an independent federal agency that develops accessibility guidelines. She notes that walking is the only independent mode of travel for people who are blind. "Complete streets build a network," she says, "and that's what everyone needs." Sidewalks are a necessity for disabled travel, but details such as curb ramps and audible crossing signals are critical as well.

Planning for disabled people is certainly not a new issue. Projects built with federal highway funds have been required to be accessible to all travelers since 1973, and the Americans with Disabilities Act of 1990 broadened the requirement to apply to all facilities, regardless of funding.

Even with this history, however, implementation has been slow. That's because, in most cases, pedestrian planning continues to be treated separately from routine road improvements. The Federal Highway Administration is now developing new policy guidance that spells out the responsibility of transportation agencies to work on pedestrian facilities in conjunction with routine roadway resurfacing and alteration.

The new policy is expected to direct transportation agencies to consider pedestrian and cyclist access in every road improvement project. This brings pedestrians "into the same house, with somewhat equal authority to ask for funds," says Thibault.

Don't forget transit

Transit is the aspect of complete streets that has been addressed least often in existing policies. Some communities have begun to consider transit needs in their corridor planning. That's true particularly in places that are considering bus rapid transit, which calls for enhanced service in the existing right-of-way.

In some cases, transit vehicles get dedicated lanes; bus pullouts improve traffic flow, and "queue jumping" lanes help buses get through intersections. In Los Angeles, the Metro Rapid bus routes depend on a signal priority system that allows buses to extend green lights or shorten red ones.

But the key to complete streets for transit may be less in new technology and more in paying attention to the basics of pedestrian access.

"All transit trips start and end with a pedestrian component, so streets don't work for transit unless you can complete the trip," says Robin Blair, transportation planning manager for the Los Angeles Metropolitan Transportation Authority. The MTA is now developing "transit streets" that restrict automobiles but enhance pedestrian access.

The big challenge

Finding enough right-of-way can be the biggest challenge for a complete streets program. Even if the right-of-way is in the transportation agency's hands, any widening, even for a sidewalk, may get a thumbs-down from residents who want to preserve existing landscaping and parking, or informal, private use of the right-of-way. This is the case along Florida's A1A, where plans to add a bike lane have met stiff opposition.

In response, many communities have begun to create complete streets where it is easiest — at a location where a wide travel lane can be narrowed or where traffic volume allows a four-lane road to be converted to two lanes with the addition of a center turn lane and bike lanes.

Fear of high costs is an equally great obstacle. Most complete streets policies don't come with special funding attached, and project budgets are sometimes set before bicycle and pedestrian facilities are considered. Street policies commonly cite "disproportionate cost" — defined by the U.S. DOT as 20 percent of the project budget — as a reason for exemption.

Experienced officials say the issue of cost can be overblown. Jeff Morales, former director of Caltrans, has said that integrating access for bicyclists, pedestrians, and disabled people right from the start actually minimizes costs.

Bridges offer a dramatic example. Providing enough room for cyclists and pedestrians during initial construction is far more effective than widening a bridge later.

Learning curve

Two fundamental challenges to instituting a complete streets policy are a mind-set that is geared to following manuals and a lack of training. Until very recently, few schools offered either undergraduate or graduate courses on bicycle and pedestrian planning, and even fewer courses on planning for multiple users.

Keith Knapp, assistant professor of engineering and professional development at the University of Wisconsin–Madison, travels the country offering continuing education classes to engineers and planners. "I've talked for hours about the needs of bicyclists and pedestrians," he says, "only to have 80 percent of the students say at the end of the class that they don't plan to consider them."

Knapp attributes the students' resistance to the direction engineers get from their state transportation department directors and to engineers' typical reliance on standard traffic manuals. They fear that unconventional solutions will lead to unintended consequences, he says.

The manuals themselves are inadequate, in Knapp's view. The two manuals most commonly used — AASHTO's Green Book and the Highway Capacity Manual , published by the Transportation Research Board — are geared to rural construction and new roads that maximize traffic volume.

Knapp is looking forward to two forthcoming volumes that will take an integrated approach to designing for diverse users: an urban street design handbook from the Institute of Transportation Engineers, and urban arterial design guidelines being developed by ITE and the Congress for the New Urbanism.

Users, most notably bicyclists, are helping some state transportation departments to overcome the hurdles of implementing complete streets and urging other agencies to address the issue. In South Carolina, the League of American Bicyclists and local bicycle advocates are working with the state DOT to help implement its new policy, including training department personnel.

Several local and state bicycle advocacy organizations that are part of the national Thunderhead Alliance are pushing for new policies and planning Complete the Streets campaigns in Washington, Colorado, and Illinois (where a complete streets bill has passed through a legislative committee). And Advocates representing a long list of national groups — from AARP to Smart Growth America — met in January to consider strategies for spreading the idea.

Taking the next step

Despite the challenges, a few communities are taking complete streets a step further. They are not simply adding a requirement to existing road plans or limiting themselves to rewriting their design manuals. They are reinventing their entire planning process to serve the needs of all road users.

Boulder, Colorado, has been promoting alternative modes for decades. Its GO Boulder initiative encourages bicycling, walking, and transit, and its innovative Hop, Skip, and Jump bus lines have reinvigorated the city's transit system with colorful vehicles and frequent service. But until recently, planning and funding were handled separately for each mode.

In 2003, Boulder eliminated the separate categories to create a multimodal corridor plan, so that every project considers every mode. "The change in the language and funding changed the dynamic," says Tracy Winfree, the city's director of public works for transportation. "The competition we had experienced before between modes disappeared."

The new plan calls for converting 10 city arterials into multimodal corridors, with the aim of integrating and coordinating automobile, transit, foot, and bicycle use citywide. Some arterials have already been converted. In addition, transportation network plans are to be developed for specific areas of the city.

Charlotte, North Carolina, has traditionally taken an auto-oriented approach to road design. Today, the city is taking a different tack. "We're looking to create a thought process that ensures that all users and all modes are considered," says city transportation planner Tracy Newsome.

A multidisciplinary team convened by the Charlotte DOT is creating a six-step process to evaluate each project in terms of the needs of various users, and in terms of the broader transportation and land-use context.

The process, now under review, will identify opportunities in each street segment to close gaps and increase connections in the bicycle, pedestrian, transit, and automobile networks, before selecting and modifying one of five multimodal street types. While the system won't result in equal treatment of everyone on every street, the intent is to complete the travel network for all users.

Converging trends

The complete streets movement represents a convergence of several existing trends, spearheaded by a variety of groups. Bicycle advocates have long fought for "routine accommodation" policies. Innovative cities have adopted multimodal plans to free residents from automobile dependence. New urbanist builders have emphasized the need for walkable communities.

They have been joined recently by public health advocates seeking to increase physical activity and stem the obesity epidemic. Finally, more and more state and local transportation agencies are recognizing the need to do things differently.

At last January's annual meeting of the Transportation Research Board — an event usually dominated by traditional highway engineering concerns — more than 180 people packed a session called "Complete the Streets," with highway planners sitting side by side with disability and bicycle advocates. A series of similar sessions is planned for next year's meeting.

Complete streets may yet become a way for all road users, and all road designers, to shape the future of a maturing road network.

Barbara McCann is a transportation and land-use consultant in Washington, D.C.

Sidebar: Obstacle Course

Sidebar: The Path to Pedestrianization

Resources

Images: Top — A Boulder arterial that was built as a multimodal corridor for auto, pedestrian, bicycle, and transit use. Photo by Phil Sanders. Middle — A commercial street filled with activity in Santa Rosa, California. Photo www.pedbikeimages.org. Bottom — Water Street in Vancouver, British Columbia. Photo Dan Burden.

Advocates: Reach Barbara McCann at **www.bmccann.net**.

For more on complete streets, go to **www.completethestreets.net**.

America Bikes is at **www.americabikes.org/completestreets.asp**.

Get the Thunderhead Alliance report at **www.thunderheadalliance.org**.

State and local: Oregon's "Bike Bill" is at **www.odot.state.or.us/techserv/bikewalk/plan_app/366514.htm**.

For information on the University of Wisconsin's continuing education courses, go to **http://epdwww.engr.wisc.edu**.

The Boulder Transportation Master Plan is at **www.ci.boulder.co.us/publicworks/depts/transportation/masterplan**.

Federal: For the U.S. DOT Design Guidance, "Accommodating Bicycle and Pedestrian Travel", see **www.fhwa.dot.gov/environment/bikeped/design.htm**.

The U.S. Access Board is at **www.access-board.gov**.

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Complete the

www.pedbikeimages.org/Dan Burden

Streets for Smart Growth

Planners figure out the puzzle to pedestrian-friendly roadways

By Barbara McCann

Complete the streets so everyone can use them safely and conveniently—that's the new cry of advocates, planners and elected officials who are behind a movement to fundamentally alter the way roads are planned, designed and built.

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A basic tenet of Smart Growth is the creation of walkable communities that provide transportation choices. But in many cases, state and local transportation agencies have been slow to get the message. Yes, they may have spent extra time and energy on redesigning that one boulevard to include a bicycle lane and wide sidewalks, but everywhere else, they keep churning out high-speed roads for cars with little thought to the needs of bicyclists, pedestrians and transit riders who are also using that street.

www.pedbikeimages.org/Annie Lux

The needs of bicyclists, pedestrians, transit users and disabled people are integrated into every aspect of design.

Recently, the mayor of Louisville, Ky., Jerry Abramson, joined a growing chorus that wants to change that practice. "For decades, we in Louisville—and cities around the nation—have built roads only for vehicles. That was an urban planning mistake," Abramson said in a statement. "The Complete Streets policy will help rectify that." Louisville's combined city/county government is considering adoption of a comprehensive complete streets policy that would require the city to take into account the needs of all users, every time engineers set out to change or build a street. Those users include motorists, transit riders, bicyclists and pedestrians of all ages and abilities—including older people, children and people with disabilities. The city worked with a broad advisory group to create the comprehensive policy.

Louisville is expected to soon join close to 50 other places—ranging from states to small towns—that have adopted some form of a complete streets policy. In some cases, lawmakers have passed laws or ordinances, or citizens have approved ballot measures; in others, planning agencies have written internal policies or re-written their design manuals. But, everywhere the intent is the same—to change long-standing transportation planning practices that narrowly focus on moving as many cars as possible.

In Massachusetts, a state law passed in 1996 required the state Highway Department to accommodate bicyclists and pedestrians in projects. Initially, the law was poorly implemented. But, ultimately it helped spark a citizen-led planning process that tossed out the old highway manual that had focused on improving automobile 'Level of Service'—a measure of traffic congestion. Thomas DiPaolo, assistant chief engineer for Mass Highway, says, "What we tried to do, was make it acceptable to advance projects that have purposes other than improving vehicular Level of Service for a road. For example, now supporting economic development would be a legitimate 'design control' to make a project worthwhile." The new guide, adopted in January of 2006, sets multi-modal accommodation as one of its three guiding principles—and the needs of bicyclists, pedestrians, transit users and disabled people are integrated into every aspect of design, from intersections to bridges.

About one year earlier, the city council of Colorado Springs, Colo., adopted a complete streets policy, which recently led to the inclusion of bike lanes and sidewalks on a new bridge project. But, the policy isn't just about adding extra pavement.

Cheyenne Boulevard "was a four-lane road with on-street parking, driveways, a cross street every 400-500 feet, a transit line and hopscotch pedestrian facilities that start and stop," according to Colorado Springs Senior Transportation Planner Kristin Bennett. "There were always lots of complaints of people speeding, and people were uncomfortable using the on-street parking because cars were going 40 miles per hour." The road was put on a 'diet', with just two through lanes, a center turn lane, and bicycle lanes, as well as street parking. Many road diets also include pedestrian 'refuge' islands. On Cheyenne Boulevard, speeds are lower and residents are happy. A similar road diet on a nearby business street with diagonal parking was welcomed by business owners, according to Beth Kosley, executive director of the Downtown Partnership. "Delivery trucks have better places to pull in and make deliveries without interrupting customers; that's a great thing, and our diagonal parking is much more accessible and safe. Apparently tempers have calmed down a lot."

Dan Gallagher, transportation planning section manager in Charlotte, N.C., learned about such transformations when he was working in Orlando, Fla. There, a road diet accomplished on the cheap, mainly with paint, resulted in reduced speeding, a dramatic reduction in crashes and injuries (down 35 percent and 68 percent respectively), and an increase in bicycle and pedestrian use (up 23 percent and 30 percent). The change helped spur economic development. "All of a sudden there are

By providing for these diverse users, complete streets can improve safety and health.

Complete streets also improve mobility for transit vehicles and the people who use them.

million-dollar condos, it has become a real restaurant row, and it wasn't before it got road dieted," says Gallagher. "Maybe some of that would have happened on its own, but it would not have been to this level without the road diet." Such economic impact may extend to residential areas—after a road diet in West Palm Beach, Fla., residents reported to planners that it dramatically increased property values.

Now, Gallagher is making sure that Charlotte's complete streets policy changes the way his department does business. Traditional measures such as 'Average Daily Traffic' and Level of Service are considered—but they do not drive the process as they did in the past. The new "six-step" design process starts with questions about where a road is located and who is using it. The third step is to identify deficiencies—with the intent to fill in gaps in the street and sidewalk network for bicyclists, pedestrians and transit users.

By providing for these diverse users, complete streets can improve safety and health. A recent Federal Highway Administration assessment of what safety features are effective in protecting pedestrians listed many items found on a complete street—sidewalks, raised pedestrian medians, better bus stop placement, measures that slow or 'calm' traffic and treatments for disabled travelers. On the health front, public health officials fighting the obesity epidemic are calling for complete street networks with continuous sidewalks that allow children to walk to school and adults to walk to destinations, getting essential physical activity along the way.

Complete streets also improve mobility for transit vehicles and the people who use them. A study in Houston found that sidewalks are not provided between home and the nearest bus stop for three out of five disabled and older residents; nearly three-quarters said streets near their homes also lack curb ramps and bus shelters. As a result, few take the bus. Transit advocates point out that better access to transit stops will help reduce the number of times disabled people will need specialized (and expensive) door-to-door paratransit service.

After: Bridgeport Way in University Place, Washington

Complete streets policies can also spark new cooperation between transit agencies and public works agencies to include design features that help buses operate more smoothly.

A broad coalition has formed to urge adoption of complete streets policies at the local, state and federal level. The National Complete Streets Coalition has brought together bicycle advocates—who have been fighting for complete streets the longest—with those working on behalf of pedestrians, disabled people, seniors and transit.

But, the Coalition does not stop at such "user groups." Transportation professionals, such as the Institute of Transportation Engineers and the American Planning Association, are actively involved, as well as groups working on wider development issues, such as the Congress for the New Urbanism and Smart Growth America. All see different benefits in complete streets.

"Walking, bicycling and easy access to transit are all important elements of a livable community that works for older Americans," says AARP's Elinor Ginzler. "Complete streets help get us there." AARP is an active supporter of the national coalition, and AARP's Honolulu state office recently joined with Hawaii bicycle advocates to pass a complete streets amendment to the Honolulu City Charter.

Thomas DiPaolo of Massachusetts says involvement from outside groups led the way in Massachusetts in changing the set ways of the transportation agency. "We had a lot of pushes from outside. It is hard to change from within, we really do need outside organizations, as well as people in very high positions saying this is what we want to do." The bicycle advocacy group, the Thunderhead Alliance, is training advocates across the country to push for new complete streets legislation. The National Complete Streets Coalition maintains a growing Web site (www.completestreets.org) to share best practices on complete streets. Many members of the Coalition have developed presentations and training materials aimed at planners, transit operators, engineers and advocates on how to advance complete streets—whether from the outside or from within transportation planning agencies. The Coalition is also working with members of Congress to craft a federal complete streets bill that would require that federal transportation spending support complete streets.

Elected officials and agencies have sometimes objected that building complete streets will cost too much. But, Dan Burden of Glatting Jackson and Walkable Communities Inc., questions that logic. "It is a matter of what we value," says Burden. "We spend all the money on intersections, and it is considered a normal cost of doing business. But, when it comes to walking or bicycling, that's a frill; we'll tax you [to pay for] that. It is not quite fair. It says one mode is more important than the other." Complete streets policies are about ending that inequity—and making sure the public right-of-way really works for everyone.

Barbara McCann serves as Coordinator of the National Complete Streets Coalition. She also writes on transportation and land-use issues and is the co-author of the book "Sprawl Costs" from Island Press.

Complete Streets 2009

Sacramento, Calif.

By Barbara McCann

When tiny University Place outside of Tacoma, Wash., incorporated in the mid 1990s, one of the first priorities was adding sidewalks to the former county roads. From there, the town made an early commitment to what is now called 'complete streets' — the idea that all future road projects would integrate the needs of everyone using the road — not just motorists, but also people walking, riding bicycles or catching the bus. The town started by cajoling the gas company to split costs for transforming gravel shoulders into sidewalks during gas line replacements. They looked for opportunities to install bike lanes during repaving projects and to put in pads to provide space for county bus shelters. Then they started making more radical changes.

"People from outside University Place comment about how much they love driving down Bridgeport Way," says Steve Sugg, deputy city manager, of one of the first streets to get a full Complete Streets treatment. "There is a sense of calm."

The redesigned road features a landscaped median, new pedestrian crossings, bicycle lanes, a multi-use path and improved sidewalks. Sugg notes that when Trader Joe's was looking for a place to locate a store in the Tacoma region, they picked a site on Bridgeport Way, perhaps because of the extensive street improvements. University Place has added 23 miles of sidewalks to their streets since incorporation and has installed several modern roundabouts, the first in Washington State. Now the town is working with citizens on planning a Town Center to realize broader smart growth principles.

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Sacramento, Calif.

A growing number of communities are using the deceptively simple tool of complete streets policies to change the way they approach transportation.

University Place is not alone. Across the country, a growing number of communities are using the deceptively simple tool of complete streets policies to change the way they approach transportation. Adopted as a state law, local ordinance or even as a city council resolution, these policies set a new vision for transportation investments. More than 85 states, regions and cities have adopted such policies, including new state laws passed in California and Illinois and policy resolutions or ordinances in major cities including St. Paul, Miami, Chicago, Seattle, Sacramento and Charlotte. And the pace is accelerating.

In Jefferson City, Mo., in March, disability advocates, trail-building organizations, bicycle advocates, health groups and even a REALTOR® spoke at a state House hearing or wrote letters in support of a complete streets bill. In Hawaii, bicycle advocates and the state AARP chapter made common cause this spring to push for a similar bill with a particularly Hawaiian twist — they've linked it to a Hawaiian tradition known as 'the splintered paddle' — a native myth that asserts everyone's right to travel safely. State legislators in Connecticut, Texas, West Virginia and Maine have also introduced complete streets bills.

Complete streets policies are also getting federal attention. Sen. Tom Harkin and Rep. Doris Matsui have introduced the Complete Streets Act of 2009 into the U.S. House and Senate (S.584, H.R.1443).

"We need to ensure streets, intersections and trails are designed to make them easier to use and maximize their safety," said Sen. Harkin upon introduction of the bill. "This legislation will encourage Americans to be more active, while also providing more travel options and cutting down on traffic congestion."

The bill would require states and metropolitan planning organizations to adopt complete streets policies to be applied to federally funded road projects, and it is expected to become part of the upcoming authorization of the federal transportation bill.

The success of a complete streets approach is starting to show up in research that shows fewer crashes on redesigned roads, as well as increased physical activity. A recently released study of a new pedestrian pathway along a major bridge in Charleston, S.C., found that two-thirds of the users of the bridge said the new facility had led them to get more exercise.

Promoting physical activity as a part of daily life has been at the center of a strong move in Minnesota toward complete streets, with three jurisdictions adopting policies in the first months of 2009: Hennepin County (Minneapolis), Saint Paul and Rochester. Rochester's city council passed the policy unanimously after hearing a variety of supportive testimony.

We need to ensure streets, intersections and trails are designed to make them easier to use and maximize their safety.

"Really it was the result of a lot of different people speaking and testifying at the public hearing and sending e-mails and letters in advance," says Mitzi Baker, senior transportation planner for the city of Rochester. "It was the power of civic engagement."

The insurer Blue Cross/Blue Shield (BCBS) of Minnesota has been supporting 'active living' initiatives across the state, based on research that shows that people who live in walkable environments, or who regularly take public transportation, are more likely to be active enough to ward off chronic disease. BCBS sponsored three Complete Streets Workshops in December to help planners and engineers understand how to broaden their scope when planning road projects to take into account the needs of pedestrians, bicyclists and public transportation users.

"It is probably a good deal, as it will make a residential development a little more attractive to people who are going to move in," says Ward Opitz of Bigelow Homes in Rochester, who met with city planners to see if the proposed policy would affect an upcoming subdivision. "I'm a little leery of what fees they may conjure up next time."

In University Place, REALTORS® and appraisers are unsure if the improvements have made much difference to property values. But for some supporters, the economic impact is a primary reason to support a complete streets approach. Chris Leinberger, author of "The Option of Urbanism: Investing in a New American Dream," has been watching the downward trajectory of home prices and notes that most of the dive has been in places built for "drivable suburbanism," places where the road network features high speed arterials designed only for cars.

"Places that are walkable urban neighborhoods have held their value over the last two years," says Leinberger.

An indicator of the potential importance of a multimodal transportation network to property values is the new real estate tool, Walk Score. Walk Score uses the magic of Google Maps to give every address in the nation a score from 0 to 100, based on the number and variety of destinations within walking distance. The Walk Score Web site is enormously popular, but it isn't just a parlor game. Front Seat, the firm behind Walk Score, has commissioned research to determine if a higher Walk Score correlates to a higher home value. Economist Joe

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Cortright says the preliminary results show that each additional point on the Walk Score scale correlates with increased housing values on the order of $1,000 or more, depending on the regional market. Two major real estate Web sites, Zip Realty and Zillo, now feature Walk Score on property listings.

Walk Score is based on the crow-fly distance to nearby destinations, so it doesn't take into account the disconnected street network common in many newer developments, or the lack of sidewalks and crosswalks that can make walking unpleasant, impractical or plain dangerous. But connected, complete streets are a prerequisite to true walkable urbanism, according to Leinberger.

"If you have an eight-lane arterial without complete streets infrastructure, you will never see high-density walkable urbanism take place along that corridor. Complete streets will be a precondition before you can get walkable urban development that will help meet the pent-up demand for this type of neighborhood."

He notes that the beauty of complete streets is being able to begin changing the street infrastructure right away, as transportation projects come up.

Health, economic development and sustainability are behind many complete streets efforts — the bill in Maine's legislature is part of a broader strategy to fight climate change. But complete streets policies are gaining ground for more fundamental reasons of simple demographics and safety. By 2025, nearly one in five Americans will be over the age of 65, and they will make up one-quarter of the driving population. As they age, many will face disabilities that will force them to give up driving during the last decade of their lives. Yet they may be reluctant to give up the keys when they face neighborhoods with infrequent and inadequate crosswalks, no sidewalks, poorly designed bus stops and inadequate speed control.

A recent AARP poll found that 47 percent of older adults said they did not feel safe crossing a major street near their home. In another large survey, AARP found that nearly two-thirds of the more than 1,000 planners and engineers surveyed have not yet begun considering the needs of older users in their multimodal planning. AARP recently issued a report based on this research, "Complete Streets for an Aging America," that makes three broad recommendations for transforming road design to better cope with an aging population, summarized as "Slow Down, Make it Easy, and Enjoy the View." It recommends re-engineering streets for slower travel speeds, making intersections less complex while providing lower-speed routes and reducing visual clutter.

Health, economic development and sustainability are behind many complete streets efforts

It is no coincidence that the recent push for complete streets comes against a backdrop of a steady decline in the amount of driving and a rise in the use of public transportation — even as more people take part in Bike to Work Day activities every year. Communities are responding by making a commitment to complete their streets. ●

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