# Designing Highway Facilities To Encourage Walking, Biking and Transit

*Requested by*
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*The Caltrans Division of Research and Innovation (DRI) receives and evaluates numerous research problem statements for funding every year. DRI conducts Preliminary Investigations on these problem statements to better scope and prioritize the proposed research in light of existing work on the topics nationally and internationally. Online and print sources for Preliminary Investigations include the National Cooperative Highway Research Program (NCHRP) and other Transportation Research Board (TRB) programs, the American Association of State Highway and Transportation Officials (AASHTO), the research and practices of other transportation agencies, and related academic and industry research.*

## Background

As outlined in Caltrans' October 2, 2008, Deputy Directive 64-R1 (DD-64-R1), "Complete Streets—Integrating the Transportation System," Caltrans is committed to addressing the safety and mobility needs of bicyclists, pedestrians and transit users in its highway facility designs. In addition, a team within Caltrans was charged in late October 2008 with updating the Highway Design Manual (HDM) "to better communicate design guidance on bicycle, pedestrian, and transit user needs into its text." However, Caltrans needs more information on the impacts that design—or specific design strategies—may have on travelers' decisions to choose biking, walking and transit travel modes. This information will enable the department to focus on the most effective strategies.

Caltrans staff proposed a research project aimed at documenting the "mode shifting" effects of particular highway design approaches; that is, increasing walking, biking and transit use. To support this proposed research project, we reviewed recent research, national guidance and related efforts of other state departments of transportation to determine:

- What state and federal standards exist for designing highways, streets and transit facilities (e.g., transit plazas) to encourage walking, biking and transit use?
- What research is available or still needed to document the impacts of design changes on mode shifting and safety?
- What facility design features (and related factors) are most effective at encouraging higher levels of walking, biking and transit use?

## Summary of Findings

We have organized our findings in the following sections: **Research in Progress; National Best Practices, Design Guides and Additional Resources; California Guidance; Other State and Local Guidance;** and **Related Research.** Key highlights of our research include:

**Research in Progress**

- There is very little research available that systematically measures the impact of highway design on mode shifting and safety. However, a major federally funded study, the Nonmotorized Transportation Pilot Program (NTPP), is currently under way to document the effects of improving walking and bicycling infrastructure on mode share.
- FHWA is producing a *Best Practices Manual on Complete Streets*, to be completed in December 2009.

**National Best Practices, Design Guides and Additional Resources**

- There are numerous existing national, state and local resources for pedestrian-, bicycle- and transit-friendly design. Particularly useful is the Federal Highway Administration (FHWA) *Pedestrian Facilities Users Guide—Providing Safety and Mobility*, which includes chapters on pedestrian crash factors, selecting pedestrian safety improvements, and specifications for design of pedestrian facilities, roadways and intersections, as well as sections on traffic calming features, traffic management elements, signals and signs, and other measures.
- AASHTO's *Guide for the Development of Bicycle Facilities*, originally published in 1999, will be updated in March 2009, and will include a major synthesis of state, local and national design guidance, referencing Texas, California (including the city of Davis), Florida, Idaho, Kansas City, Vermont, Washington State, and Wisconsin.

**California Guidance**

- California is a leader in bicycle-friendly communities and traffic calming, and particularly notable are the cities of Davis and Oakland, respectively.

**Other State and Local Guidance**

- Two significant pieces of state guidance being used for the Caltrans HDM revision include New Jersey's *Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities* and the *Massachusetts Highway Department Project Development & Design Guide*.
- Other leading states for the development of pedestrian and bicycle facilities include Massachusetts, Florida, Texas, Vermont, Oregon and North Carolina.

**Related Research**

- Reid Ewing and Robert Cervero's *Travel and the Built Environment* is a comprehensive synthesis of the effect of transit variables (including bus ridership and walk/bike share) on transportation network design variables, including the continuity of street networks and their access to stations and bus stops, proportions of four-way intersections and blocks with sidewalks, measures of walking quality, presence of bike paths, street layouts, number of signalized crosswalks between sites and stations, crosswalk and sidewalk widths, presence of trees, street lighting, ease of street crossing, sidewalk conditions, building setbacks, and parking-related site design variables.
- European infrastructure may hold lessons for the United States—see *Making Cycling Irresistible*.

## Gaps in Findings

There is a paucity of available research that systematically demonstrates the impact of the design of highways, streets and transit facilities on mode shifting and safety. The Nonmotorized Transportation Pilot Program is one of the first major undertakings addressing this shortage of data. According to NTPP Federal Director Gabe Rousseau, government priorities seem to be shifting toward providing more funding for such studies, and the NTPP may be expanded after its final report is submitted in 2011.

## Next Steps

Caltrans may want to consider:

- Monitoring the NTPP web site for ongoing results and resources, which are expected to be released incrementally before the final report to Congress in 2011.
- Contacting individual communities funded by the NTPP concerning their methods and implemented designs; communities have wide latitude in the kinds of infrastructure they may deploy using their grants.
- Looking to impacts of the built environment on physical activity and public health as an indirect means of measuring mode shift; see *Does the Built Environment Influence Physical Activity*? *Examining the Evidence*.

## Contacts

This report incorporates the results of discussions with the following individuals:

- Ronald L. Epstein, vice chair of AASHTO Standing Committee on Public Transportation (director of the New York State Department of Transportation Transit Bureau).
- Karla H. Karash, chair of TRB Public Transportation Group (vice president of TranSystems Corporation).
- Gabe Rousseau, FHWA Bicycle & Pedestrian Program Manager (see Research in Progress below).
- Kevin Herritt, Chief, Office of Geometric Design Standards, Division of Design, Caltrans.
- Dwight Kingsbury, Vice Chair of the AASHTO Joint Technical Committee on Nonmotorized Transportation.

Interviewees confirmed the scarcity of research documenting the effect of highway design on walking, bicycle and transit use and safety, and pointed to several of the Best Practices and Related Research documents summarized below.

Kevin Herritt, chief of the team reviewing the Caltrans Highway Design Manual, noted that it will likely be extensively rewritten (rather than receiving piecemeal modifications) to incorporate design guidance for pedestrian, bicycle, and transit facility design. Two significant pieces of state guidance being used for rewrite recommendations include New Jersey's *Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities* and the *Massachusetts Highway Department Project Development & Design Guide*, both of which are considered exemplary (see **Other State and Local Guidance**). A report with recommendations is due no later than the end of June 2009.

## Research in Progress

**Nonmotorized Transportation Pilot Program (NTPP)**
http://www.fhwa.dot.gov/environment/bikeped/ntpp.htm

Established through the 2005 Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (SAFETEA-LU), NTPP is providing $25 million to four communities (Columbia, MO; Marin County, CA; Minneapolis area, MN; and Sheboygan County, WI) to improve their walking and bicycling networks. The goal is to demonstrate how improvements to walking and bicycling infrastructure can increase mode share for walking and bicycling.

With this money, the communities have been working to introduce a network of nonmotorized transportation infrastructure facilities that connect directly with transit stations, schools, residences, businesses, recreation areas, and other community activity centers. "Before" data collection is underway in these communities and one control community. Researchers will collect data on the impacts of these programs and deliver findings to Congress. An Interim Report was submitted to Congress in January 2008, and the final report will be submitted in 2011. Subsequently, Congress may allocate funds to expand this program in a future transportation bill.

The final report will review changes in:

- Vehicle and transit use.
- Rates of walking and bicycling.
- Health and environmental measures.

Additional information:

- Pilot programs: http://www.smartmobility.us/
- Marin County, CA description of specific projects being implemented: http://www.walkbikemarin.org/projects.php

NTPP Federal Director Gabe Rousseau noted that this study is the first of its kind, with the only other study resembling it being the Sustrans project in the United Kingdom. This project performed a cost-benefit analysis of cycling and walking schemes via case studies in three English cities (see http://www.sustrans.org.uk/default.asp?sID=1164381904000).

**Best Practices Manual on Complete Streets**, expected completion December 2009
http://rip.trb.org/browse/dproject.asp?n=20316
This research project undertaken by the Federal Highway Administration will clarify and disseminate a number of the most effective tools and techniques for implementing complete streets planning processes and designing techniques.

## National Best Practices, Design Guides and Additional Resources

In this section we highlight reports issued by FHWA, NCHRP, TRB, AASHTO, the Transit Cooperative Research Program (TCRP) and the Federal Transit Administration (FTA) with regard to pedestrian and bicycle facility design and transit-oriented development.

### Bicycle and Pedestrian Facility Design

**AASHTO Guide for the Development of Bicycle Facilities,** 1999
http://www.sccrtc.org/bikes/AASHTO_1999_BikeBook.pdf
This guide provides information on developing bicycle facilities, including an extensive chapter on design. This chapter details recommendations for shared roadways, signed shared roadways, bike lanes, shared use paths, and other design considerations in order to encourage biking. Many states use this guide as their own manual for bikeway design details. In those states, towns and cities are expected to do so, as well.

This guide is being updated with an expected completion date of March 11, 2009, and will include a major synthesis of state, local and national design guidance: http://www.trb.org/TRBNet/ProjectDisplay.asp?ProjectID=417. A preliminary draft of recommendations is available here: http://www.trb.org/NotesDocs/20-07(187)_FR.pdf. Researchers performed a literature review and surveyed nearly 500 users of the existing AASHTO *Guide for the Development of Bicycle Facilities* to determine what additional information or revisions are necessary. The new guide will make use of select state, local and national design sources, including guidelines and plans from Texas, California (including the city of Davis), Florida, Idaho, Kansas City, Vermont, Washington State, and Wisconsin.

**AASHTO Guide for the Planning, Design and Operation of Pedestrian Facilities**, January 2004
https://bookstore.transportation.org/item_details.aspx?id=119
The purpose of this document is to provide guidance on the planning, design, and operation of pedestrian facilities along streets and highways. The guide focuses on identifying effective measures for accommodating pedestrians on public rights-of-way, and describes methods for accommodating pedestrians, which vary among roadway and facility types.

**FHWA: Bicycle and Pedestrian Provisions of Federal Transportation Legislation**, October 2008
http://www.fhwa.dot.gov/environment/bikeped/bp-guid.htm
This document summarizes "provisions to improve conditions for bicycling and walking and increase the safety of the two modes" in recent federal transportation legislation and "describes the range of opportunities to improve conditions for bicycling and walking."

**FHWA: Pedestrian Facilities Users Guide—Providing Safety and Mobility**, March 2002
http://ntl.bts.gov/lib/18000/18900/18916/PB2002103024.pdf
This guide provides useful information on how to identify safety and mobility needs and improve conditions for pedestrians within the roadway right-of-way. Highlights include:

- Chapters on pedestrian crash factors, selecting pedestrian safety improvements, and specifications for design of pedestrian facilities, roadways and intersections, as well as sections on traffic calming features, traffic management elements, signals and signs, and other measures.

- A chapter on implementation and resources and appendices with pedestrian facility case studies and recommendations for sidewalks, walkways and crosswalk installation.
- A chart mapping the effectiveness of 20 potential countermeasures for reducing the probability of various types of crashes. These countermeasures include curb extensions (which improve sight distance between pedestrians and motorists), pedestrian crossing islands, crosswalk enhancements, and others.
- A chart summarizing the usefulness of various designs for various objectives, including traffic speed and volume reduction, improved visibility and reduced exposure for pedestrians.

**FTA: Pedestrian- and Transit-Friendly Design: A Primer for Smart Growth,** 1999
http://www.fta.dot.gov/documents/ptfd_primer.pdf
This primer is based on *Pedestrian- and Transit-Friendly Design,* a manual prepared for the Florida Department of Transportation and the American Planning Association. Pedestrian- and transit-friendly features include short to medium-length blocks, transit routes every half-mile, two- or four-lane streets (with rare exceptions), continuous sidewalks, safe crossings, and appropriate buffering from traffic. The primer includes diagrams and specifications for each of these features.

**FHWA: Design Guidance Accommodating Bicycle and Pedestrian Travel: A Recommended Approach**, 2008
http://www.fhwa.dot.gov/environment/bikeped/Design.htm
This Website is a policy statement adopted by the United States Department of Transportation for the incorporation of bicycling and walking facilities into all transportation projects.

**FHWA: Designing Sidewalks and Trails for Access Part II: Best Practices Design Guide**, September 2001
http://www.fhwa.dot.gov/environment/sidewalk2/pdf.htm
This guidebook was created to provide planners, designers, and transportation engineers with a better understanding of how sidewalks and trails should be developed to promote pedestrian access for all users, including people with disabilities.

**FHWA: Selecting Roadway Design Treatments to Accommodate Bicycles**, 1994
This manual is designed to assist transportation planners and engineers in selecting roadway design treatments to accommodate bicycles

**NCHRP: Guidelines for Analysis of Investments in Bicycle Facilities**, 2006
http://trb.org/news/blurb_detail.asp?id=6093
This report was recommended by Dwight Kingsbury, Vice Chair of the AASHTO Joint Technical Committee on Nonmotorized Transportation, and focuses on developing guidelines to measure the benefits and costs in order to achieve four principal objectives:

1) To compare investments in bicycling with other modes.
2) To evaluate whether a bicycle facility is justified.
3) To choose the appropriate bicycle facility.
4) To better integrate cycling into the general transportation planning process.

The research described in the report has been used to develop a set of web-based guidelines, available online at http://www.bicyclinginfo.org/bikecost/, that provide a step-by-step worksheet for estimating costs, demands, and benefits associated with specific facilities under consideration.

**Built Environment Effects on Physical Activity**

**TRB: Does the Built Environment Influence Physical Activity? Examining the Evidence**, 2005
http://onlinepubs.trb.org/Onlinepubs/sr/sr282.pdf
FHWA Bicycle & Pedestrian Program Manager and NTPP Federal Director Gabe Rousseau noted that measuring public health in response to design changes is a useful component in understanding impacts, and recommended this report, which explores the need for further research as to how the built environment can facilitate or constrain physical activity. The report also reviews the broad trends affecting the relationships among physical activity, health, transportation and land use, and identifies priorities for future research. Mr. Rousseau also recommended

FHWA's resource page "Health and Environmental Benefits of Bicycling and Walking" (http://www.fhwa.dot.gov/environment/bikeped/benefits_research.htm).

**Selected FHWA National Bicycle and Walking Case Studies**, 1992-1994

**Analyses of Successful Provincial, State, and Local Bicycle and Pedestrian Programs in Canada and the United States: Bicycle Federation of America**, 1993
http://drusilla.hsrc.unc.edu/cms/downloads/CS18_SuccessfulPedinUSCanada_final1992.pdf
This report reviews the success of various bicycle and pedestrian programs. Indicators include increased bicycling and walking, accident reductions and user-friendly infrastructure.

**Traffic Calming, Auto-Restricted Zones and Other Traffic Management Techniques—Their Effects on Bicycling and Pedestrians**, 1994
http://safety.fhwa.dot.gov/PED_BIKE/docs/case19.pdf
The report reviews the history and traffic-calming techniques installed in Europe, Japan and the United States, and examines the practical and policy implication of traffic calming in light of these techniques.

**The Effects of Environmental Design on the Amount and Type of Bicycling and Walking: The Project for Public Spaces**, 1993
http://drusilla.hsrc.unc.edu/cms/downloads/CS20_EnvrDesign_BikeWalk1992.pdf
This report assesses the effectiveness of a wide range of bicycle and design improvements made in downtown environments in the United States since the 1960s, revealing broad principles concerning the successful and unsuccessful design of pedestrian- and bicycle-friendly environments.

**Transit-Oriented Development and Livable Communities**

**TCRP Report 102: Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects,** 2004
http://onlinepubs.trb.org/Onlinepubs/tcrp/tcrp_rpt_102.pdf
This study uses interviews with transit agencies, local governments, redevelopment agencies, metropolitan planning organizations, and state departments of transportation to examine the state of the practice and the benefits of transit-oriented development and joint development throughout the United States.

**FTA: Building Livable Communities with Transit. Planning, Developing, and Implementing Community-Sensitive Transit**, August 2006
http://www.fta.dot.gov/documents/Building_Livable_Communities.pdf
Across the United States, communities are becoming actively involved in enhancing the connections between transit and local quality of life. This booklet presents some successes – in terms of planning, programming, development and implementation – of the community-sensitive transportation facility development process. Although a comprehensive process is described here, not every project involves the full range of steps. By applying the techniques outlined in this booklet, transportation agencies, metropolitan planning organizations, local governments and communities can help achieve transportation goals beyond "asphalt, concrete and steel" to reap quality of life rewards involving the economic, social and environmental benefits of transit investments.

**NCHRP: Transit-Oriented Development: Developing a Strategy to Measure Success**, February 2005
http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rrd_294.pdf
This digest offers a strategy to systematically evaluate the potential success of transit-oriented development (TOD). The digest identifies and evaluates various indicators of the impacts of TOD, provides the results of a survey of TOD indicators, and identifies ten indicators that can be used to systematically monitor and measure impacts. The digest summarizes research conducted to determine the wide range of outcomes and benefits of TOD and looks at who is evaluating TOD across the United States, what are the most useful indicators, how difficult it is to collect data, and how often progress should be monitored. It concludes with suggestions for developing a strategy to monitor the success of TOD.

**FHWA Recommended Web Sites**

- http://www.walkinginfo.org/
- http://www.bicyclinginfo.org/

## California Guidance

### Bicycle and Pedestrian Facility Design

**Caltrans Highway Design Manual – Chapter 1000, Bikeway Planning and Design**, January 2006
http://www.dot.ca.gov/hq/oppd/hdm/pdf/chp1000.pdf
This manual includes criteria for selection of type of facility and design criteria for each: widths, clearance to obstructions, signing and delineation, intersections with highways, separation between bike paths and highways.

**Sacramento Transportation & Air Quality Collaborative Best Practices Reports**, October 2005

*Best Practices for Pedestrian Master Planning and Design*
http://www.ulisacramento.org/documents/tod/1.BestPractices/BP2.pdf
This report details pedestrian facility design best practices, and discusses such elements as corner radii, curb extensions, lighting, and methods for enhancing walkability.

*Best Practices for Complete Streets*
http://www.completestreets.org/documents/CA_SactoBestPractices.pdf
This report suggests complete streets design guidelines using examples from Sacramento, CA, and Eugene, OR; it includes guidance on including traffic calming measures, street width, block length, connectivity, and pedestrian and bicycle amenities.

**Pedestrian and Bicycle Facilities in California: A Technical Reference and Technology Transfer Synthesis for Caltrans Planners and Engineers**, July 2005
http://www.dot.ca.gov/hq/traffops/survey/pedestrian/TR_MAY0405.pdf
The primary purpose of this document is to provide the staff of the California Department of Transportation with a synthesis of information on non-motorized transportation. Relevant federal and state statutes and policies are summarized, along with the Caltrans planning process, regional and local planning efforts, and the project development process including facility design.

**Evaluation of Pedestrian Safety Policies and Practices on California State Highways**, 2001
This document contains the nationwide best practices related to pedestrian transportation and safety. Contributions to the best practices included 50 state departments of transportation, the 50 largest U.S. cities, and 12 metropolitan planning organizations. The document also presents a review of current practices of the California Department of Transportation and compares them to other best practices. In addition to general recommendations, specific recommendations are given regarding practices that Caltrans should maintain, study and implement.

**Davis, California Bicycle Master Plan**, 2006
http://cityofdavis.org/pw/pdfs/2006_BikePlan_withMaps.pdf
According to the League of American Bicyclists, California has more bicycle-friendly communities than any other state, with Davis one of only three cities (along with Portland, OR, and Boulder, CO) receiving a platinum rating. Appendix 2 includes design standards for bicycle facilities, including coordination with other transportation modes.

**City of Oakland Pedestrian Master Plan**, 2002
http://www.oaklandnet.com/government/Pedestrian/index.html
The city of Oakland has a thorough Pedestrian Master Plan with an extensive chapter on design:
http://www.oaklandnet.com/government/Pedestrian/Ch_5.pdf

### Transit Oriented Development and Livable Communities

**Travel Characteristics of Transit-Oriented Development in California,** Hollie Lund, Robert Cervero and Richard Willson, January 2004.
http://www.csupomona.edu/~rwwillson/tod/Pictures/TOD2.pdf
APA Presentation April 26, 2004: http://www.csupomona.edu/~rwwillson/tod/APApres_files/frame.htm
Data were collected from sites along light, heavy, and commuter rail lines in California's four major regions. Findings demonstrated that TOD residents, TOD office workers, and hotel patrons in TODs all use rail transit more frequently than the average for the same cities.

## Other State and Local Guidance

### Bicycle and Pedestrian Facility Design

***Massachusetts***
**Massachusetts Highway Department Project Development & Design Guide**, 2007
This guide is one of the most highly esteemed state transportation manuals, and is one of the documents being used by Caltrans in the rewrite of its Highway Design Manual: http://www.vhb.com/mhdGuide/mhd_GuideBook.asp

**Cambridge Pedestrian Design Guidelines**, 2000
Cambridge, MA, has the highest pedestrian commuting rate in the United States, and has an extensive pedestrian design guide: http://www.cambridgema.gov/~CDD/et/ped/pedplan/ped_plan_c3.pdf

***Florida***
**Florida Department of Transportation Pedestrian Planning & Design Handbook**, 1999
http://www.dot.state.fl.us/safety/ped_bike/ped_bike_standards.shtm
Florida has done significant work in developing its own bicycle and pedestrian facility design guidelines:

- Bicycle Facilities Planning and Design Handbook: http://www.dot.state.fl.us/safety/ped_bike/ped_bike_standards.shtm#FloridaBike%20Handbook
- Pedestrian Planning and Design Handbook: http://www.dot.state.fl.us/safety/ped_bike/handbooks_and_research/PEDHBTOC.PDF

**Best Practices in State Bicycle and Pedestrian Planning**, 2005
http://www.coss.fsu.edu/durp/sites/coss.fsu.edu.durp/files/Best_Practices_Guide_2005.pdf
This report includes a literature review concerning bicycle and pedestrian safety, accessibility, and mobility in order to identify empirically-proven best practices, as well as a review of bicycle and pedestrian plans in other states to determine established practices and experimental initiatives in place throughout the country. The report concludes that while it appears that factors in the built environment are associated with mode shift and safety, more study and more evidence is necessary to confidently determine which interventions work in particular situations.

**Other plans from states and localities with leading bicycle and pedestrian programs**

- Vermont: http://www.aot.state.vt.us/progdev/Documents/LTF/FinalPedestrianAndBicycleFacility/PedBikeTOC.html
- Oregon: http://www.oregon.gov/ODOT/HWY/BIKEPED/planproc.shtml
- North Carolina: http://www.ncdot.org/transit/bicycle/safety/programs_initiatives/Transportation_Plans/Transportation_Plan_Template.pdf
- Austin, TX: http://www.ci.austin.tx.us/bicycle/downloads/sstf_appendix_c.pdf
- San Francisco, CA: http://sfgov.org/site/frame.asp?u=http://www.sfmta.com/cms/bhome/homebikes.htm

### Transit Oriented Development and Livable Communities

*New Jersey*
**Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities**, 2008
http://www.dvrpc.org/asp/pubs/reports/08030A.pdf
New Jersey is the leading state in making advances in public transit. This guidebook, the result of a collaboration between the New Jersey and Pennsylvania departments of transportation, is one of the most well-regarded in its area, and is one of the documents being references in the rewrite of the California Highway Design Manual. It emphasizes context-sensitive roadway design to address transportation challenges and foster sustainable communities. It includes guidelines on designing and planning non-limited access roads and highways—from local streets through multi-lane highways. Although the publication reflects local conditions in New Jersey and Pennsylvania, it is based on many design principles that can be applied universally.

## Related Research

### Pedestrian and Bicycle Facilities

**Context Sensitive Solutions, Bicycles and Pedestrians: Some Lessons Learned in New England**, Lisa Aultman-Hall, Chapin Spencer, Amy Bell, TRB 2008 Annual Meeting CD-ROM, 2008
Speakers at this conference presented a series of case studies in order to evaluate what factors led to successful bicycle and pedestrian transportation improvements during a range of design processes.

**Travel and the Built Environment: A Synthesis**, R. Ewing, R. Cervero, *Transportation Research Record 1780*, 2001: 87-114.
This article is a major synthesis of the effect of the built environment on travel, and includes a chapter that synthesizes studies measuring changes in transit variables (including bus ridership, walk/bike share, etc.) as a function of transportation network design variables including the continuity of street networks and their access to stations and bus stops, proportions of four-way intersections and blocks with sidewalks, measures of walking quality, presence of bike paths, street layouts, number of signalized crosswalks between sites and stations, crosswalk and sidewalk widths, presence of trees, street lighting, ease of street crossing, sidewalk conditions, building setbacks, and parking-related site design variables.

The major conclusion of the article is that "If urban design features have any effect on travel, independent of land use and transportation variables, it is likely to be a collective effect involving multiple design features. It may also be an interactive effect involving land use and transportation variables." Further, "Given the disparate indices tested and the mixed results, what exactly constitutes transit friendliness or walking quality remains unclear, and its relationship to travel choices remains equally unclear. This is an area requiring much more empirical testing and replication of results."

**Complete Streets: We Can Get There from Here**, John LaPlante, Barbara McCann, *ITE Journal* Vol. 78 No. 5: 24-28, May 2008.
This article explores ways to make urban thoroughfares more complete, focusing on processes for the planning, designing, construction and operation of roadways. These processes include techniques for designing an arterial street that can control traffic speeds and permit more comfortable and safe pedestrian and bicycle access via calming measures that include narrower travel lanes, road diets, tightening corner curb radii, eliminating free-flow right-turn lanes, and making pedestrian crossing locations more safe, comfortable and frequent.

**Retrofitting Urban Arterials into Complete Streets**, John LaPlante, 3rd Urban Street Symposium: Uptown, Downtown, or Small Town: Designing Urban Streets That Work, 2007.
This paper explores ways to make urban thoroughfares more pedestrian and bicycle friendly and respectful of the surrounding community, while not unduly compromising motor vehicle travel. The major culprit in incompatible urban arterial street design is equating high speed with roadway mobility and capacity. Techniques for designing an arterial street that can control traffic speeds, thus permitting more comfortable and safe pedestrian and bicycle access, are described.

**Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany**, John Pucher, Ralph Buehler, *Transport Reviews* Vol. 28 No. 4: 495-528, July 2008.
http://policy.rutgers.edu/faculty/pucher/Irresistible.pdf
This article shows how the Netherlands, Denmark and Germany have made bicycling a safe, convenient and practical way to get around their cities. The key to achieving high levels of cycling appears to be the provision of separate cycling facilities along heavily traveled roads and at intersections, combined with traffic calming of most residential neighborhoods. For comparison, the article portrays the marginal status of cycling in the United Kingdom and the United States, where only about 1 percent of trips are by bike.

**Sensitive Solutions for Changing Times**, John L. Flint, Dennis J. Decker, Dennis J. Kennelly, *CE News* Vol. 19 No. 7: 24-27, August 2007.
http://www.cenews.com/article.asp?id=2255
This article provides an overview of the history and techniques for context-sensitive solutions (CSS), including widened curb lanes and designated bike lanes, bump-outs at intersections, reduced speeds and increased access. Transportation planners and designers are increasingly asking questions concerning accommodating bicycles on the roadway, whether widening sidewalks is effective, pedestrian safety improvements and slowing traffic (among others). Key in CSS is the use of techniques such as widened curb lanes and designated bike lanes; bump-outs at intersections; combination street and pedestrian pole lighting; roundabouts; widening downtown sidewalks (with a minimum width of 6 feet and a preferred width of 8 feet); traffic calming through use of narrowed travel lanes, lighting and well-defined access points; continually evolving techniques that comply with the Americans with Disabilities Act; and selection of materials reflecting the architectural style and urban fabric of the surrounding area. The article concludes with a useful list of CSS resources.

**Bridging the Gaps: How Quality and Quantity of a Connected Bikeway Network Correlates with Increasing Bicycle Use**, Mia Birk, Roger Geller, TRB 85th Annual Meeting, 2006.
Data collected by Portland demonstrates a strong correlation between a connected, bikeway system constructed to the highest standards, and increases in bicycle use. The authors believe that the city's investments in specific facility improvements to its downtown Willamette River bridges, as well as to key bridge access routes and connections, have been the primary impetus behind increasing bicycle use.

**Reassessing On-Street Parking**, Wesley W. Marshall, Norman Garrick, Gilbert Hansen, *Transportation Research Record 2046*, 2008: 45-52.
This study explores the effect of on-street parking on street walkability. It focuses on addressing the basic question of safety in a more precise way than previous studies by taking into account actual vehicle speeds and crash severity levels. The investigation points to on-street parking playing a crucial role in lowering speeds and reducing crash rates and fatalities (streets with on-street parking also had the lowest fatal and severe crash rates of any road category in the study of 250 Connecticut roadway segments). Results suggest that streets with on-street parking are safer and more walkable.

**Parking And Pedestrians: Balancing Two Key Elements in Downtown Development**, K. A. Robertson, *Transportation Quarterly* Vol. 55 No. 2: 29-42, 2001.
This article discusses the characteristics, problems, and strategies associated with downtown pedestrians and parking, and advocates an integrated approach to balance the needs of pedestrians and motorists. The keys to

achieving this balance are: 1) finding appropriate locations for off-street parking lots and garages that do not impede pedestrian flow, and 2) designing parking areas that are sensitive to pedestrians and facilitate pedestrian connections.

**Shared-Use Streets – An Application of "Shared Space" to an American Small Town**, Celeste Gilman, Robert Gilman, 3rd Urban Street Symposium: Uptown, Downtown, or Small Town: Designing, 2007.
This paper presents a case study in which a city anticipating growth is implementing design standards to support all users and modes. The city will use "shared-use" streets that mix pedestrians, bicyclists, and drivers in a low-speed environment that emphasizes the community function of the street. Precedent for shared-use streets comes from the European "shared space" movement, which differentiates between the traffic world (the highway) and the social world (streets within a town). Traffic-world features (traffic signals, lane markings, etc.) are removed within the town. Streets are instead designed as public spaces, providing strong contextual cues to drive slowly and carefully while implementing features that support safe and enjoyable use by walkers, bikers, and others.

**Transit Facilities**

**Building Transit Oriented Development in Established Communities**, S. J. Hendericks, J. Goodwill, National Center for Transit Research; Florida Department of Transportation; Research and Special Programs Administration, November 2002.
This report provides a literature review, five case studies of communities that have taken steps to become transit oriented, and guidance for the use of transit-oriented design, including ensuring pedestrian and bicycle access. Several approaches are identified, such as the use of transit oriented design, focusing transit oriented development (TOD) around park and ride lots, predesignating transit corridors, ensuring pedestrian and bicycle access, adapting transit services to the needs of suburban communities, and ideas for dealing with community resistance toward applying transit friendly measures to car oriented communities.

**Does Transit-Oriented Development Affect Metro Ridership? Evidence from Taipei, Taiwan**, Jen-Jia Lin, Ting-Yu Shin, *Transportation Research Record 2063*, 2008: 149-158.
This study analyzes the use of transit-oriented development for increasing transit ridership and dispersing transit ridership distribution in a timely manner. Results of an analysis of 46 metro stations in Taipei City, Taiwan, China showed that daily ridership was positively affected by the floor-space area of the station areas, negatively affected by the percentage of four-way intersections, and insignificantly affected by mixed land use. The influences of density and pedestrian-friendly urban design on daily ridership differ significantly between weekdays and weekends.

**BRT Stations: What Matters? What's Important?**, Cliff Henke, 2008 American Public Transportation Association (APTA) Bus & Paratransit Conference, 2008.
This paper addresses the design features of Bus Rapid Transit (BRT) stations and their impacts on overall system performance, particularly with respect to ridership and economic development. Examples of good station design are also presented.

**Development-Oriented Transit Emphasizes Station Design**, G. B. Arrington, *Metro* Vol. 100 No. 5, June 2006.
Development-oriented transit (DOT) is a variation on the concept of transit-oriented development (TOD) that concentrates on designing transit stations to be more fully integrated into the community and more accessible to bicyclists and pedestrians. Various design possibilities are discussed, including eliminating parking around a transit hub, and dispersing parking lots throughout the neighborhood so that the station is not cut off from pedestrians and bike users.

**Transit-Oriented Development and Joint Development in the United States: a Literature Review,** Robert Cervero, *TCRP Research Results Digest 52*, October 2002.
This review organizes research findings on TOD into chapters that cover: definitions; institutional issues such as collaboration, government and transit agency roles and community outreach; supportive public policies, including tax policies, zoning, and long range planning; successful design characteristics; and evaluation of impacts and benefits.

**Developing Transit Station Design Criteria with a Focus on Intermodal Connectivity**, Geophrey Mbatta, Thobias Sando, Ren Moses, *Journal of the Transportation Research Forum*, Vol. 47 No. 3: 2008.
This paper presents a procedure that could be used to develop transit station design criteria and guidelines with a focus on intermodal connectivity. The proposed procedure is appropriate for high-capacity transit systems, including rail and bus rapid transit. The design guidelines focus on ensuring safety, seamlessness and comfortable use. The procedure proposed in this paper is inclusive of all user groups, including people with disabilities. Although the proposed procedure was developed for transit stations in Florida, it can be used by any transportation planners and engineers when developing and evaluating transit station designs.