NCHRP 15-48: DRAFT FINAL REPORT

Guidelines for Designing Low- and Intermediate-Speed Roadways That Serve All Users

Prepared for:
National Cooperative Highway Research Program
Transportation Research Board
of
The National Academies

by

Marshall Elizer, P.E., PTOE
Principal Investigator
Gresham, Smith and Partners

with

Midwest Research Institute

Alta Planning and Design

November 17, 2017

ACKNOWLEDGMENT OF SPONSORSHIP

This work was sponsored by the American Association of State Highway and Transportation Officials and was conducted in the National Cooperative Highway Research Program, which is administered by the Transportation Research Board of the National Academies.

DISCLAIMER

This is the Final Report prepared under NCHRP 15-48, '*Guidelines for Designing Low- and Intermediate-Speed Roadways that Serve All Users*' as submitted by the research agency. The opinions and conclusions expressed or implied in this memorandum are those of the research team. They are not necessarily those of the Transportation Research Board, the National Academies, or the program sponsors.

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ABSTRACT

Roadway designers, strive to provide for the needs of highway users while maintaining the integrity of the surrounding context, community values and environment. Unique combinations of design requirements controls and constraints that are often conflicting among different roadway users will require unique design solutions. The guidance supplied by the Guidelines document (Design Guide for Low-Speed Multimodal Roadways, hereinafter referred to as "Guide") developed in this project is based on established best practices and is supplemented by recent research where possible.

The intent of this Guide product is to provide best practice guidance to the designer by referencing a range of acceptable elements, criteria and values for critical dimensions in the design of low- to intermediate-speed (45 mph and lower design speed) roadways with a mix of users. Good design involves balancing safety, mobility, and preservation of scenic, aesthetic, historic, cultural, and environmental resources. The Guide provides extensive information and guidance for multimodal design, but is not intended to be a detailed design manual that eliminates the need for the application of sound principles by the knowledgeable design professional.

The Guide produced in this project is intended to assist designers in establishing a balance between the operational efficiency, comfort, safety, and convenience for modes on the low- and intermediate-speed roadways. Context sensitivity and environmental quality are also key considerations in the design process and should result in aesthetic consistency with the surrounding terrain or urban setting as appropriate to create roadways that are safe and efficient for users, acceptable to non-users, and in harmony with the environment.

1. Purpose of DRAFT Final Report

The purpose of this DRAFT Final Report is to provide NCHRP and the Project Panel with work product summaries for Phase I of the project (Tasks 1, 2, 3, 4, 5 and 6) as outlined in the project's Amplified Work Plan, and then the products delivered in Phase II of the project.

The material included in this report has built on the information provided in the Interim Report, both in response to comments from the Project Panel and to reflect further considerations on the part of the research team.

Briefly, the objectives of the first six (6) tasks included in Phase I are as follows:

Task 1 - The objective of Task 1 is to summarize the state of the knowledge and state of the practice in designing for safety and efficient travel of all users along low- and intermediate-speed roadways. This is being accomplished by conducting a thorough review of relevant literature and conducting a survey of state and local roadway design agencies.

Task 2 - The objective of Task 2 is to identify performance measures that will help designers accommodate all users in the design of low- and intermediate-speed roadways. Performance measures provide procedures and tools for comparing and evaluating alternative designs with respect to meeting overall project goals and objectives.

Task 3 - Building upon the findings of the literature review and agency survey in Tasks 1 and 2, Task 3 has developed a range of alternative approaches that could assist designers and other design project stakeholders in the process of coordinating, balancing and "optimizing" the geometric design elements of a roadway project in low- and intermediate-speed environments.

Task 4 – In this task the research team has evaluated the methodologies developed in Task 3 against the full range of facility types and speed ranges that can be encountered in the design process for low-speed and intermediate-speed roadways. The goal of this task was to find the best balance of roadway classifications, speed ranges and user types around which to build the specific final work plan in Task 5 which will guide creation of the ultimate research product, the design guidelines document.

Task 5 – In Task 5 the research team has developed a recommended work plan to be executed in developing the guidelines document in Phase II of the project. The plan includes a recommended DRAFT table of contents for the guidelines document along with an example guidelines section on vehicle lane widths. The guidelines will address the methodologies for combining qualitative and quantitative performance measures across user types/modes and context for use in evaluating alternative designs for low- and intermediate-speed roadways. The research team would revise these products based on comments from the Panel and be included in the updated work plan for Phase II.

Finally, the recommended work plan would develop a prioritized list of gaps in current knowledge and research associated with multimodal performance measures and design criteria across user types/modes.

Task 6 – This task included finalizing the Interim Report and Updated Work Plan for Phase II as provided by this Preliminary Draft Interim Report and subsequent direction from the project Panel and TRB. The final Interim Report will describe the work completed in the Phase I tasks and also include the updated Work Plan for Phase II of the project. The research team was not to begin work on any Phase II tasks until the updated work plan was approved by NCHRP.

Phase II of the project included Tasks 7 through 9 and described below.

Task 7: This task involved developing the Phase II Work Plan based on comments received from NCHRP and the Project Panel on the Interim Project Report. These comments were received in writing and also generated at a full-day work session held in Washington, D.C., on February 3, 2016.

The research team developed the recommended approach and schedule to be executed in developing the guidelines document and project final report in Phase II of the project. This approach, as outlined below, was approved by the NCHRP Project Manager and Project Panel in March, 2016.

Task 8 – This task involved developing the Preliminary and Revised Draft Guidelines document.

Step 1: Develop DRAFT Guidelines Document

The research team used the feedback and guidance provided by the Panel in their review of this document and the DRAFT Interim Report to develop the DRAFT Guidelines document consistent with the approved Table of Contents and example section module.

Step 2: PRELIMINARY DRAFT Guidelines Review by NCHRP, Panel & Selected Agencies

The DRAFT guidelines document was simultaneously shared for review and comments with NCHRP staff and the Project Panel in May of 2017. The initial goal was to also share the document with three selected state or local roadway agencies, followed by focus groups with three reviewing agencies to discuss their overall reaction to the effectiveness and usefulness of draft guidelines document. Due to schedule and budget concerns, the on-site agency focus group reviews were eliminated from Step 2 and replaced with written agency reviews. Written comments were received by the research team in June and July, 2017.

Step 3: Revise PRELIMINARY DRAFT Guidelines to REVISED Document

In this step the Research team responded to all written Panel comments and updated the PRELIMINARY DRAFT Guidelines document to reflect the feedback given by the Panel, NCHRP staff and reviewing agencies. The resultant document was titled the REVISED PRELIMINARY DRAFT Guidelines document and submitted for NCHRP staff and Panel review in August, 2017.

Task 9

Step 1: REVISED DRAFT Guidelines Review by NCHRP and Panel

In this step the Revised Draft Guidelines document was reviewed by the Panel and additional comments received in September 2017. A conference call was held with NCHRP staff and Panel members in October 2017 to discuss the major outstanding comments in order to develop revisions to the FINAL Guidelines document.

Step 2: Final Guidelines and DRAFT Final Report Review by NCHRP and Panel

In this step, the final proposed revised versions of the Guidelines and the Final Report were submitted for review. Any comments were addressed and revised FINAL documents re-submitted to NCHRP for processing and publishing.

2. Background

The process of roadway geometric design should effectively provide an appropriate balance of service and safety for all the users the roadway and its right-of-way intends to serve. An effective roadway design must obviously consider motor vehicles of many types, such as passenger vehicles and trucks, but it must also often accommodate transit vehicles and non-motorized travelers (where legally allowed to travel) such as pedestrians and bicyclists. These other categories of users may be present at the time of design, or they may be planned for some point in the future. Increasingly, roadway designs in urban areas are being tasked with accommodating transit-ways for light rail transit, streetcars and bus rapid transit.

Roadway geometric design in urban and suburban areas is often further complicated by limited rights-of-way that must accommodate a wide range of other features including underground and above-ground utilities, stormwater systems, traffic control devices, trees and landscaping, street furniture and a range of other urban uses. AASHTO's 2011 edition of *A Policy on Geometric Design of Highways* and *Streets* (Green Book) recognizes these needs and challenges through its many references to the need to coordinate and balance roadway geometric design with other uses of the right-of-way. The Green Book also speaks frequently of the need for geometric design to support and coordinate with the context of adjacent land use and community plans through the use of design flexibility where appropriate.

Although AASHTO's Green Book and other roadway design guidance recognizes the need to consider and safely serve all users and adjacent land use context, it provides limited specific guidance on how designers should evaluate and balance their requirements and needs during the traditional roadway design process. This guidance is especially critical in urban and suburban areas where a broad mix of roadway users are more prevalent and much of the principal roadway system has design speeds in the low-speed (35 mph or less) to intermediate-speed (40-45 mph) ranges. AASHTO policy considers the upper limit for low-speed design (i.e., design speed) is 45 mph, and the lower limit for high-speed design is 50 mph.

2.1 Project Purpose

The geometric design profession has recognized for quite some time that a more comprehensive and "multimodal" roadway design process is needed in order to effectively address the challenges and needs discussed above. Numerous research projects have been conducted regarding the importance of designing for safe and efficient travel of all user modes along a roadway facility. In addition, the latest edition of the *Highway Capacity Manual* (2016) along with other research has developed alternative approaches to assessing multimodal levels of service (MMLOS). This guidance provides for an integrated multimodal approach to the analysis and evaluation of urban streets from the points of view of automobile drivers, transit passengers, bicyclists, and pedestrians. It also addresses the proper application of micro-simulation analysis and the evaluation of those results to help guide multimodal design decisions. Unfortunately, these tools and guidance have not been widely accepted nor used by the roadway design profession.

Although various MMLOS techniques exist, little established practical engineering design guidance exists on how to more effectively integrate and balance the service to all transportation modes along a roadway segment or corridor or within an intersection. Most available geometric design guidance has been founded on safety and efficiency considerations of vehicular users and does not fully address or incorporate the other transportation modes that may be present and need to be accommodated. Little information is documented regarding a methodology to comprehensively assess the safety, operational, and usability impacts of a comprehensive roadway design process that helps the designer understand and assess trade-offs in balancing roadway design features, controls and criteria for multi-modal facilities across low- and intermediate-speed ranges. User needs and priorities can vary by many factors in any given design project, including roadway functional classification, roadway operating speed, current and projected user demand, adjacent land use context, community goals and more.

Another important consideration and justification for this research project is that pedestrians and cyclists are involved in a disproportionate number of serious injury and fatal collisions at intersections because of their vulnerability. Allocation of space within the right-of-way and roadway for sidewalks, bicycle lanes, separated bikeways, crosswalks, islands, median refuges, transit shelters and other features can address these needs but may also reduce or conflict with space for motor vehicles. All of these factors present designers with a challenge to create roadway geometric designs that adequately recognize and provide for a mix of transportation modes and trip types, as well as reflect the balance of priorities that each user group desires. For many low- and intermediate-speed situations in particular, the integration of multimodal features are difficult to evaluate and in fact are often mutually-exclusive.

Finally, the research problem statement identified the following items to be considered in the development of the guidelines:

- User groups and their needs;
- Livable, sustainable community concepts;
- Accessibility:
- Performance metrics addressing operations and safety;
- Best practices for developing design policies, including those of local government;
- Best practices for implementation of multimodal projects;
- "Complete streets" concepts;
- Constraints, e.g., right-of-way, roadside features, environmental, etc.;
- Balance among principal elements of design;
- Flexibility through:
    - Allocation of cross section design elements;
    - Use of design exception process;
    - Use of low cost options;
- Use of geometric design and traffic control elements to create optimum roadway operation and safety for all users;
- Use of TRB's *Highway Capacity Manual* and AASHTO's *Highway Safety Manual*, including intermodal chapters;
- Consistency with AASHTO, TRB, and ITE references; and
- Use of graphical illustrations.

This NCHRP 15-48 research project is intended to develop a geometric design methodology and design guidelines that result in:

(1) roadway designs that serve the full range of users of each roadway functional classification in the low- and intermediate-speed categories, and

(2) an assessment process that identifies how to best serve the mix of users found in each classification and speed range.

The final recommended design process is intended to help the designer fit a balanced geometric design into roadways and contexts of all types, but particularly those in challenging contextual environments with limited right-of-way, presence of multimodal demand and many other design challenges typically encountered in urban and suburban transportation networks.

2.2 Current Challenges

Improving pedestrian, bicycle and transit access and safety along and across roadways - especially urban roadways - is receiving increased national and international attention. Non-motorized travel is playing a growing role in the development of livable, healthy and sustainable communities. Livable and sustainable communities are both key policy initiatives for the U.S. DOT (in partnership with U.S. HUD and the EPA) as well as for AASHTO's Center for Environmental Excellence and for many state, regional and local agencies.

Many new and unique geometric design treatments aimed at enhancing pedestrian and bicycle mobility and safety have been developed in the U.S. and abroad and increasingly applied on various State, Federal-aid and local roadways throughout the U.S. In addition, many urban communities are reinvesting in their transit systems, not only in traditional bus systems but also streetcars, trolleys, light rail and bus rapid transit (BRT) that are integrated into roadway environments.

These transit systems and facilities can create unique challenges for roadway designers, particularly when these transit facilities and operations are integrated into the street environment in mixed traffic lanes or in adjacent separated running ways. AASHTO has recognized and responded to these trends by the recent development of a new publication, *Guide for Geometric Design of Transit Facilities on Highways and Streets* (2014). The National Association of City Transportation Officials (NACTO) has also developed *The Transit Street Design Guide* released in 2016. The importance of effectively considering transit in the geometric design process is explained in the following excerpt from the Introduction chapter of the AASHTO transit facility design guide document:

> *Public transportation is important to communities in contemporary America. It provides high passenger capacities in heavily-traveled corridors, and allows high employment concentrations in city centers. It permits compact urban developments that are pedestrian friendly, and helps reinforce urban design objectives. It provides mobility for people that are unable to drive or do not have access to motor vehicles. From an environmental perspective,*

it has lower emissions and energy consumption on a per-capita basis than personal motor vehicles.

Transit vehicles operate in a wide range of environments—both on-street and off-street. Commuter rail and rapid transit operate in exclusive rights-of-way that are frequently grade-separated from intersecting roadways. However, buses, light rail, modern streetcar and trolley operations may share or intersect with the street environment.

Streets and highways often must accommodate transit vehicles as well as motor vehicles, bicyclists, and pedestrians. Transit provisions are best accomplished when incorporated into all phases of street planning, design, and operation. This is essential especially where agencies at the state, county, and municipal level are required to plan, design, or modify streets and highways to accommodate public transportation vehicles and facilities.

As a result of U.S. trends in walking, bicycling and transit use, there is clearly a need for this research project to develop a methodology and guidelines for the most effective application of such integrated and often complex design solutions, especially on lower- and intermediate-speed facilities in urbanized areas where higher levels of walking, bicycle and transit activity are often present. These guidelines will also be appropriate for use in small and/or rural communities where walking and biking are important elements of their main street designs.

2.3 Trends in Walking, Bicycling and Transit Use

To better understand current trends in bicycling and walking travel modes in the United States and how those trends may impact and influence future roadway design practices, the following information has been taken from APTA and the report Bicycling and Walking in the United States: 2014 Benchmarking Report, published by the Alliance for Biking and Walking.

LEVELS OF BICYCLING AND WALKING

The most recent nationwide data on bicycling and walking mode share show that only 1.0% of all trips taken in the U.S. are by bicycle, and 10.4% are on foot according to the 2009 National Household Travel Survey (NHTS). Of commuters nationwide, 2.8% get to work by walking and 0.6% get to work by bicycle. These numbers are slightly higher in large cities (5.0% and 1.0%, respectively). Though these numbers are low, they represent a continuing gradual increase in bicycling and walking in the U.S. Among large cities, Portland, Oregon, has the highest bicycle commuting rate at 6.1 percent.

Partially due to the current lack of data on bicycling and walking numbers, many states and cities conduct their own counts to find out their local mode share. Of the 52 most populous cities surveyed, 43 have completed counts of bicyclists and 37 have completed counts of pedestrians. Thirty-eight states have conducted counts on bicyclists and 36 states have counted pedestrians. States and cities conduct their counts at varying times and frequencies, making it difficult to compare results consistently.

The 2014 benchmarking survey, which collected 2011/2012 data, recorded three types of counts in particular: commuter counts, household surveys, and cordon counts (see **Exhibit 2-1**). Cordon counts are conducted to track the number of travelers who cross a specified line into or out of a designated area, such as a neighborhood or downtown that is "cordoned off." In addition to these, many cities have also conducted other types of counts including installing automated counters and outdoor video cameras, and other types of "spot" counts, which are included in this updated report.

Exhibit 2-1: Overview of U.S. Mode Share – 2014

Mode of Travel	% of Commuters		% of All Trips Nationwide (3)
	Nationwide (1)	52 Large U.S. Cities (2)	
Pedestrian	2.8%	5.0%	10.4%
Bicycle	0.6%	1.0%	1.0%
Transit	5.0%	17.2%	2.2%
Vehicle (4)	91.6%	76.7%	86.4%
All Modes	100%	100%	100%

Sources: (1) ACS 2011 (2) ACS 2009–2011 (3) NHTS 2009 **Notes**: The term "mode share" is used to describe the percentage of all trips or percentage of trips to work by each mode of transportation. (4) This includes trips by private car and "other" means that are not public transportation, bicycling, or walking—such as taxi, motorcycle, recreational vehicle, school bus, etc.

CONNECTING TO TRANSIT

The American Public Transit Association (APTA) notes these statistics regarding the growth and use of transit systems in the United States includes:

- In 2013, Americans took about 10.7 billion trips on public transportation -- the highest in 57 years;
- People access and board public transportation 35 million times each weekday;
- Since 1995, public transit ridership is up 37.2 percent, outpacing population growth, which is up 20.3 percent, and vehicle miles traveled (VMT), which is up 22.7 percent; and
- More than 7,200 organizations provide public transportation in the United States.

Over 90% of people who use public transit walk or bike to reach transit stops (Pucher, et al. 2011). In the most populous U.S. cities, 17% of commuters use public transportation to get to work. The benchmarking report shows how improving facilities for bicyclists and pedestrians can help make those connections to public transit more accessible.

Providing system designs for bicyclists and pedestrians comes in many forms including installing bicycle racks on buses, providing safe and secure bicycle parking, and ensuring safe and convenient sidewalks and crosswalks to transit stops. All of the large cities studied in this report have bicycle racks on their buses, except for New York City. Thirteen cities allow an unlimited number of bicycles on their trains. In addition,

several cities in recent years have removed-restricted hour’s policies for bicycles on trains.

HEALTH AND SAFETY

This report shows the relationship between bicycling and walking to work and several health indicators. Levels of diabetes, high blood pressure, and obesity are all lower in cities with higher shares of commuters bicycling or walking to work. Likewise, where commuters bicycle or walk to work in higher shares, more of the population is meeting the recommended amount of weekly physical activity.

Safety, too, has a close relationship with bicycling and walking levels. In cities where a higher percent of commuters walk or bicycle to work, corresponding fatality rates are generally lower. This is in contrast to critics who fear a higher rate of crashes when more bicyclists and pedestrians use the roadway.

Though bicycle and pedestrian fatalities have seen a slight increase in recent years, the long-term trend is a clear decline. Since 1980, the national pedestrian fatality rate fell from 3.6 fatalities per 100,000 people to 1.4 fatalities per 100,000 people in 2011. Though not as dramatic a drop, the bicyclist fatality rate also decreased, from 0.4 fatalities per 100,000 people in 1980 to 0.2 fatalities per 100,000 people in 2011.

However, some cities have much higher rates of bicycle and pedestrian fatalities. Both Detroit and Jacksonville have pedestrian fatality rates over 4 per 100,000 people. These two cities, as well as Fort Worth, also have the highest bicyclist fatality rates—all see more than three fatalities per 100,000 people.

ECONOMIC BENEFITS

Increasingly, cities and states are publishing studies that show the economic benefits of increases in bicycling, walking and transit use. This benchmarking report provides an overview of some of the most recent studies, which show the positive impact on job growth, individual transportation costs, retail sales, traffic congestion, air quality, property values and stability, health and worker productivity, and events and tourism.

Twenty-two states, ten of the 52 most populous cities, and five of the midsized cities have conducted related economic impact studies. Most of these studies looked at the impact of bicycling, but other studies show the impact of walking and trails. Washington state and New York City have also studied the economic impact of car-free zones.

POLICIES AND FUNDING

Since 2010, 11 states and 12 of the 52 most populous cities have added new goals to increase bicycling and walking, or to decrease bicycle and pedestrian fatalities. Overall, 88% of states and 90% of the most populous cities currently report having at least one of these goals. Nine large cities and several states (Georgia, Michigan, Louisiana, Maryland, Massachusetts, Minnesota, New York and others) have recently passed Complete Streets legislation, policies or guidelines. Currently, 54% of states and 52% of cities now have Complete Streets policies or legislation.

For the first time, over 2% of federal transportation funding went to bicycle and pedestrian projects. Recognizing that this is still a disproportionately low level of dedicated funding, it is also a continuation of the trend to increase funds to bicycling and walking over the past several years.

The federal Transportation Enhancements (TE) program has historically been the largest single source of dedicated funding for bicycle and pedestrian projects. However, with MAP-21, the TE program, Safe Routes to School (SRTS), and the Recreational Trails Program (RTP) have been consolidated into the Transportation Alternatives Program (TAP), with a specific set-aside for the RTP. Funds for TAP are 26% less in fiscal year 2014 than the combined funding for these three separate programs in 2012. However, bicycle and pedestrian projects are eligible for all Federal-aid Highway Program categories.

INFRASTRUCTURE AND DESIGN

The 50 most populous cities in the U.S. (plus New Orleans and Honolulu) have a combined total of more than 8,600 miles of bicycle lanes. Combining the mileage of bicycle lanes, multi-use paths, and signed bicycle routes in these cities, they have an average of 1.6 miles of bicycle infrastructure per square mile. This is an increase from 1.3 miles per square mile in 2010 (reported in the *2012 Benchmarking Report*). San Francisco has, by far, the densest network of bicycle facilities with 7.8 miles of lanes, paths, and routes per square mile in the city.

2.4 Safety Considerations

Safety considerations in roadway design are important to all users of the right-of-way although safety discussions in the traditional roadway design process are often focused primarily on vehicular crashes and occupant safety. The AASHTO Green Book discussion of safety in Chapter 2, Design Controls and Criteria, emphasizes the need to consider the safety implications of geometric design but exclusively references the vehicular aspects of roadway and roadside design and traffic control device applications.

Key safety resources such as the *Highway Safety Manual* (HSM) and *NCHRP Report 500: Guidance for Implementation of the AASHTO Strategic Highway Safety Plan* (SHSP) are noted in the Green Book as important aides to the designer in managing and improving roadway and

roadside safety. AASHTO's SHSP identifies four main areas of concern in making walking along and crossing streets safer, with the highest priority involving inadequacies in pedestrian facilities and the lack of good design information for them. The HSM, published in 2010, presents a variety of methods for quantitatively estimating crash frequency or severity at a variety of locations with a primary focus on vehicle crashes. The *Interactive Highway Safety Design Module* (IHSDM) and *Safety Analyst* are associated sets of software simulation tools used to evaluate the safety and operational effects of geometric design decisions on highways.

The *NCHRP Report 500* series produced *Report 500-10, A Guide for Reducing Collisions Involving Pedestrians,* and *NCHRP Report 500-18, A Guide for Reducing Collisions Involving Bicycles.* These documents provide guidance to transportation professionals on providing appropriate accommodations for pedestrians and bicyclists while still maintaining the functionality of highways in terms of accommodating vehicle needs. They include examples of state-of-the art practices and design guidance. While these guides provide a wealth of design information and guidance to address pedestrian and bicycle needs and issues, there is a strong focus on managing and controlling these users such that there is as little impact to vehicular capacity and safety as possible.

<u>Crash Trends</u>

Any discussion of safety in the geometric design process for low- and intermediate-speed roadways must include a consideration of all modes legally able to travel along or across those facilities. To better understand the representative crash statistics and conditions for vehicle, pedestrian and bicycle modes on the transportation system, the following information has been taken from data and reports produced by the National Highway Traffic Safety Administration (NHTSA) for U.S. roadways. The data presented is for 2013. More recent crash trends through 2015 have shown a marked increase in fatalities, with higher increases being seen for pedestrian and bicycle users.

PASSENGER VEHICLES

Passenger vehicles (cars, pickup trucks, vans, SUVs, and other light trucks) make up over 90 percent of registered vehicles, and account for nearly 90 percent of total vehicle miles traveled (VMT). In 2013 there were an estimated 9,892,000 vehicles involved in police-reported traffic crashes, 96 percent (9,538,000) of which were passenger vehicles. There were 44,811 vehicles involved in fatal crashes, of which 77 percent (34,691) were passenger vehicles. In 2013, there were 21,132 passenger vehicle occupants who lost their lives in traffic crashes, and an estimated 2.05 million were injured.

PEDESTRIANS

In 2013, 4,735 pedestrians were killed and an estimated 66,000 were injured in traffic crashes in the United States. On average, a pedestrian was killed every 111 minutes and injured every 8 minutes in traffic crashes. In 2013, pedestrian deaths accounted for 14 percent of all traffic fatalities, and made up 3 percent of all the people injured in traffic crashes. Furthermore, it appears from research into hospital records (Source: Pedestrian

and Bicycle Information Center) that a majority of pedestrian crashes that cause injury are not officially recorded by the police. Other relevant pedestrian safety facts include:

- almost three-fourths (73%) of these pedestrian fatalities occurred in an urban setting versus a rural setting;
- over two-thirds (69%) of pedestrian fatalities occurred at non-intersections versus at intersections;
- eighty-nine (89) percent of pedestrian fatalities occurred during normal weather conditions (clear/cloudy), compared to rain, snow and foggy conditions; and
- a majority of the pedestrian fatalities, 72 percent, occurred during the nighttime (6 p.m.–5:59 a.m.).

The 4,735 pedestrian fatalities in 2013 represented a slight decrease from 2012 and were the second highest number of fatalities in the last 6 years of analysis.

Older pedestrians (age 65+) accounted for 19 percent (896) of all pedestrian fatalities and an estimated 10 percent (7,000) of all pedestrians injured in 2012. The fatality rate for older pedestrians (age 65+) was 2.0 per 100,000 population – higher than the rate for all the other ages under 65. Starting at age 45 the fatality rates are generally higher than they are in the younger age groups. In 2013, people 65 and older made up only 14 percent of the country's population.

In 2013, the average age of pedestrians killed in traffic crashes was 46 and the average age of those injured was 36. Over the past 10 years the average age of those killed has remained almost unchanged, while the age of those injured has steadily increased. The highest three pedestrian injury rates by age group were 21-24, 16-20 and 10-15.

In 2013, more than one-fifth (21%) of all the children ages 5 to 14 who lost their lives in traffic crashes were pedestrians. Children age 14 and younger accounted for 5 percent of the pedestrian fatalities in 2013 and 15 percent of all pedestrians injured in traffic crashes.

BICYCLISTS

In 2013, 743 bicyclists (bicycles includes all "pedalcyclists" defined as riders of two-wheel, non-motorized vehicles, tricycles, and unicycles powered solely by pedals) were killed and an additional 48,000 were injured in motor vehicle traffic crashes. Bicycle deaths accounted for 2 percent of all motor vehicle traffic fatalities, and made up 2 percent of the people injured in traffic crashes during the year.

The number of bicyclists killed in 2012 is 1 percent higher than the 734 bicyclists killed in 2012. The majority of bicyclist fatalities in 2013 occurred in urban areas (68%) and at non-intersections (57%). Over half of all bicyclist fatalities (56%) occurred from 3 p.m. to 11:59 p.m.

In 2013, the average age of bicyclists killed in traffic crashes was 44. During the past 10 years, there has been a steady increase in the average age of bicyclists killed and

injured. Bicyclists ages 55 to 59 had the highest fatality rate (4.86 per million people) based on population. However, the highest injury rate (376 per million people) occurred in the 20-to-24 age group.

Children under 15 accounted for 7 percent of all bicyclists killed and 11 percent of all those injured in traffic crashes in 2013. Bicyclists ages 45 to 54 were 23 percent of those killed and 15 percent of those injured in that year.

2.5 Current Federal and State Policy Regarding Designing for All Users

There are many terms and concepts used in today's transportation design practice that relate to the subject of this project - designing road and street facilities that safely and effectively serve all users. These terms have evolved in practice as the USDOT, FHWA, AASHTO and other agencies have moved towards developing policies, design guidance and approaches that give more consideration to the "context" and community goals in scoping and designing projects. A common theme throughout most of these concepts is that all legal users of the transportation facility, particularly pedestrians and bicyclists in urban and suburban environments (and also main streets in smaller towns and villages), are given significant consideration, often times equal to or beyond the needs of motorized users.

Applying these concepts often requires the use of geometric design *flexibility* to accomplish many of their objectives. Both AASHTO and FHWA have developed significant guidance on applying design flexibility, including excellent training courses conducted by the National Highway Institute (NHI). The guidance and training recognize that use of flexibility is a necessary aspect of the geometric design process and is expressly allowed and even encouraged in AASHTO's *Green Book*. Further, FHWA notes that flexible design philosophy requires:

- Recognizing that flexibility is a necessary and desired aspect of the design process,
- Using a risk assessment and risk management approach for all aspects of the design, and
- Applying performance criteria in evaluating flexible design decisions, as well as condition criteria.

Applying flexibility involves understanding the risks and consequences for design decisions, which typically requires more information and higher level analysis then simply applying criteria "by the book".

More information on use of design flexibility can be found at these AASHTO and FHWA sites:
http://www.fhwa.dot.gov/environment/publications/flexibility/ch02.cfm
http://environment.transportation.org/center/products_programs/webinars/understanding_flexibility_green_book.aspx .

2.6 Evolving Concepts in Designing for All Users

A number of unique roadway design concepts focused on improving the safety, accessibility and convenience on all roadway users have evolved over the past two decades. Three of the more common concepts that are relevant to the purpose of this research project are briefly discussed below. Each of these concepts embody the goal of considering and providing for all users in the design process.

CONTEXT SENSITIVE SOLUTIONS

The term most used in practice and increasingly applied since the late 1990's is "context sensitive solutions, or "CSS". Context sensitive design, or "CSD" was an early term that was used prior to "CSS" and is now considered a part of the CSS process. USDOT/FHWA and AASHTO both maintain a website dedicated to the understanding and advancement of CSS principles: AASHTO (http://environment.transportation.org/environmental_issues/context_sens_sol/) and USDOT/ FHWA (www.contextsensitivesolutions.org).

These sites and other sources define the core principles and outcomes of CSS as follows:

Core Principles of CSS - These core CSS principles apply to transportation processes, outcomes, and decision-making.

- Strive towards a shared stakeholder vision to provide a basis for decisions.
- Demonstrate a comprehensive understanding of contexts.
- Foster continuing communication and collaboration to achieve consensus.
- Exercise flexibility and creativity to shape effective transportation solutions, while preserving and enhancing community and natural environments.

Outcomes of CSS - A Context Sensitive Solutions process should achieve solutions that:

- Are in harmony with the community and preserve the environmental, scenic, aesthetic, historic, and natural resource values of the area.
- Are safe for all users.
- Solve problems that are agreed upon by a full range of stakeholders.
- Meet or exceed the expectations of both designers and stakeholders, thereby adding lasting value to the community, the environment, and the transportation system.
- Demonstrate effective and efficient use of resources (people, time, budget,) among all parties.

Information from FHWA's Context Sensitive Solutions.org website lists the following states that have adopted a formal DOT policy regarding CSS:

- California
- Connecticut
- District of Columbia
- Iowa
- Illinois
- Kentucky
- Maryland
- Massachusetts
- Minnesota
- Mississippi
- New Hampshire
- New Jersey
- New York
- Pennsylvania

- Utah
- Washington
- Wisconsin

FHWA lists the following states as having issued some type of CSS policy statement:

- Florida
- Indiana
- Louisiana
- Montana
- New Hampshire
- North Carolina
- Ohio
- Rhode Island
- Tennessee
- Texas
- Virginia
- Vermont

Finally, FHWA notes that the State of Illinois has passed state legislation regarding CSS and the states of Massachusetts, Michigan, Minnesota and Washington have issued CSS executive orders. The CSS concept has been almost exclusively applied in federal and state transportation agencies with local agencies (cities, counties, MPOs) choosing to use the "complete streets" concept as discussed in the next section.

COMPLETE STREETS

FHWA explains the concept of "complete streets" as follows:

- Complete streets are designed and operated to enable safe access for all users.
- Pedestrians, bicyclists, motorists, and transit riders of all ages and abilities may move safely along and across a complete street.
- Transportation agencies routinely design and operate the entire right of way to enable safe access for all users.

The State of Oregon enacted the first "complete streets"-like policy in the United States in 1971, requiring that new or rebuilt roads must accommodate bicycles and pedestrians, and also calling on state and local governments to fund pedestrian and bicycle facilities in the public right-of-way. As of 2015, nineteen (29) additional states plus the District of Columbia and Commonwealth of Puerto Rico have adopted policy, legislation or guidelines addressing the accommodation of pedestrians and bicycles on their transportation systems.

The term "routine accommodation" was used for many years to address the consideration of pedestrians and bicyclists in roadway projects but in the mid-2000's the term "complete streets" was coined by advocacy groups as a more effective name to refer both to a comprehensive approach to street design and a new coalition promoting the concept.

The National Complete Streets Coalition (NCSC) was founded in 2005 by a coalition of advocacy and trade groups, including the American Association of Retired Persons (AARP), the American Planning Association (APA) and the American Society of Landscape Architects (ASLA). Many other organizations have joined the coalition since then and include the American Public Transportation Association (APTA), Blue Cross Blue Shield Minnesota, the National

Association of Realtors, the Alliance for Biking and Walking, the Association of Pedestrian and Bicycle Professionals (APBP), and the Institute of Transportation Engineers (ITE).

The National Complete Streets Coalition's stated goal is to integrate people and places in the planning, design, construction, operation, and maintenance of transportation networks. The Coalition promotes the development and implementation of policies and professional practices that ensure streets are safe for people of all ages and abilities, balance the needs of different modes, and support local land uses, economies, cultures, and natural environments. Today the NCSC is a program of Smart Growth America (SGA).

In 2010 the U.S. Department of Transportation issued a policy statement on bicycle and pedestrian accommodation, declaring its support for their inclusion in federal-aid transportation projects and encouraging community organizations, public transportation agencies, and state and local governments to adopt similar policies. The policy statement includes this language:

> *The DOT policy is to incorporate safe and convenient walking and bicycling facilities into transportation projects. Every transportation agency, including DOT, has the responsibility to improve conditions and opportunities for walking and bicycling and to integrate walking and bicycling into their transportation systems. Because of the numerous individual and community benefits that walking and bicycling provide — including health, safety, environmental, transportation, and quality of life — transportation agencies are encouraged to go beyond minimum standards to provide safe and convenient facilities for these modes.*

The complete policy statement can be found at:
(http://www.fhwa.dot.gov/environment/bicycle_pedestrian/overview/policy_accom.cfm).

Subsequent to the USDOT accommodation policy statement, FHWA issued a design guidance memorandum on August 20, 2013 expressing the Federal Highway Administration's support for taking a flexible approach to bicycle and pedestrian facility design. The memorandum noted that AASHTO's bicycle and pedestrian design guides are the primary national resources for planning, designing, and operating bicycle and pedestrian facilities, but in addition noted that the National Association of City Transportation Officials (NACTO) *Urban Bikeway Design Guide* and the Institute of Transportation Engineers (ITE) *Designing Walkable Urban Thoroughfares* guide build upon the flexibilities provided in the AASHTO guides, which can help communities plan and design safe and convenient facilities for pedestrian and bicyclists.

FHWA's memorandum also states that the Administration supports the use of all these resources to further develop non-motorized transportation networks, particularly in urban areas. The complete memorandum may be accessed at:
(http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/design_flexibility.cfm).

As of September 2017, over 1,200 regional and local agencies, 33 states, the Commonwealth of Puerto Rico, and the District of Columbia have adopted complete streets policies and/or guidelines. Some of these jurisdictions passed legislation enacting their policies into law, while

others chose to implement their policies by executive order or internal policy. Still more jurisdictions have passed non-binding resolutions in support of Complete Streets, or created transportation plans and design guidance that incorporate Complete Streets principles.

ROAD DIETS (Roadway Reconfigurations)

In 2014 the FHWA identified road diets (also referred to as "roadway reconfigurations") as one of the Every Day Counts 3 initiatives. According to FHWA, a road diet offers several high-value improvements at a low cost when applied to traditional four-lane undivided highways. In addition to low cost, the primary benefits of a road diet include enhanced safety, mobility and access for all road users and a "complete streets" environment to accommodate a variety of transportation modes.

A classic road diet typically involves converting an existing four-lane, undivided roadway segment to a three-lane segment consisting of two through lanes and a center, two-way left-turn lane. On a four-lane undivided road, vehicle speeds can vary between travel lanes, and drivers frequently slow or change lanes due to slower vehicles or vehicles stopped in the left lane waiting to turn left. On three-lane roads with two-way left turn lanes (TWLTLs), left-turning vehicles are separated from through vehicles, and the vehicle speed differential is limited by the speed of the lead vehicle in the through lane. This reduces the vehicle-to-vehicle conflicts that contribute to crashes.

Road diets have been implemented for at least two decades and are steadily increasing in popularity. More than 1,200 state, regional and local jurisdictions have adopted or have committed to adopting Complete Streets policies, establishing the expectation that all future roadway projects will adhere to the principle that streets should be designed with all users in mind rather than merely providing enough capacity for vehicle throughput.

FHWA's Office of Safety added Road Diets to its Proven Safety Countermeasures list in January 2012. FHWA provides guidance on Road Diet application, including effective use of Road Diets without reducing highway capacity and Road Diet-related crash modification factors for use in safety countermeasure benefit-cost analysis.

The FHWA Safety Office has developed a Road Diet Informational Guide that includes safety, operational, and quality of life considerations from research and practice as well as design guidance. It provides guidance for the decision-making process to determine if Road Diets are a good fit for certain corridors.

Road diet resources from FHWA can be found at:

EDC-3 Road Diets Web page:
http://www.fhwa.dot.gov/everydaycounts/edc-3/reconfiguration.cfm

FHWA Office of Safety Proven Safety Countermeasures Road Diet website:
http://safety.fhwa.dot.gov/road_diets/

FHWA Office of Safety Road Diet Informational Guide:
http://safety.fhwa.dot.gov/road_diets/info_guide/

3. Research Approach

The goal of this research project was to collect and review the latest research and best practices from which a design methodology and process can be developed that results in balanced service to the full range and mix of users of each roadway functional classification in the low- and intermediate-speed categories…and that is also sensitive to the context of the roadway environment. The recommended design process is intended to fit a balanced street design into low- and intermediate-speed roadways of all types in all contexts, but with particular emphasis on those facilities in an environment of limited right-of-way, congested traffic conditions and other anticipated design challenges typically experienced in settings where roadways are designed at low and intermediate speeds (45 MPH and lower).

The integrated design guidelines will help designers understand how to best evaluate and accommodate all users in the design process. The guidelines will establish a method to identify and assess the users and user needs and service levels that should be addressed in project design. This method will consider and address relevant roadway network functional classifications, land use context, community goals, vehicle speed ranges and other relevant factors identified through the research and best practices.

The guidelines will also outline a methodology that designers can use to balance and optimize geometric design criteria, controls and elements in a multimodal environment to ideally "optimize" effective and safe operations for all users. While this methodology will be supported by available empirically based research as available, the research team understands that research for many non-motorized and contextual-related design considerations and relationships are non-existent or limited. Therefore, some aspects of the proposed methodology will likely be based on best practices, case study results, application of engineering judgment and other qualitative considerations of the research team. Areas needing future empirical research to validate and advance qualitative recommendations will be identified in the final project report.

Other aspects of the guidelines will address the following elements under varying roadway classifications, contexts and speed ranges:

- Identifying all user groups and sub-groups (i.e., pedestrians - older, young and disabled),
- Assessing current and future demand of all modes,
- Best practices for assessing multimodal level and quality of service,
- Balancing the principal elements of design among all users,
- Performance metrics (quantitative and qualitative) for user groups addressing operations, safety, and accessibility,
- Methods for identifying and addressing typical constraints such as limitations in right-of-way, fixed roadside features, utility conflicts, etc.,
- Guidance for applying design flexibility considering reallocation of cross section design elements, controls and criteria,
- Use and approach to design exceptions, and use of low cost options, and
- Integration of geometric design with traffic control to optimize operations and safety for all user groups.

The guidelines are also intended to identify and highlight national best practices for developing multimodal design policies, processes, and approaches to implementation at the local, regional and state government levels. Many communities and several U.S. states have already begun to address multimodal roadway design in their design manuals and guides in an attempt to create more livable, sustainable and healthy communities and neighborhoods.

Finally, the guidelines will be referenced to established AASHTO, FHWA and TRB policy, standards and guidance documents that govern or advise various elements of low- and intermediate-speed multimodal roadway design. In addition, there are a growing number of complimentary design guidance and best practice documents produced by other federal agencies (U.S. Access Board, FTA, etc.) and professional organizations such as the Institute of Transportation Engineers (ITE) and National Association of City Transportation Officials (NACTO) that will be considered and referenced as appropriate.

To accomplish this research and establish guidelines development, the Work Plan was divided into two phases.

Phase I included Tasks 1-6 which primarily involve information gathering and planning tasks, culminating in the submittal of the Interim Report. This Final Report presents the work completed in the Phase I tasks and also the updated Work Plan tasks for Phase II.

Based on feedback from NCHRP and the Panel, the preliminary Phase II Work Plan was updated. The updated Phase II plan addressed the manner in which our Team utilized the information obtained in Phase I and resultant Panel and NCHRP staff feedback to better satisfy the project objectives.

The Plan involved a face-to-face meeting with NCHRP staff and project panel in Washington, D.C, in February of 2016 to discuss the interim report, after which the team refined Phase II tasks as needed in Task 6 and then began work on those elements.

3.1 Relationship to Other Design Guidance

These guidelines are anticipated to supplement and work in conjunction with several leading national policies, standards and guidance commonly used by state and local transportation, engineering and public works engineers and planners in designing roadways in low- and intermediate-speed environments. Those primary publications in use today include:

- *A Policy on Geometric Design of Highways and Streets* (AASHTO 2011);
- *Guide for the Planning, Design and Operation of Pedestrian Facilities* (AASHTO 2004b);
- *Guide for the Development of Bicycle Facilities, 4th Edition* (AASHTO 2012);
- *Roadside Design Guide,4th Edition* (AASHTO 2011);
- *Highway Safety Manual (HSM),* (2010 & 2014 Supplement)
- *Highway Capacity Manual (HCM),* (2010)
- *Manual on Uniform Traffic Control Devices (MUTCD),* (FHWA 2009);
- *Guide for Geometric Design of Transit Facilities on Highways and Streets (2014)*

- *Transit Capacity and Quality of Service Manual (TCQSM), Third Edition, TCRP Report 165 (2013)*
- *A Guide for Achieving Flexibility in Highway Design* (AASHTO 2004c)
- *Flexibility in Highway Design* (FHWA 1997);
- *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, *RP-036A* (ITE 2010)
- *Urban Street Design Guide*, (NACTO 2014);
- *Urban Bikeway Design Guide* (NACTO 2011);
- *Highway Safety Design and Operations Guide* (AASHTO 1997);
- *Americans with Disabilities Act Standards for Accessible Design* (ADA/SAD), (USDOJ 2010); and
- *Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way* (PROWAG 2011).

In addition to the above sources of design guidance, state and local agencies often rely on a wide range of other design policies, manuals, standards and guides published by other transportation organizations at the state, regional and local levels. As noted earlier, the guidance developed by this project will to build on existing AASHTO and FHWA design guidance for low- and intermediate-speed roadway improvement projects that will strive to accomplish compatibility with all users, local community objectives, and the context across a range of urban, suburban and rural settings.

Designing for all users, especially in urban and rural town/village contexts, often requires generous use of design flexibility and engineering judgment. AASHTO's Green Book recognizes and allows for this need as noted in this sentence from the books Foreword; "...sufficient flexibility is permitted to encourage independent designs tailored to particular situations."

The flexibility guidance included in these design guidelines will be consistent with the policies and intent expressed in AASHTO's *Policy on Geometric Design of Highways and Streets*, FHWA's *Flexibility in Highway Design,* FHWA's August 20, 2013 design guidance memorandum titled *Bicycle and Pedestrian Facility Design Flexibility*, and many other relevant research and best practices developed over the past decade or so. The guidelines will provide roadway designers with useful guidance on:

1. Applying multimodal and context sensitive principles in the planning and design of low- and intermediate-speed roadways;
2. Considering a broader set of factors during the design of these types of roadways beyond motorized vehicle considerations;
3. Recognizing and considering the importance of context, the role of adjacent properties and development and how this context influences the design of the roadway and vice versa; and
4. Providing an understanding of how roadway design criteria appropriately can and should vary depending on the users present and the land use context through which the roadway passes.

"Practical design" strategies can also provide a set of design tools and tactics that agencies can use to improve their roadways for all users in the near-term while waiting for additional funding or approvals in the future. These approaches can include low-cost, interim designs or

materials, new public amenities, and creative partnerships with local stakeholders, which together enable faster project delivery, and more flexible and responsive geometric design better serving a multimodal, integrated user environment.

While the concept of practical design is not planned to be specifically addressed in the guidelines produced by the research project, this approach is often a valid and complimentary approach to multimodal accommodation in many low- and intermediate-speed environments. With limited funding, often complex approval and regulatory processes, and generally lengthy construction timetables (especially where utility relocations are involved), agencies are often challenged to deliver basic roadway project elements that fully address the needs of all legal users.

3.2 Framework for Combining Qualitative and Quantitative Performance Measures

Based upon the information and knowledge gained through the Tasks 1 and 2, the research team has developed options for combining qualitative and quantitative performance measures across user modes and types and context for use in evaluating alternative designs for low- and intermediate-speed roadways. This involved blending a combination of performance measures given the current state of practice and current priorities of roadway design agencies. While some of these performance measures may be quantitative in nature, many of them are qualitative in nature as noted earlier in this report.

The approach for combining these performance measures must be flexible recognizing that different roadway agencies and communities, and for different roadways within a given community, will have different priorities. For example, some agencies may give equal importance to safety and operational conditions, while others may give higher priority to safety over operations, and still others may be focused on creating a roadway environment more conducive to "livable communities" focusing on priorities for walking, biking and enhanced connections to transit.

The methodology must also be flexible because different types of roadway facilities should often be evaluated differently. For example, a 25-mph two-lane local road should be evaluated using different criteria than a 35-mph multi-lane collector or minor arterial, and those facilities should also be evaluated differently at times in consideration of the surrounding context and community goals.

The methodology should also consider the quality and thoroughness of the relevant performance measures. The designer is faced with making choices on how best to measure anticipated performance of the design alternatives. This can include use of several available procedures as defined in the HCM, HSM, or TCQSM, or use several other alternative approaches addressing a wide range of level and quality of service indicators for each mode. In addition, the methodology should not always be independent of volume or design speed because some roadways may need to be designed with a greater priority on pedestrian needs (due to higher pedestrian usage and contextual issues), while other roadways will need to be designed with a greater priority on the needs of bicyclists or transit users.

4. Summary of Research Findings and Observations

Work was accomplished on Tasks 1, 2, 3 and 4 as described in the findings for each task as presented below.

4.1 Task 1: Literature Search, Roadway Agency Survey, Best Practices

The objective of Task 1 was to review the state of knowledge and state of practice in designing for safety and efficient travel of all users along low- and intermediate-speed roadways. This has been accomplished by (1) conducting a thorough review of relevant literature, (2) conducting a survey of state and local roadway design agencies, and (3) conducting a review of best practices for geometric design for all users as identified in the literature search and agency survey. Each effort is summarized below.

4.1.1 Literature Review

The research team has identified and reviewed current literature relative to the geometric design process of low- and intermediate-speed roadways and streets, with particular attention to those documents that address how to consider and provide mobility opportunities to all users in a collaborative, coordinated manner.

These sources have been identified from an extensive review of transportation agency/organization websites along with general Internet searches using a wide range of key terms and concepts related to the research topic elements. We have also identified other sources from a series of online searches using the Transport Research International Documentation (TRID) database and the Transportation Research Board (TRB) Research in Progress database as well as from the reference lists of the sources already identified, including several leading non-US practice documents.

The published documents, technical papers and presentations, policy papers and technical standards and guidance manuals that have been selected as key references to the guidelines development have been assigned to the following six (6) source categories:

1. Transportation and university research programs and activities;
2. Federal agencies;
3. AASHTO;
4. State agencies;
5. Local government agencies (cities, counties, metropolitan planning organizations (MPOs) and others);
6. Industry associations, professional organizations and conference proceedings (AASHTO, FHWA, FTA, ITE, NACTO, AARP, National Complete Streets Coalition (NCSC), Association of Pedestrian and Bicycle Professionals (APBP), university research centers, etc.); and
7. Transportation agencies outside the United States.

Listed below are the key sources that have been selected from the literature search as assigned to each of the categories listed above. This list is not intended to be a bibliography. The goal has been to identify which documents, and which elements of these documents, will inform and provide beneficial guidance and support to the development of the guidelines being created by this project. The following documents (listed in reverse chronological order by category) have been found to be most relevant to the intent of this research and will continue to be referenced and used as necessary in the development of the final guidelines document.

1. Transportation and University Research Programs and Activities

- Ongoing - NCHRP 15-45: *Proposed Update of the AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities* (draft guide is under review)
- Ongoing - NCHRP 15-47: *Developing an Improved Highway Geometric Design Process* (expected completion late 2015, early 2016)
- Ongoing – NCHRP 03-112: *Operational and Safety Considerations in Making Lane Width Decisions on Urban and Suburban Arterials* (expected completion 2017)
- Ongoing – NCHRP 15-52: *Developing a Context-Sensitive Functional Classification System for More Flexibility in Geometric Design* (expected completion 2016)
- NCHRP Report 803: *Pedestrian and Bicycle Transportation Along Existing Roads – ActiveTrans Priority Tool Guidebook* (2015)
- NCHRP 737: *Design Guidance for High-Speed to Low-Speed Transitions Zones for Rural Highways* (2014)
- NCHRP 737: *Appendix B: Design Guidance Document* (2014)
- NCHRP Report 766: *Recommended Bicycle Lane Widths for Various Roadway Characteristics* (2014)
- NCHRP Report 783: *Evaluation of the 13 Controlling Criteria for Geometric Design* (2014)
- NCHRP Report 785: *Performance-Based Analysis of Geometric Design of Highways and Streets* (2014)
- NCHRP 15-34A: *Performance-Based Analysis of Geometric Design of Highways and Streets: Supplemental Research Materials* (2014)
- *Addressing Deficiencies in the Highway Capacity Manual Bike Level of Service Model for Arterial Roadways*, Theodore A Petritsch, Bruce W Landis, Tyrone Scorsone, Transportation Research Record 2641 (2014)
- *The Highway Capacity Manual's Method for Calculating Bicycle and Pedestrian Levels of Service: The Ultimate White Paper*, Herbie Huff And Robin Liggett, University of California Transportation Center (2014)
- *Exploration and Implications of Multimodal Street Performance Metrics: What's a Passing Grade?* Madeline Brozen, Herbie Huff, UCTC-FR-2014-09, University of California Transportation Center (September 2014)
- *Massachusetts Department of Transportation Complete Streets Pedestrian and Bicycle Level of Service Study*, Lovas, Nabors, Goughnour, Rabito, TRB paper Submission (2014)
- NCHRP Report 745: *Left-Turn Accommodations at Unsignalized Intersections* (2013)
- TCRP Report 165: *Transit Capacity and Quality of Service Manual* (2013)

- NCHRP Legal Research Digest 57: *Tort Liability Defense Practices for Design Flexibility* (2012)
- NCHRP Synthesis 432: *Recent Geometric Design Research for Improved Safety and Operations* (2012)
- MTI Report 11-19: *Low-Stress Bicycling and Network Connectivity*, Mineta Transportation Institute (2012)
- *Safety and Operational Analysis of 4-Lane to 3-Lane Conversions (Road Diets) in Michigan*, Lyles, Richard W., M. Abrar Siddiqui, William C. Taylor, Bilal Z. Malik, Gregory Siviy, and Tyler Haan, Lansing, Michigan: Department of Civil and Environmental Engineering, Michigan State University (2012)
- NCHRP Web-Only Document 208: *Design Guidance for Channelized Right-Turn Lanes* (2011)
- NCHRP Report 707: *Guidelines for the Use of Auxiliary Through Lanes at Signalized Intersections* (2011)
- NCHRP Synthesis 417: *Geometric Design Practices for Resurfacing, Restoration, and Rehabilitation* (2011)
- NCHRP Synthesis 422: *Trade-Off Considerations in Highway Geometric Design, A Synthesis of Highway Practice* (2011)
- NCHRP Synthesis 412*: Speed Reduction Techniques for Rural High-to-Low Speed Transitions* (2011)
- *An Assessment of Multimodal Level-of-Service as a Performance Measure for Signalized Intersections*, Srinivas S. Pulugurtha1 and Prasanna R. Kusam, TRB Paper # 11-4266 (January 2011)
- *Guidelines for Road Diet Conversions*, Stamatiadis, Nikiforos, Adam Kirk, Chen Wang, Andrea Cull, and Nithin Agarwal, Lexington, Kentucky: Kentucky Transportation Center, College of Engineering, University of Kentucky (2011)
- NCHRP Web-Only Document 158: *Field Test Results of the Multimodal Level of Service Analysis for Urban Streets* (2010)
- NCHRP Report 659: *Guide for the Design of Driveways* (2010)
- TCRP SYNTHESIS 83: *Bus and Rail Transit Preferential Treatments in Mixed Traffic, A Synthesis of Transit Practice* (2010)
- NCHRP 20-07/Task 263: *Update of the AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities* (2010)
- *Pedestrian and Bicyclist Safety and Mobility in Europe*, International Technology Scanning Program, FHWA in cooperation with AASHTO/NCHRP (2010)
- NCHRP Web-Only Document 128: *Multimodal Level of Service Analysis for Urban Streets: Users Guide* (2009)
- NCHRP Report 642: *Quantifying the Benefits of Context Sensitive Solutions* (2009)
- NCHRP Report 616: *Multimodal Level of Service Analysis for Urban Streets* (2008)
- NCHRP Report 612: *Safe and Aesthetic Design of Urban Roadside Treatments* (2008)
- NCHRP Report 500: *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan - Volume 18: A Guide for Reducing Collisions Involving Bicycles* (2008)
- *Pedestrian and Bicyclist Level of Service on Roadway Segments*, Transportation Research Record, Volume 2031 / 20 (2008)
- NCHRP Project 3-70: *Multimodal Level of Service Analysis for Urban Streets* (2007)

- Potts, I. B., 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*, Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 63–82.
- Potts, I. B., D. W. Harwood, D. J. Torbic, K. M. Bauer, K. R. Richard, D. K. Gilmore, D. K. Lay, J. F. Ringert, J. D. Zegeer, D. L. Harkey, and J. M. Barlow, *Lane Widths, Channelized Right Turns, and Right-Turn Deceleration Lanes on Urban and Suburban Arterials*, Final Report of NCHRP Project 03-72, Midwest Research Institute, August 2006.
- NCHRP Report 562/TRCP Report 112: *Improving Pedestrian Safety at Unsignalized Crossings* (2006)
- *Transforming an Urban Arterial into a Multiway Boulevard: A Design Proposal for Kennedy Boulevard in Tampa Florida*, Mikulski, Andrzej Kris, Gainesville: Urban and Regional Planning Department, University of Florida (2006)
- NCHRP Report 500: *Guidance for Implementation of the AASHTO Strategic Highway Safety Plan - Volume 10: A Guide for Reducing Collisions Involving Pedestrians* (2004)
- NCHRP Report 504: *Design Speed, Operating Speed, and Posted Speed Practices* (2003)
- *Intersection Level of Service: The Bicycle Through Movement*, Bruce W. Landis, Venkat R. Vattikuti, Russell M. Ottenberg, Theodore A. Petritsch, Transportation Research Record 1828 (2003)
- TCRP REPORT 90: *Bus Rapid Transit, Volume 2: Implementation Guidelines (2003)*
- NCHRP Report 480: *A Guide to Best Practices for Achieving Context Sensitive Solutions* (2002)
- *Bicycle Facility Selection: A Comparison of Approaches*, Pedestrian and Bicycle Information Center and Highway Safety Research Center, University of North Carolina – Chapel Hill (2002)
- *Evaluation of Lane Reduction" Road Diet" Measures on Crashes and Injuries*, Huang, Herman F., J. Richard Stewart, and Charles V. Zegeer. Transportation Research Record: Journal of the Transportation Research Board 1784 (2002)
- NCHRP Synthesis 299: *Recent Geometric Design Research for Improved Safety and Operations* (2001)
- TRB Circular E-C019, Urban Street Symposium 1999 *Conference Proceedings: Linking Land Use and Transportation through Street Design* (2000)
- *Real-Time Human Perceptions Toward a Bicycle Level of Service*, Bruce W. Landis, Venkat R. Vattikuti, and Michael T. Brannick, Transportation Research Record 1578 (1997)
- TCRP Report 19, *Guidelines for the Location and Design of Bus Stops*, Transportation Research Board (1996)
- NCHRP Report 362: *Roadway Widths for Low-Volume-Traffic Roads* (1994)
- NCHRP Report 330: *Effective Utilization of Street Width on Urban Arterials* (1990)

<u>2. Federal Agencies</u>

- *Delivering Safe, Comfortable, and Connected Pedestrian and Bicycle Networks: A Review of International Practices*, FHWA-15-051 (May 2015)

- *Pedestrian Safety Guide and Countermeasure Selection System (PEDSAFE)*, FHWA (2015)
- *Bicycle Safety Guide and Countermeasure Selection System (BIKESAFE)*, FHWA (2015)
- *Interactive Highway Safety Design Model* (IHSDM), and Safety Analyst Software Suite, FHWA (2015)
- *Road Diet Informational Guide*, FHWA (2014)
- *Statewide Pedestrian and Bicycle Planning Handbook*, Report FHWA-HEP-14-035, FHWA (2014)
- *Signalized Intersections Informational Guide, Second Edition, Report* FHWA-SA-13-027 (2013)
- *Highway Functional Classification: Concepts, Criteria and Procedures*, 2013 Edition, FHWA
- *Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way,* U.S. Access Board (2011)
- *Guide to Sustainable Transportation Performance Measures*, EPA Report 231-K-10-004 (2011)
- *Highway Capacity Manual*, TRB (2010)
- *Designing for Nonmotorists - Highway and Street Facilities: Designing for All Users*, Presented at the FHWA Field Engineers Learning & Development Seminar, April 20, 2010, Dallas, TX, Christopher Douwes, Trails & Enhancements Program Manager, FHWA
- *Sustainable Design and Green Building Toolkit for Local Governments*, EPA 904B10001 (June 2010)
- *Manual on Uniform Traffic Control Devices,* FHWA (2009)
- *Speed Concepts: Informational Guide*, FHWA-SA-10-001 (2009)
- *A Resident's Guide for Creating Safe and Walkable Communities*, FHWA-SA-07-016 (February 2008)
- *Context Sensitive Solutions Strategic Planning Process Summary Report,* AASHTO/ FHWA (March 2007)
- *Special Report: Accessible Public Rights-of-Way Planning and Design for Alterations*, U.S. Access Board (2007)
- *Pedestrian and Bicyclist Intersection Safety Indices: User Guide*, FHWA-HRT-06-130 (April 2007)
- *Mitigation Strategies for Design Exceptions, Report* FHWA-SA-07-011, FHWA (July 2007)
- *Pedestrian and Bicycle Crash Analysis Tool (PBCAT): Version 2.1.1*, FHWA
- *Draft Guidelines for Accessible Public Rights-of-Way (Revised),* U.S. Access Board (2005)
- *Flexibility in Highway Design*, FHWA (2004)
- *A Review of Pedestrian Safety Research in the United States and Abroad*, Report FHWA-RD-03-042 (2004)
- *Context Sensitive Solutions in Large Central Cities*, Allison L. C. de Cerreño, Ph.D., and Isabella Pierson, Rudin Center for Transportation Policy & Management (2004)
- *Safety Effects of Marked Vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines,* Report FHWA-RD-01-075 (2002)

- *Pedestrian Facilities Users Guide - Providing Safety and Mobility*, FHWA-RD-01-102 (March 2002)
- *Geometric Design Practices for European Roads*, FHWA (2001)
- *An Analysis of Factors Contributing to "Walking Along Roadway" Crashes: Research Study and Guidelines for Sidewalks and Walkways*, Report FHWA-RD-01-101 (2001)
- *Designing Sidewalks and Trails for Access: Part II of II: Best Practices Design Guide*, FHWA/Beneficial Designs, Inc. (2001)
- *Designing Sidewalks and Trails for Access, Part I of II: Review of Existing Guidelines and Practices*, FHWA/Beneficial Designs, Inc. (1999)
- *Bicycle Lanes versus Wide Curb Lanes: Operational and Safety Findings and Countermeasure Recommendations*, Report FHWA-RD-99-035 (1999)
- *A Comparative Analysis of Bicycle Lanes Versus Wide Curb Lanes: Final Report*, FHWA-RD-99–034 (1998)
- *Selecting Roadway Design Treatments to Accommodate Bicycles*, Report FHWA-RD-92-073 (1994)

3. AASHTO

- *Guide for Geometric Design of Transit Facilities on Highways and Streets* (2014)
- *Highway Safety Manual* (2010 & 2014 Supplement)
- *Guide for Development of Bicycle Facilities* (2012)
- *A Policy on Geometric Design of Highways and Streets* (2011)
- *Roadside Design Guide & Chapter 11 (Erecting Mailboxes on Streets & Highways)*, (2011)
- *Roadway Lighting Design Guide* (2005)
- *Guide for Accommodating Utilities within Highway Right-of-Way* (2005)
- *Guide for Planning, Design, and Operation of Pedestrian Facilities* (2004)
- *A Guide for Achieving Flexibility in Highway Design* (2004)
- *Guidelines for Geometric Design of Very Low-Volume Local Roads* (ADT $\leq$ 400), (2001)
- *Guide for Transportation Landscape and Environmental Design* (1991)

4. State Agencies

- *Bicycle Policy and Design Guidelines*, Maryland State Highway Administration (2015)
- *Oregon Analysis Procedures Manual*, Chapter 14 Multimodal Analysis, Oregon DOT (2014)
- *Design Policy Manual: Chapter 9. Complete Streets Design Policy*, Georgia DOT (2014)
- *Multimodal System Design Guidelines*, Virginia Department of Rail and Public Transportation, Virginia Department of Transportation (October 2013)
- *Indiana DOT Design Manual, Chapter 51: Special Design Elements*, Indiana Department of Transportation (2013)
- *Facilities Development Manual: Chapter 11 Design, Section 46 Complete Streets, Bicycle and Pedestrian Elements Affecting Complete Streets*, Wisconsin Department of Transportation (2013)
- *2013 Quality/Level of Service Handbook*, Florida Department of Transportation (2013)

- LOSPLAN Software, Florida DOT (2012)
- *Complete Streets Planning and Design Guidelines,* North Carolina Department of Transportation, (2012)
- *Highway Design Manual,* Oregon Department of Transportation (2012)
- *Missouri Livable Streets Design Guidelines,* University of Missouri Extension (2011)
- *Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways: Chapter 8, Pedestrian Facilities, and Chapter 9, Bicycle Facilities,* Florida Department of Transportation (2011)
- *Bicycle and Pedestrian Design Guide,* Oregon Department of Transportation (2011)
- *Complete Intersections: A Guide to Reconstructing Intersections and Interchanges for Bicyclists and Pedestrians*, California Department of Transportation (2010)
- *MnDOT Road Design Manual: Chapter 11- Special Designs,* Minnesota Department of Transportation (2010)
- *Wisconsin Guide to Pedestrian Best Practices: Chapter 5, Designing Pedestrian Facilities,* Wisconsin Department of Transportation (2010)
- *Connecticut Statewide Bicycle and Pedestrian Plan, Bicycle and Pedestrian Design Toolbox,* Connecticut Department of Transportation (2009)
- *Smart Transportation Guidebook; Planning and Designing Highways and Streets that Support Sustainable and Livable Communities,* New Jersey and Pennsylvania Department of Transportation (2008)
- *MnDOT Bikeway Facility Design Manual,* Minnesota Department of Transportation (2007)
- *MassHighway Project Development and Design Guidebook,* Massachusetts Department of Transportation (2006)
- *Understanding Flexibility in Transportation Design – Washington,* Washington State Department of Transportation (2005)
- Fitzpatrick, Kay et al, *Design Factors That Affect Driver Speed on Suburban Arterials*, Research Report 1769-3, Texas Transportation Institute (June 2000)
- Project Summary Report 1769-S, *Project 0-1769: Identify Design Factors That Affect Driver Speed and Behavior*, Kay Fitzpatrick, P.E., Paul J. Carlson, P.E., Mark D. Wooldridge, P.E., and Marcus A. Brewer, Texas Transportation Institute, November, 2000

<u>5. Local Government Agencies</u>

- *Redesigning The Street - A Report on Right-Sizing Projects in Austin, TX 1999-2014,* City of Austin, TX Transportation Department (2015)
- *Draft Program Environmental Impact Report for the Carlsbad General Plan Update Chapter 3.13: Transportation MMLOS*, City of Carlsbad CA (2014)
- *Bicycle Facility Design Standards*, City of Alameda CA (2013)
- *Pedestrian and Bicycle Design Guidelines, Mobility Master Plan,* City of Tacoma WA (2013)
- *Complete Streets Design Guidelines for Livable Communities,* Regional Transportation Commission of Southern Nevada (2013)
- *Complete Streets Chicago: Design Guidelines,* Department of Transportation, City of Chicago IL (2013)

- *Boston Complete Streets: Design Guidelines*, City of Boston MA (2013)
- *Complete Streets/Multi-modal Level of Service (CSLOS/MMLOS)*, Report for San Diego Association of Governments, Fehr & Peers (2012)
- *Philadelphia Complete Streets Design Handbook*, City of Philadelphia PA (2012)
- *Complete Streets/Complete Networks: A Manual for the Design of Active Transportation*, Active Transportation Alliance, Chicago IL (2012)
- *Multimodal Level of Service in King County: A Guide to Incorporating Alternative Modes of Transportation Into Local Jurisdictions' Roadway Performance Measurements*, Seattle and King County, Washington (June 2011)
- *Pedestrian Plan, Level of Service Analysis*, City of Fort Collins CO (2011)
- *Model Design Manual for Living Streets*, Los Angeles County CA (2011)
- *Bikeway Facility Design: Survey Of Best Practices, Portland Bicycle Plan For 2030*, City of Portland OR (2010)
- *Pedestrian Injury Model* , San Francisco Department of Public Health (2010)
- *Bicycle Environmental Quality Index*, San Francisco Department of Public Health (2009)
- *Pedestrian & Bicycle Level of Service: Methodology for Crossings at Signalized Intersections*, City of Charlotte NC (2007)
- *Portland Pedestrian Design Guide*, City of Portland OR (1998)
- *Pedestrian Environmental Quality Index*, San Francisco Department of Public Health (2008)
- *Pedestrian & Bicycle Level of Service Methodology for Crossings at Signalized Intersections*, Charlotte Department of Transportation (February 2007)
- *Street Design Guidelines: Burlington Transportation Plan*, City of Burlington VT (2007)
- *Creating Livable Streets: Street Design Guidelines for 2040*, Second Edition, Portland (OR) Metro Government, 2002
- *Portland Pedestrian Design Guide*, City of Portland OR (1998)

6. Industry Associations, Professional Organizations and Conference Proceedings

- *Evaluating Complete Streets Projects: A Guide for Practitioners*, American Association of Retired Persons, Smart Growth America (2015)
- *National Bicycle and Pedestrian Documentation Project*, Alta Planning and Design and the Institute of Transportation Engineers (ITE) Pedestrian and Bicycle Council (2015)
- *Effects of Multimodal Operations on Urban Roadways*, Kathrin Arnet, S. Ilgin Guler, Monica Menendez, TRB Paper Submission (2014)
- *Rethinking LOS and Transportation Impacts of Development*, Bruce Wright, Blog Post, Fairfax Advocates for Better Bicycling (March 2014)
- *Level of Service Study*, Daniel Lovas, Daniel Nabors, Elissa Goughnour, Luciano Rabito, TRB Paper Submission (2014)
- *Development of a Method to Measure Multimodal Conditions on Urban Streets*, Ilona O. Kastenhofer, Antoine G. Hobeika, Charles E. Via, Jr., Montasir M. Abbas, TRB Paper Submission (2014)
- *Urban Street Design Guide*, NACTO (2013)
- *Urban Bikeway Design Guide, 2nd Edition*, NACTO (2012)

- *Complete Enough for Complete Streets? Testing the Sensitivity of HCM 2010 Multimodal LOS under Conditions of Change*, Peter Carter, Miguel Núñez, Sarah Peters, Julia Campbell, TRB Paper Submission (2012)
- *Statewide Multimodal Planning: Current Practice at State DOTs*, Anthon H. Sonnenberg, Frank Southworth, Michael D. Meyer, Carol L. Comer, TRB Paper Submission (2012)
- *Travelers' Preferences in Multimodal Networks: Design and Results of a Comprehensive Series of Choice Experiments*, Theo A. Arentze, Eric J. Molin, TRB Paper Submission (2012)
- *What's a Passing Grade? A Synthesis and Review of Multimodal Street Performance Measures*, Michael J. Smart, Madeline Brozen, TRB Paper Submission (2012)
- *Multimodal Analysis in the 2010 Highway Capacity Manual: It's Not Just Cars Anymore!*, Jamie Parks, Jamie Healthy Communities Active Transportation Conference (2011)
- *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, an ITE Recommended Practice, ITE (2010)
- *Urban Street Performance: Level-of-Service and Quality-of-Progression Trade-off Analysis*, R. Deshpande, N. H. Gartner and M. L. Zarrillo (2010)
- *Moving Beyond Prevailing Street Design Standards - Assessing Legal and Liability Barriers to More Efficient Street Design and Function*, The Center for Law, Energy, and the Environment at the Berkeley Law School, University of California, Berkeley (2010)
- *Planning Complete Streets for an Aging America*, AARP Public Policy Institute (2009)
- *Urban Street Geometric Design Handbook*, ITE (2008)
- *Road Diet Handbook: Setting Trends for Livable Streets*, Jennifer Rosales (2006)
- *Bicycle LOS for Arterials*, Theodore A. Petritsch, Bruce W. Landis, Herman F. Huang, Peyton S. McLeod (2006)
- *Street Design Guidelines for Healthy Neighborhoods*, Center for Livable Communities, Local Government Commission (2002)

7. Transportation Agencies Outside the United States

- *Multi-Modal Level-of-Service Indicators: Tools for Evaluating the Quality of Transport Services and Facilities*, TDM Encyclopedia, Victoria Transport Policy Institute (2014)
- *Narrower Lanes, Safer Streets*, Dewan Masud Karim, P.Eng., PTOE, a paper presented at the Canadian Institute of Transportation Annual Meeting (June 2015)
- *Cycling Aspects of Austroads Guides*, Austroads (2014)
- *Guide Information for Pedestrian Facilities*, Austroads (2013)
- *Complete Streets by Design*, Toronto Centre for Active Transportation (2012)
- *Shared Use Routes for Pedestrians and Cyclists*, UK Department of Transport (2012)
- *Pedestrian Planning and Design Guide*, New Zealand Transport Agency (2009)
- *Cycle Safety: Reducing the Crash Risk*, NZ Transport Agency Research Report 389 (October 2009)
- *Cycle Infrastructure Design*, UK Department of Transport (2008)
- *Guidelines for Assessing Cycling Level of Service*, Main Roads Western Australia (2006)
- *Inclusive Mobility – A Guide to Best Practice on Access to Pedestrian and Transport Infrastructure*, UK Department of Transport (2002)

Selected Primary References

Our review of the above documents has provided useful information to the research team in understanding current practices in geometric design for various roadway user groups. Most of these documents informed the team and provided unique guidance and support to the development of the multimodal design guidelines being created by this project.

In order to maintain a manageable library of resources from which to routinely reference in the guidelines development process, the following research and best practice documents were determined to contain the most relevant and useful guidance given the intent of this research. They have been the primary resources utilized in the development of the final guidelines document.

<u>Key National Guidance</u>

- *A Policy on Geometric Design of Highways and Streets (AASHTO, 2011)*
- *Guide for Planning, Design, and Operation of Pedestrian Facilities (AASHTO, 2004)*
- *Guide for Development of Bicycle Facilities (AASHTO, 2012)*
- *Guide for Geometric Design of Transit Facilities on Highways & Streets (AASHTO, 2014)*
- *Highway Safety Manual (AASHTO 2010 & 2014 Supplement)*
- *Guide for Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts (FHWA, 2016)*

<u>Key Research Documents</u>

- NCHRP Report 785: *Performance-Based Analysis of Geometric Design of Highways and Streets* (2014)
- NCHRP 15-34A: *Performance-Based Analysis of Geometric Design of Highways and Streets: Supplemental Research Materials* (2014)
- NCHRP Synthesis 422: *Trade-Off Considerations in Highway Geometric Design, A Synthesis of Highway Practice* (2011)
- NCHRP 737: *Design Guidance for High-Speed to Low-Speed Transitions Zones for Rural Highways* (2014)
- NCHRP 737: *Appendix B: Design Guidance Document* (2014)
- NCHRP Report 766: *Recommended Bicycle Lane Widths for Various Roadway Characteristics* (2014)
- TCRP Report 165: *Transit Capacity and Quality of Service Manual* (2013)
- NCHRP Synthesis 412*: Speed Reduction Techniques for Rural High-to-Low Speed Transitions* (2011)

<u>Key Best Practice Documents</u>

- *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, an ITE Recommended Practice, ITE (2010)
- *Urban Street Design Guide*, NACTO (2013)
- *Urban Bikeway Design Guide, 2nd Edition*, NACTO (2012)
- *MassHighway Project Development and Design Guidebook*, Massachusetts Department of Transportation (2006)

- *Smart Transportation Guidebook; Planning and Designing Highways and Streets that Support Sustainable and Livable Communities,* New Jersey and Pennsylvania Department of Transportation (2008)
- *Complete Streets Design Guidelines for Livable Communities*, Regional Transportation Commission of Southern Nevada (2013)
- *Complete Streets Chicago: Design Guidelines*, Department of Transportation, City of Chicago IL (2013)
- *Boston Complete Streets: Design Guidelines*, City of Boston MA (2013)
- *Philadelphia Complete Streets Design Handbook*, City of Philadelphia PA (2012)
- *Model Design Manual for Living Streets,* Los Angeles County CA (2011)
- *MnDOT Bikeway Facility Design Manual,* Minnesota Department of Transportation (2007)
- *Smart Transportation Guidebook; Planning and Designing Highways and Streets that Support Sustainable and Livable Communities*, New Jersey and Pennsylvania Department of Transportation (2008)

4.1.2. Roadway Agency Survey

The Roadway Agency Survey is assisting the project by helping the team understand how state and local roadway design agencies address the range of roadway users in their current design processes, procedures and standards for low- and intermediate-speed roads and streets. It has also helped us understand what has worked well for those agencies in addressing these needs as well as what has not worked well. This information is allowing the research team to identify issues, needs and gaps in the current design philosophy and applications of those agencies. Understanding these aspects of current design practice is helping us to better refine the literature review efforts, and also the broader focus group process that will occur in Task 5.

The survey was distributed to roadway designers and traffic engineers in all 50 state highway agencies as well as representatives of 217 local agencies that were identified through previous design-related research engagements and involvement with the National Association of County Engineers (NACE), the American Public Works Association (APWA), the Institute of Transportation Engineers (ITE) and the National Association of City Transportation Officials (NACTO). The survey was structured to solicit responses from both geometric designers and traffic engineers. The survey was conducted online using the Survey Monkey software, which allowed for automated tabulation of results.

Each of the twenty-four (24) survey questions is provided below with a brief summary of the responses received. Detailed responses are provided in **Appendix A**.

1. <u>What type of agency do you represent?</u>

   A total of seventy-four (74) agencies, or approximately 27.4% of the distribution responded to all or a portion of the survey. Twenty-four (24) of the respondents were state transportation agencies (32.4%) while the remainder (48) were county, city or township respondents.

2. What technical specialty do you work in (select all that apply)?

   A total of sixty (60) respondents identified their technical specialties as roadway design (55%), traffic or safety (27%), traffic operations (13%) and transportation planning (5%).

3. Which design reference(s) does your agency use for urban streets, including mode-specific guidance (e.g., AASHTO Ped Guide)?

   There were forty-eight (48) respondents. Most noted significant use of AASHTO Green Book and other AASHTO key design policies and guides (pedestrian, bicycle, roadside, low volume, followed by state design manuals and local design guides. There were several references to the NACTO Bicycle and Urban Street design guides and various ITE publications including Designing Walkable Urban Thoroughfares.

4. Does your agency have design criteria for low-speed and intermediate-speed (≤45 mph) roadways that are intended specifically to accommodate all applicable roadway users?

   Twenty-four respondents (47%) replied YES and twenty-seven (53%) replied NO.

5. If you answered "Yes" to the previous question, please describe your design criteria below or provide a link to your design criteria. Alternatively, you can email copies of your design criteria to ___________.

   Twenty-five (25) persons responded to the question and provided numerous links to state and local design manuals and/or instructions for how to obtain hard copies.

6. Does your agency have a formal process to determine the user types (e.g., passenger cars, trucks, transit, pedestrians, bicycles) that need to be served on a given roadway or functional class?

   Nineteen persons, or 40% of the respondents, answered YES. Twenty-nine (60%) answered NO.

7. If you answered "Yes" to the previous question, please describe your process below or provide a link to documents that describe your process. Alternatively, you can email copies of relevant documents to ____________.

   Twenty (20) respondents provided brief descriptions or links to their process guidance. The majority of approaches appear to focus on modal consideration through checklists or minimum requirements based on functional classification. Other processes mentioned conducting modal counts, projecting future modal demands, requiring "multimodal" plans, relying on adjacent zoning, and modal accommodation templates.

8. Is the surrounding roadway network/infrastructure considered in determining the user types that need to be served on a given roadway? (For example, bike lanes are eliminated from a project with constrained right-of-way if there is an adjacent parallel bike path.)

Thirty respondents (64%) answered YES, while seventeen (36%) answered NO.

9. Is the functional classification of the roadway and/or the adjacent land use (zoning and context) considered in determining the user types to be served in a given roadway design?

   Thirty-five respondents (73%) answered YES while thirteen (27%) answered NO.

10. If you answered YES to the previous question, please describe your process below or provide a link to documents that describe your process. Alternatively, you can email copies of relevant documents to __________.

    Twenty-nine (29) persons responded. Several respondents replied that functional classification is a major consideration in determining user accommodations, while other relay on a range of considerations including urban/rural, local thoroughfare plans, adjacent land use/zoning, traffic volumes, context, engineering judgment and local ped/bike plans.

11. What method(s) does your agency use to determine the design speed of a low- to intermediate-speed roadway?

    Forty-four (44) persons responded. Responses were varied and included 85^{th} percentile speed, 5 MPH over the existing speed limit, matching posted speed, functional classification, urban/rural location, crash data, speed study, design guide tables, context, traffic volumes, terrain, land-use density, ADT, existing ped/bike use, engineering judgment, "target" users, prima facie speeds, ordinance, street typology matrix.

12. Does your agency select specific design vehicles for the design of low-speed and intermediate-speed roadways?

    Of the forty-five (45) responses, 24% replied YES and 76% replied NO.

13. If you answered "Yes" to the previous question, please describe your process below or provide a link to documents that describe your process. Alternatively, you can email copies of relevant documents to __________.

    Thirteen (13) respondents provided varied responses including design manual requirements, the largest truck anticipated, traffic volume and mix, roadway classification, emergency vehicle requirements, WB-67, 40 ft. bus, largest legally allowed vehicle.

14. For projects with constrained right-of-way, how do you prioritize or balance the elements of design for all users? Does your agency have a defined policy or protocol for prioritizing the elements of design for all users? If so, please provide a link to documents that describe your policy/protocol or email your policy/protocol to __________.

    Thirty-five (35) respondents provided a varied range of answers. Most respondents noted there was no formal process for balancing design among users, but noted that through the

scoping and design processes a number of factors were considered in making those decisions. Those factors included utility impacts, available ROW, environmental impacts, costs, community objectives, adjacent land use, traffic volumes, functional classification, context, public input, user input, practical design, identify the user class that is paying the most roadway fees, staff consultation, vehicles-first, citizen's advisory committees, safety, "team approach", feasibility and cost.

15. In your planning, design, and/or development projects, does your agency estimate levels of service for all user types (motor vehicles, pedestrians, bicyclists)?

    Of the forty-three (43) respondents, four (9%) answered YES while thirty-nine (91%) answered NO.

16. If you answered "yes" to the previous question, how is level of service for each user type determined? What tools are used?

    Of the seven (7) persons who responded to this question, answers ranges from "exploring quantitative methods from the HCM", "safety is most important", "Amish community requires wider shoulders", and "pedestrian and bicycle usage has been hard to quantify".

17. Does your agency use quantifiable performance measures (e.g., reduction in injuries and fatalities, increase in modal split) to compare the multimodal performance of design alternatives?

    Forty-two (42) persons responded. Eight respondents (19%) replied YES while 34 respondents (81%) replied NO.

18. If you answered "Yes" to the previous question, please list (or describe) the performance measures used?

    Eight (8) persons responded. Answers included HCM measures, safety of all modes, Highway Safety Manual, before/after studies of similar locations, reference to statistics from other technical studies, reduction in fatal/severe injury crashes, V/C ratio, crosswalk spacing, occasional MMLOS.

19. Does your agency formally evaluate projects after they are completed to determine how well they serve relevant user groups (e.g., review before/after crash data, review before/after modal split, conduct user survey several months following completion of a project to obtain feedback)?

    There were forty-four (44) responses. Ten responses (23%) were NO, and thirty-four (77%) responses were YES.

20. If you answered YES to the previous question, please list (or describe) the types of evaluations performed.

There were twelve (12) responses. Answers primarily focused on before/after crash data comparisons, but vehicle travel times, HCM, interviews and surveys were also mentioned.

21. Has your agency adopted any "Complete Streets" laws and/or policies to ensure that projects provide the safest achievable access for all users and modes of transportation?

    Forty-four (44) responses were received. Twenty (45%) were YES, and twenty-four (55%) were NO.

22. If you answered "Yes" to the previous question, please provide a link to these documents or send them via email to ________. If unpublished, please describe the law and/or policy below.

    There were twenty-two responses to this question. Several links to complete streets policies were provided. Other responses included the following: every project considers ped and bike facilities, and when they are found to be warranted they are included in the plans; we don't have a policy and will not as long as I am the County Engineer….the "Complete Street" concept is just the latest in a long line of jargon terms….; we re-think design of the transportation infrastructure to attempt to provide all pedestrians, bicyclists, and transit riders equal access to all destinations; we consider all modes in our design standards; we did not adopt complete streets policies; we have a Creating Livable Streets document.

23. Has your agency had any projects where multiple user needs (possibly conflicting needs) were successfully addressed?

    Of the forty-one (41) respondents, twenty-three (56%) were YES and eighteen (44%) were NO.

24. If you answered "Yes" to the previous question, please describe those "success story" projects.

    Successful stories included these topics: modified shoulder rumble strips for bicyclists; SH 7 (Arapahoe Road) in Boulder CO where extensive public involvement was used to make difficult mode service issues among the user groups; multiple projects in Washington state, several involving roundabouts; shoulder expansions for bicycle use; providing sidewalks and bike trails in bridge rehabilitation projects; road diets; separate rail crossings for bicycles; added bicycle lanes; added sidewalks; green pavement markings for bicycle awareness; midblock pedestrian crossings; medians; on-street parking; mixed-use paths.

4.1.3. Roadway Agency Interviews

As a follow-up to the survey, the research team has interviewed representatives of several roadway design agencies. The interviews where structured to delve deeper into their policies, processes, manuals, guidelines and experience with designing low- and intermediate-speed streets that serve all users. Several of these agency interviewees are also involved in design committees

and activities of AASHTO, ITE, NACTO, APBP and other design guidance-creating organizations.

The following questions and subject areas were addressed in each of the interviews:

- How different user groups and sub-groups are addressed;
- What performance metrics are used for all modes that address operations, safety, accessibility and convenience;
- How the principal elements of design are balanced among all users;
- How multimodal level of service is assessed;
- What methods are used to identify and address typical constraints such as limitations in right-of-way, roadside features, utility conflicts, excessive access points, etc.:
- The process for applying design flexibility considering allocation/reallocation of cross section design elements, use of design exceptions, and use of low cost options;
- The integration of geometric design with traffic control to optimize operations and safety for all user groups;
- How U.S. Access Board accessibility guidelines are addressed; and
- Other methods for creating street and road designs that support livable, sustainable and healthy communities and neighborhoods.

The agency interviews have confirmed the research team's initial conclusions from the agency survey that most, if not all public roadway agencies are in an "evolutionary" mode of creating design guidance to safely and conveniently accommodate all legal users of the right-of-way. The majority of state DOTs and increasing numbers of local agencies have recognized this need, and in fact have developed policies and/or implementation plans to produce new or revise existing design guidance addressing all users, but very few at this time have developed truly comprehensive, integrated design guidance that provides advanced methods and techniques for balancing safety and service to all modes in the geometric design process.

Selected results of the agency interviews are summarized below with the agency interviewees noted.

Agency: North Carolina DOT - Lauren A Blackburn, Bicycle and Pedestrian Division Director

1. How were different user groups and sub-groups addressed during both the development and implementation stages of your NCDOT design guidelines?

Using our Complete Street Guidelines as an example, we developed those between 2009 and 2012. The initial committee was made up of DOT personal to establish the policy. A working group was then organized which included FHWA, NCDOR, local governments which was led by the DOT head of design and a co-chair of a City of Charlotte employee (Charlotte had recently completed their own Complete Street guidelines). This group took a couple of years to get the framework in place for the policy. A second committee of design/planning personal from the major cities and DOT worked on the details of the guidelines. The group pulled design resources from existing documents. The draft was circulated to all state MPO's for final reviews.

A training program rolled out with the completion of the guidelines. Over 1000 individuals were trained. Within NCDOT the guidelines have become embedded in our practice. Many local governments have adopted the DOT guidelines as their guidelines.

The document is intended to be flexible. Our current situation is that the users of the document are aware of what is in the guidelines but are asking the questions about how to apply them in certain situations.

2. What performance metrics are used for all modes that address operations, safety, accessibility and convenience?

There are no performance measures in the guidelines. There have been discussions about quality of service but no specifics established on acceptable level of safety. We are having discussions on how to measure success for implementation and also trying to understand the intent of measuring prior to establishing what would be measured.

A success is that the Bike and Pedestrian Division is included in the project development phase of all projects.

3. How are the principal elements of design balanced among all users? e.g., lane width (vehicles, bicycle, transit, pedestrian), corner radius, etc.?

Initial involvement is in the Scoping Phase. We are asked to provide input on if there is a plan or vision. We generally reach out to local governments to understand their desires and also their commitment. At the Public Meeting Phase additional input is received by the local government/community.

The Bike and Pedestrian division is asked to provide a review of the draft design, looking more at coordination of modes than actual details.

NCDOT also has a Cost Share program where for different aspects the local government is asked to share the construction cost based on a formula. Sidewalks are maintained by the local government so this also develops a commitment to the project.

4. How is multimodal level of service assessed for a project?

NCDOT is not using the HCM multimodal LOS. We are looking for projects that have Transportation input (mobility) and safety, e.g., why is the project needed? Over the last 2 years we have been doing data collection since a main issue has been lack of data to evaluate LOS for all modes.

5. What methods are used to identify and address typical constraints such as limitations in right-of-way, roadside features, utility conflicts, excessive access points, etc.?

During site visits we also have discussions with the local government, looking at existing bike or pedestrian plans, existing physical evidence such as dirt paths, and so forth.

The goal of this early coordination about future projects is to make scope and concept decisions earlier rather than later. This also requires more than a line on a map and has to have some definition to the project elements.

The Bike and Pedestrian division has a limited staff so that roadway designers do most of the investigation.

6. What is your process for applying design flexibility considering allocation/reallocation of cross section design elements, use of design exceptions, and use of low cost options?

It is rare to have a design exception since a majority of the design will follow the NCDOT standards which is generally provided in the Green Book. We typically follow all of the AASHTO publications although we are considering an appeal process where senior level staff will review and rule on exception decisions.

7. How does the agency integrate geometric design with traffic control to optimize operations and safety for all user groups?

We are not using anything outside of AASHTO/MUTCD. Our innovation has been in the phasing of the work especially on resurfacing type projects where we have used marking material rather than a hard physical feature to direct traffic. An example is painting a curb extension to ensure that it would work prior to constructing it.

Local governments want to separate bike/peds from traffic but that increases cost to the projects including ongoing maintenance costs. They also often include landscape buffers and wider sidewalks to improve the comfort of the user.

8. How are U.S. Access Board accessibility guidelines addressed?

Curb ramps and other requirements have been mandated from the top down and used on all new projects.

9. Do you use any other methods for creating street and road designs that support livable, sustainable and healthy communities and neighborhoods?

Our process of prioritization of projects ranks all modal projects. There is an opportunity to establish a preferred cross section at the early stage of the project which also identifies the cost. We need to educate the MPO's to ensure that they are thinking about all aspects at this stage as there is an added cost to add them later which can be significant.

Suggested websites to review are: http://completestreetsnc.org/ and http://www.walkbikenc.com/ .

Agency: City of Boston - Vineet Gupta, Director of Planning, Boston Transportation Department

To facilitate the discussion, Mr. Gupta referred us to the Boston Complete Streets Guidelines located at this link: http://bostoncompletestreets.org/about/

1. How were the different user groups and sub-groups addressed during both the project design development and implementation stages of your guidelines?

We used an interagency group rather than consultants – and let involved agencies state their constraints and recommendations; for example, the agency responsible for Parks provided

concerns about sufficient space for trees in sidewalks. The goal was that the agencies owned the guidelines. The group met every couple of months and did not rush into it – took 2 ½ years to develop. The process was as important if not more important than the actual guidelines. Special interest groups were also part of the process and attended a lot of the meetings. Not all agencies have fully bought into the guidelines. The guidelines are expected to be a living document with changes and while not in legislation today it is hoped that at some point they will have that level of standing and support.

2. What performance metrics are used for all modes that address operations, safety, accessibility and convenience?

Boston did not address performance measures but it has been something that is being considered for future discussions. The agency has held to the accepted practice from the past such as using minimum volumes to establish turning lanes.

3. How are the principal elements of design balanced among all users? e.g., lane width (vehicles, bicycle, transit, pedestrian), corner radius, etc.

Preserving community is a key part of the decision process and we are less concerned about the technical aspects and more concerned about speeding, not enough parking, safety and being able to cross the street. The process was designed to identify what the designers thought was needed and then required evaluation of the choices and trade-offs on how to assign cross-section width and what dimensions to reduce. At least three alternatives are typically taken to public meetings to get the communities involvement. Extra effort was made to get all of the impacted members involved including special interest groups. Phone calls were made to known interested groups involved in the project area.

4. How is multimodal level of service assessed?

Boston has not used Multimodal LOS much. Future discussions will consider it along with other ideas such as throughput, percent of sidewalk open space and amenities. It is more about the experience of each mode and less about the LOS.

5. What methods are used to identify and address typical constraints such as limitations in right-of-way, roadside features, utility conflicts, excessive access points, etc.?

Methods are determined in conjunction with each specific project. Guidelines attempt to accommodate bikes on all facilities but they will not always have a designated bike lane. The decision depends on factors such as the community direction, the constructability within constraints and maintenance potential. The guidelines have established minimum lane widths after lengthy discussions. They are typically less than MassDOT will allow so design exceptions are normally required on Mass DOT routes.

6. What is your process for applying design flexibility considering allocation/reallocation of cross section design elements, use of design exceptions, and use of low cost options?

The key decision milestone is 25% where major cross section widths have to be set in order to minimize time and cost implementations later. For State funded routes we will use the State Design Guidelines as the base for the need to get design exceptions. For City regulated streets the guidelines are recommendations and generally used as a minimum.

7. How does the agency integrate geometric design with traffic control to optimize operations and safety for all user groups?

The guidelines establish direction for corner radius, cross walk design, the multimodal intersection, signals, intersection design, speed tables, operating speeds, etc.

8. How are U.S. Access Board accessibility guidelines addressed?

The Boston Disability commission could be considered too active as they required a higher level of implementation such as specific requirements of no joints within the curb return ramp.

9. Do you use any other methods for creating street and road designs that support livable, sustainable and healthy communities and neighborhoods?

Our guidelines not only include MULTIMODAL but also look at GREEN requirements and how to have SMART facilities. The guidelines are applicable to every user's facility within the City limits. Revisions will be incorporated soon but and we are working out how they will be incorporated.

Agency: Portland Metro, Oregon - Anthony Buczek, Traffic Engineer and Lake Strongheart McTighe, Senior Active Transportation Planner

Metro has an existing set of guidelines called "Creating Livable Streets: Street Design Guidelines for 2040" which they are currently updating.

1. How were the different user groups and sub-groups addressed during both the development and implementation stages of your guidelines?

We utilized input from different User Groups, an example being involvement of the Port of Portland to address freight and goods movement needs. We also had the input from advocacy groups such as Bike and Transit and a separate a citizen user group to provide input on how design issues impact daily lives.

2. What performance metrics are used for all modes that address operations, safety, accessibility and convenience?

Performance measures were developed at a State level and they are being incorporated into all design guidance for all cities and communities. The Oregon Transportation Commission adopted performance measures calling for a reduction in transportation-related deaths from 16.7 per 100,000 population in 2003 to 9.75 (or 342 lives lost) per 100,000 population by 2010 and a

further reduction to a rate of 9.00 (or 315 lives lost based on 2002 population figures) per 100,000 population by 2025.

Rather than set a standard for different measures such as volume-to-capacity (V/C) ratio, Metro is establishing V/C targets.

For specific projects the expectation is to meet the minimum established criteria in the guidelines but it is not a requirement.

We have also adopted Vision Zero - eliminating all traffic deaths and serious injuries by 2025

3. How are the principal elements of design balanced among all users? e.g., lane width (vehicles, bicycle, transit, pedestrian), corner radius, etc.

Oregon DOT requirement is 12 ft. lanes on all roads that utilize state funding. Certain jurisdictions are allowing 8 to 9 ft. lanes but the guidance is a preferred 10 ft. minimum.

For major projects a technical advisory Committee is set up with a mixture of stakeholders to work thru any design issues and come to the best solution which means that all group have to give but not break.

Have had a lot of discussions about lane widths and corner radius. Currently for an industrial area with pedestrian have developed a plan to address the issues of both sides.

4. How is multimodal level of service assessed for a project?

We have used the HCM Multimodal LOS but it has not caught on as users consider it too difficult and too much work. A condensed process would be better that utilizes some of the elements used in planning since projects are often defined and budgeted by the time they get into design.

5. What methods are used to identify and address typical constraints such as limitations in right-of-way, roadside features, utility conflicts, excessive access points, etc.?

Our guidelines contain a matrix that has land use and type of facility addressed. The goal is to not be rigid but be flexible based on the context and situation. We are also trying wherever possible to provide separation of modes. Another goal is to lower speed limits to improve safety and mobility of all modes. We have adopted the concept of complete streets but it does not contain the details that are contained in the guidelines. A specific concern is that when using a bike lane adjacent to a traffic lane the buffer space is claimed by both, but the space is a benefit for wide vehicle traffic.

6. What is your process for applying design flexibility considering allocation/reallocation of cross section design elements, use of design exceptions, and use of low cost options?

Our state DOTs perspective is that anything less than a 12 ft. lane will require a Design Exception. Left Turn Lanes are 14 ft. and right turn lanes are 15 to 16 ft. Design Exceptions are generally approved but Cities are not requested because they do not have the funds for the extra engineering cost to request. We are generally going along with the State standard which everyone realizes is stricter than even the Green Book requires. Other typical Design Exceptions are turn

bay requirements of being 95% of the queue length and vehicle mobility which requires a V/C of .75 for 20 years.

7. How does the agency integrate geometric design with traffic control to optimize operations and safety for all user groups?

We currently utilize:
Bicycle Signals, especially for diagonal crossings and one way streets;
Bicycle Boxes – helps to prevent Right Hook crash issues but not a total solution;
Blue Light – detection to indicate that a bicycle is waiting and used to prevent bicycles from running the red light; and
Bike Detection Loops – to provide warning to vehicles to yield.

8. How are U.S. Access Board accessibility guidelines addressed?

All new facilities provide for current ADA requirements but the issue is the older facilities. We have several instances of mid-block crossings and use of median refuge islands.

9. Do you use any other methods for creating street and road designs that support livable, sustainable and healthy communities and neighborhoods?

A bike bill was passed in 1972 that made it a State Law for any new road construction project that provides added capacity to also provide bike lanes. This has helped move toward better consideration of bikes and pedestrians since these are legal requirements.

We do not anticipate having Guidelines that address all of the issues, but rather recommend using a diverse group of professionals as an advisory board to discuss the design conflicts.

We also need to consider the Green aspect to provide trees, storm water swales and other means to reduce the roadway's stormwater impact on the environment.

We feel that neighborhood roads should be designed to enhance the bike/pedestrian experience. We try to create safer environments by designing low speed facilities with traffic diversion, speed humps and other means.

We also manage major roadway speeds by establishing signals at every block and set at a 12.8 mph timing for bicycle traffic.

Agency: Michigan DOT - Brad Wieferich, Brad Peterson, Kelby Wallace, Imad Gedaoun, Carlos Torres

1. How are different user groups and sub-groups addressed during both the development and implementation stages of your design process?

The department had a strong complete streets policy and guidelines for stakeholder engagement. We also have a guide titled Best Design Practices for Walking and Bicycling in Michigan. Our planning and design guides require and/or encourage our staff and consultants to consider all user groups in both our planning and design processes although we have plans to expand and strengthen the guidance and processes contained in several of our documents. We also

have a Complete Streets Implementation Plan (version 1.1 draft) which identifies our goals in these areas.

2. What performance metrics are used for all modes that address operations, safety, accessibility and convenience?

MDOT's Long Range Transportation Plan discusses a number of performance metrics in the Goals, Objectives and Performance Measures Report, but it also notes a lack of multimodal measures. It calls out non-motorized transportation, intercity passenger rail/bus, environment and land use/local coordination as missing/weak links in the current metrics. Motorized metrics are the predominant approach in the current design processes.

3. How the principal elements of design are balanced among all users? i.e. Lane width (vehicles, bicycle, transit, pedestrian), corner radius

We look at existing and projected demand for all modes, although the non-motorized projects are generally qualitative whereas the motorized demand is usually analyzed in a quantitative way using capacity analysis and operations studies. We always interact closely with the local agency in which the project resides to see what their non-motorized plans call for and what they prefer. We also consider public input through stakeholder engagement on most projects. Once all the desires and needs are identified, we work with the local agency to develop the best balanced design with consideration to the function and purpose of the state roadway and the role it serves in the local roadway system.

4. How multimodal level of service is assessed?

We use the Highway Capacity Manual to determine vehicular LOS in our normal roadway design process. We realize it has procedures for non-motorized LOS analysis. Our CSS Manual has guidance for evaluating quality and level of service of non-motorized facilities based on the Florida Department of Transportation's Multi-modal Quality/Level of Service Model. Honestly, we don't really do MMLOS on a routine basis.

5. What methods are used to identify and address typical constraints such as limitations in right-of-way, roadside features, utility conflicts, excessive access points, etc.?

Of course we use aerials and surveys for our design projects. All constraints are usually identified through that process. We also coordinate with the local agency to see if they have additional information or plans that may impact available ROW of other aspects of the project.

6. What is your process for applying design flexibility considering allocation/reallocation of cross section design elements, use of design exceptions, and use of low cost options?

Our DOT follows our CSS and Complete Streets policy in using design flexibility because it's usually necessary in reconstruction and any urban project. We do follow state and federal guidelines for design exceptions and process them accordingly. For local agency projects, we have a LAP Design Exception Review Process that identifies when an exception is needed and how to

process it through the department. Essentially, when deviating from either AASHTO or 3R standards as defined in "Michigan Department of Transportation Local Agency Programs Guidelines for Geometrics" (3R), a design exception must be requested.

7. How does the agency integrate geometric design with traffic control to optimize operations and safety for all user groups;

We have several documents that give us guidance and techniques to do this. As mentioned earlier, we have a Best Design Practices for Walking and Bicycling in Michigan document which is very helpful. We also have seven non-motorized plans for various regions of the state along with a Non-Motorized Technical Report of the State Long range Transportation Plan. We also have several traffic operations design guidance documents for non-motorized users. All of these resources are available to our staff and design consultants through the project planning and design phases.

8. How are U.S. Access Board accessibility guidelines addressed?

We have and use the PROWAG accessibility guidelines and use them in all projects. Curb ramps and other ADA requirements are considered standard practice in the department, consistent with our adopted 2009 ADA Transition Plan.

9. Do you use any other methods for creating street and road designs that support livable, sustainable and healthy communities and neighborhoods?

In addition to our intent to implement our Complete Streets Policy and plans and our CSS plan, the Michigan Transportation Plan contains an Integration Technical Report that includes the following statement about the long-term value of having a more integrated, multimodal transportation system:

"A more fully integrated transportation system can boost Michigan's economic vitality. An integrated variety of transportation modes will encourage the economic participation of people and businesses in a greater number and variety of activities, all of which have the potential to enhance Michigan's economic performance. An integrated transportation [system] can also save money by reducing transportation costs or increasing efficiency. The more integrated the transportation system is the easier and more cost-effective it is for people and businesses to participate in the activities that drive Michigan's economy."

Agency: Washington DOT, Andrew Beagle, PE

1. Does your agency have a formal process for identifying the mix of users that need to be served on a given roadway or functional classification?

WSDOT is in the process of adopting a policy concept referred to as "Modal Compatibility". Modal priority is established based on land use and transportation context. A multiagency and interdisciplinary advisory team is to be formed that will work to develop consent-based recommendations for projects/designs.

The new policy is being reviewed and updated. A link is the policy is available here. [http://www.wsdot.wa.gov/Design/Manual/ActiveRevisions.htm#PracticalDesign.](http://www.wsdot.wa.gov/Design/Manual/ActiveRevisions.htm#PracticalDesign)

The most relevant chapters to Project 15-48 are Chapters 1100-1106

2. Does your agency have specific design criteria for low- and intermediate-speed roadways that accommodate all applicable roadway users?

WSDOT rewrote their geometric cross-section chapter with quite a bit of distinction based on the speed environment. Recommended cross sections are based on speed and individual environments.

The policy includes differentiating between roadside vs streetside environments.

3. How does your agency evaluate project levels of service for all users? (Or do you?)

WSDOT does not have multimodal LOS. Evaluations are performance based.

A performance metric is based on modal priority. The metric will vary with mode.

4. How does your agency determine priorities and balance the service to all modes?

WSDOT is in the process of adopting a policy concept referred to as "Modal Compatibility". Modal priority is established based on land use and transportation context.

5. If the roadway is owned/managed by multiple agencies, how are they involved in the design process?

A multiagency and interdisciplinary advisory team is to be formed that will work to develop consent-based recommendations for projects/designs.

6. Does your agency formally evaluate projects after they are completed to determine how well they serve relevant user groups?

WSDOT has a research program that looked at evaluating projects and helped WSDOT formulate their proposed policy referred to as "Modal Compatibility". I requested a copy of the research report.

WSDOT has a freight mobility tool that helps to evaluate the impact of freight traffic on other modes.

7. Has your agency recently developed a project where you feel it has successfully accommodated all users? If so, what type of project was it, and why do you think it was so successful?

Mr. Beagle could not think of any projects off the top of his head, but indicated that he will think further about it and seek some input and get back to me.

8. How are U.S. Access Board accessibility guidelines addressed?

WSDOT is committed to making all our facilities accessible to all persons, regardless of abilities and has developed Standard Plans to comply with state and federal ADA laws. These standards deal with pedestrian facilities, such as curb cuts and driveways. The Design Manual has been updated to reflect the current laws. They also list a number of other ADA design resources on their website.

9. Do you use any other methods for creating street and road designs that support livable, sustainable and healthy communities and neighborhoods?

The Foreword of WSDOT's Design Manual Volume 1 includes this language: "…The complexity of transportation design requires designers to make fundamental trade-off decisions that balance competing spatial considerations. Although this adds to the complexity of design, it acknowledges the unique needs of specific projects and the relative priorities of various projects and programs…. The Design Manual emphasizes "practical design" as a means to produce environmentally conscious, sustainable, context-based designs that achieve the purpose and need for the lowest cost. Implementing practical design addresses the needs of all users, fostering livable communities and modally integrated transportation systems used safely by all, including motorists, freight haulers, transit, pedestrians, and bicyclists."

Volume 2 of the Design Manual (Design Criteria) includes several chapters that provide multimodal design guidance for livable communities including:

Chapter 1150 - Context and Modally Integrated Main Streets
Chapter 1410 – High-Occupancy Vehicle Facilities: Evaluating and designing high-occupancy vehicle (HOV) facilities.
Chapter 1420 – HOV Direct Access: Design guidance on left-side direct access to HOV lanes and transit facilities.
Chapter 1430 – Transit Benefit Facilities: Operational guidance and information for designing transit facilities such as park & ride lots, transfer/ transit centers, and bus stops and pullouts.
Chapter 1510 – Pedestrian Facilities: Designing facilities that encourage efficient pedestrian access that meets ADA.
Chapter 1515 – Shared-Use Paths: Guidance that emphasizes pedestrians are users of shared-use paths and accessibility requirements apply in their design.
Chapter 1520 – Roadway Bicycle Facilities: Selecting and designing useful and cost-effective bicycle facilities.

Agency: Caltrans, Timothy Craggs

1. Does your agency have a formal process for identifying the mix of users that need to be served on a given roadway or functional classification?

Caltrans does have a process to evaluate the mix of users to be served on a given roadway, but it is not formal process.

2. Does your agency have specific design criteria for low- and intermediate-speed roadways that accommodate all applicable roadway users?

Mr. Craggs indicated that design criteria for low- and intermediate-speed roadways to accommodate applicable roadway users is incorporated into their design guidance. In 2014 the design division issued a memorandum titled Design Flexibility in Multimodal Design in response to a Caltrans program review report that identified a need to provide more flexibility in Caltrans' highway design standards and procedures, especially in the context of urban environments and multimodal design. Caltrans is continually improving its standards and processes to provide flexibility while maintaining the safety and integrity of the state's transportation system. This commitment is evident in the recent update to the Highway Design Manual (HDM) to facilitate the design of Complete Streets, recognizing that the State highway system needs to be multimodal, not just for cars and trucks.

In addition, Caltrans developed in 2013 a document titled Main Street, California - A Guide for Improving Community and Transportation Vitality to address design of California State Highways that also function as main streets through communities. Those situations challenge Caltrans with balancing the public's need for roadways that provide local, regional and statewide connections, with local needs for a vibrant community street. The document states that "…just as mobility is essential to California's economic and civic vitality, the planning, design and operation of main streets is tied to the prosperity of local communities. Well-conceived main streets function efficiently as multimodal transportation facilities, and are important civic spaces that support vibrant community life and ecological health. Prudent investments to provide multimodal travel options are a crucial strategy for reducing greenhouse gas emissions and other environmental impacts associated with single occupancy driving habits."

3. How does your agency evaluate project levels of service for all users? (Or do you?)

Caltran's main focus over the years has been to accommodate motor vehicles. They are currently struggling on how to measure LOS for other users.

4. How does your agency determine priorities and balance the service to all modes?

No formal method is in place.

5. If the roadway is owned/managed by multiple agencies, how are they involved in the design process?

The agencies are involved as stakeholders in the design process and provide input into the project, but the agencies are not involved in the design process.

6. Does your agency formally evaluate projects after they are completed to determine how well they serve relevant user groups?

Caltrans has not historically evaluated projects after they are completed.

7. Has your agency recently developed a project where you feel it has successfully accommodated all users? If so, what type of project was it, and why do you think it was so successful?

Mr. Craggs did not have any particular project in mind but indicated that Caltrans does not have a formal process to obtain feedback after a project is completed but Caltrans often will hear back from partners/user groups if they are happy/satisfied with a project.

8. How are U.S. Access Board accessibility guidelines addressed?

Caltrans design policy and standards were developed in accordance with ADA and PROWAG guidelines and have been reviewed by FHWA. Additional design guidance has also been developed for curb ramp scoping and design. The Caltrans ADA Infrastructure Program ensures that Caltrans facilities are in compliance with Title II of the ADA and makes Caltrans infrastructure equally accessible to persons with disabilities.

9. Do you use any other methods for creating street and road designs that support livable, sustainable and healthy communities and neighborhoods?

Caltrans has established an Active Transportation and Livable Communities (ATLC) group that includes California Department of Transportation management and external stakeholder representatives. The ATLC group meets quarterly to discuss and recommend solutions and action items pertaining to active transportation and livable community concepts. The Caltrans Division of Design is a member of this group and is charged with providing the procedures, policy, standards, guidance, technical assistance, and training needed to facilitate California transportation improvements and system integrity related to livable communities.

4.1.4. Roadway Agency Design Guidance Reviews – Identifying Best Practices

In addition to the literature review, agency survey and selected agency interviews, the research team has also conducted a review of state and local roadway agency design manuals and any associated guidance and policies for accommodation of non-motorized users. Our research team identified and performed a cursory review of the roadway design manuals and policies of all fifty (50) U.S. state roadway agencies plus the District of Columbia and Commonwealth of Puerto Rico. We also identified eighteen (18) local government agencies that have developed their own design manuals focused on improved accommodation of pedestrian, bicycle and transit users, primarily for facilities in urban and suburban areas.

The primary goal of the design manual reviews was to first understand the range and depth of existing agency approaches to designing for all users on facilities with design speeds equal to or

less than 45 MPH. Secondly, the reviews were to evaluate in more depth those agencies that have established specific processes and approaches that are in use today to evaluate and address the needs all users in those low- and intermediate-speed environments. Many state and local agencies have established legislation, policies and conceptual guidelines that promote accommodation of all users in roadway planning and design, but a large number of those agencies have not advanced their guidance to the level of establishing in-depth design processes and guidance that guide designers in effectively accomplishing that accommodation.

Our research has found that twenty-eight (28) states and territories have policies or design guidelines that specifically address the level and quality of service to pedestrians, bicyclists and other non-motorized users *at least at a cursory level* in the project development and design process. Nineteen (19) of those DOTs have been identified as having developed guidance at a *much more comprehensive level*. These DOTs are considered to employ a level of best practices that will significantly inform the development of the guidelines document developed in this research project

In these targeted states having more advanced guidance, the DOTs typically have either (1) sections of their roadway design manuals specifically dedicated to the unique needs and accommodation of one or more classes of non-motorized users, or (2) separate companion documents that contain significant design guidance that addresses accommodating needs of non-vehicle user modes. The state DOTs that have been noted by the research team as having developed this significant level of advanced design guidance, listed in alphabetical order, include:

- California
- Colorado
- Connecticut
- Florida
- Georgia
- Indiana
- Maine
- Maryland
- Massachusetts
- Michigan
- Minnesota
- New Jersey
- North Carolina
- Oregon
- Pennsylvania
- Vermont
- Virginia
- Washington
- Wisconsin

The District of Columbia and Commonwealth of Puerto Rico also have adopted complete streets policies or legislation although no specific design guidance has been developed as of this date.

Accommodating all users is also a component of the context sensitive solutions process where those users are or will be present. Information from FHWA's Context Sensitive Solutions.org website list the following states that have <u>adopted</u> a formal DOT policy regarding Context Sensitive Solutions:

- California
- Connecticut
- District of Columbia
- Iowa
- Illinois
- Kentucky
- Maryland
- Massachusetts

- Minnesota
- Mississippi
- New Hampshire
- New Jersey
- New York
- Pennsylvania
- Utah
- Washington
- Wisconsin

FHWA also lists the following states as having issued some type of CSS policy statement:

- Florida
- Indiana
- Louisiana
- Montana
- New Hampshire
- North Carolina
- Ohio
- Rhode Island
- Tennessee
- Texas
- Virginia
- Vermont

Finally, FHWA notes that the State of Illinois has passed state legislation regarding CSS and the states of Massachusetts, Michigan, Minnesota and Washington have issued CSS executive orders.

In addition to evaluating state DOT activities in designing for all users, the research team has also identified through the literature review a number of local government agencies (including MPOs) that have developed significant multimodal accommodation design guidance for their organizations. These agencies are listed below. Their urban- and suburban-focused guidance documents will serve a particularly useful role in developing guidelines for the design of low- and intermediate-speed roadways with multimodal accommodation needs.

- City of Boston, MA
- City of Burlington, VT
- City of Charlotte, NC
- City of Chicago, IL
- City of Dallas, TX
- City of Deerfield Beach, FL
- City of Ft. Lauderdale, FL
- Los Angeles County, CA
- Louisville/Jefferson County Metro, KY
- Maricopa County, AZ
- City of New Haven, CT
- New York City, NY
- City of Philadelphia, PA
- Portland Metro, OR
- Regional Transportation Commission of Southern Nevada, NV
- City of San Francisco, CA
- City of Seattle, WA
- City of Tacoma, WA

The two tables on the following pages (**Exhibit 4-1** and **Exhibit 4-2**) identify the primary policy and design guidance that each of the nineteen (19) selected DOTs and eighteen (18) selected local agencies rely on to inform and guide consideration of all users and multimodal context-sensitivity in their geometric design processes. The tables specifically note whether the agency has adopted formal or informal CSS or complete streets policy guidance, along with the primary policy guidance and design guidance documents identified for each agency.

EXHIBIT 4-1: STATE DOT POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
State DOT	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
California	Formal Policy *Director's Policy on Context Sensitive Solutions (DP-22)*	Directive *Deputy Directive 64-R2*	Policy/Direction - Director's Policy on Context Sensitive Solutions (DP-22) (pdf) - Director's Policy on Context Sensitive Solutions (DP-22) (pdf) - CS Implementation Action Plan (pdf) - CS Technical Advisory Committee - Design Flexibility & NACTO Design Guide Endorsement (press release) Design Guidance - Design Flexibility in Multimodal Design Memorandum (pdf) - Complete Intersections Design Guide (pdf) - Highway Design Manual - Update to be more sensitive to the community context and incorporate best design practices for bike, pedestrian, and transit facilities - NACTO Urban Street & Bicycle Design guides - CS website
Colorado	Website Page	Bicycle & Pedestrian Policy	Policy/Direction - Bicycle and Pedestrian Policy (pdf) - Bicycle and Pedestrian Procedural Directive 1602.1 (pdf) - Policy Directive 902 - Roadway Shoulder Policy (pdf) - Bicycle/pedestrian website - Bicycle/Pedestrian Design Guidance, Chief Engineer Memo (pdf) Design Guidance - Roadway Design Guide, Chapter 14 Bicycle and Pedestrian Facilities (website) - AASHTO Bicycle and Pedestrian Design guides - NACTO Urban Street & Bicycle Design guides - FHWA Road Diet and Separated Bike Lane guides - Rumble Strip Standard (pdf)

EXHIBIT 4-1: STATE DOT POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
State DOT	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
Connecticut	Formal Policy *Department Administrative Memo 24*	Policy Statement *Policy No. EX.0.-31*	<u>Policy/Direction</u> - Complete Streets Policy Statement (Policy Number Ex.O.-31) (pdf) - Periodic Complete Streets "webletter" – "Streetlights" (pdf) - Complete Street Report (2013) (pdf) - Bicycle and Pedestrian Advisory Board - Complete Streets website <u>Design Guidance</u> - Bicycle and Pedestrian Transportation Plan (website) - Bicycle and Pedestrian Travel Needs Assessment Form (pdf)
Florida	Policy Statement *The FDOT adopted its first Context Sensitive Solutions Policy in 2008.*	Policy *Design Director - Topic No.: 000-625-017-a*	<u>Policy/Direction</u> - Complete Street Policy (pdf) - Florida Pedestrian And Bicycle Strategic Safety Plan (pdf) - Pedestrian and Bicycle Safety (http://www.dot.state.fl.us/safety/2A-Programs/Bicycle-Pedestrian.shtm) - Bicycle and Pedestrian Facilities website (http://www.dot.state.fl.us/rddesign/BikePed/Default.shtm) - Complete Street Implementation website (http://www.dot.state.fl.us/rddesign/CSI/Default.shtm) <u>Design Guidance</u> - 2013 Quality/Level of Service Handbook - Florida Green Book – Chapter 8 PEDESTRIAN FACILITIES - Florida Green Book – Chapter 9 BICYCLE FACILITIES - Florida Green Book – Chapter 13 PUBLIC TRANSIT - Florida Green Book – Chapter 19 TRADITIONAL NEIGHBORHOOD DEVELOPMENT - Florida Green Book - Chapter 21-TRANSPORTATION DESIGN FOR LIVABLE COMMUNITIES - Traditional Neighborhood Development Handbook (pdf) - Project Management Handbook Chapter 9 Context Sensitive Solutions (pdf) - Complete Street Workshops

EXHIBIT 4-1: STATE DOT POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
State DOT	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
Georgia	Design Manual	Complete Streets Policy	Policy/Direction - Complete Streets Policy (pdf) Design Guidance - Complete Streets Design Guidelines (pdf) - Design Policy Manual (Chapter 9. Complete Streets Design Policy)
Indiana	Policy Statement *CSS Website:* *http://www.in.gov/indot/div/projects/indianacss/*	INDOT Complete Streets Guideline & Policy	Policy/Direction - Complete Streets Program (http://www.in.gov/indot/3284.htm) - Bicycle & Pedestrian Program (website) - Design Flexibility in CSS (website) - Public Involvement Plan in CSS (website) - Community Context Audit in CSS (website) Design Guidance - CSS Awareness training in CSS (website) - Communication and Customer Service Training in CSS (website) - INDOT Complete Streets Guideline & Policy (pdf) - Design Manual – Chapter 307 Trail/Greenway/Non-Motorized Pedestrian Facility (pdf)
Maine	Addressed in Sensible Transportation Policy Act	Policy	Policy/Direction - MaineDOT Complete Streets Policy (http://www.maine.gov/mdot/completestreets/) - MaineDOT Complete Streets Policy Development Timeline and Process 2013-2014 (pdf) - Biking & Walking in Maine (http://www.maine.gov/mdot/bikeped/index.shtml) - Sensible Transportation Policy Act (pdf) - Practical Design – A Philosophy for MaineDOT (pdf) Design Guidance - Highway Design Guide (website) - MaineDOT Practical Design Guidance (pdf) - Sensible Transportation Handbook for Local and Inter-Community Transportation Planning in Maine (pdf)

EXHIBIT 4-1: STATE DOT POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
State DOT	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
Maryland	Formal Policy	Policy	Policy / Direction - Maryland Bicycle & Pedestrian Twenty Year Master Plan (pdf) - SHA Complete Streets Policy (pdf) - Community Safety and Enhancement Program (CSEP) (pdf) Design Guidance - When Main Street is a State Highway – Blending Function, Beauty and Identity – A Handbook for Communities and Designers (pdf0 - 2013 Bicycle Policy & Design Guidelines (pdf)
Massachusetts	Formal Policy Executive Order	Bicycle-Ped. Access Law	Policy/Direction - Healthy Transportation Policy Directive (pdf) - Healthy Transportation Engineering Directive - Mode Shift Goal to Triple the Share of Travel in Massachusetts by Bicycling, Transit and Walking (website) - Healthy Transportation Compact (website) - 1998 Massachusetts Pedestrian Transportation Plan (pdf) - Massachusetts Bicycle Transportation Plan (pdf) Design Guidance - Project Development and Design Guide (http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/ManualsPublicationsForms/ProjectDevelopmentDesignGuide.aspx) - Complete Streets Certification Program (website)
Michigan	Executive Order	Policy	Policy/Direction - Executive Directive – Context Sensitive Design for Transportation Projects (pdf) - Executive Directive – Context Sensitive Solutions (pdf) - Context Sensitive Solutions - Draft Implementation Plan (pdf) - Context Sensitive Solutions website Design Guidance - April 12, 2005 written by MDOT Design for CSS Manual - Flexibility in Michigan DOT Design Standards - Best Design Practices for Walking and Biking in Michigan - Flexibility in Design Standards (pdf) - CSS Awareness Training

EXHIBIT 4-1: STATE DOT POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
State DOT	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
Minnesota	Formal Policy Executive Order	Legislation	<u>Policy/Direction</u> - Policy Statement (pdf) - Technical Memorandum No. 14-08-TS-02 Complete Streets Guidance and Procedures - MnDOT Complete Streets website - Minnesota GO – Multimodal Transportation Vision (website) - Complete Streets Project Report (pdf) - CSS Flagship Initiative (pdf) - Statewide Pedestrian System Plan (website) <u>Design Guidance</u> - Minnesota's Best Practices for Pedestrian/Bicycle Safety (pdf) - Advanced Flexibility in Design Workshop - Bikeway Facility Design Manual (pdf) - Road Design Manual: Chapter 11 Special Design – Pedestrian Facilities (website)
New Jersey	Formal Policy	Policy	<u>Policy/Direction</u> - Complete Street policy (pdf) - Making Complete Streets A Reality: A Guide to Policy Development (pdf) - New Jersey's Guide to Creating a Complete Streets Implementation Plan (pdf) <u>Design Guidance</u> - Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities - Complete Streets training workshops (website) - Complete Streets checklist (word) - Context Sensitive Design - Design Process Chart (word) - Roadway Design Manual: Section 15 – Traffic Calming (website)

EXHIBIT 4-1: STATE DOT POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
State DOT	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
North Carolina	Policy Statement	Policy	<u>Policy/Direction</u> - Complete Street Policy (pdf) - Bicycle Policy (pdf) - Board of Transportation Resolution: Bicycling & Walking in North Carolina, A Critical Part of the Transportation System (pdf) - NCDOT Context Sensitive Solutions Goals and Working Guidelines (pdf) - Pedestrian Policy Guidelines (pdf) <u>Design Guidance</u> - Complete Streets Planning & Design Guide (pdf) - Bicycle & Pedestrian Development & Design guidance (website) - Bicycle Facilities Planning & Design Manual (website) - Two-day training courses (pdf)
Oregon	Policy (Merged CSS with Sustainable to create CS3 – "Context Sensitivity and Sustainable Solutions")	Legislation	<u>Policy/Direction</u> - Oregon Bicycle and Pedestrian Mode Plan (website) <u>Design Guidance</u> - Oregon Bicycle and Pedestrian Design Guidelines (pdf) - Bicycle and Pedestrian Design Guide (Appendix L Highway Design Manual) - Highway Design Manual: Chapter 13 - Pedestrian and Bicycle (website) - Practical Design Guidebook (pdf) - Context Sensitive and Sustainable Solutions (CS3) Guidebook - Oregon Department of Transportation Project Delivery and Public Involvement Resource Guide - The Importance of Good Design and Context - The Relationship between ODOT's Sustainability Program and The Context Sensitive and Sustainable Solutions (CS3) Approach
Pennsylvania	Formal Policy		<u>Policy/Direction</u> - Multimodal Transportation Program (website) - PennDOT Bicycle and Pedestrian Plan (pdf) - PennDOT Mobility Plan(pdf) <u>Design Guidance</u> - Pennsylvania's Traffic Calming Handbook, Publication 383 (pdf) - Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities

EXHIBIT 4-1: STATE DOT POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
State DOT	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
Vermont	Policy Statement	State Legislation Act 34	Policy/Direction - Vermont Pedestrian and Bicycle Policy Plan (website) - Strengthening Vermont's Economy by Integrating Transportation and Smart Growth Policy (pdf) Design Guidance - Complete Streets Guidance Document (pdf) - Vermont Pedestrian and Bicycle Facility Planning and Design Manual (pdf)
Virginia	Policy Statement	Transportation Commission Policy	Policy/Direction - State Bicycle Policy Plan (pdf) - Policy for Integrating Bicycle and Pedestrian Accommodations (pdf) - Context Sensitive Solutions Policy Design Guidance - Road Design Manual – Appendix B(2) Multimodal Design Standards for Mixed-Use Urban Centers - Multimodal System Design Guidelines - Guide for Preparing a Multimodal System Plan
Washington	Formal Policy Executive Order	Formal Policy Executive Order	Policy/Direction - Complete Streets Act - Context Sensitive Solutions Executive Order 1028.02 - Washington's Complete Streets And Main Street Highways Program: Case Studies and Practice Resource (pdf) - WSDOT Action Plan - Safer People, Safer Streets (pdf) - Results WSDOT – Our Strategic Plan (website) - Understanding Flexibility in Transportation Design (pdf) - Moving Washington Forward: Practical Solutions (website) - Community Design (website) Design Guidance - Designing for Pedestrians (website) - Urban Street Design Innovations (website) - Medians and Roadsides Brochure (pdf)

EXHIBIT 4-1: STATE DOT POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
State DOT	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
Wisconsin	Formal Policy - It is WisDOT policy to use "Community Sensitive Design" (CSD)	Wisconsin Act 28 created Statute 84.01(35), (aka the "complete streets" law)	Policy/Direction - Wisconsin Statewide Pedestrian Policy Plan 2020 (pdf) - Connections 2030: Wisconsin's long-range transportation plan (website) - Wisconsin Bicycle Transportation Plan (pdf) Design Guidance - Wisconsin Bicycle Planning Guidance (pdf) - Wisconsin Bicycle Facility Design Handbook (pdf) - Facilities Development Manual - Section 11-3 Community Sensitive Design (pdf) - Facilities Development Manual Chapter 11 Design Section 46 Complete Streets (pdf)

EXHIBIT 4-2: LOCAL AGENCY POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
Local Agency	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
City of Boston, MA	None	Design Guidelines	Policy Direction - Boston Bike Network plan - Boston Region Pedestrian Transportation Plan Design Guidance - Boston Complete Streets – Design Guidelines http://bostoncompletestreets.org/
City of Burlington, VT	None	Council Policy	Design Guidance - Street Design Guidelines: Burlington Transportation Plan - Burlington Complete Streets Guidance https://www.burlingtonvt.gov/DPW/Complete-Streets

EXHIBIT 4-2: LOCAL AGENCY POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
Local Agency	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
City of Charlotte, NC	None	City Ordinance	Policy Guidance - City of Charlotte Bicycle Plan - Charlotte Pedestrian Safety Action Plan Design Guidance - Urban Street Design Guidelines Policy Summary - Urban Street Design Guidelines http://charmeck.org/city/charlotte/Transportation/PlansProjects/pages/urban%20street%20design%20guidelines.aspx
City of Chicago, IL	None	Council Policy	Policy Direction - Chicago Pedestrian Plan - Bike 2015 Plan - Streets for Cycling Plan 2020 Design Guidance - Complete Streets Chicago – Design Guidelines - Sustainable Infrastructure Design Guidelines - Streetscapes Design Guidelines - Bike Lane Design Guide - Tools for Safer Streets Guide http://chicagocompletestreets.org/
City of Dallas, TX	None	None	Policy Direction - Dallas Bike Plan Design Guidance - Complete Streets Design Manual (draft 2013) http://dallascityhall.com/departments/pnv/transportation-planning/Pages/default.aspx
City of Deerfield Beach, FL	None	None	Policy Direction - Complete Streets Implementation Final Plan Design Guidance - Complete Streets Guidelines http://www.deerfield-beach.com/index.aspx?nid=1079

EXHIBIT 4-2: LOCAL AGENCY POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
Local Agency	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
City of Ft. Lauderdale, FL	None	Council Policy	Policy Direction - Long Range Transportation Plan (county) - Bicycle Safety and Action Plan (county) Design Guidance - Complete Streets Manual http://gyr.fortlauderdale.gov/greener-government/transportation-connectivity/better-streets-for-everyone/complete-streets
Los Angeles County, CA	None	County Metro Transportation Authority Policy	Policy Direction - Bicycle Master Plan - Community Pedestrian and Active Transportation Plan Design Guidance - Model Design Manual for Living Streets http://www.modelstreetdesignmanual.com/
Louisville/Jefferson County Metro, KY	None	Council Policy and Ordinance	Policy Direction - Bike Master Plan - Pedestrian Master Plan - Bike Parking Manual - Downtown Multimodal Transportation Study Design Guidance - Complete Streets Manual https://louisvilleky.gov/government/bike-louisville/complete-streets
Maricopa County, AZ	None	None	Policy Direction - Bicycle Plan Design Guidance - Complete Streets Guide (Maricopa MPO) http://www.azmag.gov/Documents/BaP_2011-01-25_MAG-Complete-Streets-Guide-December-2010.pdf
City of New Haven, CT	None	Complete Streets Order	Policy Direction - 2010 Bike Plan Design Guidance - Complete Streets Design Manual http://www.cityofnewhaven.com/Engineering/completestreets.asp

EXHIBIT 4-2: LOCAL AGENCY POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
Local Agency	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
New York City, NY	None	None	Policy Direction - Bicycle Master Plan - Pedestrian Safety Action Plan - Sustainable Streets Strategic Plan Design Guidance - Street Design Manual http://www.nyc.gov/html/dot/html/pedestrians/streetdesignmanual.shtml
City of Philadelphia, PA	None	Executive Order	Policy Direction - Pedestrian and Bicycle Action Plan Design Guidance - Complete Street Design Handbook http://www.philadelphiastreets.com/complete-streets
Portland Metro, OR	None	None	Policy Direction - Bicycle Plan for 2030 - Regional Active Transportation Plan Design Guidance - Creating Livable Streets: Street Design Guidelines for 2040 http://www.oregonmetro.gov/tools-partners/guides-and-tools/guide-safe-and-healthy-streets
Regional Transportation Commission of Southern Nevada, NV	None	Policy	Policy Direction - Regional Bicycle and Pedestrian Plan - Transit Bus Stop Guidelines Design Guidance - Complete Streets Design Guidelines for Livable Streets http://www.rtcsnv.com/planning-engineering/rtc-projects/complete-streets/
City of San Francisco, CA	None	Better Streets Policy, Transit First Policy	Policy Direction - San Francisco Bicycle Plan - WalkFirst Plan Design Guidance - Better Streets Plan http://www.sfbetterstreets.org/

EXHIBIT 4-2: LOCAL AGENCY POLICY AND DESIGN GUIDANCE TO ACCOMMODATE ALL USERS			
Local Agency	**CSS Policy Actions**	**Complete Streets (CS) Policy Actions**	**Key Policy & Design Guidance for Accommodating All Users**
City of Seattle, WA	None	Ordinance	Policy Direction - Pedestrian Master Plan - Bicycle Master Plan Design Guidance - Complete Streets Checklist - Right-of-Way Improvements Manual http://www.seattle.gov/transportation/completeStreets.htm http://www.seattle.gov/transportation/rowmanual/manual/4_1.asp#412
City of Tacoma, WA	None	Resolution	Policy Direction - Mobility Master Plan Design Guidance - Mixed-use Centers Complete Streets Design Guidelines - Residential Streets Complete Streets Design Guidelines https://www.cityoftacoma.org/government/city_departments/environmentalservices/office_of_environmental_policy_and_sustainability/green_living_resources_and_map/transportation/green_roads/complete_streets

4.1.5 Observations from Agency Interviews and Document Reviews

The research team reviewed the information provided by agencies in telephone interviews as well as identified key design policy and guidance documents from each agency as listed in the preceding tables. We feel that this effort provided us with an excellent cross-section of the current best practices used to identify and address multimodal user needs in the geometric design process.

As expected, while design criteria and guidelines are important to actually develop geometric designs that consider the safety and mobility of all users, it is equally important to identify the vision and goals for serving all users in the planning stages for transportation networks and individual facilities. If all users have not been fully considered in the early stages of planning, environmental, project scoping and program development, then attempting to adequately design for all users in the preliminary and final design stages of a project may be significantly limited with some desirable alternatives even prohibited at that stage of project development.

Based on the agency interview feedback and review of design policy and guidance documents, the research team developed the following observations on the state of current practice of designing for all users in low and intermediate speed environments.

a. <u>There is generally broad awareness of the interest in and need for multimodal design.</u>
   There is broad awareness among state and local government agency staff of the national, state and local trends to increase consideration of, and accommodation for, non-motorized users in the geometric design of roadway projects, particularly in urban and suburban areas where these needs are more evident and are often a high priority of local agencies.

b. <u>Concept design guidance is much more prevalent than detailed guidance.</u>
   While many agencies have developed policies and design concepts addressing a combination of context sensitive solutions, complete streets and multimodal design, many of those agencies have not yet developed definitive design guidance for how to achieve roadway designs that effectively evaluate and balance accommodation of service to those modes. This is a particular challenge along state and federal-aid highways in urban and suburban areas where the vision and goals of the DOT are to provide optimal mobility for local, regional and state-wide connections, but the vision of the local agency (and regional planning agency) is to safely integrate all modes into a broad, multimodal facility that is supportive of adjacent land use and community values.

c. <u>Many agencies don't understand the importance of, or make the effort to, effectively engage all users throughout the design process.</u>
   Where agencies have developed detailed criteria and guidelines for multimodal accommodation and design, there is often limited guidance on how to conduct a multimodal design process. Effective multimodal design requires effectively engaging all current and future users throughout a design process to fully understand their needs and desires. The process then assesses trade-offs for different design elements and criteria addressing all users, along with how alternative cross-sections and geometric features best complement the land use context and community goals.

d. Some local agencies have developed detailed context-driven design guidance for multimodal accommodation design, but few state DOTs have.
Large, urban cities and counties have, in general, tended to develop more focused and detailed guidelines for context-sensitive multimodal accommodation than have most state DOTs. However, these local agency accommodation and design guidelines often conflict with state DOT design policies and guidelines, especially when the project is on a state or federal-aid roadway and the National Highway System (NHS). Formal design exceptions are often requested by local agencies but not supported, processed or approved by state and federal agencies.

e. Many agencies don't realize that effective multimodal design in low- and intermediate speed environments in a complex process that is difficult to standardize.
Federal and state highway design guidance typically stresses consistency and uniformity in geometric design applications for the safety and efficiency of motorized users. Design is often accomplished through use of "standards", "typicals" and detailed design criteria tables. This approach is critical for high speed facilities (50 mph and above) where the dominant and often only users are motorized vehicles and driver error can result in serious consequences. But in low and intermediate speed settings the ability to consistently apply standard geometric design approaches are usually severely limited by constrained rights-of-way, increased private access, development patterns and other urban/suburban contextual issues. In these situations consistency and uniformity goals must transition to broad use of design "flexibility" to develop independent designs tailored to particular situations. In general, geometric design in urban and suburban settings cannot be effectively accomplished by use of standards, typicals and look-up tables.

f. Agencies have difficulty understanding and applying level and quality of service considerations in multimodal geometric design.
Most design agencies and professionals, especially those in state DOTs, clearly understand the use of HCM LOS analysis in the geometric design process for roadway sections and intersections. These same agencies and professionals are aware that HCM methodologies exist for determining level of service for various other modes, but very few actually use those methodologies for modes other than motorized vehicles. Some agencies (the Florida and Virginia DOTs, for example) have developed their own processes and guidelines for assessing level and quality of service for all modes in a roadway right-of-way, but most agencies don't have established processes or methodologies for assessing level and quality of service to all user groups and then balancing that service across all modes.

g. Few agencies have a formal process for assessing and balancing user needs in geometric design across constrained right-of-way.
Many geometric design processes for low- and intermediate-speed roadways require an assessment of level, quality and safety of service to all modes. This assessment process will typically yield ranges of geometric design elements and criteria that can be applied to for each mode within the available right-of-way. For example, trade-offs in these situations can often include the design speed, number and width of vehicle through and turn lanes, parking lanes, median treatments, bicycle treatments, pedestrian treatments, lateral offset to fixed objects, and so on. Varying the design technique and values of each

of these design elements can change the level, quality and safety of service to each mode. These elements are also impacted by how the design elements are assembled, e.g., the relationship of bicycle lanes to parking lanes and travel lanes. Research is limited in most of these areas and designers are often required to apply generous levels of design flexibility and use their experience and professional judgement in making these design trade-off decisions.

h. The formal design exception process for the thirteen (13) controlling criteria is sometimes a deterrent to applying design flexibility important to multimodal design.
Geometric design in low- and intermediate-speed environments often requires variances from the minimum or desirable standard criteria contained in agency design standards and manuals. On NHS projects, federal law requires formal design exceptions when any of the thirteen (13) controlling criteria are not met, and this requirement is also applied by many state DOTs to non-NHS projects. This situation often limits an agency's willingness to consider, or even process, a design exception as this is seen as possibly unsafe to vehicular service, a liability concern for the agency and/or design professional, or both. It is important to note that the USDOT has proposed as of October, 2015, to eliminate three (3) of the controlling criteria altogether (bridge width, vertical alignment, lateral offset to obstruction) while removing eight (8) of the remaining ten (10) criteria for roadways with design speeds less than 50 MPH. Assuming these recommendations are approved, only two formal design exceptions will be required on projects with low- and intermediate-speeds, with those being "design speed" and "design loading structural capacity" criteria.

4.2. Task 2: Methods to Determine User Service Levels

The objective of Task 2 was to identify performance measures and performance relationships that will help designers accommodate all users in the design of low- and intermediate-speed roadways. Performance measures provide procedures and tools for comparing and evaluating alternative designs with respect to meeting overall project goals and objectives.

4.2.1 Level and Quality of Service

From an operational perspective, level of service (LOS) criterion for motorized vehicles from procedures defined in the Highway Capacity Manual (HCM) has traditionally served as the primary performance measure for evaluating the quality of alternative roadway designs. However, recently with the trend toward performance-based design, development of multi-modal levels of service (e.g., NCHRP 616, TCRP 165, Florida DOT's 2013 Quality/Level of Service Handbook), publication of the Highway Safety Manual (HSM), numerous state and local complete street design guidelines, and extensive information on context sensitive design solutions and design flexibility, there is a recognized need to identify performance measures that can be used to evaluate the design of a roadway based upon how it meets the overall needs of all users/modes: automobile/truck, pedestrian, bicycle, and transit. Additionally, the various modes in a project interact with each other and improvements made in the quality of service for one mode may often improve or lower the quality of service one or more other modes.

Performance measures can cover a range of multimodal criteria including mobility, safety, accessibility, comfort, etc. For example, this could involve identifying operations measures for each mode such travel speed, delay, convenience, accessibility, LOS, etc. by user/mode. From a safety perspective, this would involve identifying measures <u>for each mode</u> such as expected number of total crashes or crashes by severity, expected number of fatalities and injuries (by severity), expected number of crashes by collision type, crash exposure, etc. And from a sustainable transportation perspective, performance measures could include transit accessibility/productivity, bicycle/pedestrian mode share, vehicle-miles traveled (VMT) per capita, levels of "bike-ability" or "walk-ability", aesthetics, air quality impacts, etc. many of these measures will need to be classified according to whether they are multimodal or mode-specific or guidance on how the measures should differ depending upon the roadway speed range (i.e., low- or intermediate-speed), functional classification and context.

Developing quantifiable performance measures requires data. As part of this task, the research team has identified the types of data necessary for quantifying selected performance measures and potential sources for the data. It is recognized, however, that any performance measure that either requires a significant amount of data, particularly if the data are difficult to obtain, or requires a significant amount of resources to collect the data, will be utilized at best for a limited number of projects and will be quickly abandoned in professional design use. In addition, even if the data is obtainable but the process to collect, analyze and evaluate the data is complex and time-consuming, the designer will probably choose to revert to qualitative, experience-based decisions rather than the more precise quantitative assessment.

Analysis tools that provide a means for calculating the performance measures of all modes have been identified in the literature and practice through the Task 1 efforts. Consideration has been given to procedures defined in leading national practice documents such as the 2010 HCM, the 2013 Transit Capacity and Quality of Service Manual (TCRP Report 165), and the Highway Safety Manual (HSM). Other highly relevant research documents and best practice reports addressing user performance measures have also been identified as key references and reviewed as a part of this task.

The research team has also given consideration to how the selected performance measures should be used collectively to evaluate alternative geometric design options. A full range of methodologies have been considered from simple qualitative approaches to more complex approaches (e.g., combining multiple performance measures into a combined weighted index for evaluation purposes). Additionally, the impact of a design choice on sometimes infrequent but important users such as emergency response vehicles, commercial service vehicles, large freight trucks, etc., needs to be factored into the overall procedures for evaluating design alternatives. Similarly, design choices can have significant impacts on variations in other modes such as older and younger pedestrians, persons with disabilities (including Americans with Disabilities (ADA) requirements), the types of bicyclists (e.g., commuter, school, recreational, etc.) and the effectiveness of transit service (e.g., local bus, bus rapid transit (BRT), streetcar, light rail).

A 2015 report titled *Evaluating Complete Streets Projects; A Guide for Practitioners* further expands the concept of performance measures by identifying seven performance goals by which "complete streets" projects can be measured. These goals include:

- Access;
- Economy;
- Environment;
- Place;
- Safety;
- Equity; and
- Public health.

The report provides a range of measures and metrics for each goal area, many of which require a level and type of data acquisition and analysis that is not typically performed by most roadway design agencies.

4.2.2 Document Review

Throughout Tasks 1 and 2 the research team identified and reviewed published literature and best practices on this topic. We looked especially for case studies that document how practicing agencies have approached the topic of using quantitative and qualitative performance measures, beyond traditional highway capacity procedures, for evaluating alternative designs covering the full range of users. Each of the primary performance measure resources identified, including the leading national practice documents, is listed below. Following the list is a brief overview of the document content and application information where appropriate.

1. NCHRP Project 3-70: *Multimodal Level of Service Analysis for Urban Streets* (2007)
2. NCHRP Report 616: *Multimodal Level of Service Analysis for Urban* Streets (2008)

3. NCHRP Web-Only Document 128: *Multimodal Level of Service Analysis for Urban Streets: Users Guide* (2009)
4. NCHRP Web-Only Document 158: *Field Test Results of the Multimodal Level of Service Analysis for Urban Streets* (2010)
5. TRB: *Highway Capacity Manual* (2010)
6. TCRP Report 165: *Transit Capacity and Quality of Service Manual* (2013)
7. Florida Department of Transportation: *2013 Quality/Level of Service Handbook* (2013)
8. AASHTO: *Highway Safety Manual* (HSM) (2010)
9. FHWA: *Interactive Highway Safety Design Model (IHSDM), and Safety Analyst Software Suite* (2015)
10. NCHRP Report 785: *Performance-Based Analysis of Geometric Design of Highways and Streets* (2014)
11. NCHRP Synthesis 422: *Trade-Off Considerations in Highway Geometric Design, A Synthesis Of Highway Practice* (2011)
12. Victoria Transport Policy Institute: *Multi-Modal Level-of-Service Indicators: Tools for Evaluating the Quality of Transport Services and Facilities* (TDM Encyclopedia, 2014)
13. San Francisco Department of Public Health: *Pedestrian Environmental Quality Index* (2008)
14. San Francisco Department of Public Health: *Bicycle Environmental Quality Index*, (2009)
15. San Francisco Department of Public Health: *Pedestrian Injury Model* (2010)
16. Seattle and King County, Washington: *Multimodal Level of Service in King County: A Guide to Incorporating Alternative Modes of Transportation Into Local Jurisdictions' Roadway Performance Measurements* (June 2011)
17. Herbie Huff and Robin Liggett, University of California Transportation Center: *The Highway Capacity Manual's Method for Calculating Bicycle and Pedestrian Levels of Service: The Ultimate White Paper* (2014)
18. EPA Report 231-K-10-004: *Guide to Sustainable Transportation Performance Measures* (2011)
19. Bruce Wright, Blog Post, Fairfax Advocates for Better Bicycling: *Rethinking LOS and Transportation Impacts of Development* (March 2014)
20. Madeline Brozen, Herbie Huff, UCTC-FR-2014-09, University of California Transportation Center: *Exploration and Implications of Multimodal Street Performance Metrics: What's a Passing Grade?* (September 2014)
21. Department of Transportation, Charlotte NC: *Pedestrian & Bicycle Level of Service Methodology for Crossings at Signalized Intersections* (February 2007)
22. Srinivas S. Pulugurtha1 and Prasanna R. Kusam, TRB Paper # 11-4266: *An Assessment of Multimodal Level-of-Service as a Performance Measure for Signalized Intersections* (January 2011)

1. Multimodal Level of Service Analysis for Urban Streets, NCHRP Project 3-70 (2007)

This report preceded Report 616 and developed and calibrated a method for evaluating the multimodal level of service (MMLOS) provided by different urban street designs and operations. This MMLOS method is designed for evaluating "complete streets," context-sensitive design alternatives, and smart growth and from the perspective of all users. The analyst can use the MMLOS method to evaluate the tradeoffs of various street designs in terms of their effects on the

auto driver's, transit passenger's, bicyclist's, and pedestrian's perceptions of the quality of service provided by the street.

This was a two-stage research project. The objective of the first stage was to develop and test a framework and enhanced methods for determining levels of service for automobile, transit, bicycle, and pedestrian modes on urban streets, in particular with respect for the interaction among the modes. The objective of the second stage of the research was to validate and refine the framework and enhanced methods developed in Stage 1, propose new material for future editions of the HCM and the TCQSM, and develop sample problems and initial software.

The scope of the project was as follows:

- Urban streets were defined as arterials and major collectors.
- The project was address all vehicular and pedestrian movements along urban streets, including turning movements and pedestrian movements across urban streets.
- Transit (i.e., bus and rail) was initially defined as at-grade, scheduled, fixed-route services that operated within the roadway right-of-way. Other forms of transit services were allowed be addressed subsequently.
- The analysis techniques were not necessarily to be restricted to 1-hour or 15-minute analysis time frames (transit or pedestrian "micro-peaks").
- Safety and economic aspects were to be included only and insofar as they influenced the perceptions of LOS.
- At the time, the 2000 HCM listed nine conditions not accounted for in the current urban streets methodology:
  1. Presence or lack of on-street parking;
  2. Driveway density or access control;
  3. Lane additions leading up to or lane drops leading away from intersections;
  4. The impacts of grades between intersections;
  5. Any capacity constraints between intersections (such as a narrow bridge);
  6. Mid-block medians and two-way left turn lanes;
  7. Turning movements that exceed 20 percent of the total volume on the street;
  8. Queues at one intersection backing up to and interfering with the operation of an upstream intersection; and
  9. Cross-street congestion blocking through traffic.

Although this project was to address automobile LOS, revisions in operational techniques (e.g., calculation of average travel speed, mid-block running times, and control delay) for the automobile mode were not a significant part of this project.

NCHRP Report 616: Multimodal Level of Service Analysis for Urban Streets was developed from this project and is described in further detail below.

2. Multimodal Level of Service Analysis for Urban Streets, NCHRP Report 616 (2008)

This final report provides a method for assessing how well an urban street serves the needs of all of its users: auto drivers, transit passengers, bicycle riders, and pedestrians. It presents the results of a 2-year investigation into how users of urban streets perceive the multimodal quality of service provided by the streets (NCHRP Project 3-70, Multimodal Level of Service for Urban Streets).

A preliminary investigation was conducted to determine the key factors influencing travelers' perceptions of urban street level of service (LOS) from the perspective of auto drivers, bus riders, bicycle riders, and pedestrians. The results of this preliminary investigation were used to design a series of video laboratories (for auto, bicycle, and pedestrian modes) and field surveys (for the bus mode).

Video clips were shot of typical urban street segments in the United States from the perspective of auto drivers, bicycle riders, and pedestrians. Between 26 and 35 video clips were shot for each mode. These video clips were then shown to 145 people in four different urban areas of the United States. Survey participants were asked to rate the quality of service displayed in each video clip on a scale from A to F, with A being defined as Best and F being defined as Worst.

In the field, on-board surveys were conducted of 14 bus routes in four different metropolitan areas. A total of 2,678 bus passengers were surveyed about their perceptions of bus quality of service.

Four separate LOS models (one for each mode) were then fitted to the video laboratory and field survey data. All four LOS models were sensitive to the street design (e.g., number of lanes, widths, and landscaping), traffic control devices (signal timing, speed limits), and traffic volumes. The models incorporated directly and indirectly the interactions of the various users of the street. For example, improved signal timing increased auto speeds and bus speeds which increased auto and bus LOS. However, the higher auto and bus speeds adversely affect the level of service perceived by bicyclists and pedestrians.

The LOS models were considered useful for evaluating the benefits of "complete streets" and "context sensitive" design options because the models help to quantify the interactions of the modes sharing the same street right-of-way. The models enable the analyst to test the tradeoffs of various allocations of the urban street cross section among autos, buses, bicycles, and pedestrians. For example, the analyst can test the effects of reducing a four-lane street to three lanes and using the width saved to provide bicycle lanes and a landscaped strip between the sidewalk and the street. The method enables the analyst to compute the before and after levels of service for auto, bus, bicycle, and pedestrians.

A User's Guide was written explaining the LOS models and their application. The User's Guide was written in the general format of a draft chapter for the *Highway Capacity Manual* to facilitate its incorporation into the 2010 *Highway Capacity Manual*.

3. Multimodal Level of Service Analysis for Urban Streets: Users Guide, Web-Only Document 128 (2009)

The user's guide presents the multimodal level of service (MMLOS) analysis method for urban streets. It consists of a set of recommended procedures for predicting traveler perceptions of quality of service and performance measures for urban streets. These procedures consider the needs of people using the four major modes of travel on the street, their impacts on each other as they share the street, and their mode specific requirements for street design and operation.

For the purposes of this project, an urban street was defined as a public road with traffic signal control at least once every 2 miles. The multimodal level of service (MMLOS) method is generally not designed to be applied to residential streets, nor to rural roads with infrequent or no signal control. The Guide stresses that users should not be afraid to over-rule the computed results with common sense when applying the level of service method in these situations.

The MMLOS method was considered not well suited to considering the needs of and the characteristics of motorized or other vehicles incapable of exceeding 25 mph for sustained periods of time (with the exception of bicycles, which the user's guide specifically addresses). Motorized or hand-propelled wheel chairs, rickshaws, horse-drawn carriages, motorized bicycles, some scooters, and some golf carts are examples of vehicles that the method cannot address well. However, the analyst may, with care, potentially adapt some of the LOS methods to these specialized vehicle types.

The MMLOS method is designed for analysis of steady state conditions during a specified analysis period. They neither address the dynamic development and dissipation of congestion during the peak period, nor can they identify the starting and ending times of congestion. The analyst should consider alternative analysis approaches, such as simulation modeling, if a dynamic analysis is required.

The MMLOS method addresses the perceived quality of service for passenger car (automobile) drivers, bus passengers, bicycle riders, and pedestrians to the extent that these perceptions are influenced by factors that fall exclusively within the right of way of the urban street. Environmental factors that fall outside of the right-of way, such as buildings, parking lots, scenery, and landscaped front yards are specifically excluded from the LOS methodology, because these factors are not specifically under the direct control of the agency operating the urban street.

The MMLOS does not address perceived quality of service for commercial vehicle drivers (trucks, taxis, etc.), auto passengers, messenger and delivery services, recreational users, and rail transit riders.

Transit level of service is designed to apply only to scheduled, fixed route public transit service operating within the street itself. Only service with pickup/drop-off service within the section of the street being studied is included in the LOS computations. Through transit service, underground service, taxi cab service, jitney (semi-private) service, and demand responsive service are not covered by the MMLOS method.

The MMLOS methodology is not designed to be applied to streets with railroad crossings, where rail traffic is so frequent that its impacts on performance and level of service cannot be neglected.

Quality of service (as expressed in terms of letter grade levels of service) is an indicator of the traveling public's perceived degree of satisfaction with the traveling experience provided by the urban street under prevailing demand and operation conditions.

Quality of service can be considered a "selfish" measure. It considers only the perspective of the traveler or the prospective traveler. It does not take into account how many people will actually use the facility or how expensive it is to the agency and the general public to provide the facility. It does not consider environmental concerns or collision rates.

Quality of service is therefore only one of several factors that must be taken into account in good design and planning practice. It is NOT the "be all and end all" of design or planning. Planning and design must take into account additional factors like capacity utilization, accessibility, safety, cost-effectiveness, the effect on the environment, and each agency's goals and objectives.

Level of service results must be evaluated in the context of other planning and design considerations. Level of service "F", by itself, does NOT mean that there is a problem that the agency must fix. Similarly, level of service "A", by itself, does NOT mean that there are no problems.

4. Field Test Results of the Multimodal Level of Service Analysis for Urban Streets, NCHRP Web-Only Document 158 (2010)

The objective of the first two phases of NCHRP 3-70 project outlined above was to develop and test a framework and enhanced methods for determining levels of service for automobile, transit, bicycle, and pedestrian modes on urban streets, in particular with respect to the interaction among the modes. Phase 2 resulted in the multimodal level of service method (MMLOS) described in NCHRP Report 616, *Multimodal Level of Service for Urban Streets*.

The objective of phase 3 of NCHRP 3-70 was to field test the MMLOS method with various public agencies around the United States. The method was field tested in 10 metropolitan areas of the United States. The field tests had the following objectives:

1) To obtain public agency perspectives on the accuracy of the MMLOS level of service ratings for their community,

2) To identify any data collection difficulties that might discourage public agencies from applying the MMLSO method,

3) To identify any gaps in the guidance provided with MMLOS, and

4) To determine if any refinements to the MMLOS models would be appropriate.

Public agency staff was extensively involved in the field tests. Agency staff was trained on the MMLOS method and software. They often performed the data collection, with assistance from

the research team. This extensive involvement was primarily for the reason of helping public agency staff completely understand the MMLOS method so they could give accurate feedback on the method. But it also had the result of establishing a core group of knowledgeable MMLOS users to help spread the news about MMLOS among public agencies in the United States. These field tests have resulted in several requests from additional agencies and local sections of the Institute of Transportation Engineers for presentations and workshops on the MMLOS method.

Based on the results of these field tests several revisions were made to the spreadsheet software for implementing MMLOS. The mid-block pedestrian crossing delay calculation was refined to take into account large medians. Several additional input error checks were added to the software. Input formats were revised to better facilitate data entry by public agency personnel.

Additional guidance was provided during the course of the workshops and field tests to deal with conditions encountered in the field that were not anticipated when the original guide, NCHRP Web-Only Document 128, was written. This additional guidance is documented in the "Results" section of the final report.

Finally, a few minor modifications to the pedestrian level of service model were recommended to improve its sensitivity to some of the conditions encountered in the field tests. These are also documented in the "Results" section of the final report.

5. Highway Capacity Manual, TRB (2010 & 2016)

TRB's Highway Capacity Manual (HCM) is the world's most recognized source on highway capacity and quality of service. Most transportation professionals probably consider the HCM as an automobile analysis document, largely as if a "highway" is a mode of travel as opposed to transportation facility. However, that changed significantly with the publication of the 2010 HCM as it incorporates an integrated multimodal approach to address the levels of service for the auto, bicycle, pedestrian and transit modes at the intersection, segment and arterial facility level simultaneously. In the new approach travelers perspectives are the basis for determination of levels of service, not necessarily capacity or operational characteristics.

Publication of the 2010 HCM was highly anticipated from those designers and communities interested in viewing urban roadways from a "complete streets" perspective and the 2010 release of the USDOT policy to incorporate safe and convenient walking and bicycling facilities into transportation projects. The 2010 HCM reflects the concept that urban streets should serve all users, not just auto travelers. As the dominant source on highway capacity and quality of service analysis, the HCM is able to offer auto, pedestrian, bicycle, and transit planners, engineers and decision makers the opportunity to use professionally accepted analytical techniques to plan, build and operate highway facilities that serve all modal travelers.

To encourage HCM users to consider all travelers on a facility when they perform analyses and make decisions, the HCM 2010 integrates material on non-automobile and automobile modes. There are no stand-alone Pedestrian, Bicycle and Transit chapters in the 2010 edition. Instead, users are referred to the Urban Streets chapter for analysis procedures for pedestrians, bicyclists

and transit users on urban streets, to the Signalized Intersections chapter for procedures relating to signalized intersections, and so on. This situation has been addressed in the new 2016 HCM and now there are chapters for all modes.

In recognition of the companion TCQSM (Transit Capacity and Quality of Service Manual, 2003, latest edition at that time) and of the difficulty in keeping the two manuals coordinated, users are referred to the TCQSM for transit-specific capacity and quality-of-service procedures. However, transit quality of service in a multimodal context is addressed in the 2010 HCM.

Urban Street Facilities was a new chapter of the 2010 HCM that contains guidance to help analysts determine the scope of their analysis (i.e., isolated intersection versus coordinated signal system) and the relevant travel modes (i.e., automobile, pedestrian, bicycle, transit, or a combination). The methodology section describes how to aggregate results from the segment and point levels of analysis into an overall facility assessment. Information on the impact of active traffic management measures on urban street performance was also added.

The Urban Street Segments chapter was completely rewritten from the 2000 HCM edition. The work of NCHRP Report 616 (Multimodal Level of Service Analysis for Urban Streets) was incorporated into the chapter, providing improved methods for estimating urban street free-flow speeds and running times, along with a new method for estimating the stop rate along an urban street. In addition, the work of the NCHRP 3-70 project (Multimodal Level-of-Service Analysis for Urban Streets, 2009) was incorporated, providing a multimodal LOS methodology that is available to evaluate trade-offs in how urban street right-of-way is allocated among the modes using the street.

In general, the 2010 HCM methodology features a determination of level of service (A-F letter grades) from a traveler's perspective for each mode. It also includes the interaction of modes, primarily how auto operating conditions affect the levels of service to pedestrians and bicyclists. For example, as auto operating speeds and level of service increase, holding other things equal, bicycle and pedestrian levels of service would likely decrease. The 2010 HCM approach does not provide one overall level of service for the roadway; rather largely because of modal uniqueness, each mode receives a distinct level of service.

The HCM 6th Edition provides methods for quantifying highway capacity. In its current form, it serves as a fundamental reference on concepts, performance measures, and analysis techniques for evaluating the multimodal operation of streets, highways, freeways, and off-street pathways. The 6th Edition incorporates the latest research on highway capacity, quality of service, and travel time reliability and improves the HCM's chapter outlines. The objective is to help practitioners applying HCM methods understand their basic concepts, computational steps, and outputs.

HCM has evolved over the years to keep pace with the needs of its users and society, as the focus of surface transportation planning and operations in the United States has moved from designing and constructing the Interstate highway system to managing a complex transportation system that serves a variety of users and travel modes. Providing mobility for people and goods is transportation's most essential function. It consists of four dimensions:

- Quantity of travel, the magnitude of use of a transportation facility or service;

- Quality of travel, users' perceptions of travel on a transportation facility or service with respect to their expectations;
- Accessibility, the ease with which travelers can engage in desired activities; and
- Capacity, the ability of a transportation facility or service to meet the quantity of travel demanded of it.

In response to the increasing need to estimate performance measures related to pedestrian, bicycle, and transit facilities, as well as their interactions with vehicles, the HCM 6th Edition provides several tools and methods for their assessment. Specific chapters include:

- Chapters 16–23 include methods for assessing non-automobile modes and their interactions with vehicular traffic,
- Chapter 24 provides methods for analyzing off-street pedestrian and transit facilities, and
- Chapter 15 provides a methodology for evaluating bicycle operations on multilane and two-lane highways.

Use of the HCM for pedestrian and bicycle analysis on urban streets can require significant data collection and analysis.

6. Transit Capacity and Quality of Service Manual, TCRP Report 165 (2013)

The *Transit Capacity and Quality of Service Manual* (TCQSM) was initially published in 1999 as a comprehensive reference resource for public transit practitioners and policy makers. It assembled for the first time in one place a set of methods for evaluating the capacity of bus and rail transit services and facilities, and introduced a framework for evaluating the quality of transit service from the passenger point of view.

This edition introduced material on ferry transit capacity, expanded coverage of demand-responsive transit (DRT) and Americans with Disabilities Act (ADA) issues, and added information about transit preferential treatments and park-and-ride access to transit. It also made changes to the quality of service framework based on user testing and additional research, including adding pedestrian environment considerations to the assessment of transit service coverage and adding a new measure of transit reliability, headway adherence. The 2nd Edition, published in late 2003 as *TCRP Report 100,* went on to become TCRP's best-selling report.

This 3rd Edition of the TCQSM incorporates new research on transit capacity and quality of service topics published since the 2nd Edition was developed, including original research conducted as part of the production contract for the manual. This edition is also significantly reorganized in response to user feedback. The "What's New" section of this chapter describes the major changes from the 2nd Edition. The TCQSM is a reference work that provides current research-based guidance on the following topics:

- Evaluating quality of service, reflecting how passengers perceive the quality of the transit service offered and provided, while also considering the transit provider's needs and objectives.

- Measuring transit capacity, speed, and reliability, and the factors that influence them-these are important operational concepts that ultimately affect the cost of providing transit service and the demand to use the service.
- Sizing elements of transit stops and stations-for example, platform areas, fare collection elements, and passenger and vehicle circulation elements.
- Guidance on ways to positively influence all of the above, including their potential effects on operations, operating costs, and existing ridership demand.

The following five key concepts appear throughout the manual.

Quality of Service

Quality of service is the overall measured or perceived performance of transit service from the passenger's point of view.

While there are many valid perspectives for assessing transit performance, the TCQSM focuses on the passenger or customer point-of-view, while acknowledging that transit operators must strike a balance between the quality of service that passengers would ideally like and the quality of service that a transit agency *(a)* can afford to provide or *(b)* would reasonably provide, given the demand for transit service.

The performance measures used to describe quality of service are different from the financial and output-focused performance measures that have traditionally been used in the transit industry. Quality of service focuses on two areas:

1. *Transit availability-Is* transit service an option for a given trip?
2. *Transit comfort and convenience-If* transit service is an option, how attractive is it to potential passengers?

The quality of service provided depends on the operating decisions made by a transit agency within the constraints of its budget, particularly decisions as to where transit service should be provided, how often and how long it is provided, and how it is provided. These decisions in turn, are often guided by the agency's goals and objectives.

Capacity

Capacity reflects the maximum number of transit vehicles, persons, or both, that can travel past a particular location in a given period of time under specified conditions.

There are several types of capacity discussed in the TCQSM:

- *Maximum (theoretical) capacity* reflects the greatest number of persons or transit vehicles that can be served *under any circumstance.* Maximum capacity is an unstable-and thus unreliable-form of operation. In the case of persons, maximum capacity is achieved under crush loading conditions, when as many people are squeezed onto a vehicle as is physically possible-a condition that North American passengers will only accept under exceptional circumstances. Consequently, maximum capacity should not be used for typical planning and operations applications.

- *Design (achievable, practical) capacity* reflects the number of persons or transit vehicles that can be served *at a specified quality of service* (e.g., design loading level, design reliability level). The TCQSM estimates design capacity, except when the term "maximum capacity" is specifically used. Greater volumes of persons or transit vehicles than the design capacity may be served on occasion, but not on a regular basis.
- *Vehicle (bus, train, vessel) capacity* is measured in vehicles per hour and expresses how many transit vehicles can pass a point in an hour.
- *Passenger capacity* is measured in persons per vehicle and expresses how many persons a transit vehicle can carry at a design passenger loading level.
- *Person capacity* is measured in persons per hour and expresses how many persons can pass a point in an hour. It is the product of vehicle and passenger capacity.

Speed and Reliability

Speed (or, more accurately, travel time) and reliability are important quality of service attributes to passengers and thus influence transit ridership. At the same time, speed and reliability directly influence the time scheduled for a transit vehicle on a route. The scheduled travel time, in turn, determines the number of vehicles required to operate the route at a given service frequency and thus the route's operating and capital costs. Ridership and the cost of providing service are issues that affect all sizes of transit agencies.

The same factors that affect transit capacity also affect transit speed and reliability. Therefore, speed and reliability are addressed side-by-side with capacity in the manual's concepts and methods chapters. Although determining transit capacity may not be the ultimate goal of an analysis, calculating it allows other useful information, such as speed and reliability, to be determined.

Local Data

The TCQSM has compiled data and methods from a variety of sources and produces estimates that reflect average conditions. However, the manual recommends that for the best results, *local data should be used whenever possible*, as every location will have its own unique characteristics that may not reflect North American averages. When local data are not available, the TCQSM's default values may be substituted. In these cases, it is recommended that the sensitivity of important results to changes in assumptions be tested.

7. 2013 Quality/Level of Service Handbook, Florida Department of Transportation

This Quality/Level of Service Handbook and its accompanying software are intended to be used by engineers, planners, and decision-makers in the development and review of roadway users' quality/level of service (Q/LOS) and capacity at generalized and conceptual planning levels. This Q/LOS Handbook provides tools to quantify multimodal transportation service inside the roadway environment (essentially inside the right-of-way).

This edition of the Q/LOS Handbook includes new analytical techniques from the Transportation Research Board's 2010 Highway Capacity Manual and updated Generalized Service Volume Tables. With these professionally accepted techniques, analysts can easily evaluate roadways from a multimodal perspective, which results in better multimodal decisions for projects in generalized and conceptual planning phases.

Two levels of analysis are included in this Q/LOS Handbook: (1) generalized planning and (2) conceptual planning. Generalized planning makes extensive use of statewide default values and is intended for broad applications such as regional analyses, initial problem identification, and future year analyses. Conceptual planning is more detailed than generalized planning but does not involve comprehensive operational analyses.

Generalized planning is most appropriate when a quick review of capacity or LOS is needed or for future long-range estimates. Florida's Generalized Service Volume Tables found at the end of this Q/LOS Handbook are the primary tools for conducting this type of planning analysis.

Conceptual planning is best suited for obtaining a more precise determination of the LOS of a facility. Examples of conceptual planning applications are determining the design concept and scope for a facility (e.g., four through lanes with a raised median and bicycle lane), conducting alternatives analyses (e.g., four through lanes undivided versus two through lanes with a two-way left turn lane), and determining needs when a generalized planning approach provides insufficient detail. Florida's LOS planning software (LOSPLAN), which includes ARTPLAN, FREEPLAN, and HIGHPLAN, is the easy to use tool for conducting these types of evaluations.

This Q/LOS Handbook and its accompanying software are intended to be used by engineers, planners, and decision-makers in the development and review of roadway users' quality/level of service (Q/LOS) and capacity at generalized and conceptual planning levels. The Q/LOS Handbook provides a discussion of basic transportation concepts. It provides direction for defining roadway, traffic, and control variables as these inputs greatly affect the Q/LOS along transportation facilities. It also provides guidance for using specific transportation planning tools, including LOS planning software (LOSPLAN) developed by the Florida Department of Transportation (FDOT), to assess Q/LOS.

Quality of service (QOS) is a traveler-based perception of how well a transportation service or facility operates. **Level of service** (LOS) is a quantitative stratification of quality of service into six letter grades. LOS provides a generalized and conceptual planning measure that assesses multimodal service inside the roadway environment (essentially inside the right-of-way). **Capacity** conceptually relates to the maximum number of vehicles or persons that can pass a point on a roadway or sidewalk in a given amount of time under normal conditions. The Generalized Service Volume Tables, found at the end of the Q/LOS Handbook, present maximum **service volumes**, or the highest numbers of vehicles for a given LOS.

Direction found within the Q/LOS Handbook provides assistance in selecting the most appropriate tools for Q/LOS analysis. There is specific instruction within the handbook on how to use the LOSPLAN software and Generalized Service Volume Tables. The Generalized Service

Volume Tables and software guidance prioritizes inputs; defines roadway, traffic, and control variables; and illustrates how to capture pertinent data.

8. Highway Safety Manual (HSM) 2010

The Highway Safety Manual is a Transportation Research Board (TRB) and American Association of State Highway and Transportation Officials (AASHTO) initiative (published by AASHTO) to provide the best factual information and tools in a useful and widely accepted form and to facilitate roadway design and operational decisions based upon explicit consideration of their safety consequences. The HSM is organized into four parts:

1. Introduction and Fundamentals.
2. Roadway Safety Management Process.
3. Predictive Methods (see table below comparing HSM and IHSDM).
4. Crash Modification Factors.

The HSM introduces a science-based technical approach that helps to reduce guesswork in safety analysis. The HSM provides tools to conduct quantitative safety analyses, allowing for safety to be quantitatively evaluated alongside other transportation performance measures such as traffic operations, environmental impacts, and construction costs.

For example, the HSM provides a method to quantify changes in crash frequency as a function of cross-sectional features. With this method, the expected change in crash frequency of different design alternatives can be compared with the operational benefits or environmental impacts of these same alternatives. As another example, the costs of constructing a left-turn lane on a two-lane rural road can be compared to the safety benefits in terms of reducing a certain number of crashes.

The HSM provides the following tools:

- Methods for developing an effective roadway safety management program and evaluating its effects. A roadway safety management program is the overall process for identifying sites with potential for safety improvement, diagnosing conditions at the site, evaluating conditions and identifying potential treatments at the sites, prioritizing and programming treatments, and subsequently evaluating the effectiveness at reducing crashes of the programmed treatments. Many of the methods included in the HSM account for regression to the mean and can result in more effectively identifying improvements to achieve a quantifiable reduction in crash frequency or severity. Safety funds can then be used as efficiently as possible based on the identified locations.
- A predictive method to estimate crash frequency and severity. This method can be used to make informed decisions throughout the project development process, including: planning, design, operations, maintenance, and the roadway safety management process. Specific examples include screening potential locations for improvement and choosing alternative roadway designs.
- A catalog of crash modification factors (CMFs) for a variety of geometric and operational treatment types, backed by robust scientific evidence. The CMFs in the HSM have been developed using high-quality before/after studies that account for regression to the mean.

> The HSM emphasizes the use of analytical methods to quantify the safety effects of decisions in planning, design, operations, and maintenance. The first edition does not address issues such as driver education, law enforcement, and vehicle safety, although these are important considerations within the broad topic of improving highway safety.

The HSM is written for practitioners at the state, county, metropolitan planning organization (MPO), or local level.

The HSM provides an opportunity to consider safety quantitatively along with other typical transportation performance measures. The HSM outlines and provides examples of the following applications:

- Identifying sites with the most potential for crash frequency or severity reduction;
- Identifying factors contributing to crashes and associated potential countermeasures to address these issues;
- Conducting economic appraisals of potential improvements and prioritizing projects;
- Evaluating the crash reduction benefits of implemented treatments; and
- Estimating potential effects on crash frequency and severity of planning, design, operations, and policy decisions.

The HSM can be used for projects that are focused specifically on responding to safety-related questions. In addition, the HSM can be used to conduct quantitative safety analyses on projects that have not traditionally included this type of analysis, such as corridor studies to identify capacity improvements and intersection studies to identify alternative forms of traffic control. The HSM can also be used to add quantitative safety analyses to multidisciplinary transportation projects.

The HSM provides methods to integrate quantitative estimates of crash frequency and severity into planning, project alternatives analysis, and program development and evaluation, allowing safety to become a meaningful project performance measure. As public agencies work toward their safety goals, the quantitative methods in the HSM can be used to evaluate which programs and project improvements are achieving desired results; as a result, agencies can reallocate funds toward those that are having the greatest benefit.

9. Interactive Highway Safety Design Model (IHSDM) and Safety Analyst

The IHSDM is a suite of software analysis tools used to evaluate the safety and operational effects of geometric design decisions on highways. IHSDM is a decision-support tool. It provides estimates of a highway design's expected safety and operational performance and checks existing or proposed highway designs against relevant design policy values. Results of the IHSDM support decision-making in the highway design process.

The *IHSDM-HSM Predictive Method 2014 Release* includes six evaluation modules: Crash Prediction, Policy Review, Design Consistency, Intersection Review, Traffic Analysis and Driver/Vehicle Modules. The Crash Prediction Module (CPM) serves as a faithful implementation of Part C (Predictive Method) of the Highway Safety Manual (HSM) for rural two-lane highways

(HSM - Chapter 10), multilane rural highways (HSM - Chapter 11), urban and suburban arterials (HSM - Chapter 12), freeways (draft HSM Chapter 18) and ramps/interchanges (draft HSM Chapter 19). The other IHSDM evaluation modules are applicable to rural two-lane highways.

The IHSDM Policy Review Module references the 1990, 1994, 2001, 2004 and 2011 editions of AASHTO's A Policy on Geometric Design of Highways and Streets, for policy checks on rural two-lane highways. The IHSDM Administration Tool includes the capability to edit values in currently available AASHTO policy tables to reflect other organizations' design policies. A limitation is that it is not possible to alter the column structure of the policy tables.

Two related initiatives share IHSDM's goal of providing quantitative safety analysis tools to decision-makers:

- Highway Safety Manual (HSM).
- SafetyAnalyst.

The following table (**Exhibit 4-3**) compares the types of predictive methods and types of facilities targeted by the HSM and IHSDM. The first edition of the HSM, published in June 2010, provides predictive methods for rural two-lane highways, rural multilane highways, and urban and suburban arterials. With the 2009 Crash Prediction Module Beta Release (June 30, 2009), Federal Highway Administration (FHWA) expanded the scope of IHSDM to include the HSM crash prediction methods for multilane rural highways and urban and suburban arterials. The Crash Prediction Module of the IHSDM – HSM Predictive Method 2013 Release is a faithful software implementation of Part C of the 1st Edition HSM, containing predictive methods for rural two-lane highways, rural multilane highways, and urban and suburban arterials. In addition, the 2013 Release includes a Beta version of predictive methods for freeway segments and freeway ramps/interchanges (including ramps. collector-distributor (C-D) roads, and ramp terminals), based on draft HSM materials. A Calibration Utility assists agencies in implementing the calibration procedures described in the Appendix to Part C of the HSM.

Exhibit 4-3: Comparison of Predictive Methods by Facility Type

Facility Type	Policy Review	Crash Prediction	Diagnostic Review
Two-Lane Rural Highway	IHSDM (2003)	IHSDM (2003) HSM (2010)	IHSDM (2003)
Multilane Rural Highway		IHSDM (2009) HSM (2010)	
Urban and Suburban Arterial		IHSDM (2009) HSM (2010)	
Freeway Segments		IHSDM (2012; Beta) HSM (2013; Draft)	
Freeway Ramps/Interchanges		IHSDM (2013; Beta) HSM (2013; Draft)	

The SafetyAnalyst was developed by FHWA and is now an AASHTOWare product. It provides state-of-the art analytical tools for use in the decision-making process to identify and manage a system-wide program of site-specific improvements to enhance highway safety by cost-effective means. The SafetyAnalyst includes tools for:

- Network screening
- Diagnosis and countermeasure selection
- Economic appraisal and priority ranking
- Evaluation of implemented improvements

The following table compares the scope and type of decisions targeted by the SafetyAnalyst and IHSDM.

Exhibit 4-4: Comparison of Safety Analyst and IHSDM

	Safety Analyst	**IHSDM**
Scope	Network-Level	Project-Level
Target	Project Selection Decisions	Geometric Design Decisions

10. Performance-Based Analysis of Geometric Design of Highways and Streets, NCHRP Report 785 (2014)

This report presents an approach for understanding the desired outcomes of a project, selecting performance measures that align with those outcomes, evaluating the impact of alternative geometric design decisions on those performance measures, and arriving at solutions that achieve the overall desired project outcomes.

This report presents ways to incorporate performance-based analysis into the project development process. This process framework begins with setting desired project multimodal outcomes and design controls. Geometric design decisions that can influence those outcomes are identified as well as analysis tools that can be used to estimate the impacts of those decisions. The report includes six project examples illustrating how this framework can be applied to actual projects. The report will be useful to geometric designers in making informed decisions about the tradeoffs inherent in design.

Most highway and street design processes rely on standards that set minimum values or ranges of values for design features. These standards are intended to provide operational safety, efficiency, and comfort for the traveler, but it is difficult or impossible for the designer to characterize quantitatively how the facility will perform. For both new construction and reconstruction of highways and streets, stakeholders and decision makers increasingly want reasonable measures of the effect of geometric design decisions on the facility's performance for all of its users.

Each agency has its own process for designing a highway or street. Three critical stages in the process are project initiation (i.e., setting the project's purpose, need, and scope), preliminary design (e.g., analyzing alternative designs and environmental impacts and setting design criteria),

and final design (i.e., preparing the construction plans); these stages may have different names in different agencies. Although the expected performance of the facility is only one of the factors that must be considered in designing a highway or street, a better understanding of the expected performance should result in better decisions during these stages. Research was needed to provide the designer with the tools to evaluate the performance of different design alternatives objectively.

NCHRP Project 15-34A completed the work begun under NCHRP Project 15-34. That project described the geometric design decisions that occur throughout the project development process and identified performance metrics that are sensitive to those decisions. They also reviewed tools that are available for evaluating the performance of a particular design. This work culminated in the interim report that also presented a plan for developing a process framework. The framework includes both an approach for integrating performance-based analysis into geometric design decisions and information on the effects that different geometric elements have on project performance measures.

This report establishes an approach practitioners can use to evaluate the performance tradeoffs of different project development and design decisions. The motivation for integrating performance-based analysis into project development and geometric design decisions is two-fold.

1. Roadway agencies have limited resources to invest and often are developing projects within a physically constrained environment (e.g., limited right-of-way in an urban area, minimizing impacts in environmentally sensitive areas). It is not always fiscally possible or reasonable to categorically construct roadways to meet design standards. Through initiatives such as context sensitive solutions and practical design, as a profession, we have learned that in many circumstances we must construct roadways using flexible design approaches to adapt to the unique needs of each contextual design environment.

2. The layout and interrelationship of highways, streets, interchanges, and intersections has a direct impact on performance measures beyond average delay or travel time for an automobile. The form of our streets and highways directly affects people's ability to comfortably travel by foot, bike, and transit.

This report presents an approach for understanding the desired outcomes of a project, selecting performance measures that align with those outcomes, evaluating the impact of alternative geometric design decisions on those performance measures, and arriving at solutions that achieve the overall desired project outcomes. Chapters 1 through 4 presents the body of knowledge that forms the basis for performance-based analysis to inform geometric design decisions. Chapters 5 and 6 presents applications guidance to incorporate performance-based analysis into project development and geometric design decisions.

Performance-based analysis of geometric design provides a principles-focused approach that looks at the outcomes of design decisions as the primary measure of design effectiveness. As public agencies meet transportation needs with less funding or engage in partnerships to support locally generated (sometimes development-funded) projects, the ability to make informed design decisions will likely increasingly rely on performance-based analysis results.

Performance-based analyses are considered an integral part of project design documentation, providing a foundation for tracking and supporting design decisions. A solid documentation regimen supported by performance-based analyses can support flexible geometric design decisions. This flexibility allows designers to implement solutions in financially or physically constrained environments and makes project design decisions informed by anticipated geometric design performance.

11. Trade-Off Considerations in Highway Geometric Design - A Synthesis of Highway Practice, NCHRP Synthesis 422, (2011)

This synthesis describes the processes that transportation agencies currently use to evaluate geometric design trade-offs between competing interests. It also highlights existing key publications on conventional approaches, context-sensitive solutions/context-sensitive design, and performance-based approaches, as well as gaps in information or analysis processes available to support design decisions.

The goal of this Synthesis was to discover what processes transportation agencies are currently using to evaluate design trade-offs between competing interests. The report also attempts to highlight any existing gaps in information or analysis processes available to support the design decision. The ability to adequately identify trade-offs associated with design decisions and strike a balance between competing factors is critical to developing transportation projects that maintain safety and mobility while preserving the scenic, aesthetic, historic, social, and environmental resources of a community.

This synthesis is based on a survey distributed to 52 state transportation agencies (STAs), which resulted in responses from 43 agencies: 41 STAs, the District of Columbia, and Puerto Rico. In addition, a literature review focused on key publications outlining the conventional approach to design, as well as the newer context-sensitive solutions/context-sensitive design (CSS/CSD) and performance-based planning approaches. It also presents publications that outline complimentary fields that can be used to evaluate trade-offs, such as value engineering, choosing by advantages, risk analysis, and management and safety. Rather than an exhaustive literature search on a single topic area, the synthesis attempts to present an overview of the wide range of techniques available from the highway design and related fields and how they relate to trade-off analysis.

One of the key issues that the survey identified was that few STAs have codified procedures for evaluating trade-offs in highway geometric design. Based on the input received, the agencies surveyed generally had to rely on engineering judgment when conducting trade-off analyses. Most agencies evaluate trade-offs during preliminary engineering or environmental clearance. However, several agencies pointed out that frequently trade-offs are not raised until a design is nearly complete, often because of a lack of available design resources and decision makers in the predesign period. However, the later in the project development process trade-off decisions are made, the more limited the flexibility in dealing with them becomes.

Eleven typical categories of trade-offs were identified for inclusion in the survey instrument:

1. access management.

2. cost,
3. environmental issue,
4. historic impact,
5. human factors/driver expectancy,
6. operational efficiency,
7. right-of-way (ROW) availability,
8. safety,
9. schedule,
10. social concerns, and
11. tort liability exposure.

STAs overwhelmingly identified safety as the trade-off most used as justification for design decisions. Cost and environmental issues are also frequently used to justify design decisions.

Approximately half of the STAs believed that there were gaps, problems, or missing components in their procedures and tools for evaluating design trade-offs. Some of the concerns identified were associated with a lack of formal guidance and procedures, which force STAs to rely on engineering judgment. Weaknesses of this approach are limitations associated with inexperienced staff, inconsistencies associated with informal practices, failure to adequately identify and consider appropriate trade-offs, and inconsistencies in documentation of decisions. Conversely, those agencies that did not believe there were gaps often pointed to processes and policies that, when followed, minimized gaps.

Approximately three-quarters of the agencies did not have risk prediction tools or techniques to help balance competing interests in the design process. Those that did have tools in place almost all used ones that combine a mixture of qualitative and quantitative analyses.

Approximately half of STAs have some tools and training to assist designers in evaluating trade-offs in the design selection process. Common tools identified are the *Highway Safety Manual*, the Interactive Highway Safety Design Model, Roadside Safety Analysis Program, value engineering, crash history, life-cycle cost analysis, and a design policy manual. However, only five agencies have developed specific performance goals regarding the evaluation of trade-offs.

Shoulder width was overwhelmingly the controlling criterion most often associated with a design exception request. Other controlling criteria are horizontal alignment, vertical alignment, and lane width. None of the respondents selected the controlling criterion of structural capacity, and several respondents added notes to the survey responses that this criterion would never be considered.

Approximately three-quarters of the agencies had no plans to reevaluate how trade-offs are handled in the design selection process in the next 6 to 12 months. Approximately 90% of the agencies had no plans to reevaluate how design exceptions are handled over the same period.

To evaluate the trade-offs associated with design, the designer's understanding of the basic controls and criteria associated with each element of the design is important. Although the *Green Book* provides little guidance on evaluating these trade-offs, it does establish the framework from

which most controls and criteria are derived. For many situations, there is sufficient flexibility within the design criteria to achieve a balanced design and still meet minimum values.

CSS and CSD both consider the overall context within which a transportation project fits. The conventional approach to design does not emphasize an interdisciplinary approach, whereas the CSS/CSD approaches do. As the design process evolves, issues that do not center on design criteria become more important to determining the ultimate success of a design. This increases the need to identify trade-offs associated with design decisions accurately and completely and strike a balance between the competing factors in an interrelated decision-making process. CSS and CSD are excellent tools for providing structure to the compromise and trade-off process.

The synthesis revealed that there are further research needs associated with evaluating trade-offs in highway geometric design. Several topics emerged as areas of interest for future study, including a formal process for evaluating trade-offs, risk prediction tools, tools for evaluating trade-offs, performance goals, online resources for the *Green Book*, impact of design consistency, the *Highway Safety Manual*, integration of project and system level trade-offs, and self-enforcing design.

<u>12. Multi-Modal Level-of-Service Indicators: Tools for Evaluating the Quality of Transport Services and Facilities, TDM Encyclopedia, Victoria Transport Policy Institute (VTPI), 2014</u>

This chapter of the VTPI TDM (Transportation Demand Management) Encyclopedia describes level-of-service (LOS) rating systems suitable for evaluating the quality of various transport modes from users' perspective. This helps create a more neutral planning decisions that involve tradeoffs between different transport modes.

Multi-Modal Level-of-Service Indicators are rating systems used to evaluate various transportation modes and impacts. *Level of Service* (also called *Quality of Service* or *Service Quality*) refers to the speed, convenience, comfort and security of transportation facilities and services as experienced by users. Level-of-Service (LOS) ratings, typically from *A* (best) to *F* (worst), are widely used in transport planning to evaluate problems and potential solutions. Because they are easy to understand (they are similar to school grades), Level-of-Service rating often influence transport planning decisions. Such ratings systems can be used identify problems, establish performance indicators and targets, evaluate potential solutions, compare locations, and track trends.

The development and use of Multi-Modal Level-of-Service Indicators is consistent with current trends toward more comprehensive and balanced transport planning that considers diverse modes and impacts. Such indicators can help respond to users' preferences and expand the range of solutions that can be considered in transport planning. For example, travelers may sometimes be willing to accept lower speeds for increased convenience and comfort, and improvements to other modes besides roadway. Multi-Modal LOS Indicators can help identify if a particular planning decision has undesirable indirect effects, such as when road or parking facility expansion degrades walking and cycling conditions. It is particularly important for TDM evaluation, because

it considers a broader range of options and impacts, and reflects factors that influence traveler behavior.

Multi-modal Level-of-Service indicators can be used to establish performance standards and targets. For example, a strategic transportation plan may include a target that all walking and cycling facilities should have at least a C Level-of-Service rating, and that the average value of public transit Level-of-Service should increase from D to C within two years, and should reach LOS B within five years. This establishes a framework for identifying problems and prioritizing transportation system improvements.

13. Pedestrian Environmental Quality Index, San Francisco Department of Public Health (SFDPH), 2008

The San Francisco Department of Public Health developed the Pedestrian Environmental Quality Index (PEQI) as a tool to prioritize improvements in pedestrian infrastructure during the planning process. The PEQI draws on published research and work from numerous cities to assess how the physical environment impacts whether people walk in a neighborhood. The PEQI is an observational survey that quantifies street and intersection factors empirically known to affect people's travel behaviors and is organized into five categories: intersection safety, traffic, street design, land use and perceived safety. Within these categories are 31 indicators that reflect the quality of the built environment for pedestrians and comprise the survey used for data collection. SFDPH has aggregated these indicators to create a weighted summary index, which can be reported as an overall index.

SFDPH consulted national experts including city planners, independent planning consultants, and pedestrian advocates to develop the indicator weights and scores for each indicator category, based on survey responses. The PEQI has been utilized by numerous agencies and community groups in San Francisco and adapted for use in other cities nationwide.

SFDPH believes that environments that support walking, both as an alternative to driving and as a leisure activity, have multiple, potential positive health impacts. Environments that encourage walking while discouraging driving reduce traffic-related noise and air pollution – associated with cardiovascular and respiratory diseases, premature death, and lung function changes especially in children and people with lung diseases such as asthma. Quality, safe pedestrian environments also support a decreased risk of motor vehicle collisions and an increase in physical activity and social cohesion with benefits including the prevention of obesity, diabetes, and heart disease as well as stress reduction and mental health improvements that promote individual and community health. Given these implications, San Francisco residents should have equal access to quality, safe pedestrian environments throughout the city.

Data required for use of the tool can be collected by using an audit form designed for use by a trained observer based on visual assessments of intersections and streets. Once collected, the data is entered into a customized Microsoft Access database and automatically scored. A PEQI score, reflecting the quality of the pedestrian environment on a 0 to 100 scale, is created for each street segment and intersection in a defined area. An accompanying manual describes how each indicator

should be evaluated, including tips for resolving ambiguous situations, and describes how to enter the data into the database and how to map the data using ESRI ArcGIS software.

This tool can be accessed at:
http://www.sfhealthequity.org/elements/24-elements/tools/106-pedestrian-environmental-quality-index

14. Bicycle Environmental Quality Index, San Francisco Department of Public Health, 2009

The Bicycle Environmental Quality Index (BEQI) is a quantitative observational survey to assess the bicycle environment on roadways and evaluate what streetscape improvements could be made to promote bicycling in San Francisco. The survey has 21 empirically-based indicators, each of which has been shown to promote or discourage bicycle riding and connectivity to other modes of transport. Several of the indicators have been used in other bicycle indices from different regions in the country, while others are new concepts that have been found significant through other studies regarding healthy bicycle environments.

SFDPH identified five main categories which embody important physical environmental factors for bicyclists: Intersection Safety, Vehicle Traffic, Street Design, Safety, and Land Use. Table 1 details each BEQI indicator under its broader environmental category. These indicators can be aggregated to create the final index (the BEQI), which can be reported as an overall index score, and/or deconstructed by the bicycle environmental categories shown in Table 1.

SFDPH believes that cycling to work, school, shopping, or leisure activities can be both a sustainable and time-efficient exercise regimen for maintaining acceptable levels of fitness. Studies have shown that bicycle commuters work more efficiently, arrive to work eager and alert, and due to a cyclists' improved health, have fewer job-related injuries. The use of non-motorized transportation provides exercise, reduces fatal accidents, increases social contacts and reduces air and noise pollution. Increased exercise protects against heart disease and exercise is also recognized to have mental health benefits. Furthermore, traffic reduction on streets increases safety and opportunities for social interaction between residents and workers.

Available results from the BEQI reveal the relative quality of the biking environment at a street-level scale in select San Francisco neighborhoods. Use of the BEQI can translate environmental variables into a set of provisions for a healthy bicycle environment and a BEQI assessment can inform neighborhood planning and prioritize improvements through the land use plans and environmental assessments. An application of the BEQI asks the following questions:

1. Does a place have adequate and safe bicycle facilities throughout the neighborhood? - BEQI indicators are used to assess baseline conditions
2. Does a plan or project advance bicycle facilities in the area? - Plans/projects should assess and evaluate the extent to which BEQI indicators are present
3. What recommendations for planning policies, implementing actions, or project design would advance the bicycle environment? - Concrete, specific recommendations are provided to the plan/project based on the evaluation

The BEQI manual, survey form, report, and the BEQI Microsoft Access Database and San Francisco GIS file.tool can be accessed at:

http://www.sfhealthequity.org/elements/24-elements/tools/102-bicycle-environmental-quality-index

15. Pedestrian Injury Model, San Francisco Department 0f Public Health, 2010

The Vehicle-Pedestrian Injury Collision Model predicts change in the number of collisions resulting in pedestrian injury or death associated with area-level changes in street, land use and population characteristics due to new development or transportation system changes. SFDPH uses this model to inform the need for pedestrian safety mitigations and improvements in the course of land use and transportation planning, to prevent people from being injured or killed by motor vehicles while walking on San Francisco streets. Significant predictors (census-tract level variables) in the current model are:

- Traffic volume
- Arterial streets (%, without MUNI Transit)
- Neighborhood commercial areas (%, land area)
- Land area (square miles)
- Employee population
- Resident population
- Below poverty level (%, population)
- Age 65 and older (%, population)

Primary preventable predictors of vehicle-pedestrian injury collisions are environmental, including: traffic volume, higher vehicle speeds, pedestrian volume, and intersection and street design factors. To achieve safe, walkable communities, planning professionals need practical tools to assess and mitigate the impact of land use and development plans and projects on pedestrian safety, including vehicle-pedestrian collisions. Currently, the tools available to evaluate the impacts of land use planning on pedestrian safety conditions are limited to existing conditions assessments of collisions or qualitative analyses of the pedestrian environment.

SFDPH began developing this multivariate model to understand how changes in traffic and other environmental factors impacted by development decisions in SF predict vehicle-pedestrian injury collisions. The model was developed in collaboration with the UC Berkeley School of Public Health and sought input from health, planning, and transportation professionals, and community advocates for pedestrian safety – both individually and through presentations at City staff and task force meetings, professional conferences, and academic settings – throughout the process. SFDPH published the pedestrian injury model findings in January 2009 in the professional scientific journal Accident Analysis and Prevention and is now writing a second manuscript detailing the practical application of the model to the Eastern Neighborhoods Area Plans in San Francisco.

SFDPH researchers developed the Vehicle-Pedestrian Injury Collision Model in collaboration with Edmund Seto, a UC Berkeley School of Public Health researcher and lecturer – drawing on traffic data generated from an on-going collaboration regarding the health impacts of traffic and transportation planning decisions.

The main aim of the application of the San Francisco Vehicle-Pedestrian Injury Collision Model is to inform the need for pedestrian safety mitigations and improvements in the course of land use and transportation planning. Potential area-level interventions that improve pedestrian safety include planning and design decisions that reduce traffic volumes, speeds, and the need to drive, while promoting more walkable, safe environments including: transportation-land use planning coordination, transportation demand management measures, traffic calming, and street and intersection engineering countermeasures and amenities. More detailed information regarding these strategies can be found at the Victoria Transport Policy Institute's Online Transportation Demand Management Encyclopedia .

The tool can be accessed at:

http://www.sfhealthequity.org/elements/24-elements/tools/108-pedestrian-injury-model

16. Multimodal Level of Service in King County: A Guide to Incorporating Alternative Modes of Transportation Into Local Jurisdictions' Roadway Performance Measurements, Seattle and King County, Washington, 2011

Seattle and King County considered traditional transportation analysis and level of service (LOS) measures and standards adopted by individual jurisdictions as a barrier toward creating a more balanced transportation system comes in the form of the. The concept of LOS has been used by traffic and transportation engineers for nearly 50 years to describe conditions for automobile travel on existing or future roadways.

These agencies feel that transportation engineering and planning in the United States has been focused primarily around the movement of the automobile. Roadways were designed and subsequently evaluated based on their performance only from the perspective of an automobile driver. LOS became the widely-accepted methodology for measuring the performance of such roadways, which worked in the favor of motor vehicle travel, often at the expense of other roadway users.

Traditional LOS measures often contradicts efforts to improve a street's functionality and safety for *all users*. For example, improving the functionality of a street to better serve bicyclists and pedestrians may result in a lower vehicle level of service for that roadway, and therefore may not be acceptable within the community's adopted LOS standards. Meanwhile, *improving* the LOS for a roadway, under a traditional LOS framework, would likely mean adding roadway capacity, which often results in increased automobile speeds, traffic volumes, and other factors that have been shown to decrease safety for bicyclists and pedestrians. Without LOS measures and standards in place that allow for all modes of transportation to be evaluated and considered in transportation

planning and analysis, adding roadway capacity, or widening the roadway, would be seen only as a positive mitigation.

Multimodal LOS standards and measures are based on *person*-capacity rather than *automobile*-capacity of a transportation system. Measuring multimodal LOS is a complex process given the degree of interaction between modes, however there are existing models and application guides to assist agencies in calculating multimodal LOS. The 2010 Highway Capacity Manual (published in 2011), provides a comprehensive framework for evaluating multimodal LOS. This is discussed further in Chapter 4.0, along with other models used across the country.

A multimodal LOS framework provides an analytical tool for cities to use when looking at tradeoffs to each roadway user group and to support decision-making around the community's vision. For example, efforts to improve LOS for vehicles might mean adding capacity in the form of additional vehicle lanes and wider intersections. Being able to determine the impacts to other modes through a multimodal LOS calculation in this scenario might indicate to the decision makers that adding automobile capacity is not the best solution to support the community's vision.

The objective of the Guide is to provide resources and examples of multimodal LOS models and to illustrate the importance of adopting multimodal analytical tools and measures. Ultimately, however, the guide suggests that it is up to each community to decide what's acceptable in terms of LOS standards and mitigation measures. The guide recommends that a community's adopted LOS standards should align with the vision and values of a community. For instance, if a community wants to improve walkability in their downtown core, the LOS standards should reflect this goal. Some communities have approached this by allowing lower automobile LOS in certain areas, like commercial districts and urban villages.

17. The Highway Capacity Manual's Method for Calculating Bicycle and Pedestrian Levels of Service: The Ultimate White Paper, Herbie Huff and Robin Liggett, University of California Transportation Center, 2014

This paper concerns the methods for calculating Pedestrian Level of Service and Bicycle Level of Service (PLOS and BLOS hereafter) as they are presented in the 2010 Highway Capacity Manual (HCM). To calculate PLOS or BLOS is to assign a grade, A through F, to a portion of roadway. This grade is meant to correspond to the perceived level of service that that roadway provides to pedestrians or bicyclists, respectively. PLOS and BLOS comprise a portion of the HCM's Multimodal Level of Service methodology (MMLOS).

The HCM MMLOS has been difficult to use for many practitioners. For various reasons, it has been challenging to use the HCM and quickly understand how PLOS and BLOS work, what variables they take into account, and how important each of these variables is in determining the final grade. The technical sensitivity of the final grade to a given variable will influence the extent to which policies employing PLOS and BLOS will be responsive to such variable.

This paper overviews the PLOS and BLOS methods. It explains the four formal units of analysis employed by the HCM: the intersection, link, segment, and facility. For each of these and

for each of the modes (pedestrian and bicycle), the paper describes in detail what variables are included and the process, definitions, and formulas that produce the final score. Also examined is the relative contribution of each variable in determining the final score under a variety of cases. In many cases they include a sensitivity analysis, setting all inputs to reasonable default values and varying a single variable. They also make note of variables to which PLOS and BLOS are not sensitive despite their importance to planners and policymakers. These allow the reader to understand what drives the PLOS and BLOS scores and thus to better interpret the final grade.

The paper makes several observations about the 2010 HCM's methodology for pedestrian level-of-service and bicycle level-of-service. They conclude that PLOS and BLOS are data-intensive, mathematically involved, multi-stage calculations, are generally not sensitive to the full range of variables of interest to planners and policymakers, and deal particularly poorly with innovative treatments. They also question the validity of PLOS and BLOS in dealing with specific variables, such as sidewalk widths and striping of bicycle lanes.

The extent to which these methods are useful for analyzing proposed changes to a street are considered dependent to a great extent on the analyst's ability to predict changes in operational variables that are not directly controlled by street design, such as traffic volumes and speeds. Finally, the PLOS and BLOS models are felt to be quite specific to formal units of analysis such as the intersection and link, and are specific to a direction of travel in the case of BLOS and a side of the street or crossing in the case of PLOS. There's a trade-off in providing this level of detail: model results are more defensible, but also take longer to calculate and are less legible to the average user.

The paper describes the problems it sees in the process for how the PLOS and BLOS models were developed, as how this process explains some of the problems they observed. They believe that a number of questionable assumptions are incorporated into the model: the model's creators assumed that users can perceive six distinct categories of quality, that these categories are equally spaced, and that a user's demographics and experience have a negligible effect on the final score.

18. Guide to Sustainable Transportation Performance Measures, EPA Report 231-K-10-004 (2011)

This document describes opportunities to incorporate environmental, economic, and social sustainability into transportation decision-making through the use of performance measures that gauge the ability of a project or system to help protect natural resources, improve public health, strengthen energy security, expand the economy, and provide mobility to disadvantaged people. Performance measures allow decision-makers to quickly observe the effects of a proposed transportation project or to monitor trends in transportation system performance over time.

The document describes how many transportation agencies are now being called upon by their stakeholders to plan, build, and operate transportation systems that – in addition to achieving the important goals of mobility and safety – support a variety of environmental, economic, and social objectives. These include protecting natural resources, improving public health, strengthening energy security, expanding the economy, and providing mobility to disadvantaged people.

Also addressed in the document are important societal priorities that are contributing to the need to consider these goals in transportation design decisions:

- *Environmental Quality.* While pollutant emissions from motor vehicles have dropped dramatically over the last three decades, air quality problems persist in many metropolitan areas, driven in part by growth in vehicle miles traveled (VMT). Recent scientific research has more clearly linked air pollution with public health problems and led the U.S. Environmental Protection Agency (EPA) to establish lower thresholds for acceptable levels of air pollution. On a global scale, the looming threat of climate change has focused attention on the environmental impacts of the transportation sector, which contributes more than 25 percent of our nation's greenhouse gas (GHG) emissions.

- *Economic Development.* Transportation has long been recognized as essential to economic development. Efficient and reliable movement of people and goods improves productivity and can spur economic growth. Moreover, with rising regional competition, quality of life has become increasingly important for drawing and retaining a talented and productive workforce. Transportation investments are key to boosting a region's attractiveness to businesses and residents.

- *Social Equity.* People who are economically, socially, or physically disadvantaged need transportation options to give them opportunities to work, learn, and participate in society. Transportation is a large and growing expense for many families. Households in locations with poor accessibility to employment opportunities and other destinations and no alternatives to driving tend to spend more on transportation. Investments that improve accessibility and provide more transportation choices allow households to save money.

The Department of Housing and Urban Development (HUD), USDOT, and EPA are using performance measures to target their resources towards planning and capital programs that support the livability principles, to create baselines for measuring progress toward sustainable communities objectives, and to evaluate federal initiatives. These livability-focused performance measures will complement traditional transportation metrics and will have varied applications for rural and metropolitan regions. The measures described in this document can help transportation agencies work toward the livability goals of their regions.

This Performance Measure Examples section of this document describes 12 performance measures that can help to incorporate sustainable communities' objectives into transportation decision-making. These examples are not intended to be a comprehensive set of measures, nor are they necessarily the 12 most appropriate measures for a given community. They were selected as representative examples that span the various phases of transportation decision-making and the different elements of sustainability. All the measures profiled have been used by one or more transportation agencies. The performance measures are:

- Transit Accessibility.
- Bicycle and Pedestrian Mode Share.
- VMT per Capita.
- Carbon Intensity.

- Mixed Land Uses.
- Transportation Affordability.
- Benefits by Income Group.
- Land Consumption.
- Bicycle and Pedestrian Activity and Safety.
- Bicycle and Pedestrian Level of Service.
- Average Vehicle Occupancy.
- Transit Productivity.

This same section of the report also includes, for each measure, a description, a list of the decision-making phases in which it can be applied, a list of possible metrics, a brief discussion of analytical methods and data sources, and one or more examples of the measure in use.

19. Excerpt from *Rethinking LOS and Transportation Impacts of Development*, Bruce Wright, Blog Post, Fairfax Advocates for Better Bicycling, March 2014

> For those of us who have worked in the fields of transportation and land use development, the term Level of Service (LOS) is well known and sometimes reviled. It is a measure that is used to calculate delay of motorized traffic at intersections. When new development is proposed, developers often are required to calculate the impact of that development on traffic in the surrounding area, with LOS as the measurement. If the development is projected to generate too much traffic, then either the development must be scaled back or resultant traffic impact must be mitigated, usually through increased road capacity.
>
> Problems with using LOS are that the mitigation measures such as wider streets, wider turning radii, dedicated turn lanes, and other measures often make conditions worse for bicyclists and pedestrians. Scaling back development can force new development into less desirable, less dense areas. California is acknowledging these negative impacts and they are rethinking their use of LOS.
>
> At the end of last year, the California Governor's Office of Planning and Research outlined the issues involved in the pdf document Preliminary Evaluation of Alternative Methods of Transportation Analysis, in response to passage of a new law. According to the report, LOS "has recently been criticized for working against modern state goals, such as emissions reduction, development of multimodal transportation networks, infill development, and even optimization of the roadway network for motor vehicles."
>
> The document outlines several problems associated with LOS:
>
> - LOS is difficult and expensive to calculate.
>
> - LOS is biased against “last in” development - infill projects disproportionally trigger LOS thresholds compared to projects in less developed areas.

- LOS scale of analysis is too small - As a result, while outlying development may contribute a greater amount of total vehicle travel and cause widespread but small increases in congestion across the roadway network, it may not trigger LOS thresholds. Further, piecemeal efforts to optimize LOS at individual intersections and roadway segments may not optimize the roadway network as a whole. Focusing on increasing vehicle flow intersection-by-intersection or segment-by-segment frequently results in congested downstream bottlenecks, in some cases even worsening overall network congestion.

- LOS mitigation is itself problematic. Mitigation for LOS impacts typically involves reducing project size or adding motor vehicle capacity. Without affecting project demand, reducing the size of a project simply transfers development, and its associated traffic, elsewhere. When infill projects are reduced in size, development may be pushed to less transportation-efficient locations, which results in greater total travel. Meanwhile, adding motor vehicle capacity may induce additional vehicle travel, which negatively impacts the environment and human health. It also negatively impacts other modes of transportation, lengthening pedestrian crossing distances, adding delay and risk to pedestrian travel, displacing bicycle and dedicated transit facilities, and adding delay and risk to those modes of travel.

- LOS mischaracterizes transit, bicycle, and pedestrian improvements as detrimental to transportation. Tradeoffs frequently must be made between automobile convenience and the provision of safe and efficient facilities for users of transit and active modes. Since LOS measures the delay of motor vehicles, any improvement for other modes that might inconvenience motorists is characterized as an impediment to transportation.

- As a measurement of delay, LOS measures motorist convenience, but not a physical impact to the environment. Other portions of an environmental analysis will account for vehicular emissions, noise and safety impacts.

To address these concerns, California is in the process of developing alternative transportation criteria and metrics that "promote the reduction of greenhouse gas emissions, the development of multimodal transportation networks, and a diversity of land uses."

Some measures that have been evaluated include:

Vehicle Miles Traveled: Although VMT counts only motor vehicle trips, not trips taken by other modes, it registers the benefits of transit and active transportation trips insofar as they reduce motor vehicle travel. In this way, VMT captures the environmental benefits of transit and active mode trips. Mitigation to reduce VMT can include designing projects with a mix of uses, building transportation demand management (TDM) features into the project, locating the project in neighborhoods that have transit or active mode transportation opportunities, or contributing to the creation of such opportunities.

Automobile Trips Generated: Mitigation to reduce VMT can include designing projects with a mix of uses, building transportation demand management (TDM) features into the project, locating the project in neighborhoods that have transit or active mode transportation opportunities, or contributing to the creation of such opportunities. Since VMT is sensitive to regional location, it can also be mitigated by choosing a more central location for the project. Used as a transportation metric under CEQA, VMT could encourage reduction of motor vehicle travel, increase transit and active mode transportation, and increase infill development.

Multi-Modal Level of Service (MMLOS) is a metric of user comfort for travelers on various modes. Along with the traditional motor vehicle LOS metric, MMLOS includes additional ratings for transit, walking, and biking modes. However, using MMLOS poses some of the same problems of using LOS.

<u>20. Exploration and Implications of Multimodal Street Performance Metrics: What's a Passing Grade? Madeline Brozen, Herbie Huff, UCTC-FR-2014-09, University of California Transportation Center, September 2014</u>

New measures have been proposed for evaluating street performance for non-automobile modes including transit service, bicyclists and pedestrians. This is in response to the critique that the current street performance measure, traditional level of service (LOS), overemphasizes the free flow of automobile traffic while neglecting other users of the transportation system.

This paper examines four often-cited multimodal level of service (LOS) metrics; those of the cities of Fort Collins, Colorado and Charlotte, North Carolina; metrics developed by the San Francisco Department of Public Health (BEQI/PEQI), and the multimodal LOS metrics of the 2010 Highway Capacity Manual; and explore the differences between each metric. They provide a literature review with an overview of each metric's development and the variables used to calculate performance scores, as well as their ease of use and threats to their validity. Finally, our literature review closes by offering our critique of the metrics, focusing on how the use of single-outcome metrics (even differentiated by mode) may skew our understanding of street performance by masking considerable variation among users.

Beyond describing the tools, the paper analyzes the scores produced by these measures to document how these metrics compare to one another. They have found that these tools, at times, can produce radically different scores for the same street segment. They next illustrate the contribution of specific variables to the overall score for each measure and mode to explain these scoring differences. This analysis is intended to help practitioners and the research community better understand the promise of these new measures and the challenges that lie ahead.

Five street segments with different physical and operational characteristics were selected and the bicycle and pedestrian scores calculated for each street segment using the three different tools (Charlotte, BEQI/PEQI, and HCM 2010). Overall, they found that if a street is performing "well" for cyclists and pedestrians, the tools produced fairly similar scores. But as the quality of the street deteriorated, the scores from each tool became increasingly different from each other. This exercise also explained some challenges in using the tools; including their inability to evaluate

innovative or unusual infrastructure; in one case, a pedestrian mall. They also saw how all of these tools must reflect the goals of the particular agency using the tools and the agency goals and perspective should be included in the decision to select one tool over another.

The paper also explored understanding how sensitive each tool is to on-the-ground change. The level of service calculation, regardless of mode, is used both to assess current conditions and to evaluate proposed future changes. They wanted to understand how the tools score realistic changes in the built environment. One street segment was selected (from the five in the comparative analysis) and proposed five different scenarios of improvements to both the bicycle and pedestrian environment. They found that all of the scoring mechanisms recommended a road diet scenario with a painted buffer next to a bicycle lane. But they also found that newer bicycle configurations and treatments were often difficult and sometimes impossible to evaluate using these tools. The favored pedestrian scenario was not the same as the favored bicycle scenario and the results were less consistent. Overall, the results demonstrate that these tools can evaluate changes to the street and guide future improvements. However, their ability to measure the effectiveness of innovative treatments is limited.

<u>21. Pedestrian & Bicycle Level of Service Methodology for Crossings at Signalized Intersections, Charlotte Department of Transportation, February 2007</u>

The Charlotte Department of Transportation has developed a methodology to assess the important design features that affect pedestrians and bicyclists crossing signalized intersections. Referred to as Level of Service (LOS), this methodology identifies and evaluates features according to their influence on the comfort and safety of pedestrians and bicyclists. Among the key features identified and rated are crossing distance, roadway space allocation (i.e., crosswalks, bike lanes), corner radius dimension and traffic signal characteristics.

This methodology can be used as a diagnostic tool to assess and improve pedestrian and bicyclist levels of comfort and safety by modifying design and operational features of intersections. The results can be compared with those for traffic levels of service of an intersection and weighed according to user priorities. This methodology is intended to be used to select design and operational features that can help achieve desired levels of service for pedestrians and bicyclists.

<u>22. An Assessment of Multimodal Level-of-Service as a Performance Measure for Signalized Intersections, Srinivas S. Pulugurtha1 and Prasanna R. Kusam, TRB Paper # 11-4266, January 2011</u>

Planning and building infrastructure to support one mode may have an adverse effect on the operational performance of another mode. However, agencies have no scientifically accepted or widely used methods or tools to analyze operational performance of a facility from a multimodal perspective. Currently, Highway Capacity Manual (HCM) 2000 is used for operational analysis of vehicular traffic while the second edition of the 2003 Transit Capacity and Quality of Service Manual (TCQSM) and Florida’s 2009 Quality/Level-of-Service (FQLOS) Handbook are used for

operational analysis of public transit service and pedestrian/bicycle level-of-service (LOS) analysis.

This paper focuses on the development and assessment of a method to compute LOS as a performance measure for signalized intersections from a multimodal perspective. The effects of different weight combinations based on travel demand (percent trips), number of fatal crashes and crash rates by each selected mode are also examined. Data collected at eight signalized intersections along a study corridor in the City of Charlotte, North Carolina are used to illustrate the working of the proposed method. Results obtained are sensitive to LOS of individual modes as well as when different weights were used to determine a combined multimodal LOS. The developed method can be used by planners and engineers to effectively evaluate the operational performance of a signalized intersection from a multimodal perspective.

Conclusions and Recommendations

This paper presents a method to determine the level-of-service (LOS) as an operational performance measure for signalized intersections from a multimodal perspective. Results obtained are as expected and sensitive to LOS from individual modes as well as when different weights based on percent trip (travel demand), number of fatal crashes and crash rates by modes were used to determine multimodal LOS score. The combined multimodal LOS score as a performance measure serves as an overall indicator of LOS for a signalized intersection from a multimodal perspective.

Using weighted factors based on percent trip, number of fatal crashes (or crashes, in general) and crash rates to compute multimodal LOS score may help evaluate and plan transportation infrastructure to better serve all the modes of transportation at signalized intersections. Such analysis using the proposed method could help identify modes that require attention from travel demand as well as from a safety point of view. A sensitive and thorough interpretation of combined and individual scores and the multimodal LOS is required for using the method to its fullest extent.

4.2.3 Conclusions

There are a wide variety of tools available to geometric designers to assess the level and quality of service to all modes using low and intermediate streets. These tools range from detailed quantitative processes requiring considerable field data collection and mathematical analysis to more simple qualitative methods. Overall, these tools can assist designers in evaluating changes to the street and guide future improvements. However, their ability to measure the effectiveness of evolving innovative treatments, such as separated bike lanes, is limited.

The leading geometric design LOS tool used by roadway design agencies is the Highway Capacity Manual and its analysis software. Many agencies and professionals consider the HCM analysis to be the most comprehensive and thorough LOS available. However, several literature sources expressed concern with the difficulty in using this tool and concerns about the relationship of its bicycle, pedestrian and transit level and quality of service findings to actual field conditions

and user group perceptions. Some of the observations and concerns stated by users of these software analysis tools include:

Pedestrian LOS

- Requires extensive data inputs, many of which must be measured in the field.
- May not be feasible as a stand-alone measure (significantly integrated with HCM 2010 Auto LOS measure).
- Pedestrian LOS score is heavily influenced by auto traffic volumes, which are difficult to mitigate in a planning or engineering context.

Pedestrian Delay at Signalized Intersections

- Limited application
- Not responsive to typical intersection improvements

Pedestrian Delay at Unsignalized Intersections

- Method is less accurate in conditions with vehicle platooning or heavy directional bias
- Not accurate for undivided streets with more than four through lanes
- LOS is heavily influenced by auto traffic volumes, which are difficult to mitigate in a planning or engineering context

Bicycle LOS

- Requires significant data inputs, many of which must be measured in the field.
- May not be feasible as a stand-alone measure (reliant on HCM 2010 auto LOS measures).
- Heavily biased towards off-street facilities; difficult to get an "A" score for on-street lanes.

Transit LOS

- Requires extensive data inputs, many of which must be measured in the field.
- May not be feasible as a stand-alone measure as it requires user to calculate Pedestrian LOS, which is significantly integrated with HCM 2010 Auto LOS measure.

In the research team's agency interviews and review of agency design guidance, we did not find evidence of extensive use of the HCM tools for evaluating and designing multimodal projects. While all agencies knew the HCM tools existed, it appears that this analysis method is being selectively used for possibly larger and more complex projects that involve major investment such as lengthy corridor improvements.

We found that other types of level/quality of service tools are being selectively applied by agencies for some projects. For example, there are a number of other available level/quality of service tools available to designers beyond the HCM and several of these were discussed earlier in this chapter. They include:

- Florida DOT – Quality/Level of Service Handbook
- Transit Capacity and Quality of Service Manual, 3rd Edition, TCRP Report 165

- San Francisco Department of Public Health – Pedestrian and Bicycle Environmental Quality Indices
- Fort Collins, Colorado - Multimodal Transportation Level of Service Manual
- City of Charlotte, North Carolina – Multimodal LOS Standards for Signalized Intersections
- City of Charlotte, North Carolina – Pedestrian & Bicycle Level of Service Methodology for Crossings at Signalized Intersections
- King County Washington (Seattle) – Multimodal LOS - A Guide to Incorporating Alternative Modes of Transportation into Local Jurisdictions' Roadway Performance Measurements
- Flagstaff, Arizona MPO – Level of Service Guidelines for Pedestrian, Bicycle and Transit Facilities
- Mineta Transportation Institute - Low-Stress Bicycling and Network Connectivity
- Bicycle LOS (BLOS) Model – Sprinkle Consulting
- Pedestrian LOS (PLOS) Model – Sprinkle Consulting
- Multimodal LOS Toolkit – Fehr & Peers

The design guidelines produced by this research project will identify these various tools and provide guidance for which methodologies may be most appropriate to use for different ranges of roadway types, speed ranges, multimodal accommodation priorities and context settings.

4.3 Task 3: Methods to Balance / Optimize Geometric Design Elements for all Users

Building upon the findings of Tasks 1 & 2, the research team developed a range of alternative approaches that could assist designers and other design project stakeholders in the process of coordinating, balancing and "optimizing" the multimodal geometric design elements of a roadway project in low- and intermediate-speed environments.

The literature and best practice review in Task 1 confirmed that there is no generally accepted or "best practice" for balancing service to all modes in the geometric design process. In fact, the process of balancing and "optimizing" the level, quality and safety of service to all modes in any multimodal project depends on an evaluation of many factors including (1) establishing minimum accommodations for each mode, (2) selecting performance metrics that support project outcomes, (3) addressing context-sensitivity, (4) understanding community values and (5) achieving the priorities of the responsible roadway agencies.

4.3.1 Multimodal Design Elements

Based on this information, the research team believed the following design elements and considerations would need to be addressed in the guidelines to address how they are balanced and optimized for varying conditions through the design process.

<u>Roadway Design Cross-Section Areas</u>

- Traveled Way

- Roadside
- Intersections

Roadside Design

- Roadside Width
- Functional Zone Requirements (Edge, Furnishings, Throughway, and Frontage zones)
- Context of adjacent land use
- Driveway Crossings
- Lighting
- Utilities, stormwater, snow removal/storage, traffic control consideration

Traveled Way Design

- Number/Type/Width of Lanes
- Total Traveled Way Width
- Medians
- Lateral Clearance
- Bicycle Lanes
- On-Street Parking Type & Width
- Midblock Pedestrian/Bicycle Crossings
- Midblock Curb Extensions
- Raised Crosswalks
- Geometric Transition Design
- Driveway Approaches
- Pedestrian Refuge Islands
- Transit Facility Design (lanes, stations, etc.)
- Bus Stops
- Stormwater Management Consideration
- Snow Removal Consideration
- Lighting
- Utility Coordination
- Traffic Control Features

Intersection Design

- Intersection Geometry
- General Intersection Layout
- Curb Return Radii
- Auxiliary Lanes – Number/Width
- Channelized Right-Turns
- Roundabouts
- Pedestrian Crosswalk Treatments
- Curb Radii Extensions
- Bicycle Lane Treatment
- Bus Stops at Intersections
- Displaced Left Turn Intersections
- Traffic Control Considerations

4.3.2 Considering Performance Measures

4.3.2.1. Application of NCHRP 785

NCHRP 15-48 has utilized the recent research completed in NCHRP Report 785, *Performance-Based Analysis of Geometric Design of Highways and Streets*. The purpose of NCHRP Report 785 was to present ways to incorporate performance-based analysis into the project development process. The report establishes a process framework that begins with setting desired project multimodal outcomes and design controls. Geometric design decisions that can influence those outcomes are then identified as well as analysis tools that can be used to estimate the impacts of those decisions. The report also includes six hypothetical case studies illustrating how this framework can be applied to actual projects, with one of those being a focused multimodal "complete streets" project. The report is useful to geometric designers in

understanding how to make informed decisions about the tradeoffs that are inherent in the design process.

The abstract for NCHRP Report 785 further explains the need and purpose for the research effort:

"For both new construction and reconstruction of highways and streets, stakeholders and decision makers increasingly want reasonable measures of the effect of geometric design decisions on the facility's performance for all of its users. Although the expected performance of the facility is only one of the factors that must be considered in designing a highway or street, a better understanding of the expected performance should result in better decisions during the design process. This report presents ways to incorporate performance-based analysis into the project development process. This process framework begins with setting desired project multimodal outcomes and design controls. Geometric design decisions that can influence those outcomes are identified as well as analysis tools that can be used to estimate the impacts of those decisions. The report includes six project examples illustrating how this framework can be applied to actual projects. The report will be useful to geometric designers in making informed decisions about the tradeoffs inherent in design."

NCHRP Project 15-34A which produced Report 785 also contains a Supplemental Information Report that was undertaken to complete the work begun under NCHRP Project 15-34 by: (1) archiving prior 15-34 work, (2) updating information from prior 15-34 documents and deliverables to include current performance-based analysis capabilities and tools, (3) documenting a process for conducting performance-based analysis to inform geometric design decisions, and (4) using case studies to illustrate the process.

The NCHRP 785 report identified five (5) areas of Geometric Design Performance Categories which included:

- Accessibility,
- Mobility,
- Quality of Service,
- Reliability, and
- Safety.

The following exhibits (**Exhibit 4-5 and 4-6**) taken from the Supplemental Information Report for 15-34A provide both the definition and primary measures for each of these five performance categories.

Exhibit 4-5 Performance Measure Categories for NCHRP 15-34A

Performance Category	Definition
Accessibility	The ability to approach a desired destination or potential opportunity for activity.
Mobility	The ability to move from one place to another and the efficiency of that movement.
Reliability	Consistency of performance over a series of time periods (e.g., hour-to-hour, day-to-day, year-to-year).

Safety	The frequency and severity of highway and street related crashes, including those resulting in deaths, injuries and property damage.
Quality of Service	Users' perceptions of transportation performance.

Exhibit 4-6 Primary Measures of Geometric Design Performance by Category

Performance Category	**Primary Measures of Geometric Design Performance[1]**
Accessibility	Measures[1] that integrate travel distances and/or travel times between selected origins[2] and destinations[2] for different modes
Mobility[3]	Average travel speed
Reliability	Travel time variability (e.g., from hour-to-hour, day-to-day, week-to-week)
Safety	Expected crash frequency, by crash severity and crash type
Quality of Service	Levels of service
1. Unless specifically noted, the measures of geometric design performance are applicable to all travel modes (e.g., automobile, bicycle, pedestrian, transit). 2. Accessibility is an emerging concept recognizing that travel time is made up of both distance and speed. Its application is relatively limited in geometric design contexts. 3. Origins and destinations, as referred to here, are not necessarily trip ends (e.g., number of businesses within two miles of freeway access)	

4.3.2.2 Modifications for Adapting to Designing Low- and Intermediate-Speed Roadways

Recommendations for the development of the Guidelines for Designing Low- and Intermediate-Speed Roadways references and builds on this previous work in NCHRP 785 where appropriate. NCHRP 785 addressed all aspects of geometric design on all types of facilities and speed ranges from the interstate system to local roads, while NCHRP 15-48 is focused only on facilities designed with low- to intermediate-speeds of 45 mph or less. The five performance categories is viewed from the perspective of not only how a vehicle travels through a roadway segment or intersection, but also the travel of the pedestrian, the bicyclist and the transit patron. For purposes of NCHRP 15-48, **Exhibit 4-7** (Exhibit 4-6 from Report 15-34A) can be better focused for multimodal use as shown below in *italics*.

Exhibit 4-7: Primary Multimodal Measures of Geometric Design Performance

Performance Category	**Primary Measures of Geometric Design Performance**
Accessibility	Measures that integrate travel distances and/or travel times between selected origins[1] and destinations[1] for different modes
Mobility[2]	Average travel speed *of the vehicle, the bicyclist, the pedestrian and the transit rider*
Reliability	Travel time variability (e.g., from hour-to-hour, day-to-day, week-to-week)
Safety	Expected crash frequency, by crash severity and crash type *(vehicle with vehicle, vehicle with fixed object, vehicle with bicyclist, vehicle with pedestrian, bicyclist with pedestrian)*

Quality of Service	Levels of service *to address all modes of travel*
1. Accessibility is an emerging concept recognizing that travel time is made up of both distance and speed. Its application is relatively limited in geometric design contexts. 2. Origins and destinations, as referred to here, are not necessarily trip ends (e.g., number of businesses within two miles of freeway access)	

4.3.3 Project Development Process

It is clear from the literature and best practice reviews that in order to allow for creativity and flexibility in the geometric design stage of a project, the early stages of project development should also consider all users from the initial project concept development through all subsequent planning and environmental stages. If design options to serve all users are not contemplated and preserved at those early stages, then the ability to develop and evaluate the full range of alternative design elements and criteria may be limited by project scope, budget, available right-of-way or environment approvals. The information below addresses these relationships.

4.3.3.1 State DOT Project Development Process

In the review of state DOT design processes our team identified a commonality on how projects are initiated and eventually moved to design and construction. While the terminology changes from agency to agency, the basic process elements are very similar in the state DOT processes reviewed. Most state DOT have five (5) basic steps in the development of a roadway improvement project.

- Project Identification
- Environmental / Concept Development
- Design
- Project Procurement
- Construction

As noted earlier in this report, it is important to identify multimodal issues and needs early in the project development process so that all feasible design alternatives can be properly considered and evaluated later on in the geometric design process. It is therefore important that geometric design agencies begin their consideration of all modes and users in the initial and ongoing phases of project development if all reasonable alternatives are to be eligible for later evaluation.

In order to better understand the project development process for state DOTs, the process employed by five (5) selected state DOTs were identified and summarized in the following table.

Exhibit 4-8: Project Development Process for Selected DOTs

California DOT	**Source: http://www.dot.ca.gov/hq/oppd/pdwt/part2.htm**				
Common Phases	Project Identification	Environmental / Concept Development	Design	Project Procurement	Construction
Major Phases	Project Initiation	PA&ED	PS&E	Approve Contract	Construction
Key Steps	Define the Problem	Engineering Studies	Survey	Contract Documents	Construction Engineering
	Develop the Alternatives	Project Report	Engineering Reports	Bid Project	
	Analyze Alternatives	Environment al Studies	Roadway Plans	Award Contract	
	Preliminary Environment al Evaluation		Structure Plans		
	Prepare PID		Traffic Plans		

Colorado DOT	**Source: https://www.codot.gov/business/designsupport/ bulletins_ manuals/project-development-manual**				
Common Phases	Project Identification	Environmental / Concept development	Design	Project Procurement	Construction
Major Phases	Program Planning	Project Development	Project Procurement		Construction
Key Steps	Project Development	Design Scoping Review	Bicycle and Pedestrian Facilities		
	Statewide Transportation Improvement Program	Typical Sections	Value Engineering		
	Project Creation	Design Data	Survey		
	Project Delivery Method	Safety Review			

Connecticut DOT	**Source: http://www.ct.gov/dot/cwp/view.asp?a=3194&Q=555206&PM=1**				
Common Phases	Project Identification	Environmental / Concept development	Design	Project Procurement	Construction

Major Phases	Project / Need / Opportunity Identification	Planning / Preliminary Design	Program Initiation, Prioritization, and Programming	Environmental, Design, and ROW Process	Construction
Key Steps	Goals	Project Definition	Project Review and Evaluation	Public Outreach Plan	Public Participation During Construction
	Transportat-ion Evaluation Criteria	Project Review and Refinement	Project Prioritization	Environmen-tal Documentat-ion and Permitting	Construction Management and Monitoring
	Project Need Form	Final Recommendat-ions	Project Programming	Project Design	
		Detailed Alternatives Analysis			

Florida DOT	**Source: http://www.dot.state.fl.us/emo/pubs/etdm/etdmmanual.shtm http://www.dot.state.fl.us/emo/pubs/pdeman/pdeman1.shtm**				
Common Phases	Project Identification	Environmental / Concept development	Design	Project Procurement	Construction
Major Phases	Efficient Transportation Decision Making (ETDM) process	Project Development and Environment (PD&E)	Design		Construction
Key Steps	Comprehensive Planning	Alternative Corridor Evaluation	Typical Section package		
	Cost Feasible Transportation Plans	Purpose and Need	Phase I Plans submittal		
	Technical Study	Alternatives Analysis	Phase II Plans submittal		
	Develop Scope		Phase III Plans submittal		
		Engineering Analysis	Phase IV Plans submittal		
		Typical Section Concurrence			

Indiana DOT	**Source: www.in.gov/indot/files/ProjectDevelopmentProcessManual.pdf**				
Project Development Process for a Major Project					
	Step 0 System-Wide Analysis / Project Identification / Draft	Step 1 Professional Services	Step 2 Conduct Research and Technical Studies	Step 3 Identify and Evaluate Conceptual Solutions	Step 4 Develop Reasonable Alternatives

	Purpose and Need				
	Step 5 Identify Preferred Alternative	Step 6 Stage 1 – Develop Preferred Alternative	Step 7 Stage 2 – Advance Preferred Alternative	Step 8 Environmental Approval	Step 9 Prepare Final Right-of-Way Plans
	Step 10 Begin Land Acquisition	Step 11 Stage 3 – Complete Preferred Alternative	Step 12 Prepare Final Tracings Package		

4.3.3.2 Project Development Workflow

In reviewing the project development workflow of the different state DOTs, the critical phases where design criteria should be included for multimodal accommodation alternatives are the Planning /Environmental and Design stages as discussed in more detail below.

Planning/Environmental Stages

- Community Input – Throughout the process the community should be engaged in establishing the needs and issues to be addressed in developing the scope of the project. This can include public meetings, stakeholder work sessions and other methods of input.
- Project Development – As a project materializes from a concept to a defined scope of work the project is reviewed for its feasibility, purpose/need, and its impact on the environment. At this stage constraints are starting to be defined that will eventually impact the necessary funding, required right-of-way and relationship with the roadway context.
- Develop Alternatives – As alternatives are being developed the various user modes should have been identified. The design criteria is being established based on the scope of work established in project development. The preliminary engineering at this stage is using the multimodal needs identified in project development and the criteria that has been established for each mode.
- Technical Studies – Different studies may be performed based on the size and unique elements of the project. These studies could include the environmental studies, traffic analysis, etc.

Design Stage

- Engineer Reports – This phase establishes formal documentation of the technical design assumptions, guidelines, criteria, etc. from the conceptual plans that will be used as a reference by the design team to establish the direction of the design.
- Typical Sections – Some agencies (such as Florida DOT) require a typical section submittal at the beginning of the design stage in order to confirm the cross section criteria. Criteria is established for number of lanes with associated widths, medians, on-street parking, location/width/amenities of bike lanes, sidewalks and shared paths, drainage requirements, landscaping, lighting and so on. Typical sections can change throughout a project length as context and user needs change.

- Design Data – The step generally includes a spreadsheet or checklist to identify the various design data to be used on the project. This can include agency or AASHTO Green Book requirements with identification of possible design exceptions that may be needed.
- Design – The design team will use the conceptual plans and documented information as the basis for design. Changes in design direction can occur with any major scope changes requiring a review of the environmental impact analysis. Typical changes often include identification of restricted right-of-way areas due to field survey information, new construction that has occurred, continuing input from the public meetings, etc. Designers should document revisions utilizing the engineering reports and design data documentation.

Based on the above design process phases, a typical outline for a project design workflow that incorporates the needs for all users would be as follows.

1. Planning and Environmental Stage
   A. Project Development – Purpose and Need Guided by Performance Measures
      i. Establish multimodal performance measures for the project
         a. Accessibility
         b. Mobility
         c. Economic Development
         d. Quality of Life
         e. Environmental & Resource Conservation
         f. Operational Efficiency
         g. Safety
         h. Safety Preservation
      ii. Data Gathering
         a. Determine the existing/future context of the surrounding area
            1. Determine if Suburban, Urban, Village/Town or other type
            2. Land use type (residential, office, retail, mixed use, industrial, etc.)
         b. Determine the functional classification of the facility (Principal Arterial, Minor Arterial, Collector, Local)
         c. Determine controlling design criteria based on the classification
            1. Speed (design and target operating)
            2. Level/quality of service
         d. Identify current/future users for the facility and relative priority of each
         e. Determine physical constraints including availability of right-of-way
            1. Distance from store front to store front
            2. Steep slopes
            3. Bridge structures
            4. Utilities
            5. Existing retaining walls
            6. Environmental constraints
            7. Historical constraint
         f. Establish the daily and peak hour volume of each user for the facility
            1. Vehicle (veh per dy/hr)
            2. Truck (% of vehicles)
      3. Transit (veh per dy/hr)
      4. Bicycle (bikes per dy/hr)
      5. Pedestrian (ped per dy/hr)
      6. Intersection crossings

iii. Identification of User Needs

   a. Determine the physical needs of each user independent of the other users.

      1. Vehicle - # of lanes / width of lanes / parking lanes
      2. Truck – Design vehicle / turning requirements
      3. Transit – Separate lanes / additional width
      4. Bicycle – Bicycle Plan / location (in roadway / shared path)
      5. Pedestrian – Pedestrian Plan / sidewalk location / width / shared path
      6. Pedestrian – Midblock crossings
      7. Border – Buffers / landscaping / furniture
      8. Median – Type / width / landscaping
      9. Parking – Location / type /width
      10. Storm drainage – Type / location
      11. Utilities – Location / access
      12. Other

   b. Identify additional needs based on the performance measures

      1. Special intersection requirements (all modes)
      2. Midblock crossing requirements
      3. Methods to control speed
      4. Other

B. Alternative Development and Selection - Multi-User Conceptual Solutions

   i. Develop alternative cross-sections by context zone

      a. Traveled Way – lanes / median / bike lanes / parking lanes / separate transit lanes
      b. Intersections – lanes / median / pedestrian control / bicycle control
      c. Border – sidewalk / utilities / grass area / sidewalk fixtures

   ii. Test the alternatives against the performance measures identified above

   iii. Select the alternative that best meets the purpose and need of the project

2. Design Process – Consideration for all Users

   A. Complete the criteria requirements for the project

      i. Radius for curb returns
      ii. Horizontal and vertical alignment
      iii. Sight distance
      iv. Type of intersections

   B. Design

   C. Check – Do Final Solution Outcomes meet desired Performance Measures?

4.3.4 Incorporating Multi-Modal Design Criteria into the Design Process

4.3.4.1 How State DOTs are Addressing Multimodal Needs: Roadway Design Manuals and/or Separate Documents

There is a wide range of approaches being employed by state DOTs in addressing multimodal needs and how they are integrated into the design decision process. The design manuals and multimodal accommodation guidance for nineteen (19) state DOTs were reviewed to understand

how these agencies have incorporated criteria for bicycle, pedestrian and transit facilities into their design process. The following table (**Exhibit 4-9**) identifies the primary sources of multimodal design guidance in these DOTs.

Exhibit 4-9: Primary Sources of State DOT Multimodal Design Guidance

State DOT	How the Design Manual Addresses Bicycle Accommodation Design	How the Design Manual Addresses Pedestrian Accommodation Design	How the Design Manual Addresses Transit Accommodation Design
California	Chapter 1000 Bicycle Transportation Design	Topic 105 - Pedestrian Facilities	
Colorado	Chapter 14 Bicycle and Pedestrian Facilities	Chapter 14 Bicycle and Pedestrian Facilities	
Florida	Chapter 8 Pedestrian, Bicycle and Public Transit facilities	Chapter 8 Pedestrian, Bicycle and Public Transit facilities	Chapter 8 Pedestrian, Bicycle and Public Transit facilities
Georgia	Chapter 9 - Complete Streets Design policy	Chapter 9 - Complete Streets Design policy	Chapter 9 - Complete Streets Design policy
Indiana	Chapter 51 Special Design Elements	51-1.0 Accessibility For Handicapped Individuals	51-5.0 Bus Stop And Bus Turnout
Minnesota	Separate Document - Bikeways Facility Design Manual	Separate Document - Statewide Pedestrian System Plan	Separate Document - Transit in Minnesota
Maine	HWY Design Guide: Geometric Design Tables and Intersections At-Grade	HWY Design Guide: Geometric Design Tables and Intersections At-Grade	
Maryland	Separate Document - Bicycle Policy & Design Guidelines	Separate Document: Pedestrian & Bicycle Master Plan	
Massachusetts	Chapter 3.3 Roadway Users Chapter 5.2 Multimodal Accommodation	Chapter 3.3 Roadway Users Elements Chapter 5.2 Multimodal Accommodation	Chapter 5 Cross-Section and Roadside Elements Chapter 5.4 Public Transit Operations
Michigan	Chapter 12 Miscellaneous Roads Index - 12.12 Bicycle Facilities	Nothing	Chapter 12 Miscellaneous Roads Index - 12.13 Carpool Parking Lots
Minnesota	Separate Document - Bikeways Facility Design Manual	Separate Document - Minnesota's Best Practices for Pedestrian/Bicycle Safety	
New Jersey	Section 4 Basic Geometric Design Elements Section 5 Major Cross Section Elements	Section 4 Basic Geometric Design Elements Section 5 Major Cross Section Elements	

State DOT	How the Design Manual Addresses Bicycle Accommodation Design	How the Design Manual Addresses Pedestrian Accommodation Design	How the Design Manual Addresses Transit Accommodation Design
North Carolina	Separate Document at http://completestreetsnc.org	Separate Document at http://completestreetsnc.org	
Oregon	Separate Document - Oregon Bicycle and Pedestrian Design Guidelines	Separate Document - Oregon Bicycle and Pedestrian Design Guidelines	
Pennsylvania	Separate Document - Bicycle/Pedestrian Checklist	Separate Document - Bicycle/Pedestrian Checklist	
Vermont	Separate Document - Pedestrian & Bicycle Facility Planning and Design Manual	Separate Document - Pedestrian & Bicycle Facility Planning and Design Manual	
Virginia	Road Design Manual Section A-5-Bicycle and Pedestrian Facility Guidelines; Separate Document: Multimodal System Design Guidelines	Road Design Manual Section A-5-Bicycle and Pedestrian Facility Guidelines; Separate Document: Multimodal System Design Guidelines	Separate Document: Multimodal System Design Guidelines
Washington	Chapter 1520 – Roadway Bicycle Facilities:	Chapter 1510 – Pedestrian Facilities	Division 14 – HOV and Transit
Wisconsin	Chapter 11 Design Section 46 Complete Streets; and Separate Document - Wisconsin Bicycle Facility Design Handbook	Chapter 11 Design Section 46 Complete Streets; and Separate Document - Wisconsin Guide to Pedestrian Best Practices	

As shown above, several state DOTs have developed separate documents to address accommodation and design for pedestrian and bicycle modes with a few also addressing transit. While this focused design guidance concept provides significant detail and guidance for the design of those modes, agency interviews have noted challenges created when roadway design guidance is contained in one location while guidance for other modes is contained in other locations.

Several state DOTs have included multimodal design guidance within their roadway/highway design guidance manual, but in many cases they are contained in one or more separate modal chapters. While it is considered beneficial to have specific design guidance on all modes addressed in one consolidated document, the designer is still challenged in this situation to work between separate modal chapters and must often make special efforts to integrate the modes as required.

A few state DOTs have begun to integrate their modal design chapters into consolidated locations where all modes are simultaneously addressed although they may be separated by elements such as functional classification, speed ranges and context (rural, suburban, urban). The research team believes that this is the optimal guidance situation because all design elements and criteria are generally related to each other in some manner and should be considered concurrently. For example, when establishing the vehicle lane widths for the facility the designer is also establishing and balancing the widths all other cross-sectional elements (parking, bike lanes, sidewalks, medians, buffers, etc.). One example of this integrated design approach is provided in Chapter 21 of Florida DOT's Plans Preparation Manual titled "Transportation Design for Livable Communities".

4.3.4.2 Considerations in Balancing & Optimizing Geometric Design Elements for all Users

The most effective and preferable approach to balancing modal service is to have a comprehensive methodology based on quantitative data to guide all design decisions related to level and quality of service, accessibility, safety and context-sensitivity. In this situation the designer would fully understand the expected performance impacts of assembling various design elements with varying dimensions within a range of user demand ranges, design speeds and contexts. But even with this advanced understanding of design element and criteria relationships, this approach would still likely require a considerable use of designer judgment and flexibility to address unique project needs as contemplated in the following language taken from the Green Book Foreword.

> *This policy is therefore not intended to be a detailed design manual that could supersede the need for the application of sound principles by the knowledgeable design professional. Sufficient flexibility is permitted to encourage independent designs tailored to particular situations*.

The research team recognizes that in several areas of geometric design criteria and controls, and especially for the non-vehicular modes, there is insufficient data or research on which to make fully-supported recommendations for assembling various combinations of design elements and criteria. In many areas of geometric design related to non-motorized users, there is significantly less data and research than is available for design and performance relationships of motorized modes. Considerable research still needs to be done in order to quantitatively evaluate the relationships between the full range of design elements and dimensions and performance measures that exist in many urban and suburban multimodal projects. In those situations today, the designer must utilize the best data and information available in conjunction with reviews of best practices and their personal experience and professional judgment to make the required design choices based on their predictions of likely performance outcomes. While this approach may cause concerns over potential risk management and liability issues, in reality many multimodal project designs are accomplished with design and operating speeds of 35mph or less where safety implications are less critical than with higher speeds. Liability and risk concerns increase for all users as design and operating speeds move into the 40 and 45 mph ranges.

The most practical approach to developing a design balancing and optimizing process for the guidelines document is to utilize and reference the available relevant research results (e.g., NCHRP

Report 766: Recommended Bicycle Lane Widths for Various Roadway Characteristics) that are currently available to inform the balancing, optimizing and trade-off process inherent in multimodal design projects. However, while available design guidance applicable to a multimodal project includes a growing range of resources as shown in the literature review, this magnitude and diversity of resources is challenging to effectively manage in a design process and alone does not address nearly all the conceivable design element and criteria alternative relationships.

Design agencies and designers have a tremendous challenge to keep up with evolving research and technical guidance that is being produced today in the design profession, nationally and internationally. While it is certainly important for the design profession to be aware of ongoing progress in these areas, it is equally important for those agencies and designers to understand what flexibility exists in current design guidance and how to apply that flexibility using sound engineering principles and professional judgment. Only in this manner can designers create independent and innovative designs that are often necessary to meet the needs of all users.

4.3.5 Alternative Methods to Balance/Optimize Geometric Design Elements for all Users

After consideration of the knowledge gained in Task 1, the research team's deliberations in this task, and the team's experience in multimodal design, we feel that the following alternative approaches are available to build into the design guidelines document as tools to guide and inform the multimodal geometric design process.

<u>Approach 1 – Focus on Level and Quality of Service Tools</u>

This approach would provide guidance on which of the various LOS/QOS tools may be most appropriate and cost-effective to use on a particular project based on key variables such as project size, current/future multimodal demands, functional classification, design speed and context. While modal level and quality of service is certainly a key factor in the multimodal design process, it is not the only factor that drives geometric design decisions. It is very important, however, to understand the design elements necessary to achieve the desired level and quality of service for each mode even though those there will often be trade-offs required in balancing those elements due to physical, financial, environmental or other constraints. For example, road diet (roadway reconfiguration) projects often reduce through travel lanes and results in a decrease of vehicular LOS, but that reduction is usually offset by reductions in crash rates (often due to the addition of center turn lanes), increases to service and safety of other modes, and even improvements in economic activity tied to added on-street parking.

<u>Approach 2 – Focus on Performance Metric Tools</u>

This approach would build on the work completed in NCHRP Report 785, *Performance-Based Analysis of Geometric Design of Highways and Streets*. This report presents an approach for understanding the desired outcomes of a project, selecting performance measures that align with those outcomes, evaluating the impact of alternative geometric design decisions on those performance measures, and arriving at solutions that achieve the overall desired project outcomes. The five (5) recommended performance categories include Accessibility, Mobility, Quality of

Service, Reliability, and Safety. The report provides a framework for evaluating performance metrics and considering them through the design process, although the process does not focus exclusively on low- and intermediate-speed roadways with multimodal conditions. The six (6) case studies included show how the concepts, models, and performance evaluation framework presented in the report can be applied to guide analysis on various types of projects.

Approach 3 – Focus on NCHRP 15-47 Results/Recommendations

This approach would employ relevant aspects of NCHRP 15-47, *Developing an Improved Highway Geometric Design Process*. This project is not yet complete but anticipated for completion in early 2016. The objectives of this research project were relevant to NCHRP 15-48 as it includes developing a comprehensive, flexible design process to meet the needs of geometric designers in the future. This process is planned to consider these key elements:

- Specification of the project purpose and need, including the modes that will be using the facility.
- Context setting of the facility.
- Desired performance outcomes for the facility for the various modes; including safety, mobility, and access management.
- Methods for evaluating tradeoffs associated with different design alternatives.
- Optimization of the design given the project's financial and other constraints.
- Flexibility to address issues that arise from stakeholder involvement or environmental reviews.
- Documentation of decisions to address tort liability concerns.

Approach 4 – Focus on Context Sensitivity and Modal Priority

This approach seeks to balance and optimize design elements to most effectively align with the current and planned land use context and established modal priorities for that facility. Once these outcomes are identified, the designer can select design elements and criteria that best supports, complements and achieves these goals. Although definitive data and research is not available to support decision-making for all of the design choices that must be made with this or any other approach, a clear set of goals and priorities addressing all modes would establish the initial vision for what the project should accomplish for the convenience, safety and mobility of all planned modes.

Design decisions that create increases or decreases in a performance metric for one mode will often have the opposite effect on other mode performance metrics. For example, adding on-street parking to a design cross-section may have the effect of helping to achieve increased economic viability for adjacent land use and creating slower vehicle operating speeds due to parking maneuvers and vehicle entry/exit, but crash potential may also be increased from those parking maneuvers. Vehicle doors also represent a safety concern for bicyclists traveling directly adjacent to the parking lane.

The City of Charlotte, North Carolina established general guidance for a wide range of relationships between design choices as shown below in a portion of Figure 2:1 from their Urban Street Design Guidelines (**Exhibit 4-10**). In the example from that figure, the goal, or priority, is to

increase safer street crossings for cyclists. A number of supportive design treatments are listed and described with the expected associated impact on each of the user modes noted as having either a positive, negative, mixed/caution or neutral impact as shown by the colored shapes. This tool helps designers understand, in general qualitative terms, the potential implications of alternative design decisions on all user groups.

Exhibit 4-10: Relationship between Safe Cycle Crossings Options and Other Modes

		Pedestrians	Cyclists	Motorists	Transit*	Neighbors
Cyclists Want Safer Crossings						
Consider the following elements to increase cyclists' visibility:						
Bike Boxes	Brings cyclists into drivers' sight; allows cyclists a headstart through an intersection; should provide bike lane approaching intersection	◆ Positive Impact	◆ Positive Impact	◆ Mixed Impact or Use With Caution	◆ Mixed Impact or Use With Caution	◇ Neutral
Drop Bike Lane at Intersection	Achieves same as bike box, but without designated space; casual cyclists may feel less comfortable, although it is considered safer to drop the lane and have cyclists merge earlier for left-turns if there is no bike box	◆ Positive Impact	◆ Mixed Impact or Use With Caution	◆ Mixed Impact or Use With Caution	◆ Mixed Impact or Use With Caution	◇ Neutral
Leading Bike Signal	Allows cyclists a headstart through the intersection; requires driver and cyclist education	◆ Mixed Impact or Use With Caution	◆ Mixed Impact or Use With Caution	◆ Negative Impact	◆ Negative Impact	◇ Neutral
Short Blocks	Create more intersections, but potentially smaller intersections; more opportunities to avoid high volume routes; can potentially calm traffic and allow more opportunities for safe crossing treatments	◆ Positive Impact	◆ Positive Impact	◆ Positive Impact	◆ Positive Impact	◆ Positive Impact

◆ - Positive Impact ◆ - Negative Impact ◆ - Mixed Impact or Use With Caution ◇ - Neutral

4.3.6 Conclusions

The research team believes that all of the tools involved in the alternatives approaches need to be noted and discussed in the design guidelines document. Depending on the size, complexity and challenges associated with any particular project, using any one or a combination of these approaches may be considered appropriate for use by the designer. In general, at the higher levels of project investment, functional classification, traffic volumes and design speeds, design processes also become more involved and complex in assessment of alternatives and level/quality of service provided to each mode. However, simply using these methods, no matter how quantitative and precise the assessment is, will not automatically make the trade-off decisions that a designer often faces in designing multimodal urban projects.

For many mid-sized and smaller multimodal construction, reconstruction and 3R (resurfacing, restoration, rehabilitation) projects that contain elements of "re-thinking" street use (such as road diets), improving livability through more context-sensitive design (such as main streets), or simply

improving routine multimodal accommodation and safety, Approach 4 will typically yield the best combination of qualitative and quantitative assessment to consider in selecting design elements and criteria. This approach requires that a designer first understand, or at least be able to estimate based on engineering and professional judgment, the impacts and interrelationships of various choices and combinations of modal design elements and criteria. Understanding these factors will allow the designer to effectively apply the design flexibility that is not only allowed, but often encouraged, in federal, state and local design documents and processes to address multimodal user needs.

Using Standards and Minimums Versus Flexibility

To be effective in designing roadways that accommodate all users, a project designer needs to first understand the required and/or generally-accepted standards and practice for determining design controls, elements and criteria in the geometric design process. For projects on the NHS, the AASHTO Green Book has been adopted by FHWA as the geometric design standards on those facilities. Additional guidance has been developed by AASHTO, TRB and many state DOTs for 3R projects. And while not adopted by FHWA as design standards, AASHTO's *Guide for the Development of Bicycle Facilities*, *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, and *Guide for Geometric Design of Transit Facilities on Highways and Streets* are also important be familiar with and use where appropriate to guide multimodal accommodation.

FHWA has also noted in their *August 20, 2013 Bicycle and Pedestrian Facility Design Flexibility Memorandum* that NACTO's *Urban Bikeway Design Guide* and the Institute of Transportation Engineers (ITE) *Designing Urban Walkable Thoroughfares* guide build upon the flexibilities provided in the AASHTO guides, which can help communities plan and design safe and convenient facilities for pedestrian and bicyclists. FHWA supports the use of these resources to further develop non-motorized transportation networks, particularly in urban areas.

The design policies, controls, elements and criteria in the AASHTO Green Book and other AASHTO guides often form the basis for the standards used by many other transportation agencies in the U.S. When designing projects in those agencies, the designer should be aware of national design guidance as well as all local design policies, standards and guidelines that apply to the project they are designing.

In general, roadway design standards and guidance documents provide what are often referred to as "minimums" or "desirable" values and sometimes provide a range of geometric dimensions to choose from. Unfortunately, these values have been developed almost exclusively with vehicle considerations in mind and a flexible design approach is usually necessary to address other modes. FHWA has produced a number of documents that address the need to use flexibility in geometric design to address goals like multimodal needs and context-sensitivity, but little specific guidance has been developed to aid designers in assessing and making those flexible design choices. That is the main purpose of this research project – to provide specific, detailed guidance for performing flexible design that is usually necessary on low- and intermediate-speed roadways that serve multiple user modes.

4.4 Task 4: Geometric Design Framework

In this task our research team has considered the methodologies developed in Task 3 against the full range of facility classification types and speed ranges. We also believed that it was important in this task to fully consider the other key design variables of context and modal demand/priority that exist for every roadway design project serving more than motorized vehicles.

The stated goal of this task was to identify the design guidance framework that provides the best balance between (1) roadway classifications, (2) context, (3) speed ranges, (4) user types and (5) performance measures around which to build the specific work plan in Task 5, and then finally create the guidelines document. Each of these framework variables is briefly addressed in the sections that follow.

4.4.1 Roadway Classification

4.4.1.1 AASHTO Roadway Classification

The AASHTO Green Book (hereinafter referred to as AASHTO) defines rural roads as facilities that exist outside of urban areas. The terms used for the system facilities are principal arterials (roads), minor arterials (roads), major and minor collectors (roads), and local roads. The AASHTO-defined characteristics and considerations for each mode is discussed in the Green Book as follows.

Rural Principal Arterial System

The rural principal arterial system consists of a network of routes with the following service characteristics:

A. Corridor movement with trip length and density suitable for substantial statewide or interstate travel.
B. Movements between all, or virtually all, urban areas with populations over 50,000 and a large majority of those with populations over 25,000.
C. Integrated movement without stub connections except where unusual geographic or traffic flow conditions dictate otherwise (e.g., international boundary connections or connections to coastal cities).

AASHTO notes that in the more densely populated states, this class of highway includes most (but not all) heavily traveled routes that might warrant multilane improvements in the majority of states, and the principal arterial system includes most (if not all) of the existing rural freeway system.

The rural principal arterial system is stratified into the following three classifications: (1) interstate highways, (2) other freeways and expressways, and (3) other principal arterials.

Rural Minor Arterial System

The rural minor arterial road system, in conjunction with the rural principal arterial system, forms a network with the following service characteristics:

A. Linkage of cities, larger towns, and other traffic generators (such as major resort areas) that are capable of attracting travel over similarly long distances.
B. Integrated interstate and intercounty service.
C. Internal spacing consistent with population density, so that all developed areas of the state are within reasonable distances of arterial highways.
D. Corridor movements consistent with items (A) through (B) with trip lengths and travel densities greater than those predominantly served by rural collector or local systems.

Minor arterials therefore are considered to constitute routes that should provide for relatively high travel speeds and minimum interference to through movement, although their design is recommended to be consistent with the context of the project area and considering the range or variety of users.

Rural Collector System

The rural collector routes generally serve travel of primarily intra-county rather than statewide importance and constitute those routes on which (regardless of traffic volume) predominant travel distances are shorter than on arterial routes. Consequently, more moderate speeds may be typical. AASHTO further defines rural collectors into sub-classes according to the following criteria:

Major Collector Roads: These routes (1) serve county seats not on arterial routes, larger towns not directly served by the higher systems, and other traffic generators of equivalent intra-county importance, such as consolidated schools, shipping points, county parks, and important mining and agricultural areas; (2) link these places with nearby larger towns or cities, or with routes of higher classifications; and (3) serve the more important intra-county travel corridors.

Minor Collector Roads: These routes should (1) be spaced at intervals consistent with population density to accumulate traffic from local roads and bring all developed areas within reasonable distances of collector roads; (2) provide service to the remaining smaller communities; and (3) link the locally important traffic generators with their rural region.

Rural Local Road System

The rural local road system, in comparison to collectors and arterial systems, primarily provides access to land adjacent to the collector network and serves travel over relatively short distances. The local road system constitutes all rural roads not classified as principal arterials, minor arterials, or collector roads.

Functional Highway Systems in Urbanized Areas

AASHTO describes four functional highway systems for urbanized areas including urban principal arterials (streets), minor arterials (streets), collectors (streets), and local streets. The key difference between urban and rural systems are assumed to be the nature and intensity of land use development and increased presence of other modes of travel.

Urban Principal Arterial System

AASHTO recognizes that in every urban environment, one system of streets and highways can be identified as unusually significant in terms of the nature and composition of travel it serves. In small urban areas (population under 50,000), these facilities may be very limited in number and extent, and their importance may be derived primarily from the service provided to through travel (with exceptions being where these routes also serve as main streets for these communities). In larger urbanized areas, their importance also derives from service to rurally oriented traffic, but equally or even more importantly, from service for major circulation movements within these urbanized areas.

The urban principal arterial system typically serves the major centers of activity of urbanized areas, the highest traffic volume corridors, and the longest trip desires. This system often carries a high proportion of the total urban area travel even though it constitutes a relatively small percentage of the total roadway network.

The urban principal arterial system usually carries most of the trips entering and leaving an urban area, as well as most of the through movements bypassing the central city. In addition, significant intra-area travel, such as between central business districts and outlying residential areas, between major inner-city communities, and between major suburban centers, is served by this class of facility. Frequently, the urban principal arterial system carries important intra-urban as well as intercity transit routes with significant levels of other user activity. Finally, in urbanized areas, this system can provide continuity for all rural arterials that intercept the urban boundary.

Because of the nature of the travel served by the principal arterial system, almost all fully and partially controlled access facilities are usually part of this functional class. However, this system is not restricted to controlled-access routes. To preserve the identification of controlled-access facilities, AASHTO recommends that the principal arterial system be stratified as follows: (1) interstate, (2) other freeways, and (3) other principal arterials (with partial or no control of access).

AASHTO notes that for freeways and expressways, service to abutting land is obviously subordinate to travel service to major traffic movements. For facilities within the subclass of other principal arterials in urban areas, mobility is often balanced against the need to provide direct access as well as the need to accommodate pedestrians, bicyclists, and transit users consistent with community goals and land use context.

Urban Minor Arterial Street System

The urban minor arterial street system interconnects with and augments the urban principal arterial system. It typically accommodates trips of moderate length at a somewhat lower level of

travel mobility than principal arterials do. This system is expected to distribute travel to geographic areas smaller than those identified with the higher system.

AASHTO describes the urban minor arterial street system as including all arterials not classified as principal. This system places more emphasis on land access than the higher system does and offers lower vehicular traffic mobility. Such a facility may carry local bus routes and provide intracommunity continuity but ideally does not penetrate identifiable neighborhoods. This system includes urban connections to rural collector roads where such connections have not been classified as urban principal arterials for internal reasons.

Urban Collector Street System

AASHTO notes that the urban collector street system provides both land access service and traffic circulation within residential neighborhoods and commercial and industrial areas. It differs from the urban arterial system in that facilities on the collector system often penetrate and serve residential neighborhoods, distributing trips from the arterials through the area to their ultimate destinations. Conversely, the urban collector street also collects traffic from local streets in residential neighborhoods and channels it into the arterial system. In the central and outlying business districts, and in other areas of similar development and traffic density, the urban collector system may include the entire street grid. The urban collector street system may also carry local transit bus routes.

Urban Local Street System

AASHTO considers urban local street system as those comprising all facilities not in one of the higher systems. It primarily permits direct access to abutting lands and connections to the higher order systems. It generally offers the lowest level of mobility and usually contains no bus routes and varying levels of non-motorized user activity. Service to through-traffic movement usually is deliberately discouraged.

The table below (**Exhibit 4-11**) provides a brief summary of the recommended AASHTO functional classification system.

Exhibit 4-11: AASHTO Roadway Classification Summary

AASHTO ROADWAY CLASSIFICATION SUMMARY		
Classifi-cation	**Location**	**Characteristics**
Principal Arterial	**Rural**	Trip lengths for statewide or interstate travel. Integrated movement generally without stub connections. Accommodates movement between (virtually) all urban areas with pop. 50,000. Two design types: freeways and other principal arterials.
	Urban	Serves major centers of activity with the highest traffic volumes and longest trip lengths. Integrated internally and between major rural connections. Service to abutting lands is subordinate to travel service to major traffic movements. Design types are interstate, other freeways and other principal arterials.

Minor Arterial	**Rural**	Links cities, large towns and other traffic generators attracting traffic over long distances. Integrated interstate and intercounty service. Designs should be expected to provide for relatively high speeds and minimum interference to through movements.
	Urban	Trips of moderate length at a lower level of mobility than principal arterials. Some emphasis on land access. May carry local bus routes and provide intracommunity continuity but does not penetrate neighborhoods.
Collector	**Rural**	Serve intra-county travel with travel distances shorter than on arterial system. More moderate speeds. Divided into major and minor system.
	Urban	Provides both land access and traffic circulation within all areas. Penetrates neighborhoods and communities collecting and distributing traffic between neighborhoods and the arterial streets.
Local	**Rural**	Local roads primarily provide access to adjacent land and the collector network. Travel is over short distances.
	Urban	Primarily permits direct land access and connections to the higher order streets. Lowest level of mobility. Through traffic is usually deliberately discouraged.

4.4.1.2 Other Roadway Classification Systems

AMERICAN INSTITUTE OF ARCHITECTS (AIA) System

Similar to the AASHTO functional classification system, the AIA developed a proposed classification system that sees streets (or corridors) as serving one of two purposes. Unlike the AASHTO approach focused on access and mobility priorities, the AIA priorities are connection and division. AIA's approach is focused on urban land use and sees streets and roads as either helping to connect neighbors and communities or they serve to separate them. This view of how the street network impacts on the community is the basis for the AIA's alternative classification system.

More specifically, the AIA system for classifying streets is based on "capacity and character." Capacity is considered a measure of how well the particular street moves people. For motor vehicle travel it is based on the number and width of lanes, grades, intersection control, and various other factors. Character refers to a street's "suitability for pedestrian activities and a variety of building types". Street character, e.g. context, is reflected in the associated buildings, frontages and landscape types, and sidewalk width and amenities.

The AIA system has ten (10) classes that reflect differing degrees of suitability for traffic movement, pedestrian activity and building types. This system is considered applicable to all streets within a city or town. The system is shown in the table below (**Exhibit 4-12**) and it is clear in this approach that the AIA is more concerned with how the road impacts on the community and

fits in with adjacent land uses than the traditional AASHTO classification system focused on vehicular mobility and access.

Exhibit 4-12: AIA Roadway Classification System

AIA ROADWAY CLASSIFICATION SYSTEM	
Classification	**Description**
Highway	A long-distance, medium speed vehicular corridor that traverses open country. A highway should be relatively free of intersections, driveways and adjacent buildings; otherwise it becomes a strip, which interferes with traffic flow.
Boulevard	A long-distance, medium speed vehicular corridor that traverses an urbanized area. It is usually lined by parallel parking, wide sidewalks, or side medians planted with trees. Buildings uniformly line the edges.
Avenue	A short-distance, medium speed connector that traverses an urban area. Unlike a boulevard, its axis is terminated by a civic building or monument. An avenue may be conceived as an extremely elongated square.
Drive	An edge between an urban and a natural corridor, usually along a waterfront, park or promontory. One side of the drive has the urban character of a boulevard, with sidewalk and buildings, while the other has the qualities of a parkway, with naturalistic planting and rural detailing.
Street	A small-scale, low speed connector. Streets provide frontage for higher-density buildings such as offices, shops, apartment buildings, and row houses. A street is urban in character, with raised curbs, closed drainage, wide sidewalks, parallel parking, trees in individual planting areas, and buildings aligned on short setbacks.
Road	A small-scale, low speed connector. Roads provide frontage for low-density buildings such as houses. A road tends to be rural in character with open curbs, optional parking, continuous planting, narrow sidewalks, and buildings well set back. The rural road has no curbs and is lined with pathways, irregular tree planting and uncoordinated building setbacks.
Alley	A narrow access route servicing the rear of buildings on a street. Alleys have no sidewalks, landscaping, or building setbacks. Alleys are used by trucks and must accommodate dumpsters. Alleys are usually paved to their edges, with center drainage via an inverted crown.
Lane	A narrow access route behind houses on a road. Lanes are rural in character, with a narrow strip of paving at the center or no paving. While lanes may not be necessary with front loading garages, they are still useful for accommodating utility runs, enhancing the privacy of rear yards, and providing play areas for children.
Passage	A very narrow, pedestrian-only connector cutting between buildings. Passages provide shortcuts through long blocks or connect rear parking areas with street frontages. Passages may be roofed over and lined by shop fronts.
Path	A very narrow pedestrian and bicycle connector traversing a park or the open country. Paths should emerge from the sidewalk network. Bicycle paths are necessary along highways but are not required to supplement boulevards, streets, and roads, where slower traffic allows sharing of the vehicular lanes.

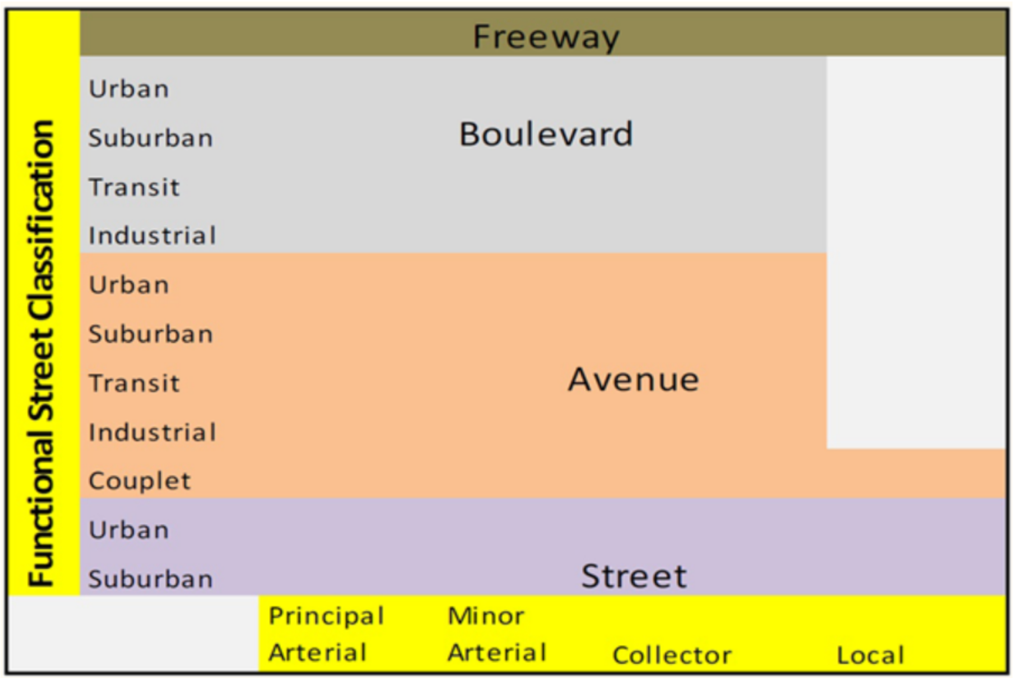
Idaho DOT

The Idaho DOT's August 2009 Technical Report 5 entitled "Highway System Classification (Functional Classification)" states that the department has come to a new understanding that

"streets should connect to their surrounding environment through adjustments in highway/street elements and functions." The new approach of multimodal street design outlined in this report encompasses four distinct elements or zones (the travel way zone, the pedestrian zone, the context zone and the intersection zone). Each element works with the others to accommodate the needs of multiple modes in harmony their abutting land uses, taking into account environmental, historical preservation and economic development objectives.

This functional classification system is consistent with other national practices which recognize the importance of the different transportation functions that are accommodated within the roadway's right-of-way. These road/street “typologies” expand the rural/urban construct into more granular categories that recognize aesthetic and neighborhood-level concerns and explicitly account for all modes of transportation. The following figure (**Exhibit 4-13**) illustrates the proposed multimodal functional street classification system (which includes the categories of Freeways, Boulevards, Avenues and Streets) and relates it to the conventional street classification system.

Exhibit 4-13: Idaho DOT Functional Classification System – Technical Report 9



ITE/CNU *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*

The design process outlined in this report refers to both functional classification and thoroughfare type to classify streets. The purpose of each classification as used in CSS applications for areas with traditional urban characteristics is described below.

• Functional classification—defines a thoroughfare's function and role in the network, in addition to governing the selection of certain design controls. The practitioner may use functional class to determine:

• Continuity of the thoroughfare through a region and the types of places it connects (such as major activity centers);

• Purpose and lengths of trips accommodated by the thoroughfare;

• Level of land access and level of access management;

• Type of freight service; and

• Types of public transit services (for example, bus, bus rapid transit, fixed guideway and so forth).

These factors are intended to be used to inform the practitioner's decisions related to both the physical design and operations of the thoroughfare. Table 4.2 from this report (**Exhibit 4-14**) is provided below and offers descriptions for each of the recommended thoroughfare types.

Exhibit 4-14: Thoroughfare Type Descriptions

Table 4.2 Thoroughfare Type Descriptions

Thoroughfare Type	Functional Definition
Freeway/Expressway/ Parkway	Freeways are high-speed (50 mph +), controlled-access thoroughfares with grade-separated interchanges and no pedestrian access. Includes tollways, expressways and parkways that are high- or medium-speed (45 mph +), limited-access thoroughfares with some at-grade intersections. On parkways, landscaping is generally located on each side and has a landscaped median. Truck access on parkways may be limited.
Rural Highway	High-speed (45 mph +) thoroughfare designed both to carry traffic and to provide access to abutting property in rural areas. Intersections are generally at grade.
Boulevard (see Chapters 8, 9 and 10 for design guidance)	Walkable, low-speed (35 mph or less) divided arterial thoroughfare in urban environments designed to carry both through and local traffic, pedestrians and bicyclists. Boulevards may be long corridors, typically four lanes but sometimes wider, serve longer trips and provide pedestrian access to land. Boulevards may be high-ridership transit corridors. Boulevards are primary goods movement and emergency response routes and use vehicular and pedestrian access management techniques. Curb parking is encouraged on boulevards.
	Multiway boulevards are a variation of the boulevard characterized by a central roadway for through traffic and parallel access lanes accessing abutting property, parking and pedestrian and bicycle facilities. Parallel access lanes are separated from the through lanes by curbed islands with landscaping; these islands may provide transit stops and pedestrian facilities. Multiway boulevards often require significant right of way.
Avenue (see Chapters 8, 9 and 10 for design guidance)	Walkable, low-to-medium speed (25 to 35 mph) urban arterial or collector thoroughfare, generally shorter in length than boulevards, serving access to abutting land. Avenues serve as primary pedestrian and bicycle routes and may serve local transit routes. Avenues do not exceed 4 lanes, and access to land is a primary function. Goods movement is typically limited to local routes and deliveries. Some avenues feature a raised landscaped median. Avenues may serve commercial or mixed-use sectors and usually provide curb parking.
Street (see Chapters 8, 9 and 10 for design guidance)	Walkable, low speed (25 mph) thoroughfare in urban areas primarily serving abutting property. A street is designed to (1) connect residential neighborhoods with each other, (2) connect neighborhoods with commercial and other districts and (3) connect local streets to arterials. Streets may serve as the main street of commercial or mixed-use sectors and emphasize curb parking. Goods movement is restricted to local deliveries only.
Rural Road	Low speed (25 to 35 mph) thoroughfare in rural areas primarily serving abutting property.
Alley/Rear Lane	Very low-speed (5 to 10 mph) vehicular driveway located to the rear of properties, providing access to parking, service areas and rear uses such as secondary units, as well as an easement for utilities.

Shaded cells represent thoroughfare types that are not addressed in this report.

Table 4.3 below from the ITE/CNU report (**Exhibit 4-15**) shows how this design guidance document treats the relationship between thoroughfare types and functional classification. In general, boulevards serve an arterial function, avenues may be arterials or collectors and streets typically serve a collector or local function in the network. It is important to note that this report only addresses urban roadways with speeds of 35mph or below.

Exhibit 4-15: Relationship Between Functional Classification and Thoroughfare Type

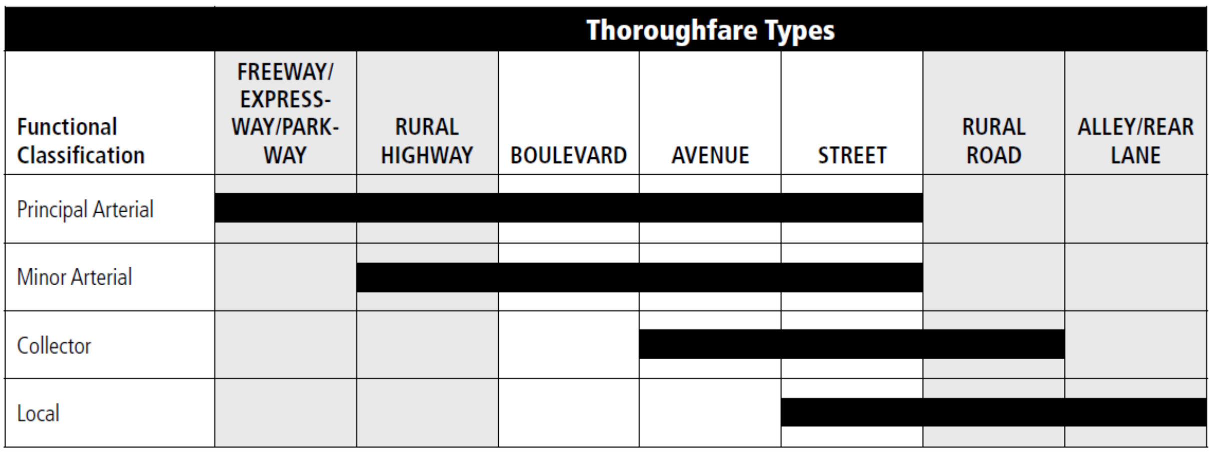


Table 4.3 Relationship Between Functional Classification and Thoroughfare Type

	Thoroughfare Types						
Functional Classification	FREEWAY/ EXPRESS-WAY/PARK-WAY	RURAL HIGHWAY	BOULEVARD	AVENUE	STREET	RURAL ROAD	ALLEY/REAR LANE
Principal Arterial	■	■	■	■	■		
Minor Arterial		■	■	■	■		
Collector				■	■	■	
Local					■	■	■

Shaded cells represent thoroughfare types that are not addressed in this report.

4.4.2 Context

AASHTO Green Book Definitions of Urban and Rural Areas

Urban and rural areas have fundamentally different characteristics with regard to density and 11 types of land use, density of street and highway networks, nature of travel patterns, and the way 12 in which these elements are related. Consequently, urban and rural functional systems are 13 classified separately.

Urban areas are those places within boundaries set by the responsible State and local 16 officials having a population of 5,000 or more. Urban areas are further subdivided into *urbanized* 17 *areas* (population of 50,000 and over) and *small urban areas* (population between 5,000 and 18 50,000). For design purposes, the population forecast for the design year should be used. (For 19 legal definition of urban areas, see Section 101 of Title 23, U.S. Code.)

Rural areas are those areas outside the boundaries of urban areas.

4.4.3 Speed Ranges

AASHTO defines design speed as follows:

> *Design speed is a selected speed used to determine the various geometric features of the roadway. The assumed design speed should be a logical one with respect to the topography, anticipated operating speed, the adjacent land use, and the functional classification of the highway.*

Design speed is different from the other controlling criteria in that it is a design control, rather than a specific design element. In other words, the selected design speed establishes the range of design values for many of the other geometric elements of the highway. Because of its effect on so much of a highway's design, the design speed is a fundamental and significant choice that a designer makes. The selected design speed should be high enough so that an appropriate regulatory speed limit will be less than or equal to it. Desirably, the speed at which drivers are operating comfortably will be close to the posted speed limit. In this research project, design speeds being considered in in the low and intermediate ranges and include 45mph and below.

In recognition of the wide range of site-specific conditions, constraints, and contexts that designers face, designs should allow for a great deal of design flexibility by providing typical ranges of values for design speed. For most cases, the ranges provide adequate flexibility for designers to choose an appropriate design speed without the need for a design exception. *A Guide for Achieving Flexibility in Highway Design* provides additional information on how to apply this flexibility for selecting appropriate design speeds for various roadway types and contexts.

NCHRP Report 504, *Design Speed, Operating Speed, and Posted Speed Practices* examined the relationship between design speed, posted speed, and operating speed. The report acknowledged that strong relationships between design speed, operating speed, and posted speed limit are desirable, and these relationships could be used to design and build roads that would produce the speed desired for a facility. However, the report concluded that "while a relationship between operating speed and posted speed limit can be defined, a relationship of design speed to either operating speed or posted speed cannot be defined with the same level of confidence."

The research also found that design speed appears to have minimal impact on operating speeds unless a tight horizontal or vertical curves are employed. It also concluded that when posted speed exceeds design speed, liability concerns may arise even though drivers can safely exceed the design speed. Several variables other than the posted speed limit show some sign of influence on the 85th percentile free-flow operating speed on tangents. These variables include access density, median type, parking along the street, and pedestrian activity level. Other studies have found that lane width, degree of curve and perception of hazard severity also affect operating speeds.

FHWA's Guidance Memorandum *Relationship between Design Speed and Posted Speed* provides the following information:

- the context along a roadway should play a significant role in determining the most appropriate operating speed for the facility, considering all users and their safety and accessibility;
- selection of a posted speed is an operational decision for which the owner and operator of the facility is responsible;
- inferred design speeds less than the posted speed limit do not necessarily present an unsafe operating condition;

- operating and posted speeds should be considered in the selection of the design speed, but there is no regulation establishing a more direct relationship; and
- in urban areas, the design of the street should generally be such that it limits the maximum speed at which drivers can operate comfortably, as needed to balance the needs of all users.

Target speed is an evolving concept that is typically defined as the highest operating speed at which vehicles should ideally operate on a roadway in a specific context. The target speed should be complimentary to the level of multimodal activity generated by adjacent land uses to provide both mobility for motor vehicles and a safe environment for pedestrians and bicyclists. The target speed is intended to become the posted speed limit. In some jurisdictions, the speed limit must be established based on measured speeds. In these cases, it is important for the design and context of the roadway to encourage the desired operating speed to ensure actual operating speeds will match the speed limit.

Conventionally, design speed, the primary design control in the AASHTO Green Book, has been encouraged to be as high as is practical. In the Guide, design speed is replaced with target speed, which is driven by the functional classification, roadway type and context, including variations in the type of land use context within the project limits. Target speed then becomes the primary control for determining the values of the following geometric design elements:

- Minimum intersection sight distance;
- Minimum sight distance on horizontal and vertical curves; and
- Horizontal and vertical curvature.

Target speeds typically range from 25 to 35 mph for roadway types that are considered *walkable* and *bikeable* by today's practices. These lower target speeds are a key characteristic of roadways in mixed use, traditional urban areas, some suburban areas, developing rural areas and small towns and villages on rural roadways. On urban and suburban roadways with higher volumes of vehicular traffic and planned operating speeds in the 40-45mph range, providing a safe and accessible design to accommodate non-motorized users is even more important. In these cases of higher volumes and speeds, additional treatments and safeguards for non-motorized users are usually warranted.

The design guidelines produced in this project should clearly relate the impacts of speeds on the safety of both motorized and non-motorized users, and address how the type and mix of users should impact the selection of design speeds, elements and features.

4.4.4 User Types

This research addresses three general categories of users of the roadway right-of-way. There are also generally-accepted "classes" within each user group and those are also important to consider in the design process. The categories of users include:

- Motorized vehicles;
- Pedestrians; and
- Bicyclists.

Pedestrians and bicyclists are often referred to as “non-motorized” or “vulnerable” road users due to their vulnerability in any crash situation with a motor vehicle. These terms are used interchangeably throughout the Guide.

AASHTO Green Book guidance recognizes that addressing the needs of all users within the right-of-way is a necessary part of the geometric design process. The following excerpt from the Foreword of the Green Book illustrates this recognition.

> *“Emphasis is placed on the joint use of transportation corridors by pedestrians, cyclists, and public transit vehicles. Designers should recognize the implications of this sharing of the transportation corridors and are encouraged to consider not only vehicular movement, but also movement of people, distribution of goods, and provision of essential services. A more comprehensive transportation program is thereby emphasized.”*

<u>Motorized Vehicles</u>

The AASHTO Green Book establishes four general classes of motorized design vehicles: (1) passenger cars, (2) buses, (3) trucks, and (4) recreational vehicles. The passenger-car class includes passenger cars of all sizes, sport/utility vehicles, minivans, vans, and pick-up trucks. Buses include intercity (motor coaches), city transit, school, and articulated buses. The truck class includes single-unit trucks, truck tractor-semitrailer combinations, and truck tractors with semitrailers in combination with full trailers. Recreational vehicles include motor homes, cars with camper trailers, cars with boat trailers, motor homes with boat trailers, and motor homes pulling cars. AASHTO also notes that if bicycle use is allowed on a roadway, the bicycle should also be considered as a design vehicle. Motorcycles are not mentioned specifically as a design class, but depending on their volumes, special design considerations may be warranted.

<u>Pedestrians</u>

A roadway that is designed to accommodate pedestrians must consider not only their volumes and travel needs, but also the possibility of a wide range of needs and physical capabilities of different pedestrian groups. An agile, able-bodied person can frequently overcome accessibility challenges and pedestrian facility design deficiencies. However, when age or functional disabilities reduce a person’s mobility, judgment, sight, or hearing, providing proper design solutions becomes much more important.

Within the pedestrian user category there are four generally-accepted and distinct classes of user:

- able-bodied pedestrians with average or better agility,
- pedestrians with mobility, vision or hearing disabilities,
- older pedestrians with limited functions and/or mobility, and
- younger pedestrians with more erratic behavior and generally smaller stature.

<u>Bicycles</u>

The bicycle is an important element for consideration in the highway design process where they are legal users. In many urban and suburban areas, the existing street and highway system provides much of the network needed for bicycle travel. Motorized vehicles and bicycles can often safely co-exist in low-speed, low-volume roadway environments such as residential local street networks. As with pedestrians, as speeds and volumes increase, bicycle facility accommodations becomes a much more critical element of the design process.

Within the bicycle category there are three or four classes of user depending on the source consulted. For the purposes of the Guide, three classes will be used:

- "A" class - advanced bicyclists with considerable experience and confidence,
- "B" class – bicyclists of average skills and confidence, and
- "C" class – generally comprised of children.

As with pedestrians, interactions of all bicycle user classes with other users are a major consideration in roadway design.

4.4.5 Performance Measures

Performance measures promote informed decision-making by relating community goals to the measurable effects of transportation investments. Key steps in developing performance measures are to decide what to measure in order to capture the current state of the system, to set targets to improve those measures, and to use the measures to evaluate and compare the effects of proposed project alternatives.

Performance measures for a project can include a wide range of multimodal criteria including capacity, mobility, safety, accessibility, comfort, reliability, etc. For example, they can include identifying unique operations measures for each mode such as travel speed, delay, crash potential, convenience, accessibility, level of service (LOS), quality of service (QOS), etc. by user/mode. From a purely safety perspective, this would involve identifying measures for each mode such as expected number of total crashes or crashes by severity, expected number of fatalities and injuries (by severity), expected number of crashes by collision type, crash exposure, etc.

From a sustainable transportation perspective, performance measures could include transit accessibility/productivity, bicycle/pedestrian mode share, vehicle-miles traveled (VMT) per capita, levels of "bikeability" or "walkability", aesthetics, air quality impacts, and so forth. Many of these measures would need to be classified according to whether they are multimodal or mode-specific and guidance on how the measures should differ depending upon the roadway speed range (i.e., low-, intermediate-, or high-speed), roadway functional classification and context.

For street and road projects with a blend of multimodal users in low- and intermediate-speed environments, performance measures should be developed for all existing and projected users in addition to identified sustainable and community goals. Safety should always be a key element of this analysis in multimodal design as the risk of fatal or severe injury to non-motorized users is significant in all vehicle environments, especially higher speed environments above 25 mph. Only through these performance metrics can the designer understand the impacts of design choices on all the measures of performance inherent in a project.

NCHRP 785 specifically addresses the five categories of performance as discussed below. The research will continue all of these in the process of developing the design guidelines document.

Accessibility: *Accessibility is defined as the ability to approach a desired destination or potential opportunity for activity using highways and streets (including the sidewalks and/or bicycle lanes provided within those rights of way).*

- ***Access to a facility by highway user type****: the ability to use a facility*
- ***Cumulative opportunity****: The number of destinations within a specified travel time or distance of a trip origin, population, facility, or design element or the percentage of population within a specific travel time or distance from a trip destination, population, facility, or design element.*
- ***Travel impedance****: A measure of user cost of making a trip to an opportunity or destination.*

Mobility: *Mobility is defined as the ability to move various users efficiently from one place to another using highways and streets.*

- *Average travel time*
- *Inferred speed*
- *Average percent time spent following*
- *Delay*
- *Volume-to-capacity ratio*

Reliability*: Reliability is defined as the consistency of performance over a series of time periods (e.g., hour-to-hour, day-to-day, year-to-year).*

- *Reliability is sensitive to geometric design, because the geometric design may impact the ability of a highway or street to 'absorb' random, additional traffic demand as well as capacity reductions due to incidents (e.g., crashes, vehicle breakdowns), weather, and maintenance operations, among others.*

Safety: *Safety is defined as the frequency and severity of crashes occurring on or expected to occur on highways or streets.*

- *Crash frequency and severity*

Quality of Service: *Quality of service is defined as the perceived quality of travel by a road user.*

- *Pedestrian LOS*
- *Bicycle LOS*
- *Transit LOS*
- *Auto LOS*
- *Large-vehicle turning and off-tracking characteristics*

4.5 Task 5 – Data Collection

In Task 5, the research team performed additional data collection and analysis, as well as a review of state and local agency design guidance documents and processes.

State and Local Roadway Agency Design Guidance

Based on the results of the literature review and roadway agency survey in Task 1, the research team identified state and local roadway agencies that have developed significant design guidance for accommodating all roadway users, and have demonstrated experience designing for the needs of all users (including pedestrians, bicyclists, transit, and motor vehicles) on low- and moderate-speed roadways. These agencies were determined to have made notable progress in developing design methods, policies and procedures for accommodating and balancing the needs of all users in their projects and programs.

The research team is very familiar with the state of practice in designing for all roadway users, and we are aware of several roadway design agencies that have already developed design policies for planning and designing streets that effectively serve all users. Based on this knowledge, we evaluated the multimodal design guidance documents and best practices of the following state and city/county agencies in this task.

- City of Charlotte, NC
- North Carolina DOT
- Washington State DOT
- Oregon DOT
- Minnesota DOT
- Florida DOT
- Massachusetts DOT
- Louisville/Jefferson County, KY
- Seattle, WA
- New York City
- Dallas, TX
- Maricopa County, AZ
- New Haven, CT
- Philadelphia, PA
- Portland, OR
- San Francisco, CA
- Chicago, IL
- Boston, MA

Geometric Design Guidance Framework

The research team used the knowledge gained in Tasks 1 through 5 to develop an expanded concept for the guidelines document to be developed as a part of this project. The table below (**Exhibit 4-16**) presented a draft outline of the design guidelines content at that interim stage of the project. Some adjustments and revisions of the organization and elements in each chapter based was expected based on Project panel guidance and additional evaluation and analysis conducted in the document development process.

Exhibit 4-16: Preliminary Guidelines Table of Contents Outline

GUIDELINES FOR DESIGNING
LOW- AND INTERMEDIATE-SPEED ROADWAYS
THAT SERVE ALL USERS

PRELIMINARY TABLE OF CONTENTS

Chapter 1. Introduction

a. Purpose, Organization and Objectives of the Guidelines
b. Objectives of the Guidelines
c. Range of Low- and Intermediate-Speed Facilities and Context Environments
d. Applicability of the Guidelines
e. Relationship to Other Design Guidance
f. Intended Users of the Guidelines
g. Sources of Additional Information

Chapter 2. State of Knowledge and Practice

a. Literature Review
b. Research in Progress
c. Survey Results
d. Field Reviews
e. Best Practices
f. Sources of Additional Information

Chapter 3. Considerations in the Multimodal Design of Low- and Intermediate-Speed Roadways

a. Purpose and Objectives
b. User Definition, Characteristics and Human Factors
c. Consideration of All Users in the Project Development and Design Process
d. Understanding Design Controls and Criteria for All Modes
e. Functional System Considerations: Roadway, Bicycle, Pedestrian and Transit Networks
f. Assessing Level and Quality of Service for All Modes
g. Safety and Operations Performance for All Modes
h. Relationship between Functional Classification and Urban Street Typologies
i. Use of Flexibility in Application of Design Criteria
j. Liability Considerations
k. Design Exceptions
l. Applying Context Sensitive Design Principles to Low- and Intermediate-Speed Facilities
m. Speed and Design Relationships
n. Speed Transitions
o. Bridge and Other Structure Considerations
p. ADA Requirements
q. Sustainability Considerations
r. Stormwater and Green Infrastructure
s. Sources of Additional Information

Chapter 4. Assessing User Service Levels in Low- and Intermediate-Speed Environments a. Purpose and Objectives b. Design Volumes, Time Periods and Years (all users) c. Capacity, Quality and Safety of Service d. Convenience and Accessibility of Service e. Multimodal Service Integration for Corridors, Segments and Intersections f. Recommended Service Level Approach by Facility, Context and Speed Range g. Sources of Additional Information
Chapter 5: Design Controls and Criteria a. Purpose and Objectives b. AASHTO Design Controls and Criteria c. Differences from Conventional Practice when Considering All Modes d. Relationship of Design, Operating and Posted Speed to Context e. Additional Controls to Consider in Multimodal Design f. Sources of Additional Information
Chapter 6: Geometric Design Elements for Modes by Facility, Context and Speed a. Purpose and Objectives b. Applicability of Design Elements to Each Mode c. Flexibility in Selection and Application of Design Elements d. Design Process in Constrained Right of Way e. Sources of Additional Information
Chapter 7: Methods to Balance Geometric Design Controls, Criteria and Elements for All Users a. Purpose and Objectives b. Separation and Integration of Modes c. Understanding and Assessing Context d. Recommended Cross-Section Development Process e. Trade-Off Analysis Techniques f. Sources of Additional Information
Chapter 8: Recommended Design Process to Serve All Users a. Purpose and Objectives b. General Design Parameters c. Relationship of Traveled Way and Roadside Environments in Various Contexts d. Traveled Way Design e. Roadside Design f. Intersections and Interchanges g. Sources of Additional Information

Chapter 9: Roadside Design Guidelines to Serve All Users a. Purpose and Objectives b. Typical Roadside Uses and Activities in Low- and Intermediate-Speed Contexts c. General Design Principles and Guidance d. Roadside Width and Functional Requirements for All Users e. Urban Area Context Principles and Considerations f. Suburban Area Context Principles and Considerations g. Rural Area Context Principles and Considerations h. Landscaping Principles and Considerations i. Driveway Crossing Principles and Considerations j. Traffic Control Device Principles and Considerations k. Lighting Principles and Considerations l. Traffic Barrier Principles and Considerations m. Utility Principles and Considerations n. Recommended Practice o. Sources of Additional Information
Chapter 10. Traveled Way Cross-Section Design Guidelines to Serve All Users a. Purpose and Objectives b. Design Considerations c. General Design Guidance
10.1 Vehicle Travel Lane Widths a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
10.2 Curbs and Shoulders a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
10.3 Medians a. General Principles and Considerations b. Recommended Practice c. Trees, Landscaping and Other Objects in Medians d. Sources of Additional Information
10.4 Bicycle Lanes/Accommodation a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
10.5 On-Street Parking Lane Configuration and Width a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
10.6 Geometric Transition Design a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information

10.7 Midblock Pedestrian/Bicycle Crossings a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
10.8 Pedestrian/Bicycle Refuge Islands a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
10.9 Integrated Transit Design a. Types of Transit and Facilities b. General Principles and Considerations c. Recommended Practice d. Sources of Additional Information
10.10 Bus/Transit Stops a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
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Chapter 11. Intersection and Interchange Design Guidelines a. Purpose and Objectives b. Design Elements for Intersections in Urban and Suburban Contexts
11.1 General Design Guidance a. Intersection Alignment and Profile b. Intersection Sight Distance c. Design Vehicle d. General Intersection Layout e. Through Lane Offsets f. General Principles and Considerations
11.2 Curb Return Radii a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information

11.3 Channelized Right-Turns a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
11.4 Modern Roundabouts a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
11.5 Pedestrian Design at Intersections a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
11.6 Bicycle Lane Treatment and Accommodation a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
11.7 Curb Extensions a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
11.8 Raised Intersections a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
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Appendix 1. Key Terms and Concepts
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4.6 Task 6 - Develop Interim Report and Updated Work Plan for Phase II

Based on the work accomplished in Tasks 1-5, the Interim Report was developed and distributed to NCHRP and the Panel in November of 2015. Panel comments were received by the project team in late December 2015 and early January 2016. A project Panel meeting was held in Washington D.C. on February 3, 2016 to discuss the Interim report and the panel comments and suggestions. The meeting agenda, presentation materials and minutes from the meeting are provided in **Appendix B**.

After Panel review of the minutes and proposed work plan revisions resulting from the February 3, 2016 meeting, a Panel conference call was conducted on March 4, 2016 to further discuss elements of the updated work plan. Final revisions were made to the Phase II work plan as outlined in the March 4, 2016 meeting minutes provided in **Appendix C**.

4.7 Task 7: Execute Updated Work Plan for Phase II

Approval of the Updated Phase II Work Plan was received by the research team in March 2016, and work on development of the guidelines document began in April 2016.

Several new key resource documents for multimodal design were being released in 2016 and the research team felt that these documents should be considered in the recommended design guidance. As a result, development of the guidelines slowed while these documents were released and then considered in the guidance being developed. These new resources released in 2016 included:

- *Achieving Multimodal Networks -Applying Design Flexibility & Reducing Conflicts,* FHWA
- *Incorporating On-Road Bicycle Networks into Resurfacing Projects,* FHWA
- *Guidebook for Developing Pedestrian and Bicycle Performance Measures*, FHWA
- *Traffic Engineering Handbook, 7th Edition,* ITE
- *Recommended Design Guidelines to Accommodate Pedestrians & Bicycles at Interchanges: An ITE Recommended Practice,* ITE
- *Transit Street Design Guide,* NACTO

4.8 Task 8: Develop Preliminary and Revised Guidelines Document

As noted in Task 7 above, work began on development of the guidelines document in April of 2016 but was paused in mid-2016 in order for several key multimodal design guidance documents to be released. Those documents were released info the fall of 2016, then work again commenced on the guidelines development.

The Preliminary Draft Guidelines document was completed and sent to NCHRP staff and the project Panel in May of 2017. The document was also sent to five state departments of transportation for their review, and their comments and suggestions were considered in the revision process. These DOTs included Virginia, Minnesota, Oregon, Kansas, California and Maryland.

Comments from the Panel were received in June and July, 2017. The research team provided written responses to all comments and made numerous edits to the guidelines document. Those deliverables were submitted to NCHRP on August 15, 2017.

The research team recommended that some of the comments without consensus be discussed with the Panel in a conference call in order to reach agreement on a path forward. That call was held with the Panel on October 3, 2017 and decisions were reached on how to address key issues of the comments. Notes from the conference were developed by the research team and approved by NCHRP staff.

Appendix D provides the initial response to Panel Comments from August 2017 as well as minutes from the following October 3, 2017 Panel conference call.

4.9 Task 9: Develop Final Guidelines Document and Final Report

Based on results of the October 3, 2017 conference call with the Panel, the research team proceeded to make final edits to the guidelines document and the DRAFT Final Guidelines document was submitted to NCHRP on November 22, 2017.

The Draft Final Report for the project was submitted to NCHRP on November 27, 2017.

5. Conclusions and Recommendations

5.1 Conclusions

The purpose of this research project was to identify and evaluate past research and current best practices associated with designing roadways that safely, efficiently and effectively serve all legal users within that roadway right-of-way. Following the research effort, the team was charged with developing a set of "guidelines" for how to design roadways that consider and accommodate all users.

As noted earlier in this report, the geometric design profession has recognized for quite some time that a more comprehensive and "multimodal" roadway design process is needed in order to effectively address the challenges and needs of integrating all user modes. Although various multimodal level of service (MMLOS) evaluation processes exist, little established practical engineering design guidance exists on how to more effectively integrate and balance the service to and performance of all transportation modes along a roadway segment or corridor or within an intersection.

Most of today's national geometric design guidance has been founded on safety, efficiency and operational considerations of vehicular users and does not fully address or incorporate the other transportation modes that may be present and need to be accommodated. Little guidance exists that comprehensively addresses the safety, operational, and usability impacts of a comprehensive roadway design process that helps the designer understand and assess trade-offs in balancing roadway design features, controls and criteria for multi-modal facilities across low- and intermediate-speed ranges.

Roadway user needs and priorities can vary by many factors in any given design project, including roadway functional classification, roadway operating speed, current and projected user demand, adjacent land use context (current and future), community goals and more. All of these factors present designers with a challenge to create roadway geometric designs that adequately recognize and provide for a mix of transportation modes and trip types, as well as reflect the balance of priorities that each user group desires. For many low- and intermediate-speed situations (45mph and less) in particular, the integration of multimodal features are difficult to evaluate and in fact may often be mutually-exclusive due to operational, budgetary or other constraints.

The NCHRP 15-48 research project was intended to develop geometric design guidance that provided methodologies and considerations for all modes that result in roadway designs that serve the full range of users of each roadway functional classification in the low- and intermediate-speed categories. Another goal of the research was to provide guidance for the assessment of service and performance to all modes that identifies how to best serve the mix of users found across a range of roadway classifications, contexts and speed range up to design speeds of 45mph. The final recommended design process contained in the guidelines is intended to help the designer fit a balanced geometric design into roadways and contexts of all types, but particularly those in challenging contextual environments with limited right-of-way, presence of multimodal demand and many other design challenges typically encountered in urban and suburban transportation networks.

Knowledge Gaps Exists in Performance Measures

The research team considered specific gaps in knowledge associated with performance measures across user types/modes, including:

- Pedestrian safety prediction methodology for urban and suburban roadway segments
- Bicycle safety prediction methodology for urban and suburban roadway segments
- Transit stop safety prediction methodology for urban and suburban roadway segments

The profession clearly needs to continue to develop more tools and guidance in conducting quantitative safety analyses for all travel modes, allowing for integrated user safety to be quantitatively evaluated alongside other transportation performance measures such as operations of all modes, environmental impacts of alternatives, and construction costs.

Framework for Combining Qualitative and Quantitative Performance Measures

Based upon the findings of Tasks 1 through 4, the research team developed in the guidelines document an approach for combining qualitative and quantitative performance measures across user types/modes and context for use in evaluating alternative designs for low- and intermediate-speed roadways. This involved blending a combination of performance measures given the current state of practice and current priorities of roadway agencies. Ideally, many of these performance measures would be quantitative in nature, but several of them will necessarily be qualitative in nature due to gaps in research for several areas of modal and intermodal performance.

The approach for combining these performance measures needed to be flexible in that different roadways agencies, and different roadways within a given agency, will have different priorities. For example, some agencies may give equal importance to safety and operational conditions, while others may give higher priority to safety over operations. The methodology must also be flexible in that different roadway/facilities should likely be evaluated differently. For example, a 25mph two-lane local road should be evaluated using different criteria than a 35mph multi-lane collector or 45mph arterial.

The methodology in the guidelines document also considers the quality of the performance measures. NCHRP Report 785, Performance-Based Analysis of Geometric Design of Highways and Streets (2014), has provided new information to the design profession on a roadway design process that considers performance metrics for all modes across safety, accessibility, mobility, reliability and quality of service. In addition, the methodology should not be independent of volume, operating speed or adjacent land use context. For example, some roadways will need to be designed with a greater focus on pedestrian needs (due to higher pedestrian usage), while other roadways will need to be designed with a greater focus on the needs of bicyclists or transit users.

Preliminary key findings and conclusions drawn from Tasks 1 through 5 are outlined below. These findings greatly influenced the development of the content and guidance contained in the guidelines document.

1. Challenges in Evaluating and Balancing Level and Quality of Service for All Modes

Multimodal level of service continues to be a challenging and evolving topic. While the 2010 Highway Capacity Manual (HCM) provided the profession with a multimodal approach to perform capacity and quality analyses to help make decisions on designs for automobile and non-automobile modes, it does not appear to have been widely accepted nor used by most design professionals and agencies. The primary reasons appear to be founded in concerns about data requirements and the complexity of the operational models, among other concerns.

Alternative approaches to assessing service levels have been developed and are in wide-spread use today, and many professionals have noted the limitations of the HCM methods for certain types of projects and user mixes. In general, design professionals are attempting to use less data-intensive analytics and processes (especially for smaller, retrofit projects) to guide what are in many situations more qualitative than quantitative decisions on balancing and providing service to non-automobile modes.

2. Lack of Nationally Recognized Central Guidance for Design of Multimodal Facilities

There is a significant void in nationally-accepted geometric design guidance for multimodal facilities on low and intermediate-speed facilities, be they local, collector or arterial classification roadways. For example, while there are numerous references throughout AASHTO's Green Book advising roadway designers to consider land use context and pedestrian, bicycle and transit users where appropriate, there is very little specific guidance to the user on how to accomplish these goals in the geometric design process.

It appears that this situation has helped generate the development of several alternative multimodal design sources that includes documents such as ITE's *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* along with NACTO's *Urban Bikeway Design Guide* and *Urban Street Design Guide* (each of these have been specifically mentioned in recent bicycle and pedestrian design flexibility guidance memorandums from FHWA).

FHWA has also developed numerous multimodal planning and design guidance documents in the past few years including:

- Small Town and Rural Multimodal Networks
- Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts
- Incorporating On-Road Bicycle Networks into Resurfacing Projects
- Guidebook for Developing Pedestrian and Bicycle Performance Measures
- Separated Bike Lane Planning and Design Guide

Additionally, supplements or revisions to several state DOT roadway design manuals (e.g., North Carolina, Massachusetts, Oregon, Georgia, Wisconsin, California) have been developed to address multimodal needs, and literally hundreds of local governments in the U.S. have developed local policies and guidelines to address what they consider "complete streets" needs addressing all users.

3. Reliance on Standards versus Use of Engineering Judgment

Geometric design is defined as the design of the visible dimensions of a highway, with the objective being the "forming" of the facility to meet the functional and operational characteristics of drivers, vehicles, pedestrians, and other traffic. This process is both a science as well as an art. Geometric design deals with features of location, alignment, profile, cross section, and intersections for a range of roadway types and classification. The geometric form and dimensions of the roadway should properly reflect the safety, desires, expectations, comfort, and convenience of all legal users. It should also do so within the context of a host of constraints and considerations, including land use, terrain, roadside and community impacts, and cost considerations. Nowhere is this process more challenging that in urban settings, particularly within constrained corridors.

Central to the geometric design process is the application of design controls, design criteria, guidelines, and standards. However, designers sometimes confuse use of design standards with providing a "standard" design. A standard design is not always the "best" design, particularly when site-specific issues dictate that another, more multimodal or "context-sensitive" solution should be considered. Roadway designers need to be creative, sensitive and use their knowledge and judgment in addressing the many facets of geometric design to fit a particular situation. This process is best achieved by experienced design professionals in consideration of all known factors and related trade-offs and should not be viewed as a reduction in geometric criteria.

4. Challenges to Applying Available Design Flexibility to Create Unique Designs

Current AASHTO and federal design guidance does not discourage or prohibit many of the design approaches to providing unique and creative multi-modal geometric design solutions where appropriate to address the needs of multiple users. However, the desire to adhere to standard, typical or “desirable” design approaches and threat of tort claims and insurance practices are discouraging many designers from trying innovative designs and effectively limiting them to use of “cookbook” guidelines and standards. This problem is not new and was noted as far back in 2004 when FHWA’s document *Flexibility in Highway Design* stated:

As a result of concerns about litigation, designers may be tempted to be very conservative in their approaches to highway design and avoid innovative and creative approaches to design problems. While it is important for design engineers to do their jobs as thoroughly and carefully as possible, avoiding unique solutions is not the answer. This may undermine design practice and limit growth in the engineering profession. Designers need to remember that their skills, experience, and judgment are still valuable tools that should be applied to solving design problems and that, with reliance on complete and sound documentation, tort liability concerns need not be an impediment to achieving good road design.

5.2 Suggestions for Further Research

The following topics are suggested for further research to advance the roadway design profession’s ability to better plan and design roadways that effectively accommodate safe and

convenient travel for all legal users of the right-of-way on low- and intermediate-speed roadways. Advanced knowledge and guidance in the following areas could result in the design profession achieving significantly improved design results for multimodal roadways which could lead to improved safety and operation of streets and intersections for all users.

Identification and research of key limitations and conflicts in current multimodal operations and safety would likely result in a better understanding of how to design for balanced operations in a variety of operating environments and facilities. Topics and issues that might be addressed in future research efforts include:

- Design Methods to Retrofit Existing Roadways to Improve Pedestrian and Bicycle Safety and Operations
- Identify and recommend the most effective performance measures for performance-based geometric design analysis of multimodal streets and intersections
- Assess the potential role of measures of accessibility and reliability in performance based geometric design analysis
- Understanding Diverse Vision Needs of Pedestrians and Bicyclists in Roadway Geometric Design
- Bicycle and Pedestrian Counting and Projections
- Cost-effective Design Retrofits for High-speed Multilane Arterial Roads for Pedestrians & Bicyclists
- The Effect of Roadway and Roadside Design Features on Pedestrian and Bicycle Crashes on Urban and Suburban Corridors
- Guidelines for Locating, Designing and Operating Pedestrian & Bicycle Midblock Crossings
- Expanded Development of Pedestrian and Bicycle Crash Modification Factors
- Best Practices and Pedestrian Safety Concerns Related to Transit Access in Urban Areas
- Effectiveness of Improved Lighting in Reducing Pedestrian and Bicycle Crashes at Intersections and Midblock Crossings
- Pedestrian and Bicycle Safety Guides and Countermeasure Selection Systems
- Pedestrian and Bicycle Intersection Design Guide

5.3 Distribution and Use of the Guidelines Document

Widespread distribution and training of the developed guidance document would likely bridge gaps in understanding and improve coordination between roadway designers, roadway planners, communities and non-vehicle mode advocates. Training would address all modes across all roadway classifications with 45mph or less design speeds and multiple roadway user groups. There are several different product awareness and delivery formats and strategies possible and they include:

- Direct Mailing/Emailing of the availability of the Guidelines document
- Event and Conference Marketing of the Research Results
- In-Person Training Course

- Software that supports Guidelines recommendations for a more robust evaluation of multimodal integration in the design process
- Web Training
- Successful Practices Guide for Multimodal Geometric Design

APPENDIX A: **Agency Survey Results (separate attachment)**

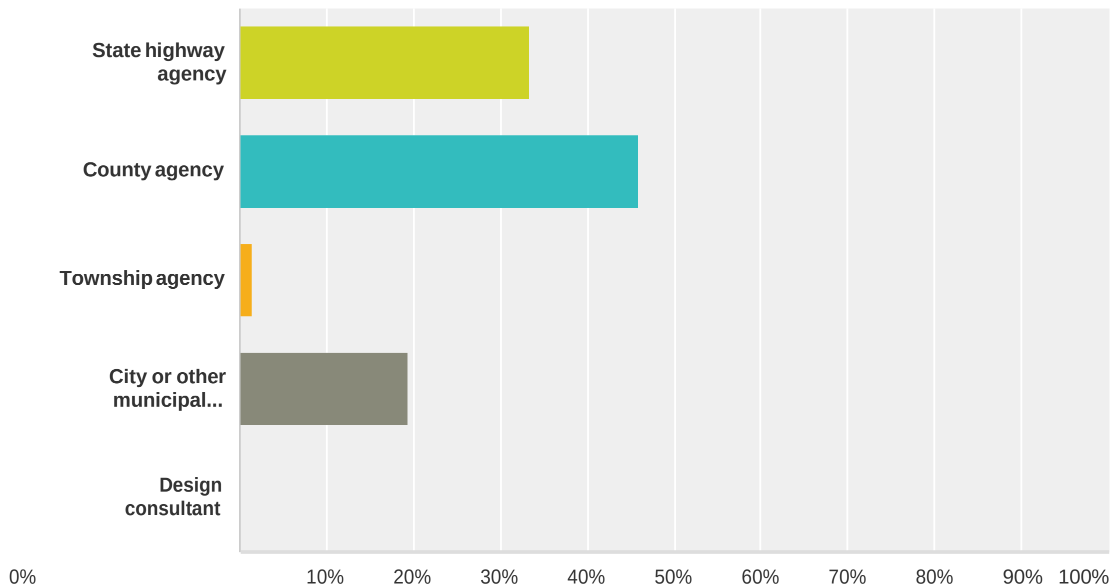
APPENDIX B: **February 3, 2016 Panel Meeting Agenda, Presentation and Minutes (separate attachment)**

APPENDIX C: **March 4, 2016 Panel Conference Call Minutes (separate attachment)**

APPENDIX D: **Response to Panel Comments for Preliminary and Revised DRAFT Guidelines (separate attachment)**

Q1 What type of agency do you represent?

Answered: 72 Skipped: 2

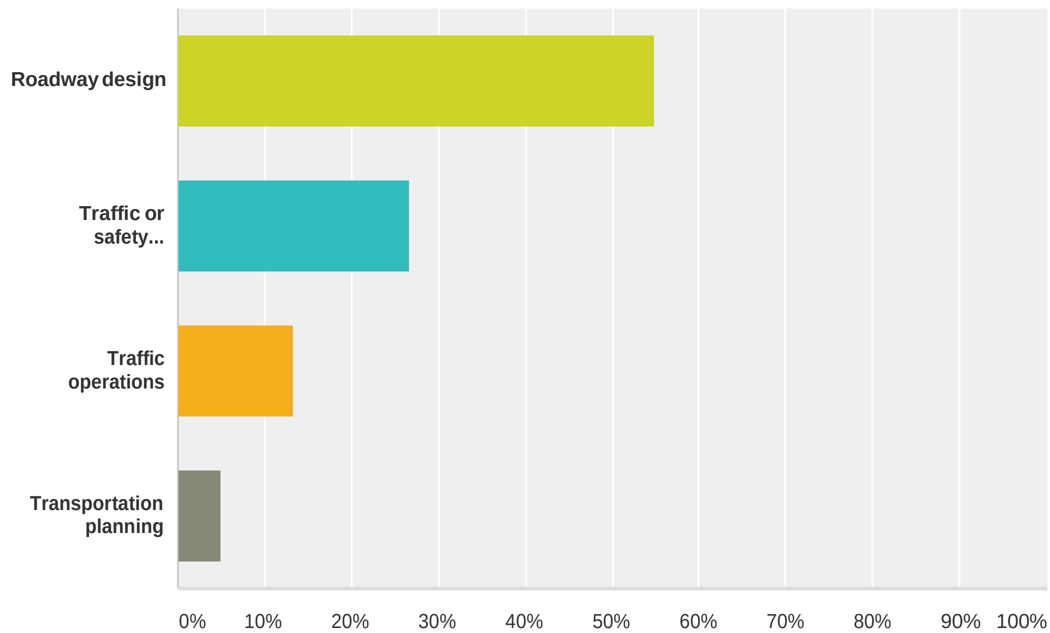


Answer Choices	Responses	
State highway agency	33.33%	24
County agency	45.83%	33
Township agency	1.39%	1
City or other municipal agency	19.44%	14
Design consultant	0.00%	0
Total		**72**

#	Other (please specify)	Date
1	MPO and Regional Government	5/21/2014 4:00 PM

Q2 What technical specialty do you work in?

Answered: 60 Skipped: 14



Answer Choices	Responses	
Roadway design	**55.00%**	33
Traffic or safety engineering	**26.67%**	16
Traffic operations	**13.33%**	8
Transportation planning	**5.00%**	3
Total		**60**

#	Other (please specify)	Date
1	All apply	7/24/2014 4:22 PM
2	All of the Above	7/22/2014 6:35 AM
3	Roadway, Traffic and Safety	7/17/2014 4:35 PM
4	All of the above	7/17/2014 1:54 PM
5	Street Maintenance	7/16/2014 6:10 PM
6	Management - Agency Head	5/27/2014 3:55 PM
7	As county engineer I am responsible for all areas listed.	5/24/2014 11:43 AM
8	Highway engineering, inclusive of those above	5/23/2014 8:51 AM
9	also Traffic or safety engineering, transportation planning, and roadway design	5/22/2014 3:49 PM

10	County Engineer - all of the above	5/22/2014 10:13 AM
11	All the above	5/22/2014 7:48 AM
12	DPW Admin (All of the above.)	5/21/2014 2:52 PM
13	Construction Management	5/21/2014 11:02 AM

Q3 Which design reference(s) does your agency use for urban streets, including mode-specific guidance (e.g., AASHTO Ped Guide)?

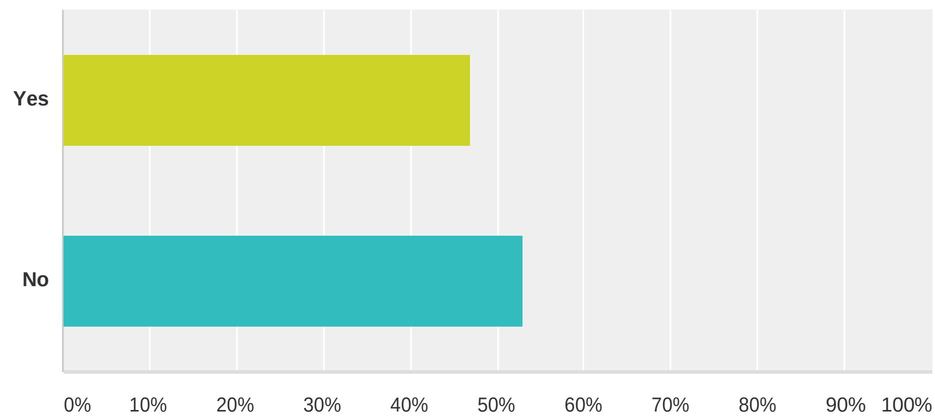
Answered: 48 Skipped: 26

#	Responses	Date
1	AASHTO Green Book, Ped. Guide	7/23/2014 7:41 AM
2	AASHTO Green Book WSDOT Design Manual AASHTO Bike Guide NATCO ITE Urban Streets Guide MUTCD	7/22/2014 3:52 PM
3	Ohio DOT Design Manual, Highway Safety Manual (HSM)	7/22/2014 6:42 AM
4	Green Book Guide for Low-Volume . . . Bike Guide / Ped Guide	7/21/2014 7:32 AM
5	AASHTO Green Book, Bike Guide, Ped Guide, applicable NCHRP/TRB Reports, SDDOT Road Design Manual	7/17/2014 5:02 PM
6	WSDOT Design Manual - http://www.wsdot.wa.gov/publications/manuals/fulltext/M22-01/design.pdf WSDOT Traffic Manual - http://www.wsdot.wa.gov/Publications/Manuals/M51-02.htm NACTO USDG - http://nacto.org/usdg/ WSDOT Local Agency Guidelines - http://www.wsdot.wa.gov/Publications/Manuals/M36-63.htm Multiple WSDOT Guides by mode - http://www.wsdot.wa.gov/walk/design.htm	7/17/2014 4:44 PM
7	MnDOT Design Guides	7/17/2014 1:56 PM
8	AASHTO publications such as: Green Book, Bicycle Guide, Pedestrian Guide, Roadside Design Guide, Hydraulics and Hydrology, and KDOT Road Design Manual	7/17/2014 12:24 PM
9	AASHTO Green Book, Roadside Safety Design Guide, Ped Guide, Local Agency Guidelines.	7/17/2014 11:07 AM
10	AASHTO Green Book AASHTO Roadside Design Guide MoDOT Engineering Policy Guide	7/17/2014 8:43 AM
11	AASHTO Guide	7/16/2014 5:35 PM
12	AASHTO Green Book, AASHTO Bike Guide, AASHTO Ped Guide; all these inform our local documents, which are our official policy and criteria; recently added the NACTO Urban Street Design Guide as an official reference	6/16/2014 4:28 PM
13	State highway design manual is used as the design base document, supplemented with State Bicycle and Pedestrian Guide, AASHTO Green Book, AASHTO Bike Guide, AASHTO Pedestrian Guide, and other State Context Sensitive documents, such as Main Street handbook and Practical Design strategy.	6/5/2014 1:04 PM
14	- NJDOT Roadway Design Manual - AASHTO publications - NJ Ped/Bicycle guidelines:	6/2/2014 9:38 AM
15	Illinois DOT manuals	5/29/2014 10:08 AM
16	Green Book and other County Policy.	5/28/2014 2:43 PM
17	AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities; AASHTO Guide for the Development of Bicycle Facilities; NACTO Bikeway Design Guide; An ITE Recommended Practice/Designing Walkable Urban Thoroughfares: A Context Sensitive Approach; and VDOT Road Design Manual, Appendix A Section A-5 Bicycle and Pedestrian Facilities Guidelines VDOT Road Design Manual, Appendix A, Section A-5 contains Bicycle and Pedestrian Facilities Guidelines http://www.extranet.vdot.state.va.us/locdes/Electronic_Pubs/2005%20RDM/appenda.pdf http://www.extranet.vdot.state.va.us/locdes/Electronic_Pubs/2005%20RDM/RoadDesignCoverVol.1.pdf	5/28/2014 10:55 AM
18	AASHTO Green book ITE Traffic Engineering Handbook AASHTO Bicycle Facilities ULI Residential Streets	5/28/2014 8:53 AM
19	A Policy on Geometric Design of Highways and Streets - 2011	5/27/2014 2:48 PM
20	AASHTO Green Bike, Ped Guide, Bike Guide NACTO Urban Streets and Bike Guide ITE Flexible Street Design, etc.	5/27/2014 1:25 PM

21	AASHTO	5/27/2014 12:26 PM
22	No urban streets	5/24/2014 11:51 PM
23	MnDOT State Aid Rules MnDOT Highway Design Manuals MnDOT Bicycle Design Manual AASHTO Green Book AASHTO Ped Guide	5/24/2014 11:44 AM
24	MUTCD, AASHTO Ped Guide 4th Edition, City Design Standards	5/23/2014 11:54 AM
25	AASHTO Ped Guide, AASHTO Bike Guide, NACTO Urban Bikeway Design Guide, VT State Standards, VTrans Ped/Bike Design Manual	5/23/2014 8:58 AM
26	AASHTO design guides	5/23/2014 7:31 AM
27	AASHTO Green Book AASHTO Bike Guide NACTO Bike Guide AASHTO Ped Guide	5/22/2014 3:57 PM
28	Caltrans HDM, AASHTO Green Book, NACTO, various ITE publications	5/22/2014 3:51 PM
29	AASHTO green book / State of Michigan	5/22/2014 1:25 PM
30	Iowa SUDAS design guides and specifications	5/22/2014 10:48 AM
31	AASHTO Green Book or Low volume road manual.	5/22/2014 7:50 AM
32	Local standards AASHTO bicycle design guide AASHTO Green Book	5/21/2014 6:46 PM
33	MUTCD, AASHTO guide for bicycle facilities, AASHTO geometric design	5/21/2014 4:40 PM
34	AASHTO Green Book, D.O.J. Laws, ADA Access Board.gov, 42 USC 3, CFR's; 23, 28, & 49, MAP-21, Guide for the Development of Bicycle Facilities, Roadway Design Manual.	5/21/2014 4:24 PM
35	AASHTO, NACTO Bikeways, ITE Walkable Thoroughfares, Regional Design Guidelines	5/21/2014 4:02 PM
36	AASHTO "Green Book" and INDOT Design Manual, http://www.in.gov/indot/design_manual/AASHTO Bicycle Facilities Design Guide	5/21/2014 3:50 PM
37	ITE Guides AASHTO Guides NYSDOT Design Manuals	5/21/2014 2:53 PM
38	AASHTO Green Book; AASHTO Roadside Design Guide; AAHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities; AASHTO Guide for the Development of Bicycle Facilities; Idaho Transportation Department (ITD) Roadway Design Manual; AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads; MUTCD	5/21/2014 11:42 AM
39	Minnesota State Aid Rules	5/21/2014 11:18 AM
40	We do not provide services for urban areas.	5/21/2014 11:07 AM
41	AASHTO, Indiana Design Manual (INDOT)	5/21/2014 11:02 AM
42	SUDAS	5/21/2014 11:02 AM
43	AASHTO Geometric Design of Highways and Streets AASHTO Ped Guide AASHTO Development of Bicycle Facilities AASHTO Roadside Design Guide	5/21/2014 9:51 AM
44	MaineDOT Highway Design Guide, AASHTO Green Book, PROWAG, FHWA Designing Sidewalks and Trails for Access, AASHTO Guide for Development of Bicycle Facilities	5/21/2014 7:14 AM
45	FDOT has our own Plans Preparation Manual, a manual for design of local roads, and we reference several AASHTO publications for this purpose, we also are about to publish a 'Complete Streets' policy along with requirements for implementing the policy in design.	5/21/2014 6:52 AM
46	AASHTO Green Book, Ped Guide, Bike Guide...	5/21/2014 6:13 AM
47	State published design manuals and all available AASHTO, ITE, etc. pubs that address the specific topics.	5/21/2014 5:46 AM
48	California Highway Design Manual AASHTO Green Book	5/20/2014 5:10 PM

Q4 Does your agency have design criteria for low-speed and intermediate-speed (≤45 mph) roadways that are intended specifically to accommodate all applicable roadway users?

Answered: 51 Skipped: 23



Answer Choices	Responses	
Yes	**47.06%**	24
No	**52.94%**	27
Total		**51**

Q5 If you answered YES to the previous question, please describe your design criteria below or provide a link to your design criteria. Alternatively, you can email copies of your design criteria to Chris Fees (cfees@mriglobal.org).

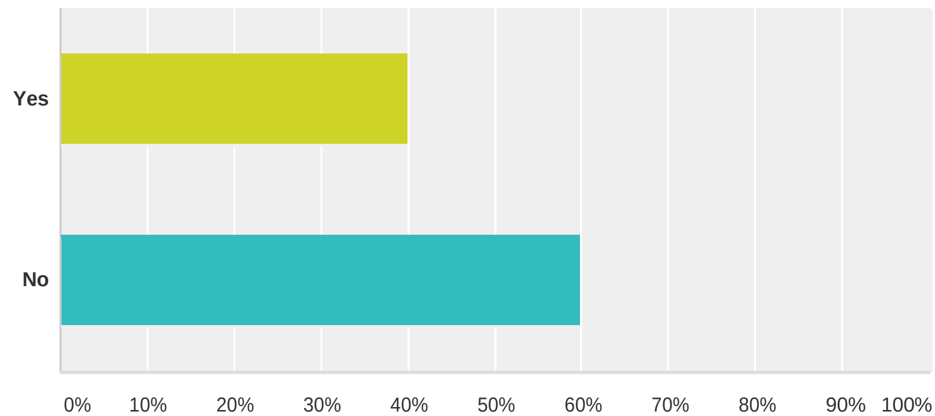
Answered: 25 Skipped: 49

#	Responses	Date
1	City of Olympia Engineering Design and Development Standards - http://www.codepublishing.com/wa/olympia/?edds/OlympiaEDDSNT.html Washington Department of Transportation Design Manual - http://www.wsdot.wa.gov/publications/manuals/ City of Lacey Development Guidelines & Public Work Standards - http://www.ci.lacey.wa.us/city-government/city-departments/public-works/plans-and-documents/library Thurston County Road Standards - http://www.co.thurston.wa.us/publicworks/Published_Documents.aspx#_DEVREV Note - we use all of the above depending on the location of the work and funding source. You can contact me at davissa@co.thurston.wa.us if you want further details how we use these design standards.	7/22/2014 3:52 PM
2	Roadway Design Manual on website txdot.gov	7/21/2014 7:32 AM
3	See SDDOT Road Design Manual at http://sddot.com/business/design/forms/roaddesign/Default.aspx. Chapter 7 - Cross Sections would be a good start, specifically when talking about lane and shoulder widths (Bicyclists). Pedestrian and bike accommodations are noted in Chapter 16 - Miscellaneous.	7/17/2014 5:02 PM
4	Recently developed WSDOT Design Manual Chapter -http://www.wsdot.wa.gov/NR/rdonlyres/A2566409-0F2B-42D7-98E7-4F5F606E9BE1/0/Ch1150AFU51214.pdf To be further expanded to cover agency objective of adopting NACTO - USDG	7/17/2014 4:44 PM
5	Currently in development.	7/17/2014 1:56 PM
6	Will DropBox you a copy. Use a combination of old County Guidelines and Appendix 1 from Chapter 10 of the City of Houston Infrastructure Design Manual.	7/17/2014 11:07 AM
7	Below is a link to State Highway Design Manual. Chapter 6 covers urban (non-freeway) design guidelines and is broken down into categories using a planning/land use description of different highway segments tied to specific design criteria (for example-Commercial business districts, varying levels of retail centers, and urban fringe/suburban development areas). HDM link: http://www.oregon.gov/ODOT/HWY/ENGSERVICES/pages/hwy_manuals.aspx#2012_English_Manual	6/5/2014 1:04 PM
8	- NJDOT Roadway Design Manual - AASHTO publications - NJ Bicycle guidelines (below): http://www.state.nj.us/transportation/publicat/pdf/BikeComp/introtofac.pdf - NJ Pedestrian Guidelines (below): http://www.state.nj.us/transportation/publicat/pdf/PedComp/pedintro.pdf - Other info (note, the bike/ped links above are within the link below): http://www.state.nj.us/transportation/commuter/pedsafety/planning.shtm	6/2/2014 9:38 AM
9	We have design criteria in our Multimodal System design Guidelines, Appendix A, Corridor Matrix for roadways (≤45 mph) that are intended specifically to accommodate all applicable roadway users, such as walkers, bikers and transit riders. Department of Rail and Public Transportation (DRPT) web site contains the Multimodal System Design Guidelines, which also include the design criteria in Appendix A. http://www.drpt.virginia.gov/activities/MultimodalSystemDesignGuidelines.aspx. VDOT's Road Design Manual, Appendix B(2) contains Multimodal Design Standards for Mixed-Use Urban Centers http://www.extranet.vdot.state.va.us/locdes/Electronic_Pubs/2005%20RDM/AppendB(2).pdf	5/28/2014 10:55 AM
10	Will send copy	5/28/2014 8:53 AM
11	The City of Milwaukee has a Complete Streets approach but no policy on the books yet. Policy is currently being developed and development of design guide(s) and formal adoption of some of the aforementioned design guides and references is anticipated in 2014 and 2015.	5/27/2014 1:25 PM

12	All our streets are design speed 45 or less. Please reference our engineering design standards found on our website at www.siouxfalls.org under the Engineering department.	5/27/2014 12:26 PM
13	http://vtransengineering.vermont.gov/publications - VT State Standards and Complete Streets Guidance	5/23/2014 8:58 AM
14	Not design guidelines, per se, but plans that provide guidance in the design and implementation of complete streets. General Plan: http://www.smgov.net/Departments/PCD/Plans/2010-Land-Use-and-Circulation-Element/, Bicycle Action Plan: http://www.smgov.net/Departments/PCD/Plans/Bike-Action-Plan/, Pedestrian Action Plan: http://www.smgov.net/Departments/PCD/Plans/Pedestrian-Action-Plan/	5/22/2014 3:51 PM
15	We use the Iowa DOT design guides as contained in the Manual for local agencies. http://www.iowadot.gov/local_systems/publications/im/imtoc.pdf	5/22/2014 10:48 AM
16	Designs are based on volumes of traffic and speeds of the traffic.	5/22/2014 7:50 AM
17	State Minimum Design Standards Chapter 2 pg 18 http://www.transportation.nebraska.gov/gov-aff/pdfs-docs/manuals/proc-class-stan-min-des.pdf Chapter 4 of our Roadway Design Manual http://www.transportation.nebraska.gov/roadway-design/rw-design-man-chapters.htm	5/21/2014 4:24 PM
18	Metro's Creating Livable Streets document - hard copy only. Available via anthony.buczek@oregonmetro.gov Supports creation of street accommodating all users including design for urban contexts.	5/21/2014 4:02 PM
19	Idaho Transportation Department (ITD) Roadway Design Manual, A.15 – STATE DESIGN STANDARDS FOR NON-NHS http://itd.idaho.gov/manuals/Manual%20Production/RoadwayDesign/RoadwayDesignAppendixA.htm For <= 400 ADT see AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads	5/21/2014 11:42 AM
20	http://www.dot.state.mn.us/stateaid/programlibrary/stateaidrules.pdf	5/21/2014 11:18 AM
21	We use the State of Oklahoma County Highway System Design Guidelines Manual.	5/21/2014 11:07 AM
22	Indiana Design Manual (INDOT)	5/21/2014 11:02 AM
23	Guidance for Horizontal Alignment, Speeds for allowing Crosswalks, use of curb based on speeds and use, allowable cross slopes for roadway and sidewalks, allowable grades, utility locations in urban settings, widths of lanes, shoulders and sidewalks, locations of drainage relative to ped crossings, driveway details for sidewalk and non-sidewalk areas, other...	5/21/2014 7:14 AM
24	Chapter 21 of FDOTs PPM is available on-line.	5/21/2014 6:52 AM
25	refer to penndot home page and link to very wide array of design pubs	5/21/2014 5:46 AM

Q6 Does your agency have a formal process to determine the user types (e.g., passenger cars, trucks, transit, pedestrians, bicycles) that need to be served on a given roadway?

Answered: 48 Skipped: 26



Answer Choices	Responses	
Yes	**39.58%**	19
No	**60.42%**	29
Total		**48**

Q7 If you answered YES to the previous question, please describe your process below or provide a link to documents that describe your process. Alternatively, you can email copies of relevant documents to Chris Fees (cfees@mriglobal.org).

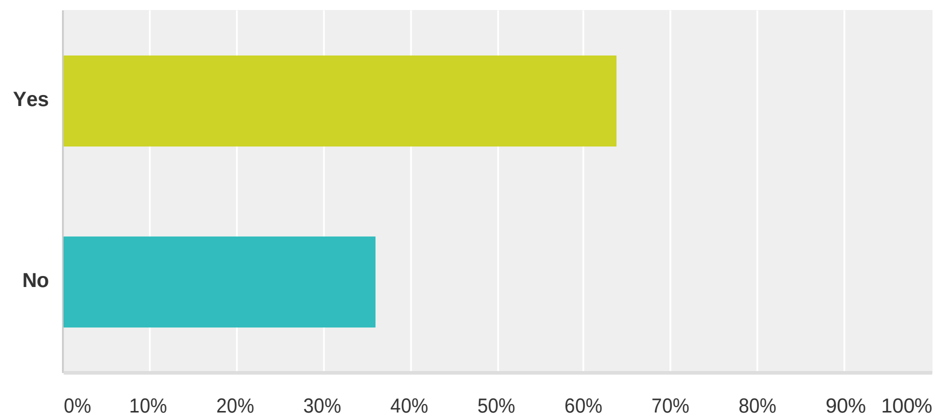
Answered: 20 Skipped: 54

#	Responses	Date
1	http://epg.modot.mo.gov/index.php?title=Category:642_Pedestrian_Facilities	8/4/2014 2:31 PM
2	We do multi-modal counts.	7/21/2014 7:34 AM
3	Some guidance for low speed facilities in new WSDOT Design Manual Chapter Developing more robust modal hierarchy concept - due out by 7/2015	7/17/2014 4:51 PM
4	As part of implementation of our complete streets policy, we have developed a scoping document related to complete streets (which is in final stages of development) and are in the process of developing a complete streets guidance document (which is approx 60% complete).	6/16/2014 4:31 PM
5	Most modernization projects conduct traffic studies to determine the volume of modes such as; cars, trucks, transit, pedestrians, bicyclists. Preservation type projects do not normally capture specific modes.	6/5/2014 1:04 PM
6	During our Concept Development Phase, our designer will identify the appropriate road users. - We also have a "Complete Streets Policy": http://www.state.nj.us/transportation/eng/completestreets/policy.shtm http://www.state.nj.us/transportation/eng/completestreets/pdf/completestreetspolicy.pdf - We also consider Context Sensitive Design: http://www.state.nj.us/transportation/eng/CSD/ - In addition, NJDOT has a Bureau dedicated to Bike/pedestrians users. They are involved in all projects (other than freeways). - Our Traffic Safety Unit also keeps prioritized Management Lists. The lists are prioritized by frequency and severity. A few of the safety Management lists are: pedestrian, run-off-road, crossing yellow lines, intersections.	6/2/2014 9:38 AM
7	traffic counts / ped counts	5/29/2014 10:09 AM
8	If a locality chooses to use our Multimodal Design Standards for Mixed-Use Urban Center than they are required to develop a Multimodal System Plan which aligns with their comprehensive plan and identifies the types of users on the roadway and in the public space. However, these guidelines do not reduce the number of existing vehicles lanes. The Multimodal System Design Guidelines document can be accessed at: http://www.drpt.virginia.gov/activies/MultimodalSystemDesignGuidelines.aspx. VDOT Road Design Manual: http://www.extranet.vdot.state.va.us/locdes/Electronic_Pubs/2005%20RDM/AppendB(2).pdf DRPT Multimodal System Design Guidelines: http://www.drpt.virginia.gov/activities/MultimodalSystemDesignGuidelines.aspx.	5/28/2014 10:56 AM
9	Our functional classification of local roads are divided into sub-sets.	5/28/2014 8:55 AM
10	Many City projects are governed by state design requirements because of the use of state and federal funding on projects. The City follows a similar approach but is more open to design flexibility and accommodation of modes on adjacent corridors (e.g., using adjacent low volume parallel streets to accommodate bicycling via bicycle boulevards) versus removing parking/trees/parkway space, constraining cross sections to bare minimums across the board, etc. on a busier arterial corridor with constrained ROW for example.	5/27/2014 1:30 PM
11	We consider all users in all street designs. We consider bikes, peds, and buses. Those are the only other modes we have at this time.	5/27/2014 12:27 PM
12	We have a check list of issues to consider	5/24/2014 11:45 AM
13	Our Complete Streets Guidance addresses this to some degree. The guidance can be found at http://vtransengineering.vermont.gov/publications	5/23/2014 9:23 AM
14	Our General Plan Land Use and Circulation Element identified priority users on specific facilities.	5/22/2014 3:52 PM

15	Chapter 4 of the Roadway Design Manual http://www.transportation.nebraska.gov/roadway-design/rw-design-man-chapters.htm	5/21/2014 4:25 PM
16	Roadway user types should be documented through the project scoping process (project purpose and need). The scoping of the project is documented in the Project Charter: http://itd.idaho.gov/manuals/Manual%20Production/ProjectCharter/ProjectCharterPrintable.htm (search for "scope") The NEPA/Public evolvement/Practical Design/ and Environmental phases of the project are tools used to document and identify roadway users and insure the project is properly scoped. http://itd.idaho.gov/manuals/Manual%20Production/Environmental/environmental_cover.pdf http://itd.idaho.gov/manuals/Manual%20Production/CSS/CSS_Guide.pdf http://itd.idaho.gov/manuals/Manual%20Production/PublicInvolve/PublicInvolve.pdf http://itd.idaho.gov/manuals/Manual%20Production/DesignSolutions/DesignSolutionsPrintable.htm	5/21/2014 11:42 AM
17	All roads service vehicular traffic of all types. We use zoning ordinances to determine need for bike & pedestrian needs.	5/21/2014 11:05 AM
18	Planning level analysis and then the Team approach with members representing the different modes	5/21/2014 7:17 AM
19	We accommodate all users within one mile of urban areas, plus provide 5' paved shoulders on rural roadways.	5/21/2014 6:55 AM
20	PennDOT pubs, especially Design Manuals 1 and 2, provide bike/ped check lists and pedestrian accommodation study templates. See penndot home page and link to all design pubs.	5/21/2014 5:50 AM

Q8 Is the surrounding roadway network/infrastructure considered in determining the user types that need to be served on a given roadway? (For example, a bike lane may not be necessary because one is provided on a parallel street or there is an adjacent bike path).

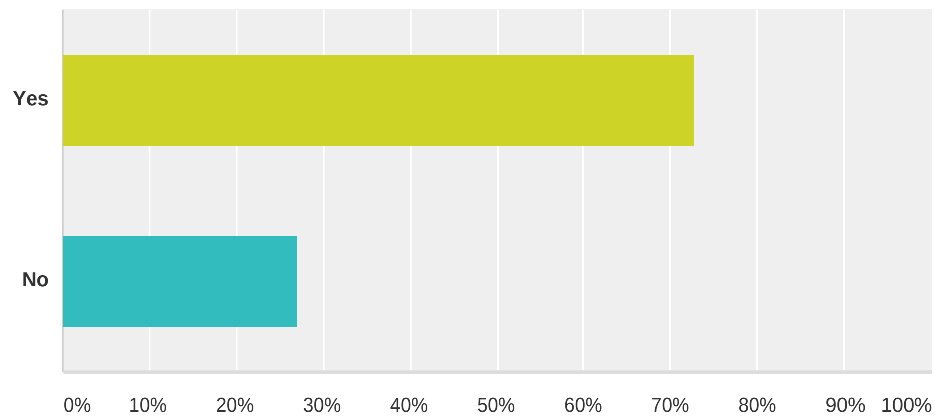
Answered: 47 Skipped: 27



Answer Choices	Responses	
Yes	**63.83%**	30
No	**36.17%**	17
Total		**47**

Q9 Is the functional classification of the roadway and/or the adjacent land use (zoning and context) considered in determining the user types to be served in a given roadway design?

Answered: 48 Skipped: 26



Answer Choices	Responses	
Yes	**72.92%**	35
No	**27.08%**	13
Total		**48**

Q10 If you answered YES to the previous question, please describe your process below or provide a link to documents that describe your process. Alternatively, you can email copies of relevant documents to Chris Fees (cfees@mriglobal.org).

Answered: 29 Skipped: 45

#	Responses	Date
1	See Question 5. Essentially if the area is zoned rural then wide shoulders are provided. Alternatively if the area is zoned urban then the full array of urban features are provided (sidewalks, lighting, bike lanes, etc...). Bike lanes are only added to identify bike routes though.	7/22/2014 3:58 PM
2	Nothing formal	7/22/2014 6:42 AM
3	We use the functional classification as one determinant of the criteria in the Roadway Design Manual.	7/21/2014 7:34 AM
4	Currently functional classification is a primary tool for assigning standards for criteria that are considered in design (see chapters 1100,1120,1130, 1140 in WSDOT Design Manual). Developing a land use based system that is more specific to the contextual factors than functional class - due out 7/2015	7/17/2014 4:51 PM
5	Personal familiarity with the area as well as local government and public input.	7/17/2014 1:57 PM
6	A Local Street, or urban collector would be more conducive to use by bicyclists and peds that a rural freeway. That is inherent in consideration of developing design options.	7/17/2014 12:42 PM
7	Roadway classification as defined by City of Houston Major Thoroughfare Plan.	7/17/2014 11:12 AM
8	Consideration of the end user is inherent to the design of the overall transportation project. Colorado DOT does not have a formal process to determine this. Rather CDOT's guides use language such as "The needs of bicyclists and pedestrians shall be included in the planning, design, and operation of transportation facilities, as a matter of routine". (CDOT Roadway Design Guide, Chapter 14) CDOT has adopted the use of context sensitive design and identification of the end user is inherent to this process.	7/17/2014 9:42 AM
9	The in-development resources described above will serve these functions.	6/16/2014 4:31 PM
10	See answer to question #5. Urban and suburban design manual requirements take into account facility type, traffic volumes, land use context, and mode accommodation.	6/5/2014 1:04 PM
11	see previous answer (Complete Streets/ Context Sensitive Design)	6/2/2014 9:38 AM
12	considered but not the sole determinant	5/29/2014 10:09 AM
13	No defined process	5/28/2014 2:46 PM
14	The functional classification and adjacent land use (zoning and context) are considered in determining the type of users to be served in a given roadway and public space design. There is a Functional Classification / Multimodal Corridor Types translation matrix on page RDM B(2)-6. VDOT Road Design Manual: http://www.extranet.vdot.state.va.us/locdes/Electronic_Pubs/2005%20RDM/AppendB(2).pdf DRPT Multimodal System Design Guidelines: http://www.drpt.virginia.gov/activities/MultimodalSystemDesignGuidelines.aspx.	5/28/2014 10:56 AM
15	Will send a copy	5/28/2014 8:55 AM
16	The road classification determines if the pedestrian facility is a 5 foot wide sidewalk vs an 8 foot wide pathway. See pathway map in lower right hand corner of link http://www.rochesterhills.org/index.aspx?nid=101 Also, here is link to complete streets info. http://roch.legistar.com/Legislation.aspx	5/27/2014 2:51 PM

17	The City's approach is not currently well codified; however, we are currently undertaking the development of a Complete Streets policy and associated design checklist/guidance development to codify our approach and better sync it with our Green Streets policies and design approaches and our City streetscape guidance.	5/27/2014 1:30 PM
18	Our Complete Streets Guidance addresses this to some degree. The guidance can be found at http://vtransengineering.vermont.gov/publications	5/23/2014 9:23 AM
19	Engineering judgment is used to determine road user needs on a case by case basis.	5/23/2014 7:34 AM
20	See General Plan, Pedestrian Action Plan, and Bicycle Action Plan, linked previously	5/22/2014 3:52 PM
21	MDOT - Federal Highway	5/22/2014 1:28 PM
22	No formal process. We do not have, nor plan to implement a complete streets policy or program. Our road system is primarily rural, 80% granular surfaced with little pedestrian and bicycle traffic.	5/22/2014 10:50 AM
23	State Minimum Design Standards Chap 2 pg 18 Municipal stds http://www.transportation.nebraska.gov/gov-aff/pdfs-docs/manuals/proc-class-stan-min-des.pdf Chapter 4 of the Roadway Design Manual http://www.transportation.nebraska.gov/roadway-design/rw-design-man-chapters.htm	5/21/2014 4:25 PM
24	We use a regional classification system classifying streets based on context and traffic type (long-distance vs. local access). Boulevard treatments in town centers focus on multimodal access while throughways focus on vehicle movement. Referenced in Metro's Creating Livable Streets document (hard copy only) available from anthony.buczek@oregonmetro.gov	5/21/2014 4:04 PM
25	INDOT Design Manual, AASHTO "Green Book" or AASHTO Low Volume Local Roads Design Guide	5/21/2014 3:50 PM
26	See question 7.	5/21/2014 11:42 AM
27	Planning level analysis based on the corridor and then Team approach	5/21/2014 7:17 AM
28	Chapter 2 of the FDOTs PPM includes criteria based on functional classification.	5/21/2014 6:55 AM
29	In addition to pubs and Traffic Engineering templates, staff local knowledge and experience are used.	5/21/2014 5:50 AM

Q11 What method(s) does your agency use to determine the design speed of a low- to intermediate-speed roadway?

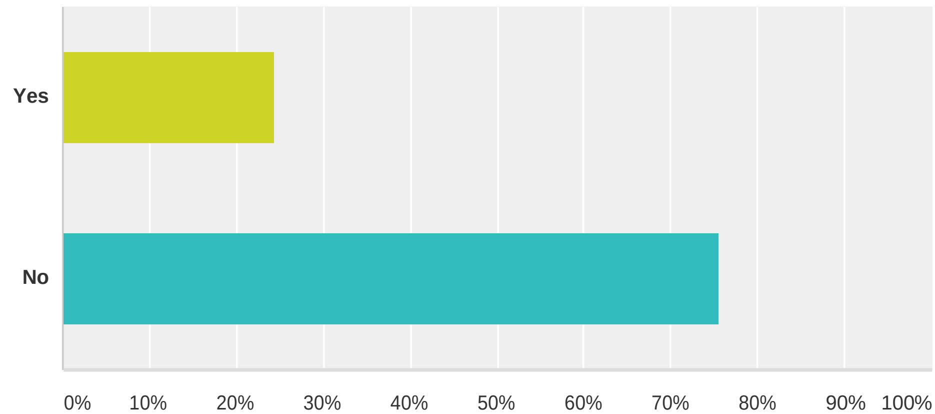
Answered: 44 Skipped: 30

#	Responses	Date
1	The 85th percentile speed is determined and used as a baseline for the speed determination. This baseline is tempered with other factors such as crash history and adjusted (slightly) accordingly. According to MoDOT policy, design speed and posted speed are synonymous.	8/7/2014 12:36 PM
2	Typically, 5 mph over existing speed limit.	7/23/2014 7:45 AM
3	Roadway classification	7/22/2014 3:59 PM
4	AASHTO Green Book for rural sections, Urban sections would be posted speed.	7/22/2014 6:42 AM
5	Functional class, users profile, accident data.	7/21/2014 7:35 AM
6	Existing Posted Speed, Speed Study	7/17/2014 5:07 PM
7	Current method is posted speed or based off speed study (ops speed). Future will incorporate a 'target speed' approach based on land use and modal makeup for a given location.	7/17/2014 4:55 PM
8	MnDOT design guide	7/17/2014 1:59 PM
9	We consider the posted speed and the planned speed for an overall route segment upgrade.	7/17/2014 12:48 PM
10	Use a 45 mph design speed per HC guidelines	7/17/2014 11:12 AM
11	No specific process is utilized. The design speed used for each project is determined by the project team utilizing the general guidance given in the Green Book. However, CDOT projects' design speeds generally vary from 5 to 10 MPH over the posted speed. And, in some cases, the design speed matches the posted speed, if conditions warrant this.	7/17/2014 9:54 AM
12	Our Road Design Manual provides allowable ranges of design speed drawn from the AASHTO Green Book as well as some general guidance and principles.	6/16/2014 4:38 PM
13	State highway design manual provides guidance on design speed and is based on; facility type (urban or rural), surrounding context (downtown CBD, commercial retail area, suburban), volumes, terrain, and speed. Design speed is finalized by technical staff.	6/5/2014 1:04 PM
14	the following are balanced - regional significance - traffic volumes - rural/urban - context sensitivity	6/2/2014 9:38 AM
15	Illinois DOT procedures	5/29/2014 10:10 AM
16	We do a speed study and look at many factors including the existing speed and changes in current land use.	5/28/2014 2:47 PM
17	The land use, density based on jobs + people per acre and types of users on the roadway. Also see answer to question 10.	5/28/2014 10:57 AM
18	Functional classification first, ADT, housing density, ped/bike use	5/28/2014 8:59 AM
19	Traffic volumes, existing topography, road classification.	5/27/2014 2:54 PM
20	The City of Milwaukee has a limited range of road types due to the dense gridded nature of our roadway network. Most streets are designed at 25 or 30 mph with only a small percentage designed above 30 mph.	5/27/2014 1:32 PM
21	The design speed depends on the functional classification. We have local streets, collector street, arterials street, and regional arterial streets. Our design standards dictate the design speed. Our design standards are found on our website.	5/27/2014 12:31 PM
22	Historic safety data	5/24/2014 11:53 PM

23	Match posted speeds unless there is a compelling reason to seek a change.	5/24/2014 11:48 AM
24	Our Complete Streets Guidance addresses this to some degree. The guidance can be found at http://vtransengineering.vermont.gov/publications Also, see the VT state standards at the same link.	5/23/2014 9:25 AM
25	Engineering judgment along with Chapter 5 (Local roads and streets) of the AASHTO Green Book	5/23/2014 7:39 AM
26	See chapter 12 of the MDT Road Design Manual: http://mdtinfo.mdt.mt.gov/mdt/manuals.shtml#roaddesign	5/22/2014 4:07 PM
27	We start with the target users - is it a low-speed residential street, a "greenway," a transit street, or something else.	5/22/2014 3:53 PM
28	prima facie speed limit speed study	5/22/2014 1:30 PM
29	Use rural design guides developed by Iowa County Engineers Association in cooperation with Iowa DOT.	5/22/2014 10:52 AM
30	area	5/22/2014 7:51 AM
31	Design consultant in consultation with city makes recommendation, based on a posted speed limit. Typically, the design speed is 5 mph higher than posted speed limit.	5/21/2014 6:50 PM
32	State law, State Minimum Design Standards, http://www.transportation.nebraska.gov/gov-aff/pdfs-docs/manuals/proc-class-stan-min-des.pdf Posted signs, AASHTO Green Book Guidance. http://www.transportation.nebraska.gov/roadway-design/rw-design-man-chapters.htm	5/21/2014 4:27 PM
33	We don't determine design speed.	5/21/2014 4:06 PM
34	Functional classification of roadway or present design speed	5/21/2014 3:50 PM
35	NYSDOT Regional Office calculates for local agencies.	5/21/2014 2:55 PM
36	See ITD Design Manual, Appendix A http://itd.idaho.gov/manuals/Manual%20Production/RoadwayDesign/RoadwayDesignAppendixA.htm For <= 400 ADT see AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads	5/21/2014 11:42 AM
37	http://www.dot.state.mn.us/stateaid/programlibrary/stateaidrules.pdf	5/21/2014 11:20 AM
38	By county ordinance	5/21/2014 11:09 AM
39	Speed counts are taken and attempt to use the 85th percentile speed. Maximum speed in an urban area is 30 mph as set forth by Indiana law.	5/21/2014 11:06 AM
40	85th percentile	5/21/2014 11:03 AM
41	adt	5/21/2014 10:58 AM
42	Design speed is equal to the posted speed	5/21/2014 7:21 AM
43	We are developing Complete Streets guidance that will consider Transec zones, design speed, etc. It will be published soon.	5/21/2014 6:56 AM
44	Typology matrix (from design manual 2) and engineering judgement from experienced staff.	5/21/2014 5:53 AM

Q12 Does your agency select specific design vehicles for the design of low-speed and intermediate-speed roadways?

Answered: 45   Skipped: 29



Answer Choices	Responses	
Yes	**24.44%**	11
No	**75.56%**	34
Total		**45**

Q13 If you answered YES to the previous question, please describe your process below or provide a link to documents that describe your process. Alternatively, you can email copies of relevant documents to Chris Fees (cfees@mriglobal.org).

Answered: 13   Skipped: 61

#	Responses	Date
1	Refer to SDDOT Road Design Manual, Chapter 12 - Intersections.	7/17/2014 5:07 PM
2	Trucks generally control the geometrics and we typically use AASHTO WB-67 if trucks are forecasted.	7/17/2014 12:48 PM
3	Our Road Design Manual has general guidance that assists in the selection of design vehicle for all speeds and classes of facility: http://dotapp7.dot.state.mn.us/edms/download?docId=1062355	6/16/2014 4:38 PM
4	Selected design vehicle is dependent on type, size, and frequency of use of specific vehicles (transit, freight, etc.). State facilities are to accommodate a certain size of vehicle on a specific route but not all intersections are designed for the same vehicle. More heavily used freight/transit intersections may have different design vehicle parameters, but also need to take into account other modes at the intersections, such as how bicycles and pedestrian are to be accommodated. Truck turning accommodation as well as crossing distance and times of pedestrians and bicyclists are considered.	6/5/2014 1:04 PM
5	Design vehicle is determined by the intended use of the roadway network: residential, industrial, commercial, regional... (mixed use)	6/2/2014 9:38 AM
6	Illinois DOT manuals	5/29/2014 10:10 AM
7	The design vehicle is selected by the locality based on land use zoning and context. VDOT does not require a specific design vehicle. However, the design vehicle must not cross into the opposing lane when turning right. http://www.extranet.vdot.state.va.us/locdes/Electronic_Pubs/2005%20RDM/AppendB(2).pdf http://www.drpt.virginia.gov/activities/MultimodalSystemDesignGuidelines.aspx.	5/28/2014 10:57 AM
8	This can be found on the website again in our design standards.	5/27/2014 12:31 PM
9	Typically our streets are designed to accommodate our most mobility-restricted emergency vehicles (HazMat Truck).	5/22/2014 3:53 PM
10	Roadway Design Manual Chapter 1 Design Standards http://www.transportation.nebraska.gov/roadway-design/rw-design-man-chapters.htm	5/21/2014 4:27 PM
11	See ITD Design Manual, 555.00 – DESIGN FOR OVERSIZED VEHICLES http://itd.idaho.gov/manuals/Manual%20Production/RoadwayDesign/RoadwayDesign500.htm For <= 400 ADT see AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads	5/21/2014 11:42 AM
12	WB-67 is the design vehicle for the MaineDOT. Once it is determined that this vehicle is not able to make the movement then the designer determines the minimum design vehicle based on adjacent uses. The minimum design vehicle is generally a 40' bus	5/21/2014 7:21 AM
13	Consider legally allowed max vehicle and land use/truck counts.	5/21/2014 5:53 AM

Q14 For projects with constrained right-of-way, how do you prioritize or balance the elements of design for all users? Does your

agency have a defined policy or protocol for prioritizing the elements of design for all users? If so, please provide a link to documents that describe your policy/protocol or email your policy/protocol to Chris Fees (cfees@mriglobal.org).

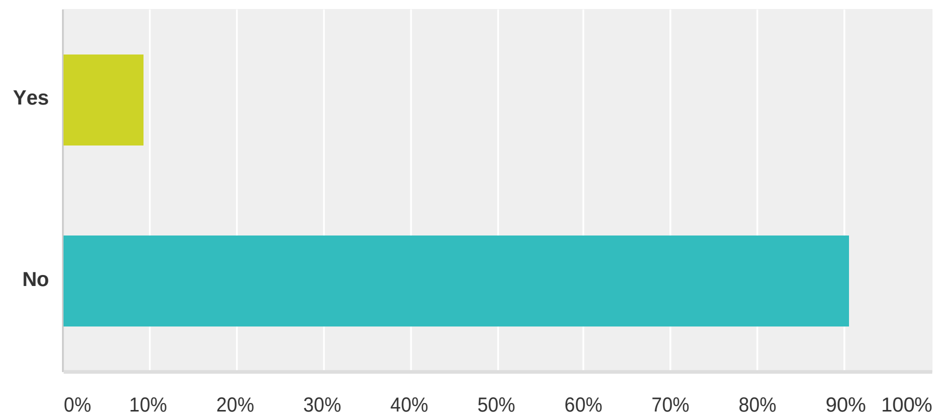
Answered: 35 Skipped: 39

#	Responses	Date
1	Delaware does not have a policy for prioritizing the elements of design but would design roadway based on the anticipated use.	7/23/2014 7:45 AM
2	No we do not have a specific policy.	7/22/2014 3:59 PM
3	No	7/22/2014 6:42 AM
4	Decisions are made project by project during the scope process based on reviewing design options, impacts to utilities, ROW, environmental, etc. and associated costs with each.	7/17/2014 5:07 PM
5	Currently no. Future land use based system will account for this selection based on the objectives of the community and modes that best support the land use.	7/17/2014 4:55 PM
6	Vehicles first (they are paying for it). Accommodate pedestrians when necessary and possible.	7/17/2014 1:59 PM
7	No defined policy. We try to be practical and use common sense to provide for the appropriate/most prevalent users.	7/17/2014 12:48 PM
8	These elements are balanced on a project-by-project basis.	7/17/2014 9:54 AM
9	Our forthcoming complete streets guidance document will provide a process for assessing functions and needs and allocating space. It will not be a policy or protocol per se but rather an analytical and thought process.	6/16/2014 4:38 PM
10	State design manual (Chapter 6- see HDM link in question #5 response) does provide some general design guidance for constrained urban areas (sometimes prioritized considerations and sometimes not prioritized considerations) using the design exception process. Along with the constrained location design guidance, each project is looked at individually and designed depending on location, facility uses, volumes, functional classification, context of the site (urban, urban fringe/suburban, rural, density, etc.), public input, and user input (freight, transit, bicycle, and pedestrian groups). State also uses a practical design approach in project development and design.	6/5/2014 1:04 PM
11	see previous answers & links	6/2/2014 9:38 AM
12	We start with the use that is paying the most for the roadway and then work our way down the list. (cars or trucks, then other users.	5/28/2014 2:47 PM
13	One of the outcomes of the Multimodal System Plan is to determine the modal emphasis (pedestrians, bicyclists, transit) based on land use (zoning and context). Once modal emphasis has been determined and prioritized the design values (optimal and minimum) allow you to balance the elements of design within constrained right of way. As a result of constrained right of way, you will choose both optimal and minimum values for elements of design based on the prioritization of modal emphasis for all users. See Appendix A, Corridor Matrix, in the Multimodal System Design Guidelines for optimal and minimum design values http://www.extranet.vdot.state.va.us/locdes/Electronic_Pubs/2005%20RDM/AppendB(2).pdf http://www.drpt.virginia.gov/activities/MultimodalSystemDesignGuidelines.aspx.	5/28/2014 10:57 AM
14	Being in a more rural environment we have ROW constraints for design, but very little ped / bike usage	5/28/2014 8:59 AM
15	Our goal is to obtain the City's master planned right-of-way to accommodate road and pedestrian needs. The City does not have transit and the discussion on bike lanes has not really taken off yet.	5/27/2014 2:54 PM

16	We are currently starting to codify our design processes with a Complete Streets policy and implementation effort. Balance among modes is typically done through a lot of staff consultation, including with staff specialists (like bike/ped manager, etc.) now.	5/27/2014 1:32 PM
17	Our protocol is to do the best with what we have and what we can afford. We struggle to get extra right of way for added width for bike lanes and extra width for sidewalks. We prioritize sidewalks over bike lanes but then try to add 1-2 ft on the outside driving lanes to at least add some room for bikes.	5/27/2014 12:31 PM
18	Vehicles first	5/24/2014 11:53 PM
19	We bring representatives of the various modal interests together and look at adjacent corridors for mode service then balance off the needs to identify where the tension lies.	5/24/2014 11:48 AM
20	Nothing formal. Case by case basis.	5/23/2014 9:25 AM
21	On existing streets, the right-of-way is considered to address how to accommodate bikes and pedestrians. Where a definitive need for non-motorized users is demonstrated, additional easement is purchased. On new roads, sufficient easement is obtained to accommodate all users.	5/23/2014 7:39 AM
22	The highway classification and over all user needs will help determine the balance, along with input from local governments and stakeholder groups. For example, an urban arterial will likely be more weighted toward through traffic, whereas a low volume collector can be weighted more to accommodate other modes of travel.	5/22/2014 4:07 PM
23	See General Plan, etc.	5/22/2014 3:53 PM
24	idk	5/22/2014 1:30 PM
25	Priority is given to vehicular usage, cars, trucks, and agricultural equipment. We do not have formal guidance documents directing this process.	5/22/2014 10:52 AM
26	There are frequently a technical and citizens advisory committees for major roadway rebuilds. These issues get worked out with these committees.	5/21/2014 6:50 PM
27	Roadway Design Manual http://www.transportation.nebraska.gov/roadway-design/rw-design-man-chapters.htm	5/21/2014 4:27 PM
28	Use of Creating Livable Streets document (hard copy only) available from anthony.buczek@oregonmetro.gov. Promotes balanced constraints - start with ideal and constrain all modes proportionally. So, a narrower sidewalk may be appropriate if we are also narrowing lanes to meet a constraint, but we should not penalize one mode while maximizing another unless the context is supportive of that (i.e. freight in an industrial area, pedestrians in a town center).	5/21/2014 4:06 PM
29	Safety is first consideration.	5/21/2014 2:55 PM
30	ITD Right of Way Manual http://itd.idaho.gov/manuals/Manual%20Production/RoW/RightofWay1.htm	5/21/2014 11:42 AM
31	http://www.dot.state.mn.us/stateaid/programlibrary/stateaidrules.pdf	5/21/2014 11:20 AM
32	It is at the discretion of the individual board of county commissioners with guidance from the county design manual.	5/21/2014 11:09 AM
33	no	5/21/2014 11:03 AM
34	The team approach and the Engineering Council is the protocol for prioritizing elements of design	5/21/2014 7:21 AM
35	Feasibility and cost are considered by experience staff to make engineering judgment.	5/21/2014 5:53 AM

Q15 In your planning, design, and/or development projects, does your agency estimate level of service for all user types (motor vehicles, pedestrians, bicyclists)?

Answered: 43 Skipped: 31



Answer Choices	Responses	
Yes	**9.30%**	4
No	**90.70%**	39
Total		**43**

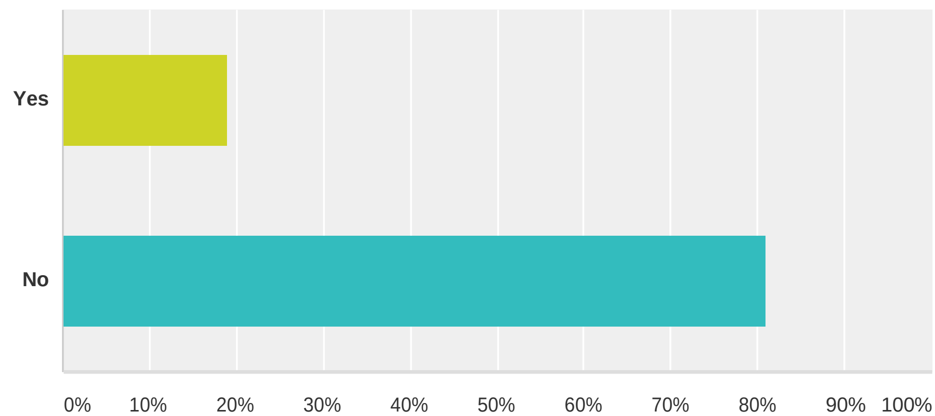
Q16 If you answered YES to the previous question, how is level of service for each user type determined? What tools are used?

Answered: 7 Skipped: 67

#	Responses	Date
1	At this time, construction projects typically estimate vehicle LOS (V/C), but currently exploring a "quantitative" measure (based on guidance in Highway Capacity Manual) of LOS for other modes, but is not yet completed. Planning documents address pedestrians and bicyclists, but they don't necessarily use a consistent method and typically not an engineering analysis to estimate functionality for alternate modes.	6/6/2014 10:26 AM
2	We try to accommodate all users. Safety is the most important, however there is no level of service measures for bikes/peds	6/2/2014 9:39 AM
3	However, the overall LOS increases due to the movement of more people via other transportation modes such as walking, biking and transit.	5/28/2014 10:58 AM
4	ITE standards	5/22/2014 1:31 PM
5	Amish community requires wider shoulders	5/22/2014 7:52 AM
6	Roadway Design Manual http://www.transportation.nebraska.gov/roadway-design/rw-design-man-chapters.htm	5/21/2014 4:27 PM
7	Pedestrian and bicycle usage has historically been hard to quantify except in a few higher usage areas.	5/21/2014 12:03 PM

Q17 Does your agency use quantifiable performance measures (e.g., reduction in injuries and fatalities, increase in modal split) to compare the multimodal performance of design alternatives?

Answered: 42 Skipped: 32



Answer Choices	Responses	
Yes	**19.05%**	8
No	**80.95%**	34
Total		**42**

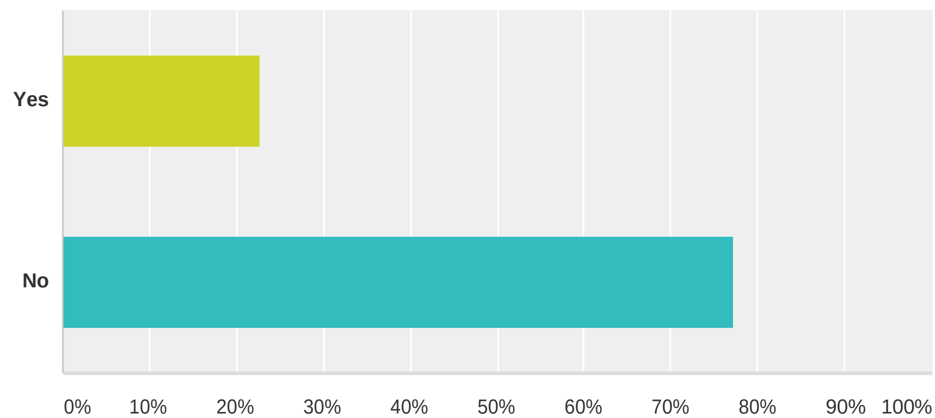
Q18 If you answered YES to the previous question, please list (or describe) the performance measures used.

Answered: 8 Skipped: 66

#	Responses	Date
1	I would use the HSM to compare	7/22/2014 6:42 AM
2	State DOT has a statewide performance measure for traffic fatalities, but does not currently use to compare multimodal performance of design alternatives. Although not specific to performance measures, projects take into account (during project development and alternative analysis), the safety of all modes.	6/6/2014 10:26 AM
3	Highway Safety manual	5/29/2014 10:11 AM
4	We use before/after studies for similar roadway designs and bring those results to the consideration of potential implications of design of mode components.	5/24/2014 11:49 AM
5	Sometimes; we cite various statistics and studies when developing our plans.	5/22/2014 3:54 PM
6	Reduction in fatal/severe injury crashes, V/C ratio, crosswalks spacing. Have used MMLOS but not consistently used.	5/21/2014 4:07 PM
7	http://itd.idaho.gov/ohs/SHSP.htm	5/21/2014 12:03 PM
8	Safety Data, modeling and HSM	5/21/2014 9:01 AM

Q19 Does your agency formally evaluate projects after they are completed to determine how well they serve relevant user groups (e.g., review before/after crash data, review before/after modal split, conduct user survey several months following completion of a project to obtain feedback)?

Answered: 44 Skipped: 30



Answer Choices	Responses	
Yes	22.73%	10
No	77.27%	34
Total		44

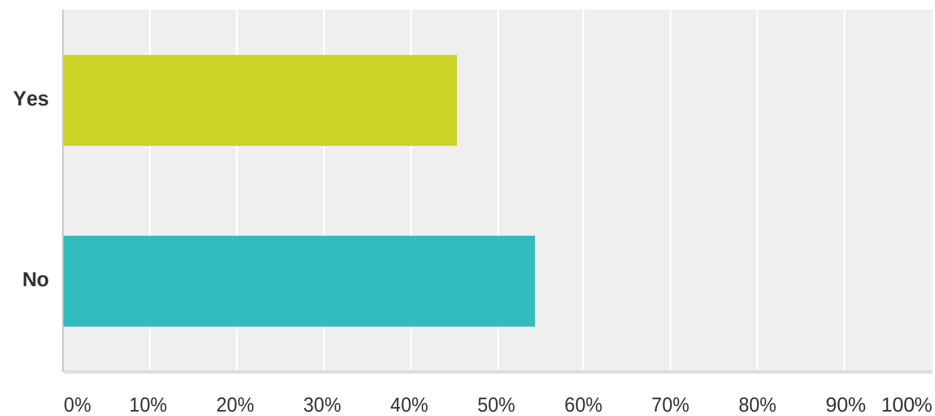
Q20 If you answered YES to the previous question, please list (or describe) the types of evaluations performed.

Answered: 12 Skipped: 62

#	Responses	Date
1	just HSM for performance	7/22/2014 6:43 AM
2	Crash data is compared, travel times for auto and transit. See http://www.wsdot.wa.gov/Accountability/	7/17/2014 5:02 PM
3	Not formally. Small county is easy to stay familiar with all roads.	7/17/2014 2:01 PM
4	Completed safety projects do conduct a before and after crash (all types of crashes) analysis, but generally do not go to the extent of user surveys or before/after modal splits.	6/6/2014 10:28 AM
5	On limited projects - evaluations depend on project type (typically crash reduction projects)	5/27/2014 1:34 PM
6	Before/after crash comparisons	5/24/2014 11:54 AM
7	We do before/after evaluations.	5/22/2014 3:54 PM
8	sometimes - crash analysis	5/22/2014 1:32 PM
9	Accident reports.	5/22/2014 7:52 AM
10	review before/after crah data	5/21/2014 4:28 PM
11	We do track crashes along roadways. Crash history along a roadway can be used to evaluate effectiveness of projects. This is done mostly as requested as opposed to a formulized process. An overall summary of ITD crash history can be found at the following link: http://itd.idaho.gov/ohs/stats.htm	5/21/2014 12:41 PM
12	Interviews, surveys, accident data	5/21/2014 9:04 AM

Q21 Has your agency adopted any "Complete Streets" laws and/or policies to ensure that projects provide the safest achievable access for all users and modes of transportation?

Answered: 44 Skipped: 30



Answer Choices	Responses	
Yes	**45.45%**	20
No	**54.55%**	24
Total		**44**

Q22 If you answered “Yes” to the previous question, please provide a link to these documents or send them via email to Chris Fees (cfees@mriglobal.org). If unpublished, please describe the law and/or policy below.

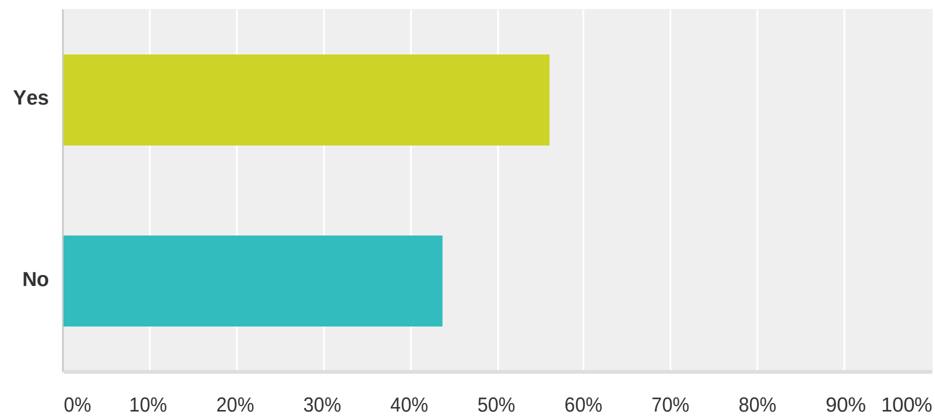
Answered: 22 Skipped: 52

#	Responses	Date
1	Missouri does not have complete streets legislation. However, we believe that our policy accounts for complete streets by requiring every project, irrespective of scope, to consider bicycle and pedestrian facilities. When the designers find such facilities to be warranted, they include them in the plans. http://epg.modot.mo.gov/index.php?title=Category:642_Pedestrian_Facilities http://epg.modot.org/index.php?title=Category:641_Bicycle_Facilities	8/7/2014 12:36 PM
2	http://deldot.gov/information/pubs_forms/manuals/complete_streets/o06_complete_streets_policy.pdf	7/23/2014 7:46 AM
3	See Roadway Design Manual and Project Development Process Manual on website txdot.gov.	7/21/2014 7:36 AM
4	See SDDOT Road Design Manual, Chapter 7 - Cross Sections. Specifically the 3' shoulder for bicycle commuter accommodations. Other info in Chapter 16 - Miscellaneous.	7/17/2014 5:09 PM
5	http://www.wsdot.wa.gov/LocalPrograms/Planning/CompleteStreets.htm	7/17/2014 5:02 PM
6	Hawaii DOT has adopted this statutes. HAWAII STATUTES AND CODES §264-20.5 - Complete streets. Listen [§264-20.5] Complete streets. (a) The department of transportation and the county transportation departments shall adopt a complete streets policy that seeks to reasonably accommodate convenient access and mobility for all users of the public highways within their respective jurisdictions as described under section 264-1, including pedestrians, bicyclists, transit users, motorists, and persons of all ages and abilities. (b) This section shall apply to new construction, reconstruction, and maintenance of highways, roads, streets, ways, and lanes located within urban, suburban, and rural areas, if appropriate for the application of complete streets. (c) This section shall not apply if: (1) Use of a particular highway, road, street, way, or lane by bicyclists or pedestrians is prohibited by law, including within interstate highway corridors; (2) The costs would be excessively disproportionate to the need or probable use of the particular highway, road, street, way, or lane; (3) There exists a sparseness of population, or there exists other available means, or similar factors indicating an absence of a future need; or (4) The safety of vehicular, pedestrian, or bicycle traffic may be placed at unacceptable risk. [L 2009, c 54, §1] Note Applies to development for which planning or design commences on or after January 1, 2010. L 2009, c 54, §4. Revision Note Section was enacted as an addition to chapter 286 but is renumbered to this chapter pursuant to §23G-15.	7/16/2014 6:11 PM
7	http://www.dot.state.mn.us/planning/completestreets/ http://www.dot.state.mn.us/policy/operations/op004.html http://dotapp7.dot.state.mn.us/edms/download?docId=1379814	6/16/2014 4:40 PM
8	For project delivery, state has developed practical design strategy in addition to practice of multi-modal design. (See responses to questions #5 and #10). State also has statutory requirement to address different modes for modernization projects.	6/6/2014 10:28 AM
9	see previous answers	6/2/2014 9:39 AM
10	Follow IDOT policies	5/29/2014 10:11 AM
11	And will not as long as I am the County Engineer. The “Complete Street” concept is just the latest in a long line of jargon terms that have been used to describe looking at projects holistically and taking the needs of all users into account when designing roadways.	5/28/2014 2:49 PM

12	The methodology contained within our Multimodal System Design Guidelines constitutes a "Complete Streets" approach. The overriding purpose of the methodology is the same as that of Complete Streets - to rethink the design of transportation infrastructure to attempt to provide all pedestrians, bicyclists, and transit riders' equal access to all destinations. In doing so, the methodology addresses the common limitation of constrained rights of way by affording localities additional flexibility to attempt to accommodate all transportation users. http://www.extranet.vdot.state.va.us/locdes/Electronic_Pubs/2005%20RDM/AppendB(2).pdf http://www.drpt.virginia.gov/activities/MultimodalSystemDesignGuidelines.aspx.	5/28/2014 10:59 AM
13	We are functioning this way now but are currently in the process of codifying it in policy.	5/27/2014 1:34 PM
14	We have not called it "complete streets" in our design standards however, we have a policy to consider all modes of users in our design standards.	5/27/2014 12:32 PM
15	http://www.hennepin.us/completestreets	5/24/2014 11:54 AM
16	Our Complete Streets Guidance addresses this to some degree. The guidance can be found at http://vtransengineering.vermont.gov/publications	5/23/2014 9:25 AM
17	St. Mary's County Road Ordinance, Chapter 3.9, see http://www.stmarysmd.com/docs/2012ROADORDINANCE7-10-2012.pdf	5/23/2014 7:43 AM
18	No, but our General Plan is a "complete streets" focused document.	5/22/2014 3:54 PM
19	Our Metropolitan Planning Commission did adopt a complete streets policies	5/22/2014 1:32 PM
20	http://www.transportation.nebraska.gov/NEUG/2012-conf/presentations/C06%20Complete%20Streets%20NUG%20presentation.pdf http://www.completestreetsbellevue.org/	5/21/2014 4:28 PM
21	Creating Livable Streets document (previously referenced).	5/21/2014 4:07 PM
22	Practical Design, Flexible Design Practice, and working on a Complete Streets Guidance	5/21/2014 9:04 AM

Q23 Has your agency had any projects where multiple, user needs (possibly conflicting needs) were successfully addressed?

Answered: 41 Skipped: 33



Answer Choices	Responses	
Yes	**56.10%**	23
No	**43.90%**	18
Total		**41**

Q24 If you answered YES to the previous question, please describe those "success story" projects.

Answered: 21 Skipped: 53

#	Responses	Date
1	Shoulder Rumble Strips. SRS are help improve vehicle safety but staff met with the local bicycle community to discuss impacts, etc... Project was modified to mitigate concerns while still using best practices. I should not SRS are still not popular nor desired by the bicycle community but they appreciated the opportunity to discuss and having a receptive government respond to their input	7/22/2014 6:37 PM
2	CDOT employs a Context Sensitive design strategy to assure that the various end users' comments and needs are integrated into the project as appropriate. An example is the SH 7 (Arapahoe Rd) in Boulder, CO. This was a two mile reconstruction of a heavily traveled corridor into and out of Boulder. On this project CDOT worked with the City of Boulder, Boulder County, the Regional Transportation District RTD (Bus and Rail), bicycle groups, adjacent businesses and land owners to accommodate the various interests. Ultimately the project included pedestrian paths, exclusive bus lanes, shoulders for bicycles, and a number of other characteristics to address various requests. The main conflict in this project was that various groups desired two through lanes in each direction. However, the project ended up being one lane each direction. However, the addition of center turn lanes, the addition of the bus lane, the addition of improved pedestrian facilities, and a number of other elements improved transportation through the area for all users.	7/22/2014 12:30 PM
3	Addressing them on all projects is our goal.	7/21/2014 7:37 AM
4	Stevenson, WA - freight bypass with mainline ped improvements - contact Andrew Beagle beagle@wsdot.wa.gov Woodenville, WA - three roundabouts, managed access, ped improvements, low speed, less delay for all modes - contact Brian Walsh walshb@wsdot.wa.gov Blaine, WA - Ramp terminals converted from signal to roundabouts and main street for city - contact Chris Damitio DamitiC@wsdot.wa.gov More examples call Brian Walsh 360-705-7986 or Andrew Beagle 360-705-7272	7/17/2014 5:18 PM
5	Since implementation of the 3' shoulder for bicycle commuter accommodations, most urban projects now include the 3' shoulder unless adjacent grid network available, cost/impact of additional width, etc.	7/17/2014 5:10 PM
6	We have had projects where sidewalks and bike trails were provided across the bridge on bridge replacement projects in partnership with local units of government.	7/17/2014 4:06 PM
7	Although we have had a formal complete streets policy for only a short time, MnDOT has had numerous successful multimodal projects in the past. This text box would probably not be sufficient for detailed descriptions of those projects, but I would be happy to discuss aspects of them by phone or through e-mail. 651-366-4673 james.rosenow@state.mn.us In general, our street design policies were revised two years ago to emulate the flexibility in the AASHTO Green Book, and guidance was provided therein to use the flexibility to balance modal functions as well as the safety and mobility of all users.	6/16/2014 4:48 PM
8	State DOT is progressive in developing projects to address all modes. Specifically individual bicycles and pedestrian projects are developed to enhance those modes of travel. State law also requires percentage of transportation funds to be spent on bicycle and pedestrian facilities. Project development and public involvement process allows for communication and interaction with stakeholders and successful project delivery process.	6/6/2014 10:29 AM
9	Projects are currently under development with VDOT's new adopted criteria.	5/28/2014 11:01 AM
10	S. Bay Street - roadway lane capacity reduced but geometrics kept to accommodate frequent large trucking. Raised bike lanes added, and on-street parking retained for large park (generator). S. 2nd Street "road diet" - typical 4-lane with parking street modified to 2 lanes plus bike lanes and parking, some sections with added parkway space for street trees and streetscaping/furniture. Transit well accommodated, parking for housing and growing business district accommodated, and bike lanes added to a lower volume arterial connecting to downtown. Wider sections being considered for protected bike lane additions while maintaining same traffic and parking capacity.	5/27/2014 1:37 PM

11	Separate rail crossings over arterial streets that are bike routes. Challenge was to get the right of way needed for bike/peds to be accommodated on both sides of the overpass.	5/27/2014 12:33 PM
12	We converted a 4 lane road to 3 lanes and introduced bike lanes while at the same time improving the area behind the curb for pedestrians via wider sidewalk with street lighting.	5/24/2014 11:54 AM
13	US7 - Shelburne Rd. improvement added travel lanes, TWLT lane, bike lanes, sidewalks and transit accommodations. US Route 2 in Danville added gateway treatments, shoulders and sidewalks.	5/23/2014 9:26 AM
14	Ocean Park Blvd. Greenway, Expo Light Rail Design	5/22/2014 3:55 PM
15	We have completed several "road diet" projects.	5/22/2014 1:33 PM
16	4' paved shoulders on a road with rumble stripes.	5/22/2014 7:53 AM
17	A project near and interstate on-ramp, we added protected bike lanes and use green pavement markings to alert motorists to the presence of cyclists. Also installed a bike/ped midblock crossing, which will eventually connect to a multi-use path.	5/21/2014 6:52 PM
18	Balancing pedestrians and freight through use of mountable aprons Improving freight turning radii while improving nearby pedestrian crossings Maintaining through lane mobility but adding multimodal elements like medians, on-street parking, mixed-use paths Numerous road diet projects to reduce number of through lanes while improving safety and better accommodating people walking and bicycling	5/21/2014 4:09 PM
19	Up-dated or new ADA compliant sidewalks have been added to several urban area projects and bike lanes were added to some existing streets or roadways.	5/21/2014 3:51 PM
20	Difficult to answer in that there have been several ITD project "success story" The current poster project(s) are those that have been involved with the City of Sandpoint. Project development has been 50+ years in moving the US-95 NHS route out of the City of Sandpoint. http://www.itd.idaho.gov/projects/d1/sandcreekbyway/ http://www.parsons.com/projects/Pages/sand-creek-byway.aspx	5/21/2014 12:46 PM
21	Augusta to Gardiner- Highway Reconstruction with shoulder and sidewalk improvements as well as construction of the Kennebec River Rail Trail, a parallel ped/bike facility linking several communities. Naples- busy tourist destination that had a highway reconstruction with shoulders and a separated shared use path	5/21/2014 9:09 AM

Q25 Thank you for taking the time to complete this survey! OPTIONAL: Please provide us with your contact information so that we can follow up, as necessary, with any further questions or discussion:

Answered: 32 Skipped: 42

Answer Choices	Responses	
Name:	**100.00%**	32
Agency:	**100.00%**	32
Address:	**0.00%**	0
Address 2:	**0.00%**	0
City/Town:	**0.00%**	0
State:	**0.00%**	0
ZIP:	**0.00%**	0
Country:	**0.00%**	0
Email Address:	**100.00%**	32
Phone Number:	**90.63%**	29

#	Name:	Date
1	Joe Jones	8/7/2014 12:36 PM
2	Thad McIlvaine	7/23/2014 7:48 AM
3	Scott Davis	7/22/2014 6:38 PM
4	Ryan Sorensen	7/22/2014 12:31 PM
5	David Brand	7/22/2014 6:44 AM
6	Mark A. Marek	7/21/2014 7:38 AM
7	Andrew Beagle	7/17/2014 5:18 PM
8	Mark Leiferman	7/17/2014 5:11 PM
9	James O. Brewer	7/17/2014 4:07 PM
10	Ron Jenson	7/17/2014 11:14 AM
11	Jim Rosenow	6/16/2014 4:49 PM
12	Kent R. Belleque	6/6/2014 10:29 AM
13	Robert Abitz Jr.	6/2/2014 9:39 AM
14	Joseph Koscinski, Jr.	5/28/2014 11:02 AM
15	James Foster	5/28/2014 9:00 AM

16	Kristin Bennett	5/27/2014 1:38 PM
17	Shannon Ausen	5/27/2014 12:33 PM

18	Jim Grube	5/24/2014 11:55 AM
19	Kevin Marshia	5/23/2014 9:27 AM
20	John Groeger	5/23/2014 8:16 AM
21	Sam Morrissey	5/22/2014 3:55 PM
22	Mark Nahra	5/22/2014 10:53 AM
23	Brian Keierleber	5/22/2014 7:54 AM
24	Diahn	5/21/2014 6:53 PM
25	Phil TenHulzen	5/21/2014 4:30 PM
26	Anthony Buczek	5/21/2014 4:10 PM
27	Richard Van Cleave	5/21/2014 3:51 PM
28	Ted Mason	5/21/2014 12:47 PM
29	Richard Sanders	5/21/2014 11:21 AM
30	Todd Kinney	5/21/2014 11:05 AM
31	Randy Robinson	5/21/2014 10:59 AM
32	Frank Sullivan	5/21/2014 6:59 AM

#	Agency:	Date
1	Missouri DOT	8/7/2014 12:36 PM
2	Delaware Dept. of Transportation	7/23/2014 7:48 AM
3	Thurston County	7/22/2014 6:38 PM
4	Colorado DOT	7/22/2014 12:31 PM
5	Madison County Engineer	7/22/2014 6:44 AM
6	Texas Department of Trans	7/21/2014 7:38 AM
7	WSDOT	7/17/2014 5:18 PM
8	SDDOT	7/17/2014 5:11 PM
9	Kansas DOT	7/17/2014 4:07 PM
10	Harris County, Texas	7/17/2014 11:14 AM
11	Minnesota Department of Transportation	6/16/2014 4:49 PM
12	Oregon Department of Transportation	6/6/2014 10:29 AM
13	NJ DOT	6/2/2014 9:39 AM
14	Virginia Department of Transportation	5/28/2014 11:02 AM
15	Mobile County Engineer Office	5/28/2014 9:00 AM
16	City of Milwaukee	5/27/2014 1:38 PM
17	City of Sioux Falls	5/27/2014 12:33 PM
18	Hennepin County, MN	5/24/2014 11:55 AM

19	VT Agency of Transportation	5/23/2014 9:27 AM
20	St. Mary's County, MD DPW&T	5/23/2014 8:16 AM
21	City of Santa Monica	5/22/2014 3:55 PM
22	Woodbury County Iowa	5/22/2014 10:53 AM
23	Buchanan County Iowa	5/22/2014 7:54 AM
24	Swartz	5/21/2014 6:53 PM
25	Nebraska Dept. of Roads	5/21/2014 4:30 PM
26	Metro	5/21/2014 4:10 PM
27	Indiana Dept. of Transportation	5/21/2014 3:51 PM
28	Idaho Transportation Department (ITD)	5/21/2014 12:47 PM
29	Polk County Public Works	5/21/2014 11:21 AM
30	Clinton County	5/21/2014 11:05 AM
31	OCCEDB	5/21/2014 10:59 AM
32	Florida DOT	5/21/2014 6:59 AM

#	Address:	Date
	There are no responses.	

#	Address 2:	Date
	There are no responses.	

#	City/Town:	Date
	There are no responses.	

#	State:	Date
	There are no responses.	

#	ZIP:	Date
	There are no responses.	

#	Country:	Date
	There are no responses.	

#	Email Address:	Date
1	joseph.jones@modot.mo.gov	8/7/2014 12:36 PM
2	thad.mcilvaine@state.de.us	7/23/2014 7:48 AM
3	davissa@co.thurston.wa.us	7/22/2014 6:38 PM
4	ryan.sorensen@state.co.us	7/22/2014 12:31 PM
5	dbrand@co.madison.oh.us	7/22/2014 6:44 AM
6	mark.marek@txdot.gov	7/21/2014 7:38 AM
7	beaglea@wsdot.wa.gov	7/17/2014 5:18 PM
8	mark.leiferman@state.sd.us	7/17/2014 5:11 PM
9	jbrewer@ksdot.org	7/17/2014 4:07 PM
10	ron.jenson@hcpid.org	7/17/2014 11:14 AM

11	james.rosenow@state.mn.us	6/16/2014 4:49 PM
12	kent.r.belleque@odot.state.or.us	6/6/2014 10:29 AM
13	Robert.Abitz@dot.state.nu.us	6/2/2014 9:39 AM
14	joseph.koscinski@vdot.virginia.gov	5/28/2014 11:02 AM
15	jfoster@mobilecounty.net	5/28/2014 9:00 AM
16	kristin.bennett@milwaukee.gov	5/27/2014 1:38 PM
17	sausen@siouxfalls.org	5/27/2014 12:33 PM
18	james.grube@hennepinus	5/24/2014 11:55 AM
19	kevin.marshia@state.vt.us	5/23/2014 9:27 AM
20	john.groeger@stmarysmd.com	5/23/2014 8:16 AM
21	sam.morrissey@smgov.net	5/22/2014 3:55 PM
22	mnahra@sioux-city.org	5/22/2014 10:53 AM
23	engineer@co.buchanan.ia.us	5/22/2014 7:54 AM
24	diahn.swartz@tucsonaz.gov	5/21/2014 6:53 PM
25	phil.tenhulzen@nebraska.gov	5/21/2014 4:30 PM
26	anthony.buczek@oregonmetro.gov	5/21/2014 4:10 PM
27	rvancleave@indot.in.gov	5/21/2014 3:51 PM
28	ted.mason@itd.idaho.gov	5/21/2014 12:47 PM
29	rsanders@co.polk.mn.us	5/21/2014 11:21 AM
30	tkinney@clintoncounty-ia.gov	5/21/2014 11:05 AM
31	randyr@okacco.com	5/21/2014 10:59 AM
32	frank.sullivan@dot.state.fl.us	5/21/2014 6:59 AM

#	Phone Number:	Date
1	573-751-3813	8/7/2014 12:36 PM
2	360-867-2345	7/22/2014 6:38 PM
3	(303) 757-9326	7/22/2014 12:31 PM
4	740-852-9404	7/22/2014 6:44 AM
5	5129637623	7/21/2014 7:38 AM
6	360-705-7272	7/17/2014 5:18 PM
7	605-773-3452	7/17/2014 5:11 PM
8	(785) 296-3901	7/17/2014 4:07 PM
9	713-755-4473	7/17/2014 11:14 AM
10	651-366-4673	6/16/2014 4:49 PM
11	503-986-3536	6/6/2014 10:29 AM
12	609.530.5515	6/2/2014 9:39 AM
13	804 225-3934	5/28/2014 11:02 AM

14	2055748595	5/28/2014 9:00 AM
15	414-286-8750	5/27/2014 1:38 PM
16	605-367-8607	5/27/2014 12:33 PM
17	612-596-0305	5/24/2014 11:55 AM
18	802-828-2932	5/23/2014 9:27 AM
19	301863-8400 ext 3516	5/23/2014 8:16 AM
20	310.458.8955	5/22/2014 3:55 PM
21	7128733215	5/22/2014 10:53 AM
22	319-334-6031	5/22/2014 7:54 AM
23	(402) 479-3951	5/21/2014 4:30 PM
24	503-797-1674	5/21/2014 4:10 PM
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27	218-470-8253	5/21/2014 11:21 AM
28	563-244-0564	5/21/2014 11:05 AM
29	850-414-4324	5/21/2014 6:59 AM

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TRB
TRANSPORTATION RESEARCH BOARD

MEETING OF NCHRP PROJECT PANEL C15-48
Developing a Methodology for Designing Low and Intermediate Speed Roadways that Serve All Users

Wednesday, February 3, 2016
9:00 a.m.
Conference Room 106
William M. Keck Center
500 Fifth Street NW
Washington, DC 20001

AGENDA

I. Welcome
   - A. Chair/staff comments
   - B. Introductions
   - C. Purpose of meeting

II. Executive Session (If needed) – Panel Only

III. Review Tasks
   - A. Discussion of Draft Interim Report and Key Panel Comments (includes Break)
     Chapters 1 & 2 – Purpose of Report, Background (pages 1-16)
     Chapter 3 – Research Approach (pages 17-20)
     Chapter 4 – Phase I Work Tasks
       - Task 1 – Literature Review, Survey, Best Practices (pages 21-65)
       - Task 2 – Methods to Determine User Service Levels (pages 66-101)
       - Task 3 – Methods to Balance/Optimize Design Elements for All Users (pgs 102-118)
       - Task 4 – Geometric Design Framework (pages 119-158)

Lunch

   - B General Discussion on Key Research Product – the Guidelines Document
     - Low to intermediate speeds are 45mph and below. Should this document address these roadways in both urban and rural contexts?
     - Who is the most important intended audience of the Guidelines?
     - What is the best format, style and content for that audience to understand the needs of all users and how best to integrate them in the geometric design process?
     - What are the key attributes that will make the document most successful in advancing the awareness, understanding and geometric design for all users?

C. Continued Discussion of Draft Interim Report

Task 5 – Phase II Work Plan
Key issues in Guidelines development (page 159-160)
Draft Guidelines Review with Focus Groups (page 161)
Example Guidelines Table of Contents (pages 162-167)
Example Lane Width Section (pages 168-178)
Key gaps in design and performance measures (page 161

IV. Future Activity

A. Research team comments

1. Work activities

2. Implementation techniques

B. Panel member responses

C. Consensus

V. Executive Session (If needed) – Panel Only

VI. Adjourn

NCHRP 15-48
Guidelines for Designing Low- and Intermediate-Speed Roadways that Serve All Users

Interim Report Panel Meeting
Wednesday, February 3, 2016, 9:00am-4:30pm
Room 202, TRB Keck Center, Washington D.C.

NCHRP Project Manager: David Reynaud

Principal Investigator: Marshall Elizer, P.E., PTOE, Gresham, Smith and Partners

Research Team: GS&P, MRIGlobal, Alta Planning

Agenda

- Introductions
- Key Goals for Today's Meeting
- Project Purpose and Scope Refresher
- Overview of Existing Guidance
- Discussion of Interim Report and Major Comments from Panel Review
- Work Plan for Phase II
  - Guidelines document intended audience, format, content, etc
  - Agency review/involvement
- Final Thoughts from Panel & Adjourn

PANEL MEETING
NCHRP 15-48: Guidelines for Designing Low- and Intermediate-Speed Roadways that Serve All Users
9:00am-4:30pm, February 3, 2016
Room 202, TRB Keck Center, Washington D.C.

9:00am-9:30am Introductions & Goals for Today's Meeting

9:30am-10:00am Project Scope & Schedule Refresher
- Project Scope
- Project Status & Schedule

10:00am-10:15am Overview of Existing Design Guidance

10:15am-11:45am Discussion of Draft Interim Report and Key Panel Comments (includes Break)
- Chapters 1 & 2 – Purpose of Report, Background (pages 1-16)
- Chapter 3 – Research Approach (pages 17-20)
- Chapter 4 – Phase I Work Tasks
  - Task 1 – Literature Review, Survey, Best Practices (pages 21-65)
  - Task 2 – Methods to Determine User Service Levels (pages 66-101)
  - Task 3 – Methods to Balance/Optimize Design Elements for All Users (102-118)
  - Task 4 – Geometric Design Framework (pages 119-158)

11:45am-12:45pm Lunch in TRB Cafeteria

12:45pm-2:00pm General Discussion on Key Research product – the Guidelines Document
- Low to intermediate speeds are 45mph and below. Should this document address these roadways in both urban and rural contexts?
- Who is the most important intended audience of the Guidelines?
- What is the best format, style and content for that audience to understand the needs of all users and how best to integrate them in the geometric design process?
- What are the key attributes that will make the document most successful in advancing the awareness, understanding and geometric design for all users?

2:00pm-2:15pm Break

2:15pm-3:45pm Continued Discussion of Draft Interim Report
- Task 5 – Phase II Work Plan
  - Key issues in Guidelines development (page 159-160)
  - Draft Guidelines Review with Focus Groups (page 161)
  - Example Guidelines Table of Contents (pages 162-167)
  - Example Lane Width Section (pages 168-178)
  - Key gaps in design and performance measures (page 161)

3:45pm-4:15pm Schedule Required to Meet Revised Project End Date of 10/31/2016

4:15pm-4:30pm Final Comments & Adjourn

Note: Schedule includes morning & afternoon breaks and lunch in TRB cafeteria

Introductions

- Panel and TRB Staff
- Research Team

  Gresham, Smith and Partners
  - Marshall Elizer
  - Jay Bockisch

  MRIGlobal Research Institute
  - Darren Torbic
  - Ingrid Potts
  - Doug Harwood

  Alta Planning + Design
  - John Cock
  - Nick Falbo
  - Hannah Kapell
  - Paul L. Wojciechowski

Key Goals for Today's Meeting

- Discuss findings, conclusions and feedback on Draft Interim Report
- Discuss Alternative Approaches for Phase II Work Plan
- Receive Panel direction on continuing work
  - Final Report content
  - Guidelines Document content
  - Guidelines Document development process

Why this NCHRP project?

Difficulties within the roadway design profession with understanding and balancing the needs of all legal roadway users in the design of low- and intermediate-speed roadways (45mph and less), especially within urban, suburban, town/village main street and other contexts where service to motorized users must be effectively integrated with non-motorized users and the surrounding land use context.

What are the considerations in designing for all users?

Project 15-48 Objective

The objective of this research is to develop a set of integrated guidelines that will help designers accommodate all users in the design of low- and intermediate-speed roadways, including:

- Methods that can be used to identify the mix of users that need to be served on various roadway functional classifications (context, area types, etc.) and speed categories (low and intermediate speeds);
- A methodology supported by empirically based research that can balance and optimize how geometric design elements provide for safe and effective operation;
- Geometric design parameters for the types and designs of facilities to serve all users, and;
- Examples showing how facilities representing various roadway functional classifications and speed categories have been or could be designed effectively.

Items to consider in development of the Guidelines:

- Performance metrics addressing operations and safety;
- Best practices for developing design policies, including those of local government;
- Best practices for implementation of multimodal projects;
- “Complete streets”;
- Constraints, e.g., right-of-way, roadside features, environmental, etc.;
- Balance among principal elements of design;
- Flexibility through:
  - Allocation of cross section design elements
  - Use of design exception process
  - Use of low cost options;
- Use of graphical illustrations;
- User groups and their needs;
- Use of *Highway Capacity Manual* & *Highway Safety Manual,* including intermodal chapters;
- Use geometric design & traffic control elements to create optimum roadway operation/safety for all users;
- Consistency with AASHTO, TRB, and ITE references;
- Create livable, sustainable communities; and
- Accessibility.

15-48 Final Deliverables Shall Include:

- A Final Report documenting the conduct of the research

- A standalone Guidelines document

Work Plan Project Task Refresher

- **Task 1** - The objective of Task 1 is to summarize the state of the knowledge and state of the practice in designing for safety and efficient travel of all users along low- and intermediate-speed roadways. This is being accomplished by conducting a thorough review of relevant literature and conducting a survey of state and local roadway design agencies.

- **Task 2** - The objective of Task 2 is to identify performance measures that will help designers accommodate all users in the design of low- and intermediate-speed roadways. Performance measures provide procedures and tools for comparing and evaluating alternative designs with respect to meeting overall project goals and objectives.

Work Plan Project Task Refresher

- **Task 3** - Building upon the findings of the literature review and agency survey in Tasks 1 and 2, Task 3 is to develop a range of alternative approaches that could assist designers and other design project stakeholders in the process of coordinating, balancing and "optimizing" the geometric design elements of a roadway project in low- and intermediate-speed environments.

- **Task 4** – In this task the research team has evaluated the methodologies developed in Task 3 against the full range of facility types and speed ranges that can be encountered in the design process for low-speed and intermediate-speed roadways. The goal of this task was to find the best balance of roadway classifications, speed ranges and user types around which to build the specific final work plan in Task 5 which will guide creation of the ultimate research product, the design guidelines document.

Work Plan Project Task Refresher

- **Task 5** – In Task 5 the research team has developed a recommended work plan to be executed in developing the guidelines document in Phase II of the project. The plan includes a recommended DRAFT table of contents for the guidelines document along with an example guidelines section on vehicle lane widths. The guidelines will address the methodologies for combining qualitative and quantitative performance measures across user types/modes and context for use in evaluating alternative designs for low- and intermediate-speed roadways. The research team will revise these products based on comments from the Panel and be included in the updated work plan for Phase II.

- **Task 6** – This task includes finalizing the Interim Report and Updated Work Plan for Phase II as provided by this Preliminary Draft Interim Report and subsequent direction from the project Panel and TRB. The final Interim Report will describe the work completed in the Phase I tasks and also include the updated Work Plan for Phase II of the project. The research team will not begin work on any Phase II tasks until the updated work plan is approved by NCHRP.

Work Plan Project Task Refresher

- **Task 7—Execute Updated Work Plan -** This task consists of working through the steps and activities as will be specifically presented in detail in the Updated Work Plan. This is the work that will use the research findings in the previous tasks to establish the foundation material for development of the recommended guidelines document.

- **Task 8—Develop Preliminary Draft Guidelines and Preliminary Draft Final Report -** This task the two major products of the research – the guidelines document and the final report. The goal of the research team is to provide a guidelines document that will serve as a companion to the AASHTO Green Book and other definitive geometric design guidance documents. The guidelines will be easy to understand and work with given the significant use of graphics and photographic examples of successful geometric design techniques and applications for low- and intermediate-speed roadways. The guidelines should establish the definitive, recommended practice for how to effectively design low-speed and intermediate-speed roadways that balance safety, service and accommodation for all present and planned users.

Work Plan Project Task Refresher

- **Task 9—Develop Final Report and Guidelines -** In this final task, the guidelines document will be revised based on the results of the agency evaluation program in combination with comments provided by the NCHRP and project panel. The final report will also be prepared, documenting all aspects of the research project including the formulation and test application of the recommended guidebook components, an analysis of the evaluation program results, and recommended areas for additional research required to improve the long-term implementation of design criteria and processes that serve all users in low- and intermediate-speed roadways.

Overview of Existing Geometric Design Guidance

Guidance at the Federal Level

United States Department of Transportation Policy Statement on Bicycle and Pedestrian Accommodation Regulations and Recommendations

March 2010

The DOT policy is to incorporate safe and convenient walking and bicycling facilities into transportation projects.

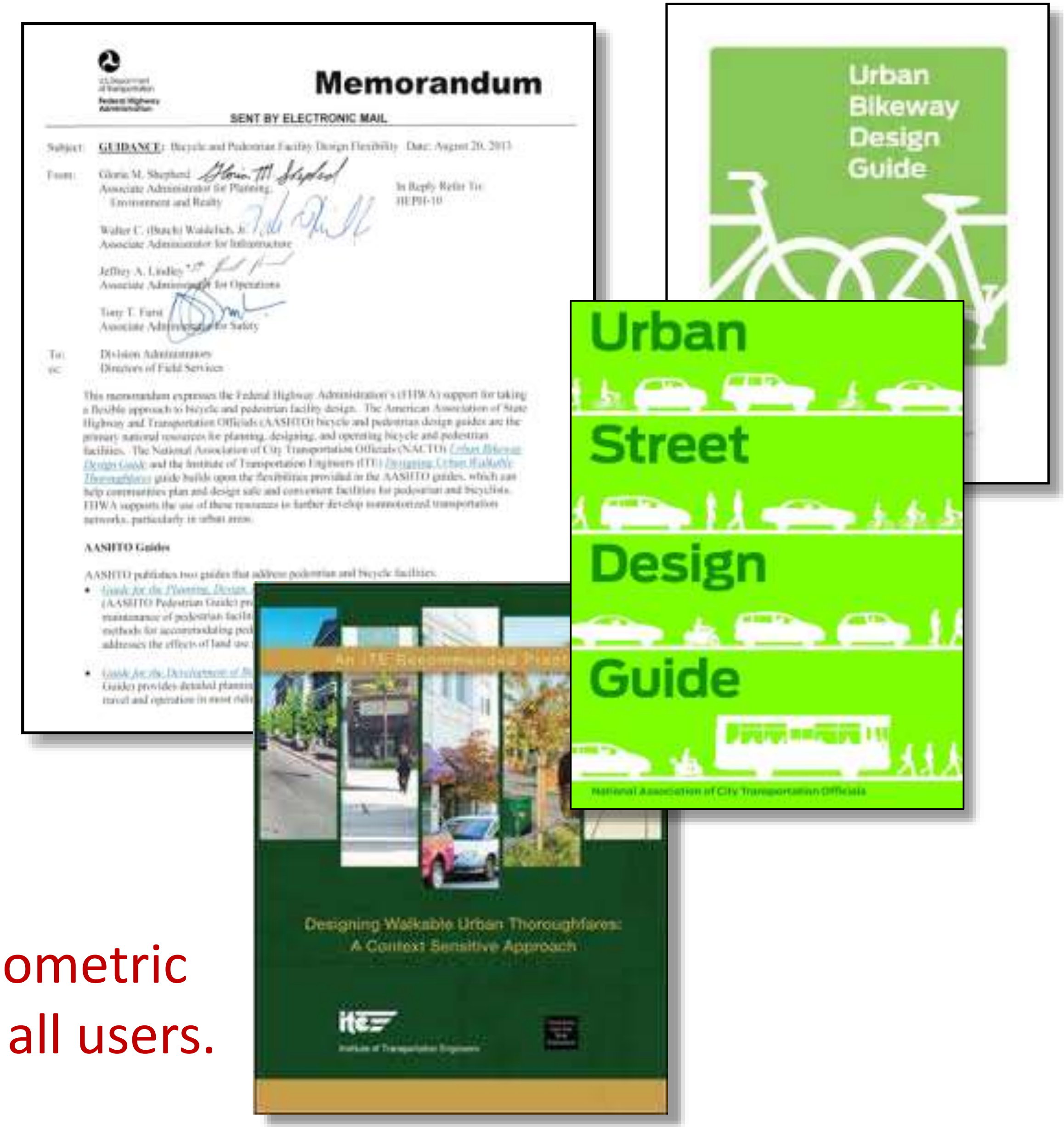
Every transportation agency, including DOT, has the responsibility to improve conditions and opportunities for walking and bicycling and to integrate walking and bicycling into their transportation systems.

…transportation agencies are encouraged to go beyond minimum standards to provide safe and convenient facilities for these modes.

http://www.fhwa.dot.gov/environment/bicycle_pedestrian/overview/policy_accom.cfm

August 2013 FHWA Guidance

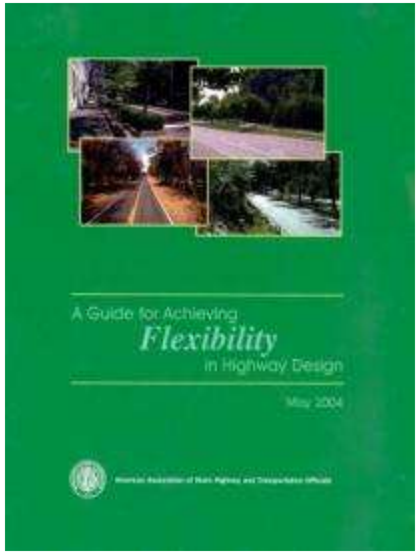
- Expresses FHWA's support for flexible approaches to design of bicycle & pedestrian facilities.
- Recognizes AASHTO's bicycle & pedestrian design guides as the primary national resources for bicycle and pedestrian facilities.
- Notes that NACTO's *Urban Bikeway Design Guide* and ITE's *Designing Urban Walkable Thoroughfares* guide build on flexibilities provided in the AASHTO guides.

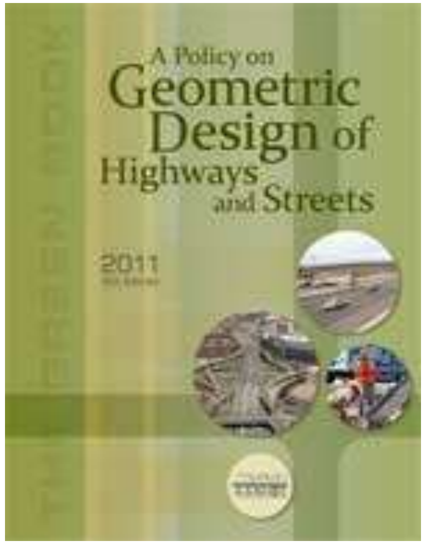


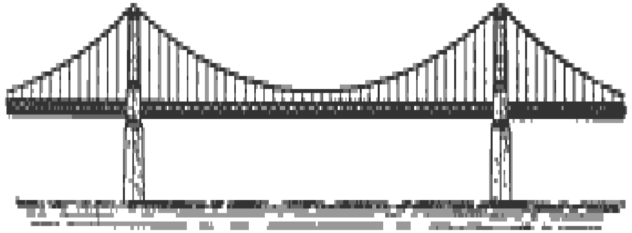
Use of *flexibility* is a key ingredient in balancing geometric design for the mobility, safety and convenience of all users.

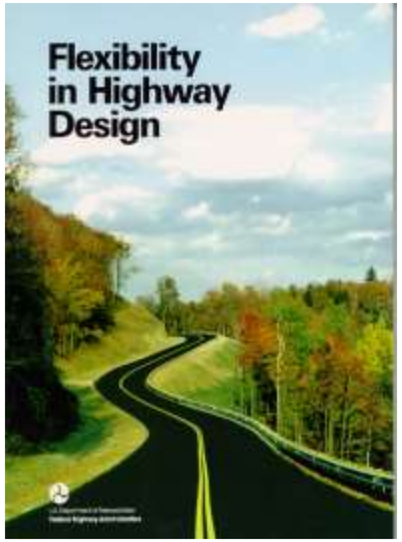
“Bridging” Flexibility in Highway Design

- **Joint effort of FHWA & AASHTO**
- **Central theme of 1998 T*hinking Beyond the Pavement Conference***
- **Led to CSD/CSS initiatives**



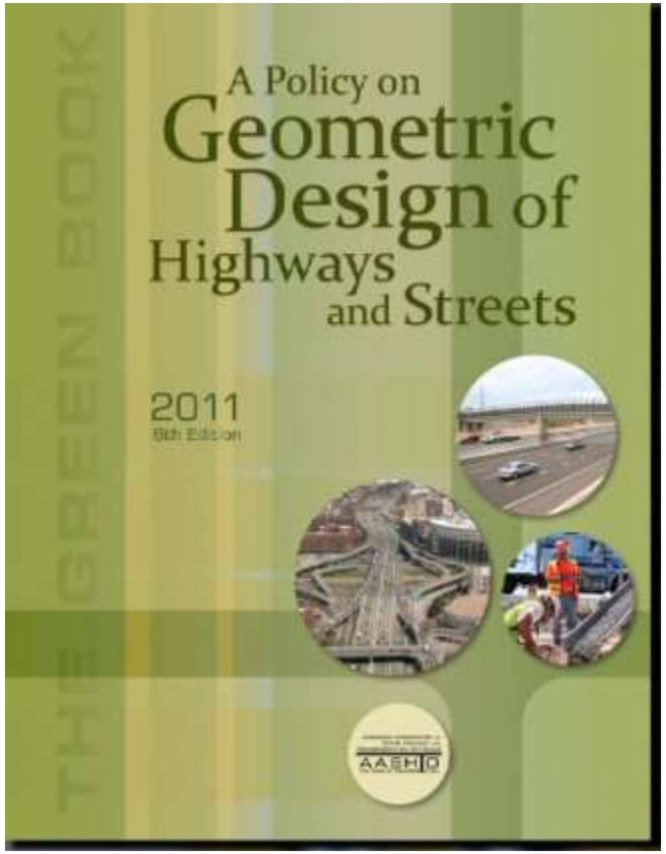






AASHTO "Green Book"

- Foundation of US geometric design policy
- State (and some local) street/highway design manuals often derive from, and explicitly reference, the AASHTO Green Book
- Must be used for NHS (National Highway System) projects



But…the Green Book is Not a Design Manual

"The intent of this policy is to provide guidance to the designer by referencing a recommended range of values for critical dimensions.

It is not intended to be a detailed design manual that could supersede the need for the application of sound principles by the knowledgeable design professional. "

Green Book Foreword, 2011

Broad Design Guidance Exists

- AASHTO/FHWA: Green Book and numerous other design references
- Other <u>national</u> guidelines & best practices
- State DOT design manuals, guidelines, standards
- Local agency manuals, standards and guidelines

Other National Guidance

An Excellent Document

Designing Walkable Urban Thoroughfares: A Context Sensitive Approach

- Covers a wide range of issues and challenges in urban complete streets design
- Provides specific guidance on many design features, techniques and tools
- Relates guidance to AASHTO policy !

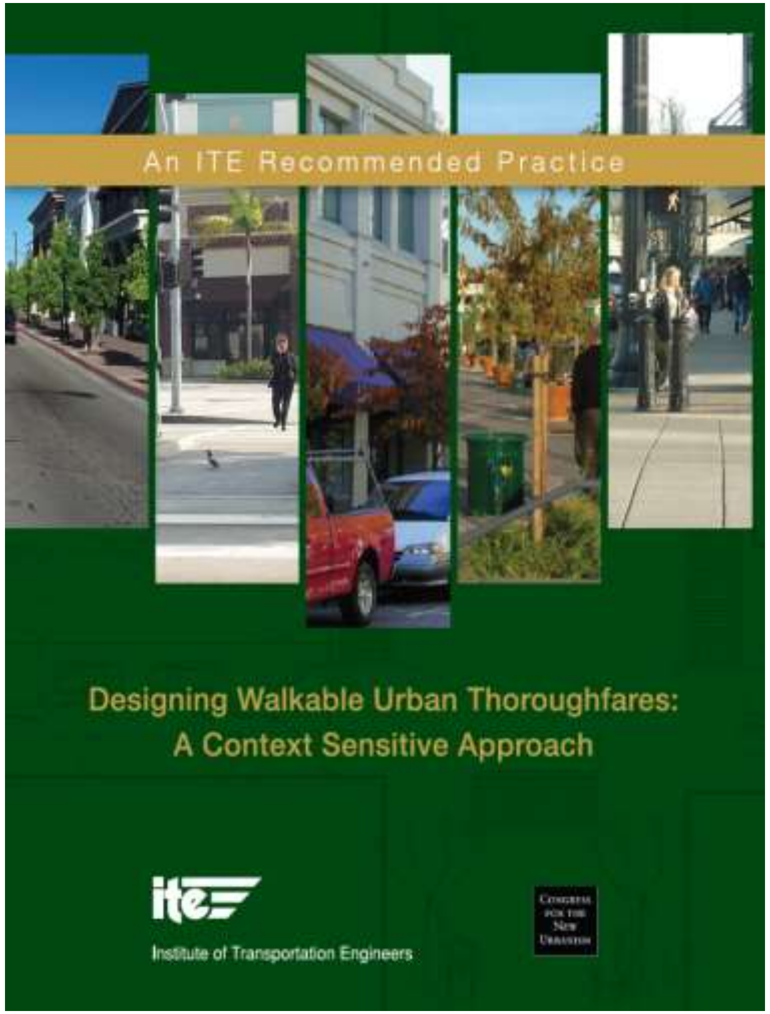
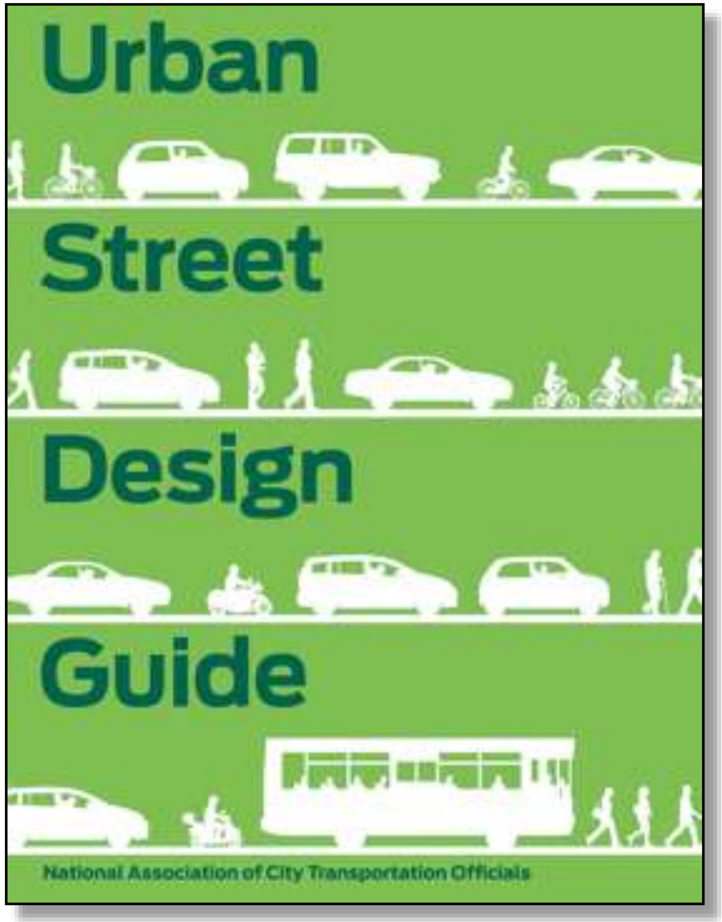


Table 6.4 Design Parameters for Walkable Urban Thoroughfares

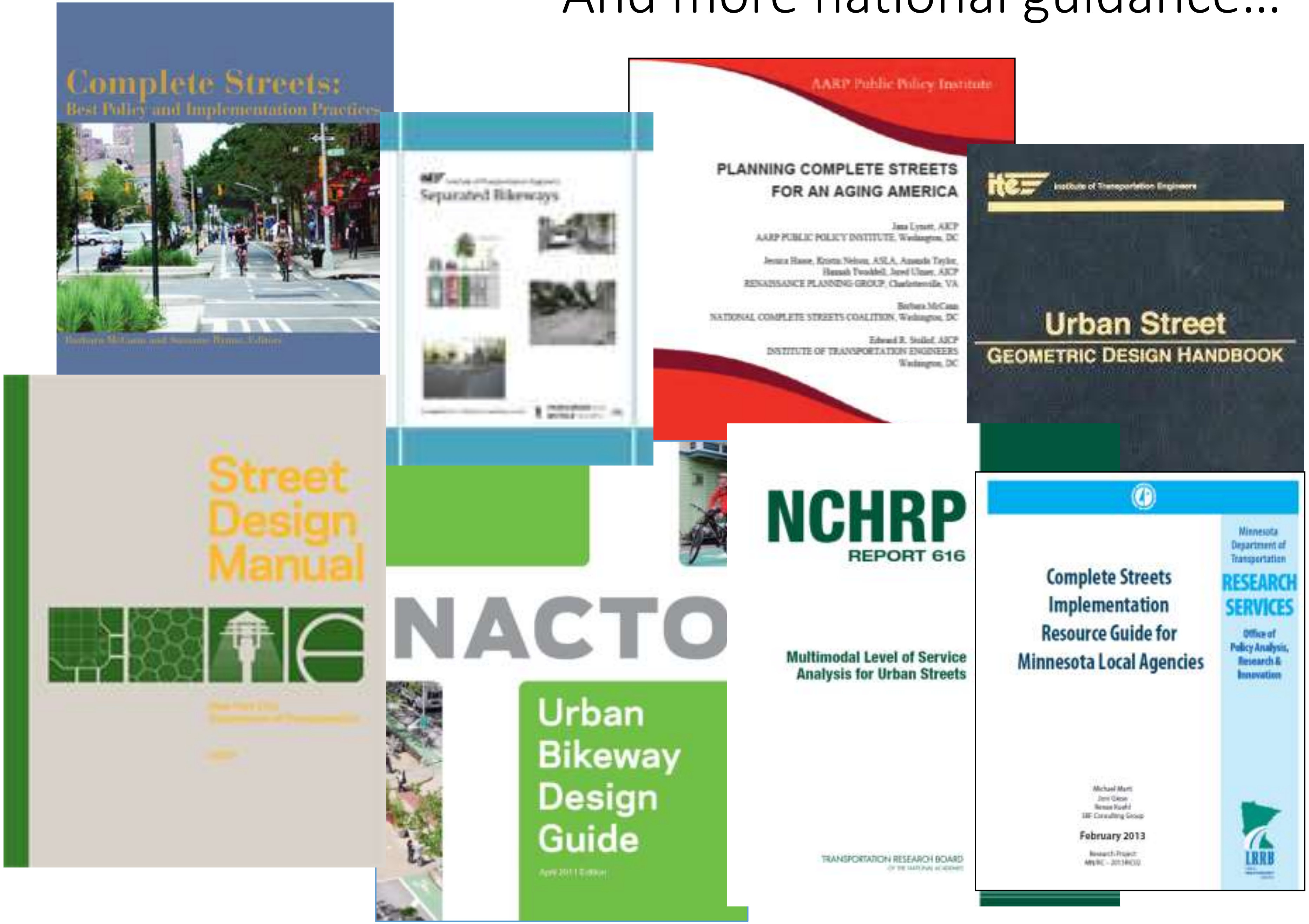
Thoroughfare Design Parameters for Walkable Mixed–Use Areas									
	Suburban (C–3)						General Urban (C–4)		
	Residential			Commercial			Residential		
	Boulevard [1]	Avenue	Street	Boulevard [1]	Avenue	Street	Boulevard [1]	Avenue	Street
Context									
Building Orientation (entrance orientation)	front, side	front, side	front, side	front, side	front, side	front, side	front	front	front
Maximum Setback [2]	20 ft.	20 ft.	20 ft.	5 ft.	5 ft.	5 ft.	15 ft.	15 ft.	15 ft.
Off-Street Parking Access/Location	rear, side	rear, side	rear, side	rear, side	rear, side	rear, side	rear	rear, side	rear, side
Streetside									
Recommended Streetside Width [3]	14.5–16.5 ft.	14.5 ft.	11.5 ft.	16 ft.	16 ft.	15 ft.	16.5-18.5 ft.	14.5 ft.	11.5 ft.
Minimum sidewalk (throughway) width	6 ft.	6 ft.	6 ft.	6 ft.	6 ft.	6 ft.	8 ft.	6 ft.	6 ft.
Pedestrian Buffers (planting strip exclusive of travel way width) [3]	8 ft. planting strip	6–8 ft. planting strip	5 ft. planting strip	7 ft. tree well	6 ft. tree well	6 ft. tree well	8 ft. planting strip	8 ft. planting strip	6 ft. planting strip
Street Lighting	For all thoroughfares in all context zones, intersection safety lighting, basic street lighting, and pedestrian-scaled lighting is recommended. See Chapter 8 (Streetside Design Guidelines) and Chapter 10 (Intersection Design Guidelines).								
Traveled Way									
Target Speed (mph)	25–35	25–30	25	25–35	25–35	25	25–35	25–30	25
Number of Through Lanes [5]	4–6	2–4	2	4–6	2–4	2	4–6	2–4	2
Lane Width [6]	10–11 ft.	10–11 ft.	10–11 ft.	10–12 ft.	10–11 ft.	10–11 ft.	10–11 ft.	10–11 ft.	10–11 ft.
Parallel On-Street Parking Width [7]	7 ft.	7 ft.	7 ft.	8 ft.	7-8 ft.	7-8 ft.	7 ft.	7 ft.	7 ft.
Min. Combined Parking/Bike Lane Width	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.
Horizontal Radius (per AASHTO) [8]	200–510 ft.	200–330 ft.	200 ft.	200–510 ft.	200–510 ft.	200 ft.	200–510 ft.	200–330 ft.	200 ft.
Vertical Alignment	Use AASHTO minimums as a target, but consider combinations of horizontal and vertical per AASHTO Green Book.								
Medians [9]	4–18 ft.	Optional 4–16 ft.	None	4–18 ft.	Optional 4–18 ft.	None	4–18 ft.	Optional 4–16 ft.	None
Bike Lanes (min./preferred width)	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft. / 6 ft.	5 ft. / 6 ft.
Access Management [10]	Moderate	Low	Low	High	Moderate	Low	Moderate	Low	Low
Typical Traffic Volume Range (ADT) [11]	20,000–35,000	1,500–25,000	500–5,000	20,000–50,000	1,500–35,000	1,000–10,000	10,000–35,000	1,500–20,000	500–5,000
Intersections									
Roundabout [12]	Consider urban single–lane roundabouts at intersections on avenues with less than 20,000 entering vehicles per day, and urban double–lane roundabouts at intersections on boulevards and avenues with less than 40,000 entering vehicles per day.								
Curb Return Radii/Curb Extensions and Other Design Elements	Refer to Chapter 10 (Intersection Design Guidelines)								

Other National Guidance

- 2013 - National Association of City Transportation Officials (NACTO)
- Guidance for creating urban streets where people can safely walk, bicycle, drive, take transit, and socialize.
- Provides a toolbox and concepts intended for cities to use to make streets safer, more livable, and more economically vibrant.



And more national guidance…

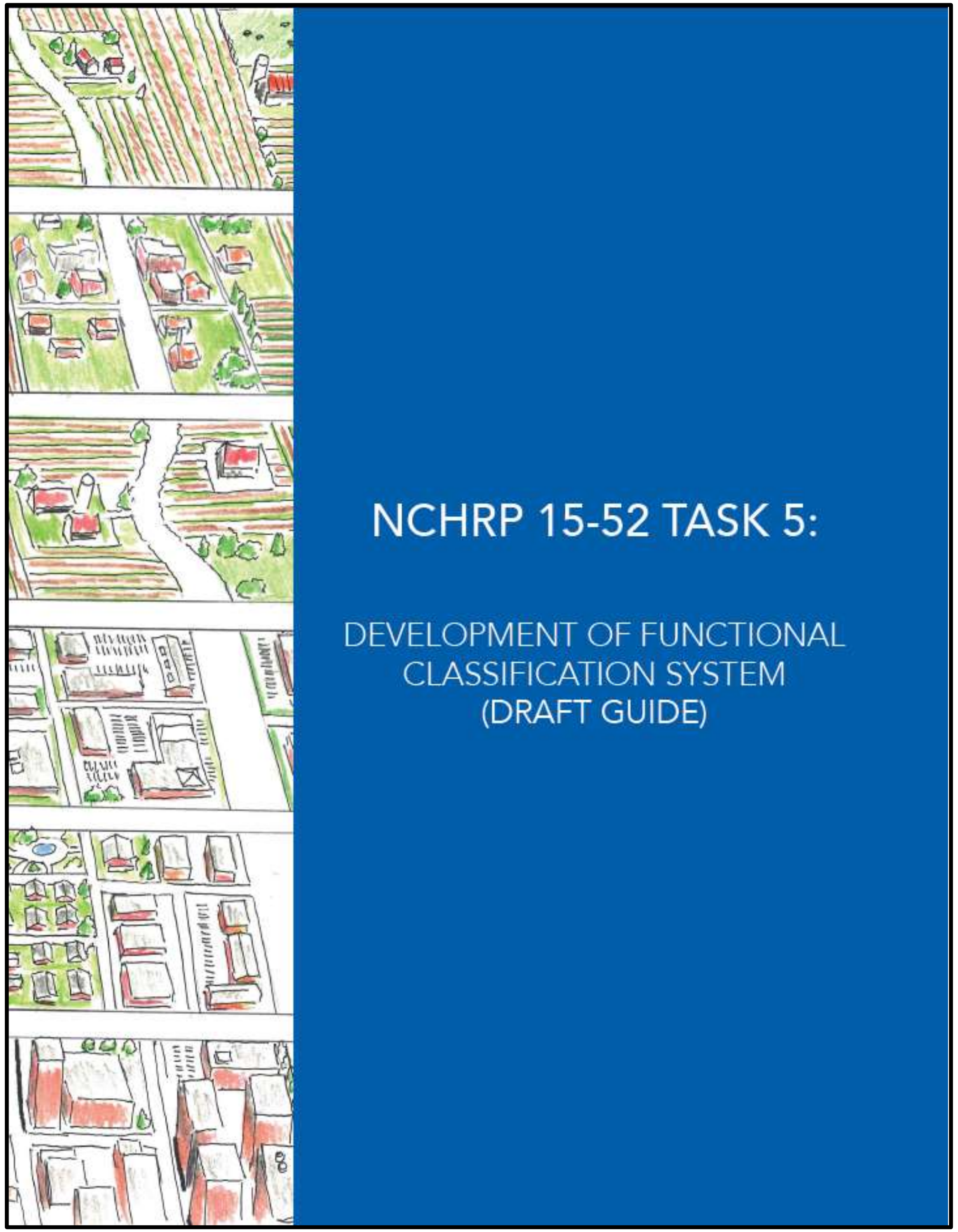


And even more…

Related Current Research

NCHRP 15-52 Developing a Context-Sensitive Functional Classification System for More Flexibility in Geometric Design

The objective of this research is to identify potential improvements to the traditional functional classification system to better incorporate the context, user needs, and functions of the roadway facility. The potential improvements should lead to a flexible framework that can be used by planners and designers in the development of optimal geometric design solutions.



DRAFT Figure 13

Context / Roadway	Rural	Rural Town	Suburban	Urban	Urban Core
Principal Arterial	H speed H mobility-L access	L speed M mobility-L access	H speed M mobility-L access	M speed M mobility-M access	L speed M mobility-M access
	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC, CC: M separation	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC, CC: M separation
	P1: NA; P2: Min; P3, P4: Enhanced	P2: Min; P3: Wide ; P4:Enhanced	P1: NA; P2: Min;P3: Wide; P4: Wide	P2: Min; P3: Wide; P4: Enhanced	P3: Wide; P4:Enhanced
Minor Arterial	H speed H mobility-M access	M speed M mobility-H access	M speed M mobility-M access	M speed M mobility-M access	L speed M mobility-M access
	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC, CC: M separation	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC, CC: M separation	LC: L separation; NC, CC: M separation
	P1, P2: NA; P3, P4: Enhanced	P2: Min; P3: Wide ; P4:Enhanced	P1: NA; P2: Min;P3: Wide; P4: Wide	P2: Min; P3: Wide; P4: Enhanced	P3: Wide; P4:Enhanced
Collector	M speed M mobility-M access	L speed M mobility-H access	M speed M mobility-H access	L speed M mobility-H access	L speed M mobility-H access
	LC: L separation; NC, CC: M separation	LC, NC: L separation; CC: M separation	LC: L separation; NC, CC: M separation	LC: L separation; NC, CC: M separation	LC, NC: L separation; CC: M separation
	P1, P2: NA; P3, P4: Enhanced	P2: Min; P3: Wide ; P4:Enhanced	P1: NA; P2: Min;P3: Wide; P4: Wide	P2: Min; P3: Wide; P4: Enhanced	P3: Wide; P4:Enhanced
Local	M speed M mobility-M access	L speed M mobility-L access	L speed L mobility-H access	L speed L mobility-H access	L speed L mobility-H access
	LC, NC, CC: L separation	LC, NC, CC: L separation	LC, NC, CC: L separation	LC, NC, CC: L separation	LC, NC, CC: L separation;
	P1, P2: NA; P3, P4: Enhanced	P2: Min; P3: Wide ; P4:Enhanced	P1: NA; P2: Min;P3: Wide; P4: Wide	P2: Min; P3: Wide; P4: Enhanced	P3: Wide; P4:Enhanced

Speed, Mobility, Accessibility and Separation levels: H: High; M: Medium; L: Low
Bicycle levels: LC: Local; NC: Collector; CC: Arterial
Pedestrian traffic levels: P1: rare/occasional; P2: low; P3: medium; P4: high
Pedestrian facility width: NA not appropriate; Min: minimum; Wide: greater than minimum; Enhanced: wide for large congregating pedestrian groups

Figure 13 1552-FCS matrix

Context / Roadway	Rural	Rural Town
Principal Arterial	H speed H mobility-L access	L speed M mobility-L access
	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC, CC: M separation
	P1: NA; P2: Min; P3, P4: Enhanced	P2: Min; P3: Wide ; P4:Enhanced
Minor Arterial	H speed H mobility-M access	M speed M mobility-H access
	LC: L separation; NC: M separation; CC: H separation	LC: L separation; NC, CC: M separation
	P1, P2: NA; P3, P4: Enhanced	P2: Min; P3: Wide ; P4:Enhanced

NCHRP 15-47 [Active]
Developing an Improved Highway Geometric Design Process

The objectives of this research are to (1) develop a comprehensive, flexible design process to meet the needs of geometric designers in the future and (2) update AASHTO's *Guidelines for Geometric Design of Very Low-Volume Roads.* The design process (Objective 1) must consider:

- Specification of the project purpose and need, including the modes that will be using the facility.
- Context setting of the facility.
- Desired performance outcomes for the facility for the various modes; including safety, mobility, and access management.
- Methods for evaluating tradeoffs associated with different design alternatives.
- Optimization of the design given the project’s financial and other constraints.
- Flexibility to address issues that arise from stakeholder involvement or environmental reviews.
- Documentation of decisions to address tort liability concerns.

NCHRP 15-63 [Pending]
Guidance to Improve Pedestrian and Bicycle Safety at Intersections

The objective of this research is to develop guidance for transportation practitioners to improve pedestrian and bicycle safety at intersections through design and operational treatments that:

(1) identifies and evaluates current practices, and emerging technologies and trends, in the U.S. and internationally;

(2) describes current best practices for measuring the effectiveness of such intersection treatments;

(3) evaluates safety outcomes of specific intersection treatments using quantitative measures; and

(4) identifies and ranks strategies, processes, and relationships that could accelerate the adoption of improved pedestrian and bicycle intersection design and operational treatments.

NCHRP 03-112 [Active]
Operational and Safety Considerations in Making Lane Width Decisions on Urban and Suburban Arterials

The objectives of this research are:

(1) to investigate the effects of urban and suburban arterial lane widths on operations and safety for all users,

(2) produce guidelines for practitioners to determine lane configuration for reconstruction and new construction projects, and

(3) propose appropriate revisions to the AASHTO Green Book.

Discussion of Interim Report

Discussion:
Key Findings & Conclusions from Phase I Effort

1. Lack of Understanding of How to Best Evaluate and Balance Level and Quality of Service for All Modes

Discussion:
Key Findings & Conclusions from Phase I Effort

2. Lack of Nationally-Recognized Detailed Guidance for Design of Multimodal Facilities

Discussion:
Key Findings & Conclusions from Phase I Effort

3. Lack of Understanding of Context and How to Address it in the Geometric Design Process

Discussion:
Key Findings & Conclusions from Phase I Effort

4. Over-reliance on Standards versus Use of Engineering Judgment (liability concerns)

Discussion: Key Findings & Conclusions from Phase I Effort

5. Challenges to Applying Available Design Flexibility to Create Unique Designs (liability concerns)

Panel Comments on Draft Interim Report - Key Items

4.2. Task 2: Methods to Determine User Service Levels

The objective of Task 2 is to identify performance measures and performance relationships that will help designers accommodate all users in the design of low- and intermediate-speed roadways. Performance measures provide procedures and tools for comparing and evaluating alternative designs with respect to meeting overall project goals and objectives.

4.2.1 Level and Quality of Service

From an operational perspective, level of service (LOS) criterion for motorized vehicles from procedures defined in the Highway Capacity Manual (HCM) has traditionally served as the primary performance measure for evaluating the quality of alternative roadway designs. However, recently with the trend toward performance-based design, development of multi-modal levels of service (e.g., NCHRP 616, TCRP 165, Florida DOT's 2013 Quality/Level of Service Handbook), publication of the Highway Safety Manual (HSM), numerous state and local complete street design guidelines, and extensive information on context sensitive design solutions and design flexibility, there is a recognized need to identify performance measures that can be used to evaluate the design of a roadway based upon how it meets the overall needs of all users/modes: automobile/truck, pedestrian, bicycle, and transit. Additionally, the various modes in a project interact with each other and improvements made in the quality of service for one mode may often improve or lower the quality of service one or more other modes.

Performance measures can cover a range of multimodal criteria including mobility, safety, accessibility, comfort, etc. For example, this could involve identifying operations measures for each mode such travel speed, delay, convenience, accessibility, LOS, etc. by user/mode. From a safety perspective, this would involve identifying measures for each mode such as expected number of total crashes or crashes by severity, expected number of fatalities and injuries (by severity), expected number of crashes by collision type, crash exposure, etc. And from a sustainable transportation perspective, performance measures could include transit accessibility/productivity, bicycle/pedestrian mode share, vehicle-miles traveled (VMT) per capita, levels of "bike-ability" or "walk-ability", aesthetics, air quality impacts, etc. many of these measures will need to be classified according to whether they are multimodal or mode-specific or guidance on how the measures should differ depending upon the roadway speed range (i.e., low- or intermediate-speed), functional classification and context.

Developing quantifiable performance measures requires data. As part of this task, the research team has identified the types of data necessary for quantifying selected performance measures and potential sources for the data. It is recognized, however, that any performance measure that either requires a significant amount of data, particularly if the data are difficult to obtain, or requires a significant amount of resources to collect the data, will be utilized at best for a limited number of projects and will be quickly abandoned in professional design use. In addition, even if the data is obtainable but the process to collect, analyze and evaluate the data is complex and time-consuming, the designer will probably choose to revert to qualitative, experience-based decisions rather than the more precise quantitative assessment.

Author: Reviewer #1 Subject: Comment on Text Date: 12/17/2015 3:29:49 PM

Quantitative assessments may be more precise, but not necessarily more correct. "Reverting" to qualitative, experience-based decisions is not necessarily bad.

measure serves as an overall indicator of LOS for a signalized intersection from a multimodal perspective.

Using weighted factors based on percent trip, number of fatal crashes (or crashes, in general) and crash rates to compute multimodal LOS score may help evaluate and plan transportation infrastructure to better serve all the modes of transportation at signalized intersections. Such analysis using the proposed method could help identify modes that require attention from travel demand as well as from a safety point of view. A sensitive and thorough interpretation of combined and individual scores and the multimodal LOS is required for using the method to its fullest extent.

4.2.3 Conclusions

There are a wide variety of tools available to geometric designers to assess the level and quality of service to all modes using low and intermediate streets. These tools range from detailed quantitative processes requiring considerable field data collection and mathematical analysis to more simple qualitative methods. Overall, these tools can assist designers in evaluating changes to the street and guide future improvements. However, their ability to measure the effectiveness of evolving innovative treatments, such as separated bike lanes, is limited.

The leading geometric design LOS tool used by roadway design agencies is the Highway Capacity Manual and it's analysis software. Many agencies and professionals consider the HCM analysis to be the most comprehensive and thorough LOS available. However, several literature sources expressed concern with the difficulty in using this tool and concerns about the relationship of its bicycle, pedestrian and transit level and quality of service findings to actual field conditions and user group perceptions. Some of the observations and concerns stated by users of these software analysis tools include:

Pedestrian LOS
- Requires extensive data inputs, many of which must be measured in the field.
- May not be feasible as a stand-alone measure (significantly integrated with HCM 2010 Auto LOS measure).
- Pedestrian LOS score is heavily influenced by auto traffic volumes, which are difficult to mitigate in a planning or engineering context.

Pedestrian Delay at Signalized Intersections
- Limited application
- Not responsive to typical intersection improvements

Pedestrian Delay at Unsignalized Intersections
- Method is less accurate in conditions with vehicle platooning or heavy directional bias
- Not accurate for undivided streets with more than four through lanes
- LOS is heavily influenced by auto traffic volumes, which are difficult to mitigate in a planning or engineering context

Author: Reviewer #1 Subject: Comment on Text Date: 12/17/2015 3:29:49 PM
clarify that this is largely about width of walkways and crosswalks. Also largely limited to locations with large volumes.

Author: Reviewer #1 Subject: Comment on Text Date: 12/17/2015 3:29:49 PM
I disagree this is limited. I've used this (from the 2000 HCM) numerous times to counter vehicle delay at intersections. And it is responsive to changes in signal timing.

Bicycle LOS

- Requires significant data inputs, many of which must be measured in the field.
- May not be feasible as a stand-alone measure (reliant on HCM 2010 auto LOS measures).
- Heavily biased towards off-street facilities; difficult to get an "A" score for on-street lanes.

Transit LOS

- Requires extensive data inputs, many of which must be measured in the field.
- May not be feasible as a stand-alone measure as it requires user to calculate Pedestrian LOS, which is significantly integrated with HCM 2010 Auto LOS measure.

In the research teams agency interviews and review of agency design guidance, we did not find evidence of extensive use of the HCM tools for evaluating and designing multimodal projects. While all agencies knew the HCM tools existed, it appears that the this analysis method is being selectively used for possibly larger and more complex projects that involve major investment such as lengthy corridor improvements.

We found that other types of level/quality of service tools are being selectively applied by agencies for some projects. For example, there are a number of other available level/quality of service tools available to designers beyond the HCM and several of these were discussed earlier in this chapter. They include:

- Florida DOT – Quality/Level of Service Handbook
- Transit Capacity and Quality of Service Manual, 3rd Edition, TCRP Report 165
- San Francisco Department of Public Health – Pedestrian and Bicycle Environmental Quality Indices
- Fort Collins, Colorado - Multimodal Transportation Level of Service Manual
- City of Charlotte, North Carolina – Multimodal LOS Standards for Signalized Intersections
- City of Charlotte, North Carolina – Pedestrian & Bicycle Level of Service Methodology for Crossings at Signalized Intersections
- King County Washington (Seattle) – Multimodal LOS - A Guide to Incorporating Alternative Modes of Transportation into Local Jurisdictions' Roadway Performance Measurements
- Flagstaff, Arizona MPO – Level of Service Guidelines for Pedestrian, Bicycle and Transit Facilities
- Mineta Transportation Institute - Low-Stress Bicycling and Network Connectivity
- Bicycle LOS (BLOS) Model – Sprinkle Consulting
- Pedestrian LOS (PLOS) Model – Sprinkle Consulting
- Multimodal LOS Toolkit – Fehr & Peers

The design guidelines produced by this research project will identify these various tools and provide guidance for which methodologies may be most appropriate to use for different ranges of roadway types, speed ranges, multimodal accommodation priorities and context settings.

Author: Reviewer #1 Subject: Comment on Text Date: 12/17/2015 3:29:49 PM

I disagree. Most of the base data (width, volume, truck designation, on-street parking) you can derive from either aerial maps or a quick survey. And it's quite useful for a comparative analysis.

4.3 Task 3: Methods to Balance / Optimize Geometric Design Elements for all Users

Building upon the findings of Tasks 1 & 2, the research team has developed a range of alternative approaches that could assist designers and other design project stakeholders in the process of coordinating, balancing and "optimizing" the multimodal geometric design elements of a roadway project in low- and intermediate-speed environments.

The literature and best practice review in Task 1 has confirmed that there is no generally accepted or "best practice" for balancing service to all modes in the geometric design process. In fact, the process of balancing and "optimizing" the level, quality and safety of service to all modes in any multimodal project depends on an evaluation of many factors including (1) establishing minimum accommodations for each mode, (2) selecting performance metrics that support project outcomes, (3) addressing context-sensitivity, (4) understanding community values and (5) achieving the priorities of the responsible roadway agencies.

4.3.1 Multimodal Design Elements

At this time the research team believes the following design elements and considerations will need to be addressed in the guidelines to address how they are balanced and optimized for varying conditions through the design process.

Roadway Design Cross-Section Areas

- Traveled Way
- Roadside
- Intersections

Roadside Design

- Roadside Width
- Functional Zone Requirements (Edge, Furnishings, Throughway, and Frontage zones)
- Context of adjacent land use
- Driveway Crossings
- Lighting
- Utilities, stormwater, snow removal/storage, traffic control consideration

Traveled Way Design

- Number/Type/Width of Lanes
- Total Traveled Way Width
- Medians
- Lateral Clearance
- Bicycle Lanes
- On-Street Parking Type & Width
- Midblock Pedestrian/Bicycle Crossings
- Midblock Curb Extensions
- Raised Crosswalks
- Geometric Transition Design
- Driveway Approaches
- Pedestrian Refuge Islands
- Transit Facility Design (lanes, stations, etc)
- Bus Stops
- Stormwater Management Consideration
- Snow Removal Consideration
- Lighting
- Utility Coordination
- Traffic Control Features

Author: Reviewer #1 Subject: Sticky Note Date: 12/17/2015 3:29:49 PM
I suggest 4 cross-section zones and 2 intersection zones. See Complete Streets Chicago or NACTO USDG.
X-S: pedestrian (roadside in rural), interstitial, traveled way, median
intersection: intersection, midblock (including driveways)

Author: Reviewer #1 Subject: Comment on Text Date: 12/17/2015 3:29:49 PM
I think we really need to get away from the concept of Roadside Design, or at least specify it applies only to rural roads. In urban areas, this is where the people and houses are, and to consign it to the "roadside" is highly pejorative.

Author: Reviewer #1 Subject: Comment on Text Date: 12/17/2015 3:29:49 PM
many of the items listed below (parking, curb extensions, bus stops, driveways) are not within the traveled way.

4.5 Task 5 - Recommended Work Plan for Phase II

Key findings and conclusions drawn from Tasks 1 through 4 are outlined below. A key goal of the guidelines produced by this project is to address each of these items by providing specific guidance in each area.

1. Challenges in Evaluating and Balancing Level and Quality of Service for All Modes

Multimodal level of service continues to be a challenging and evolving topic. While the 2010 Highway Capacity Manual (HCM) provided the profession with a multimodal approach to perform capacity and quality analyses to help make decisions on designs for automobile and non-automobile modes, it does not appear to have been widely accepted nor used by most design professionals and agencies. The primary reasons appear to be founded in concerns about data requirements and the complexity of the operational models, among other concerns.

Alternative approaches to assessing service levels have been developed and are in wide-spread use today, and many professionals have noted the limitations of the HCM methods for certain types of projects and user mixes. In general, design professionals are attempting to use less data-intensive analytics and processes (especially for smaller, retrofit projects) to guide what are in many situations more qualitative than quantitative decisions on balancing and providing service to non-automobile modes.

2. Lack of Nationally Recognized Central Guidance for Design of Multimodal Facilities

There is a significant void in nationally-accepted geometric design guidance for multimodal facilities on low and intermediate-speed facilities, be they local, collector or arterial classification roadways. For example, while there are numerous references throughout AASHTO's Green Book advising roadway designers to consider land use context and pedestrian, bicycle and transit users where appropriate, there is very little specific guidance to the user on how to accomplish these goals in the geometric design process.

It appears that this situation has helped generate the development of several alternative multimodal design sources that includes documents such as ITE's *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* (3) and NACTO's *Urban Bikeway Design Guide* (4) and *Urban Street Design Guide (5)* (each of these have been specifically mentioned in recent bicycle and pedestrian design flexibility guidance memorandums from FHWA). Additionally, supplements or revisions to several state DOT roadway design manuals (e.g., North Carolina, Massachusetts, Oregon, Georgia, Wisconsin, California) have been developed to address local multimodal needs, and literally hundreds of local governments in the U.S. have developed local policies and guidelines to address what they consider "complete streets" needs addressing all users.

Author: Reviewer #1 Subject: Comment on Text Date: 12/17/2015 3:29:49 PM
I disagree. The NACTO USDG has become this.

as possible, avoiding unique solutions is not the answer. This may undermine design practice and limit growth in the engineering profession. Designers need to remember that their skills, experience, and judgment are still valuable tools that should be applied to solving design problems and that, with reliance on complete and sound documentation, tort liability concerns need not be an impediment to achieving good road design.

Recommendations for Phase II Work Plan

In this task the research team has developed a recommended approach to be executed in developing the guidelines document in Phase II of the project. The plan includes these elements for the Panel's review:

- a recommended DRAFT table of contents for the guidelines document, edited to address earlier comments from the Panel; and

- an example guidelines section (10.1) on vehicle lane widths. This draft section is intended to be representative of the level of content provided for each of the design element sections so that the Panel can provide feedback on what they feel is the most appropriate guidelines content.

The research team will revise these example products based on comments from the Panel. This updated approach will be included in the updated work plan for Phase II.

The recommended work plan also suggests that once the draft guidelines document is prepared, it would be shared for review and comments with a focus group of twelve (12) to fifteen (15) state DOT and local transportation agencies representing (a) a diversity of geographic and climatic conditions, and (b) having varying levels of advanced multimodal design experience and documentation. These agencies would be selected from the group identified in Based on the review feedback, three (3) selected state or local roadway agencies would be visited by the research team to discuss and obtain more specific recommendations for how the guidelines can be more useful and beneficial to transportation designers. The lessons learned from these agencies will help to validate and define the specific types and level of guidance that will be developed as the research progresses into a comprehensive design guidance document.

Finally, the research team will develop a prioritized list of key gaps in knowledge associated with performance measures across user types/modes. Our initial thoughts for areas to be addressed include:

- Pedestrian safety prediction methodology for urban and suburban roadway segments
- Bicycle safety prediction methodology for urban and suburban roadway segments
- Transit stop safety prediction methodology for urban and suburban roadway segments

Author: Reviewer #1 Subject: Sticky Note Date: 12/17/2015 3:29:49 PM
I would add that reliance on state DOTs for design guidance of local streets is a main reason why the street are designed for driving, not living.

Chapter 3. Considerations in the Multimodal Design of Low- and Intermediate-Speed Roadways
a. Purpose and Objectives b. User Definition, Characteristics and Human Factors c. Consideration of All Users in the Project Development and Design Process d. Understanding Design Controls and Criteria for All Modes e. Functional System Considerations: Roadway, Bicycle, Pedestrian and Transit Networks f. Assessing Level and Quality of Service for All Modes g. Safety and Operations Performance for All Modes h. Relationship between Functional Classification and Urban Street Typologies i. Use of Flexibility in Application of Design Criteria j. Liability Considerations k. Design Exceptions l. Applying Context Sensitive Design Principles m. Speed and Design Relationships n. Speed Transitions o. Bridge and Other Structure Considerations p. ADA Requirements q. Sustainability Considerations r. Stormwater and Green Infrastructure s. Sources of Additional Information
Chapter 4. Assessing User Service Levels in Low- and Intermediate-Speed Environments
a. Purpose and Objectives b. Design Volumes, Time Periods and Years (all users) c. Capacity, Quality and Safety of Service d. Convenience and Accessibility of Service e. Multimodal Service Integration for Corridors, Segments and Intersections f. Recommended Service Level Approach by Facility, Context and Speed Range g. Sources of Additional Information
Chapter 5: Design Controls and Criteria
a. Purpose and Objectives b. AASHTO Design Controls and Criteria c. Differences from Conventional Practice when Considering All Modes d. Relationship of Design, Operating and Posted Speed to Context e. Additional Controls to Consider in Multimodal Design f. Sources of Additional Information
Chapter 6: Geometric Design Elements for Modes by Facility, Context and Speed
a. Purpose and Objectives b. Applicability of Design Elements to Each Mode c. Flexibility in Selection and Application of Design Elements d. Design Process in Constrained Right of Way e. Sources of Additional Information

Author: Reviewer #1 Subject: Sticky Note Date: 12/17/2015 3:29:49 PM
I'm not sure if I understand the point of Chap 3-7. Is it existing practices? problem statement?

Chapter 7: Methods to Balance Geometric Design Controls, Criteria and Elements for All Users a. Purpose and Objectives b. Separation and Integration of Modes c. Understanding and Assessing Context d. Recommended Cross-Section Development Process e. Trade-Off Analysis Techniques f. Sources of Additional Information
Chapter 8: Recommended Design Process to Serve All Users a. Purpose and Objectives b. General Design Parameters c. Relationship of Traveled Way and Roadside Environments in Various Contexts d. Traveled Way Design e. Roadside Design f. Intersections and Interchanges g. Sources of Additional Information
Chapter 9: Roadside Design Guidelines to Serve All Users a. Purpose and Objectives b. Typical Roadside Uses and Activities in Low- and Intermediate-Speed Contexts c. General Design Principles and Guidance d. Roadside Width and Functional Requirements for All Users e. Urban Area Context Principles and Considerations f. Suburban Area Context Principles and Considerations g. Rural Area Context Principles and Considerations h. Landscaping Principles and Considerations i. Driveway Crossing Principles and Considerations j. Traffic Control Device Principles and Considerations k. Lighting Principles and Considerations l. Traffic Barrier Principles and Considerations m. Utility Principles and Considerations n. Recommended Practice o. Sources of Additional Information
Chapter 10. Traveled Way Cross-Section Design Guidelines to Serve All Users a. Purpose and Objectives b. Design Considerations c. General Design Guidance
10.1 Vehicle Travel Lane Widths a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information
10.2 Curbs and Shoulders a. General Principles and Considerations b. Recommended Practice c. Sources of Additional Information

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Author: Reviewer #1 Subject: Sticky Note Date: 12/17/2015 3:29:49 PM
I would like to see the key design elements highlighted.

Author: Reviewer #1 Subject: Sticky Note Date: 12/17/2015 3:29:49 PM
see my comments to organization on p102.

Author: Reviewer #1 Subject: Comment on Text Date: 12/17/2015 3:29:49 PM
We really need to re-think how we think about streets. All through the document it seems that we have the roadway (traveled way) and then a bunch of other stuff. The "street" is the entire ROW. The traveled way is but a small part.

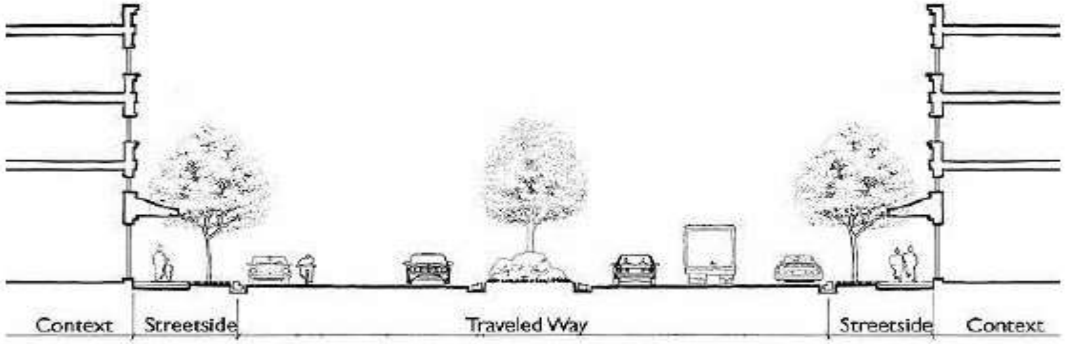
Example Guidelines Section

10.1 Vehicle Travel Lane Widths

This section discusses considerations for and provides guidance on the selection of travel lane width for the different types of travel lanes that are used in low and intermediate speed environments.

Lane widths are impacted by a wide range of factors including the type of travel lane (through, left or right auxiliary, two-way left turn), functional classification of the facility, the operating speed of the facility, the adjacent facilities in the right-of-way (e.g., medians, bicycle lanes, parking lanes, transit lanes, etc.), the presence and level of non-vehicle users and the context of the surrounding area (see Figure 10.1). Parking lanes and lanes incorporating transit operations are addressed in separate sections of this chapter.

FIGURE 10.1: TYPICAL TRAVELED WAY ELEMENTS IN LOW & INTERMEDIATE SPEED URBAN SETTINGS



Where streets are designed in areas with a significant level of existing or planned use by non-motorized users, excessive street width can create barriers for pedestrians and encourage higher vehicular operating speeds. Wide streets can reduce the level of pedestrian interchange that supports economic and community activity. Wide streets discourage crossings for transit connections and the overall width of the street can affect the building height to width ratio, a vertical spatial definition that is an important visual design component of many urban streets.

While lane width is only one component of the overall width of the street, it is often cited as the design element that most adversely affects the comfort, convenience and safety of pedestrian crossings. In fact, many factors affect pedestrian crossing safety and exposure, including the number of lanes, presence of pedestrian refuges, curb extensions, walking speed and conflicting traffic movements at intersections.

a. General Principles and Considerations

In establishing the most appropriate vehicle lane width for a particular low or intermediate speed facility, the designer should consider the needs, safety and operational impacts of alternative widths to all legal users of the roadway facility. In doing so, some of the key factors that affect lane width selection on a specific facility will include:

- **Total Travel Way Width**. The traveled way width should be adequate to accommodate through and turning traffic lanes, medians, curbs, and appropriate clearances from curb or barrier faces. The width of the traveled way, however, does affect users' perceptions of the speed and volume of the street. Wide streets with multiple travel lanes may be perceived as a barrier to crossing where frequent crossings are desired and encouraged. Wider lanes contribute to wider traveled ways and larger intersections which create longer crossing distances for pedestrians, increased pedestrian and bicycle crossing exposure time to vehicle traffic, and the need for longer traffic signal clearance intervals. The total number and width of travel lanes selected should be based on community objectives, the street's role in the overall network, and the existence or lack of parallel roadways across which traffic can be balanced.

- **Functional Classification**. The AASHTO Green Book notes that "*while the accommodation of bicyclists, pedestrians, and transit users is an important consideration in the planning and design of highways and streets, the functional classification of a highway or street is primarily based on motor vehicle travel characteristics and the degree of access provided to adjacent properties.*" Higher-order classifications serving urban areas such as principal arterial, minor arterial and collector roadways often have multiple and even competing roles in the urban street system. The Green Book goes on to say that "*even though many of the geometric design values could be determined without reference to the functional classification, the designer should keep in mind the overall purpose that the street or highway is intended to serve, as well as the context of the project area.*" It is for these reasons that the designer must be able to fully consider and balance design criteria such as travel lane width in consideration of the mobility, safety and convenience of all modes and users in the design process of these functional classifications across a broad range of network contexts and community priorities.

- **Design Vehicle**. Lane widths should obviously consider the selected design vehicle for a project. However, the safety and operational impacts of a selected lane width should be evaluated against the different types and sizes of vehicles expected and the frequency that they will use the facility. Some practitioners will conservatively select the largest design vehicle (WB 50 to WB 67) that could use a thoroughfare, regardless of the frequency although that is typically not the most cost-effective design solution in typical low and intermediate speed settings. Selecting too large a design vehicle can also serve to create wider cross-sections and intersections, creating negative impacts on other users, particularly crossing pedestrians and bicyclists. Consistent with AASHTO, Context Sensitive Solutions (CSS) emphasizes an analytical approach in the selection of a design vehicle, including evaluation of the trade-offs involved in selecting one design vehicle over another. The selection of a project design vehicle is addressed further in section 10.XX.

Author: Reviewer #1 Subject: Comment on Text Date: 12/17/2015 3:29:49 PM
I think that we need to unequivocally state that this patently untrue for city streets. It may be true for highways, but not streets. And our subject is largely streets.

it has lower emissions and energy consumption on a per-capita basis than personal motor vehicles.

Transit vehicles operate in a wide range of environments—both on-street and off-street. Commuter rail and rapid transit operate in exclusive rights-of-way that are frequently grade-separated from intersecting roadways. However, buses, light rail, modern streetcar and trolley operations may share or intersect with the street environment.

Streets and highways often must accommodate transit vehicles as well as motor vehicles, bicyclists, and pedestrians. Transit provisions are best accomplished when incorporated into all phases of street planning, design, and operation. This is essential especially where agencies at the state, county, and municipal level are required to plan, design, or modify streets and highways to accommodate public transportation vehicles and facilities.

As a result of U.S. trends in walking, bicycling and transit use, there is clearly a need for this research project to develop a methodology and guidelines for the most effective application of such integrated and often complex design solutions, especially on lower- and intermediate-speed facilities in urbanized areas where higher levels of walking, ~~bicycle~~ and transit activity are often present. These guidelines will also be appropriate for use in small and/or rural communities where walking and ~~biking~~ are important elements of their main street designs.

2.3 Trends in Walking, Bicycling and Transit Use

To better understand current trends in bicycling and walking travel modes in the United States and how those trends may impact and influence future roadway design practices, the following information has been taken from APTA and the report Bicycling and Walking in the United States: 2014 Benchmarking Report, published by the Alliance for Biking and Walking.

LEVELS OF BICYCLING AND WALKING

The most recent nationwide data on bicycling and walking mode share show that only 1.0% of all trips taken in the U.S. are by bicycle, and 10.4% are on foot according to the 2009 National Household Travel Survey (NHTS). Of commuters nationwide, 2.8% get to work by walking and 0.6% get to work by bicycle. These numbers are slightly higher in large cities (5.0% and 1.0%, respectively). Though these numbers are low, they represent a continuing gradual increase in bicycling and walking in the U.S. Among large cities, Portland, Oregon, has the highest bicycle commuting rate at 6.1 percent.

Partially due to the current lack of data on bicycling and walking numbers, many states and cities conduct their own counts to find out their local mode share. Of the 52 most populous cities surveyed, 43 have completed counts of bicyclists and 37 have completed counts of pedestrians. Thirty-eight states have conducted counts on bicyclists and 36 states have counted pedestrians. States and cities conduct their counts at varying times and frequencies, making it difficult to compare results consistently.

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bicycling

Author: Reviewer #3 Subject: Inserted Text Date: 12/23/2015 3:53:30 PM
bicycling

Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
Is this section basically all quoted directly from this report? If so, then it is not very comprehensive, even though the report is directly relevant. It is true that there is very little data on bicycling and walking, and I see a compelling case to rely heavily on this report for these two modes. There is, however, a lot more information from other sources on transit use, as well as the connections between transit and non-motorized travel. Further, it would be useful to provide some connections to how these trends relate to design practices for all road users.

3. Research Approach

The goal of this research project is to collect and review the latest research and best practices from which a design methodology and process can be developed that results in balanced service to the full range and mix of users of each roadway functional classification in the low- and intermediate-speed categories…and that is also sensitive to the context of the roadway environment. The recommended design process is intended to fit a balanced street design into low- and intermediate-speed roadways of all types in all contexts, but with particular emphasis on those facilities in an environment of limited right-of-way, congested traffic conditions and other anticipated design challenges typically experienced in settings where roadways are designed at low and intermediate speeds (45 MPH and lower).

The integrated design guidelines will help designers understand how to best evaluate and accommodate all users in the design process. The guidelines will establish a method to identify and assess the users and user needs and service levels that should be addressed in project design. This method will consider and address relevant roadway network functional classifications, land use context, community goals, vehicle speed ranges and other relevant factors identified through the research and best practices.

The guidelines will also outline a methodology that designers can use to balance and optimize geometric design criteria, controls and elements in a multimodal environment to ideally "optimize" effective and safe operations for all users. While this methodology will be supported by available empirically based research as available, the research team understands that research for many non-motorized and contextual-related design considerations and relationships are non-existent or limited. Therefore, some aspects of the proposed methodology will likely be based on best practices, case study results, application of engineering judgment and other qualitative considerations of the research team. Areas needing future empirical research to validate and advance qualitative recommendations will be identified in the final project report.

Other aspects of the guidelines will address the following elements under varying roadway classifications, contexts and speed ranges:

- Identifying all user groups and sub-groups (i.e., pedestrians - older, young and disabled),
- Assessing current and future demand of all modes,
- Best practices for assessing multimodal level and quality of service,
- Balancing the principal elements of design among all users,
- Performance metrics (quantitative and qualitative) for user groups addressing operations, safety, and accessibility,
- Methods for identifying and addressing typical constraints such as limitations in right-of-way, fixed roadside features, utility conflicts, etc.,
- Guidance for applying design flexibility considering reallocation of cross section design elements, controls and criteria,
- Use and approach to design exceptions, and use of low cost options, and
- Integration of geometric design with traffic control to optimize operations and safety for all user groups.

Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
Needs editing.

Author: Reviewer #3 Subject: Cross-Out Date: 12/23/2015 3:53:30 PM

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Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
What about going one step further & providing recommendations on how the proposed methodologies can be evaluated?

21. Has your agency adopted any "Complete Streets" laws and/or policies to ensure that projects provide the safest achievable access for all users and modes of transportation?

Forty-four (44) responses were received. Twenty (45%) were YES, and twenty-four (55%) were NO.

22. If you answered "Yes" to the previous question, please provide a link to these documents or send them via email to ______. If unpublished, please describe the law and/or policy below.

There were twenty-two responses to this question. Several links to complete streets policies were provided. Other responses included the following: every project considers ped and bike facilities, and when they are found to be warranted they are included in the plans; we don't have a policy and will not as long as I am the County Engineer….the "Complete Street" concept is just the latest in a long line of jargon terms….; we re-think design of the transportation infrastructure to attempt to provide all pedestrians, bicyclists, and transit riders equal access to all destinations; we consider all modes in our design standards; we did not adopt complete streets policies; we have a Creating Livable Streets document.

23. Has your agency had any projects where multiple user needs (possibly conflicting needs) were successfully addressed?

Of the forty-one (41) respondents, twenty-three (56%) were YES and eighteen (44%) were NO.

24. If you answered "Yes" to the previous question, please describe those "success story" projects.

Successful stories included these topics: modified shoulder rumble strips for bicyclists; SH 7 (Arapahoe Road) in Boulder CO where extensive public involvement was used to make difficult mode service issues among the user groups; multiple projects in Washington state, several involving roundabouts; shoulder expansions for bicycle use; providing sidewalks and bike trails in bridge rehabilitation projects; road diets; separate rail crossings for bicycles; added bicycle lanes; added sidewalks; green pavement markings for bicycle awareness; midblock pedestrian crossings; medians; on street parking; mixed-use paths.

4.1.3. Roadway Agency Interviews

As a follow-up to the survey, the research team ~~has~~ interviewed representatives of several roadway design agencies. The interviews where structured to delve deeper into their policies, processes, manuals, guidelines and experience with designing low- and intermediate-speed streets that serve all users. Several of these agency interviewees are also involved in design committees and activities of AASHTO, ITE, NACTO, APBP and other design guidance-creating organizations.

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Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
But only twenty answered yes to Q.22

Author: Reviewer #3 Subject: Cross-Out Date: 12/23/2015 3:53:30 PM

Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
How were they chosen? Was this a convenience sample? Random sample? Or???

The following questions and subject areas were addressed in each of the interviews:

- How different user groups and sub-groups are addressed;
- What performance metrics are used for all modes that address operations, safety, accessibility and convenience;
- How the principal elements of design are balanced among all users;
- How multimodal level of service is assessed;
- What methods are used to identify and address typical constraints such as limitations in right-of-way, roadside features, utility conflicts, excessive access points, etc.:
- The process for applying design flexibility considering allocation/reallocation of cross section design elements, use of design exceptions, and use of low cost options;
- The integration of geometric design with traffic control to optimize operations and safety for all user groups;
- How U.S. Access Board accessibility guidelines are addressed; and
- Other methods for creating street and road designs that support livable, sustainable and healthy communities and neighborhoods.

The agency interviews have confirmed the research team's initial conclusions from the agency survey that most, if not all public roadway agencies are in an "evolutionary" mode of creating design guidance to safely and conveniently accommodate all legal users of the right-of-way. The majority of state DOTs and increasing numbers of local agencies have recognized this need, and in fact have developed policies and/or implementation plans to produce new or revise existing design guidance addressing all users, but very few at this time have developed truly comprehensive, integrated design guidance that provides advanced methods and techniques for balancing safety and service to all modes in the geometric design process.

Selected results of the agency interviews are summarized below with the agency interviewees noted.

Agency: North Carolina DOT - Lauren A Blackburn, Bicycle and Pedestrian Division Director

1. How were different user groups and sub-groups addressed during both the development and implementation stages of your NCDOT design guidelines?

Using our Complete Street Guidelines as an example, we developed those between 2009 and 2012. The initial committee was made up of DOT personal to establish the policy. A working group was then organized which included FHWA, NCDOR, local governments which was led by the DOT head of design and a co-chair of a City of Charlotte employee (Charlotte had recently completed their own Complete Street guidelines). This group took a couple of years to get the framework in place for the policy. A second committee of design/planning personal from the major cities and DOT worked on the details of the guidelines. The group pulled design resources from existing documents. The draft was circulated to all state MPO's for final reviews.

A training program rolled out with the completion of the guidelines. Over 1000 individuals were trained. Within NCDOT the guidelines have become embedded in our practice. Many local governments have adopted the DOT guidelines as their guidelines.

Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
Again, how were these results selected?

Also, it appears that the Q&A below were summarized for each question but there is no overall summary. Perhaps it is useful to have these interviews available in an appendix but it would have been nice to have key themes and popular practices synthesized for the reader. It is unclear what the most relevant and important points are.

FHWA also lists the following states as having issued some type of CSS policy statement:

- Florida
- Indiana
- Louisiana
- Montana
- New Hampshire
- North Carolina
- Ohio
- Rhode Island
- Tennessee
- Texas
- Virginia
- Vermont

Finally, FHWA notes that the State of Illinois has passed state legislation regarding CSS and the states of Massachusetts, Michigan, Minnesota and Washington have issued CSS executive orders.

In addition to evaluating state DOT activities in designing for all users, the research team has also identified through the literature review a number of local government agencies (including MPOs) that have developed significant multimodal accommodation design guidance for their organizations. These agencies are listed below. Their urban- and suburban-focused guidance documents will serve a particularly useful role in developing guidelines for the design of low- and intermediate-speed roadways with multimodal accommodation needs.

- City of Boston, MA
- City of Burlington, VT
- City of Charlotte, NC
- City of Chicago, IL
- City of Dallas, TX
- City of Deerfield Beach, FL
- City of Ft. Lauderdale, FL
- Los Angeles County, CA
- Louisville/Jefferson County Metro, KY
- Maricopa County, AZ
- City of New Haven, CT
- New York City, NY
- City of Philadelphia, PA
- Portland Metro, OR
- Regional Transportation Commission of Southern Nevada, NV
- City of San Francisco, CA
- City of Seattle, WA
- City of Tacoma, WA

The two tables on the following pages identify the primary policy and design guidance that each of the nineteen (19) selected DOTs and eighteen (18) selected local agencies rely on to inform and guide consideration of all users and multimodal context-sensitivity in their geometric design processes. The tables specifically note whether the agency has adopted formal or informal CSS or complete streets policy guidance, along with the primary policy guidance and design guidance documents identified for each agency.

Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
It may be helpful to the readers to have a short explanation differentiating DOT policy regarding CSS, CSS policy statement, and CSS executive order. How do these different policy mechanisms impact the design process?

Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
Put these tables in an appendix?

Recommendations for the development of the Guidelines for Designing Low- and Intermediate-Speed Roadways will reference and build on this previous work in NCHRP 785 where appropriate. NCHRP 785 addressed all aspects of geometric design on all types of facilities and speed ranges from the interstate system to local roads, while NCHRP 15-48 is focused only on facilities designed with low- to intermediate-speeds of 45 mph or less. The five performance categories will be viewed from the perspective of not only how a vehicle travels through a roadway segment or intersection, but also travel of the pedestrian, the bicyclist and the transit patron. For purposes of NCHRP 15-48, Exhibit 4-6 from Report 15-34A can be better focused for multimodal use as shown below in *italics*.

Performance Category	Primary Measures of Geometric Design Performance
Accessibility	Measures that integrate travel distances and/or travel times between selected origins[1] and destinations[1] for different modes
Mobility[2]	Average travel speed *of the vehicle, the bicyclist, the pedestrian and the transit rider*
Reliability	Travel time variability (e.g., from hour-to-hour, day-to-day, week-to-week)
Safety	Expected crash frequency, by crash severity and crash type *(vehicle with vehicle, vehicle with fixed object, vehicle with bicyclist, vehicle with pedestrian, bicyclist with pedestrian)*
Quality of Service	Levels of service *to address all modes of travel*

1. Accessibility is an emerging concept recognizing that travel time is made up of both distance and speed. Its application is relatively limited in geometric design contexts.
2. Origins and destinations, as referred to here, are not necessarily trip ends (e.g., number of businesses within two miles of freeway access)

4.3.3 Project Development Process

It is clear from the literature and best practice reviews that in order to allow for creativity and flexibility in the geometric design stage of a project, the early stages of project development should also consider all users from the initial project concept development through all subsequent planning and environmental stages. If design options to serve all users are not contemplated and preserved at those early stages, then the ability to develop and evaluate the full range of alternative design elements and criteria may be limited by project scope, budget, available right-of-way or environment approvals. The information below addresses these relationships.

4.3.3.1 State DOT Project Development Process

In the review of state DOT design processes our team identified a commonality on how projects are initiated and eventually moved to design and construction. While the terminology changes from agency to agency, the basic process elements are very similar in the state DOT processes reviewed. Most state DOT have five (5) basic steps in the development of a roadway improvement project.

Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
Travel speed is related to travel time and can be calculated based on travel distance divided by travel time. How will transit rider travel speed be considered? Will it only include in-vehicle travel time or also out-of-vehicle travel time (i.e., wait time, transfer time, etc.). It will only include in-vehicle travel time, then it may be more appropriate to refer to average travel speed o transit vehicle instead of rider.

- Project Identification
- Environmental / Concept Development
- Design
- Project Procurement
- Construction

As noted earlier in this report, it is important to identify multimodal issues and needs early in the project development process so that all feasible design alternatives can be properly considered and evaluated later on in the geometric design process. It is therefore important that geometric design agencies begin their consideration of all modes and users in the initial and ongoing phases of project development if all reasonable alternatives are to be eligible for later evaluation.

In order to better understand the project development process for state DOTs, the process employed by five (5) selected state DOTs were identified and summarized in the following tables.

California DOT	**Source: http://www.dot.ca.gov/hq/oppd/pdwt/part2.htm**				
Common Phases	Project Identification	Environmental / Concept Development	Design	Project Procurement	Construction
Major Phases	Project Initiation	PA&ED	PS&E	Approve Contract	Construction
Key Steps	Define the Problem	Engineering Studies	Survey	Contract Documents	Construction Engineering
	Develop the Alternatives	Project Report	Engineering Reports	Bid Project	
	Analyze Alternatives	Environment al Studies	Roadway Plans	Award Contract	
	Preliminary Environment al Evaluation		Structure Plans		
	Prepare PID		Traffic Plans		

Colorado DOT	**Source: https://www.codot.gov/business/designsupport/ bulletins_manuals/project-development-manual**				
Common Phases	Project Identification	Environmental / Concept development	Design	Project Procurement	Construction

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Why/how were these selected? Are they particularly good examples?

Major Phases	Efficient Transportation Decision Making (ETDM) process	Project Development and Environment (PD&E)	Design		Construction
Key Steps	Comprehensive Planning	Alternative Corridor Evaluation	Typical Section package		
	Cost Feasible Transportation Plans	Purpose and Need	Phase I Plans submittal		
	Technical Study	Alternatives Analysis	Phase II Plans submittal		
	Develop Scope		Phase III Plans submittal		
		Engineering Analysis	Phase IV Plans submittal		
		Typical Section Concurrence			

Indiana DOT	**Source: www.in.gov/indot/files/ProjectDevelopmentProcessManual.pdf**				
Project Development Process for a Major Project					
	Step 0 System-Wide Analysis / Project Identification / Draft Purpose and Need	Step 1 Professional Services	Step 2 Conduct Research and Technical Studies	Step 3 Identify and Evaluate Conceptual Solutions	Step 4 Develop Reasonable Alternatives
	Step 5 Identify Preferred Alternative	Step 6 Stage 1 – Develop Preferred Alternative	Step 7 Stage 2 – Advance Preferred Alternative	Step 8 Environmental Approval	Step 9 Prepare Final Right-of-Way Plans
	Step 10 Begin Land Acquisition	Step 11 Stage 3 – Complete Preferred Alternative	Step 12 Prepare Final Tracings Package		

4.3.3.2 Project Development Workflow

In reviewing the project development workflow of the different state DOTs, the critical phases where design criteria should be included for multimodal accommodation alternatives are the Planning /Environmental and Design stages.

Planning/Environmental Stages

- Community Input – Throughout the process the community should be engaged in establishing the needs and issues to be addressed in developing the scope of the project. This can include public meetings, stakeholder work sessions and other methods of input.

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It is unclear whether "the process" refers to both the Planning/Environmental and Design stages. The community should be involved in both stages, particularly as different designs may include different trade-offs that the community needs to consider.

4.4 Task 4: Geometric Design Framework

In this task our research team has considered the methodologies developed in Task 3 against the full range of facility classification types and speed ranges. We also believe that it is important in this task to fully consider the other key design variables of context and modal demand/priority that exist for every roadway design project serving more than motorized vehicles.

The stated goal of this task was to identify the design guidance framework that provides the best balance between (1) roadway classification, (2) context, (3) speed ranges and (4) user types around which to build the specific work plan in Task 5, and then using that framework create the guidelines document. Each of these four (4) key framework variables is addressed in the sections that follow.

4.4.1 Roadway Classification

4.4.1.1 FHWA-AASHTO Roadway Classification System

FHWA's *Highway Functional Classification: Concepts, Criteria and Procedures, 2013 Edition*, describes the procedures and processes for assigning functional classifications to roadways and adjusting urban area boundaries concerning roadways that Federal, State and local transportation entities own and operate. These classifications are used extensively in the Federal, State and MPO planning and programming processes and are legislatively mandated for use in many systems and processes, including the creation of state and regional transportation programs (STIP, RTIP).

The AASHTO Green Book (hereinafter referred to as AASHTO) defines rural roads as facilities that exist outside of urban areas. The terms used for the system facilities are principal arterials (roads), minor arterials (roads), major and minor collectors (roads), and local roads. These AASHTO-defined characteristics and considerations for each mode is presented in the Green Book as follows.

Rural Principal Arterial System

The rural principal arterial system consists of a network of routes with the following service characteristics:

A. Corridor movement with trip length and density suitable for substantial statewide or interstate travel.
B. Movements between all, or virtually all, urban areas with populations over 50,000 and a large majority of those with populations over 25,000.
C. Integrated movement without stub connections except where unusual geographic or traffic flow conditions dictate otherwise (e.g., international boundary connections or connections to coastal cities).

AASHTO notes that in the more densely populated states, this class of highway includes most (but not all) heavily traveled routes that might warrant multilane improvements in the

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How do these roads relate to speed? What about speeding issues in lower volume roads?

The rural local road system, in comparison to collectors and arterial systems, primarily provides access to land adjacent to the collector network and serves travel over relatively short distances. The local road system constitutes all rural roads not classified as principal arterials, minor arterials, or collector roads.

Functional Highway Systems in Urbanized Areas

AASHTO describes four functional highway systems for urbanized areas including urban principal arterials (streets), minor arterials (streets), collectors (streets), and local streets. The key difference between urban and rural systems are assumed to be the nature and intensity of land use development and increased presence of other modes of travel.

Urban Principal Arterial System

AASHTO notes that in every urban environment, one system of streets and highways can be identified as unusually significant in terms of the nature and composition of travel it serves. In small urban areas (population under 50,000), these facilities may be very limited in number and extent, and their importance may be derived primarily from the service provided to through travel (with exceptions being where these routes also serve as main streets for these communities). In larger urbanized areas, their importance also derives from service to rurally oriented traffic, but equally or even more importantly, from service for major circulation movements within these urbanized areas.

The urban principal arterial system typically serves the major centers of activity of urbanized areas, the highest traffic volume corridors, and the longest trip desires. This system often carries a high proportion of the total urban area travel even though it constitutes a relatively small percentage of the total roadway network.

The urban principal arterial system usually carries most of the trips entering and leaving an urban area, as well as most of the through movements bypassing the central city. In addition, significant intra-area travel, such as between central business districts and outlying residential areas, between major inner-city communities, and between major suburban centers, is served by this class of facility. Frequently, the urban principal arterial system carries important intra-urban as well as intercity transit routes with significant levels of other user activity. Finally, in urbanized areas, this system can provide continuity for all rural arterials that intercept the urban boundary.

Because of the nature of the travel served by the principal arterial system, almost all fully and partially controlled access facilities are usually part of this functional class. However, this system is not restricted to controlled-access routes. To preserve the identification of controlled-access facilities, AASHTO recommends that the principal arterial system be stratified as follows: (1) interstate, (2) other freeways, and (3) other principal arterials (with partial or no control of access).

AASHTO notes that for freeways and expressways, service to abutting land is obviously subordinate to travel service to major traffic movements. For facilities within the subclass of

Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
Assumed by whom? AASHTO? Or the research team?

Guidelines Table of Contents

The research team has used the knowledge gained in Tasks 1 through 4 to develop an expanded concept for the guidelines document to be developed as a part of this project. Based on our Team's current thinking, the table below presents a draft outline of the design guidelines content at this stage of the project. It is anticipate that the guidelines will contain between 150 and 200 pages. We expect there to be some adjustments and revisions of the organization and elements in each chapter based on input from the Project panel and as the final work plan is developed.

PRELIMINARY Table of Contents Outline

GUIDELINES FOR DESIGNING LOW- AND INTERMEDIATE-SPEED ROADWAYS THAT SERVE ALL USERS
PRELIMINARY TABLE OF CONTENTS
Chapter 1. Introduction a. Purpose, Organization and Objectives of the Guidelines b. Objectives of the Guidelines c. Range of Low- and Intermediate-Speed Facilities and Context Environments d. Applicability of the Guidelines e. Relationship to Other Design Guidance f. Intended Users of the Guidelines g. Sources of Additional Information
Chapter 2. State of Knowledge and Practice a. Literature Review b. Research in Progress c. Survey Results d. Field Reviews e. Best Practices f. Sources of Additional Information

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Why is this here & in the following subsection?

Author: Reviewer #3 Subject: Comment on Text Date: 12/23/2015 3:53:30 PM
I hope that these sections will be in more digestible forms than how they were presented in this interim report. Information from the survey, interviews, field reviews, and site visits need to be synthesized for the reader, while the more raw forms of that data can compliment these sections in appendices.

Selected Panel Comments for Discussion

- Comment: *I was wondering if more examples can be included to show how designers can actually use the design methodology and design guidelines in real projects. This is especially important for those projects that have a purpose and needs that is hard to quantify, for example, livability or community cohesion instead of increasing capacity. I like the examples that are included in NCHRP Report 785.*

- *Reply:* The project scope did not anticipate design examples as there are so many different contexts and street/roadway situations. The intent of the guidelines was to help guide designers in their selection of road/street design controls, elements and criteria that address the needs of all legal users and is compatible with context.

Selected Panel Comments for Discussion

- Comment: *I have read the example section for lane widths and not quite sure if I get the differences between this document and other guidelines. Maybe I should wait for the final report.*

- Reply: The guidelines produced by this project are intended to bridge the gap between (1) traditional road/street design guidance used by most state DOTs and many local governments, and (2) evolving road/street design guidance that effectively integrates all user modes in the right-of-way and is consistent with current and future contexts.

  There is little debate that on high speed facilities focused on vehicle movement the traditional geometric design guidance is effective and usually appropriate. However, as speeds decrease and relationships between the roadway, roadside and land use become more integrated and complicated, the traditional geometric design process is not well suited to addressing those elements.

General Discussion of Key Elements of Guidelines Document

General Discussion - Guidelines Document

- Low to intermediate speeds are 45mph and below. Should this document address these roadways in the full range of urban, suburban and rural contexts?

General Discussion - Guidelines Document

- Who is the most important intended audience of the Guidelines?

General Discussion - Guidelines Document

- What is the best format, style and content for that audience to understand the needs of all users and how best to integrate them in the geometric design process?

General Discussion - Guidelines Document

- What are the key attributes that will make the document most successful in advancing the awareness, understanding and geometric design for all users?

General Discussion - Guidelines Document

- Other key considerations for a successful guidelines document?

Recommendations for Phase II Work Plan

- Panel feedback on:
  - Table of Contents for the guidelines document
  - Example guidelines section (10.1) on vehicle lane widths. This draft section is intended to be representative of the level of content provided for each of the design element sections so that the Panel can provide feedback on what they feel is the most appropriate guidelines content.
- The research team will revise both products based on comments from the Panel. These materials will be included in the updated work plan for Phase II.

Recommendations for Phase II Work Plan

- The initial draft guidelines document will be shared for review and comments with a focus group of twelve (12) to fifteen (15) state DOT and local transportation agencies representing (a) a diversity of geographic and climatic conditions, and (b) having varying levels of advanced multimodal design experience and documentation. Each agency will be asked to evaluate the usefulness of the document and offer ideas/suggestions for improvement.

- Three (3) of the reviewing selected state/local agencies would be visited by the research team to discuss the guidelines in depth and obtain more specific recommendations for how the guidelines can be more useful and beneficial to transportation designers. The lessons learned from these agencies will help to validate and define the specific types and level of guidance that will be developed as the research progresses into a comprehensive design guidance document.

Recommendations for Phase II Work Plan

The research team will also develop a prioritized list of key gaps in knowledge associated with performance measures across user types/modes. Initial thoughts for areas to be addressed include:

- Pedestrian safety prediction methodology for urban and suburban roadway segments and intersections.
- Bicycle safety prediction methodology for urban and suburban roadway segments and intersections.
- Transit stop safety prediction methodology for urban and suburban roadway segments and intersections.

Review of DRAFT Table of Contents and Lane Width Design Guidance Section

(see handout)

Existing AASHTO GB Guidance on Lane Width by Functional Classification, Urban/Rural and Lane Type

Table 10.1 AASHTO Lane Width Criteria on Urban Low/Intermediate Speed Facilities

Lane Type	All Classes	Local Urban Street		Urban Collector Street		Urban Arterial Street	
	Range	Minimum	Preferred	Minimum	Preferred	Minimum	Preferred
Through Lane	9-12 ft	9 ft	10-11 ft	10 ft	11-12 ft	10 ft	11-12 ft
Through Lane (Industrial)	11-12 ft	11 ft	12 ft	11 ft	12 ft	10 ft	11-12 ft
Left/Right Turn / Auxiliary Lane	10-12 ft	9 ft	10-12 ft	10 ft	11-12 ft	10 ft	11-12 ft
Two-Way Left Turn Lane	10-16 ft	n/a	n/a	10 ft	11-12 ft	10 ft	11-12 ft

Table 10-2 Recommended Lane Width Criteria for Urban Low/Intermediate Speed Facilities that Serve All Users

Multimodal User Priority Level	Design Speed Range MPH	Lane Type	Recommended Lane Widths (feet)				
			Local Urban Street (9-12 ft range)		Urban Collector Street (10-12 ft range)		Urban Arterial Street (10-12 ft range)
			Industrial	All Other	Industrial	Other	All
LOW Multimodal Priority	20-25	Through	11-12	9	11-12	10	10
		L/R Turn	11-12	9	11-12	10	10
		TWLTL	11-12	n/a	11-12	10	10
	30-35	Through	11-12	10	11-12	10	11
		L/R Turn	11-12	10	11-12	10	11
		TWLTL	11-12	10	11-12	10	11
	40-45	Through	11-12	n/a	12	11	12
		L/R Turn	11-12	n/a	12	11	12
		TWLTL	11-12	n/a	12	11	12
MODERATE Multimodal Priority	20-25	Through	11-12	9	11-12	10	10
		L/R Turn	11-12	9	11-12	10	10
		TWLTL	11-12	9	11-12	10	10
	30-35	Through	11-12	10	11-12	10	10
		L/R Turn	11-12	10	11-12	10	10
		TWLTL	11-12	10	11-12	10	10
	40-45	Through	11-12	n/a	12	11	11
		L/R Turn	11-12	n/a	12	11	11
		TWLTL	11-12	n/a	12	11	11
HIGH Multimodal Priority	20-25	Through	n/a	10	n/a	10	10
		L/R Turn	n/a	10	n/a	10	10
		TWLTL	n/a	10	n/a	10	10
	30-35	Through	n/a	10	n/a	10	10
		L/R Turn	n/a	10	n/a	10	10
		TWLTL	n/a	10	n/a	10	10
	40-45	Through	n/a	n/a	n/a	11	10
		L/R Turn	n/a	n/a	n/a	11	10
		TWLTL	n/a	n/a	n/a	11	10

NOTE: TWLTL is Two-Way Left Turn Lane; L/R is Left/Right

Proposed 15-48 Guidance on Lane Width by:

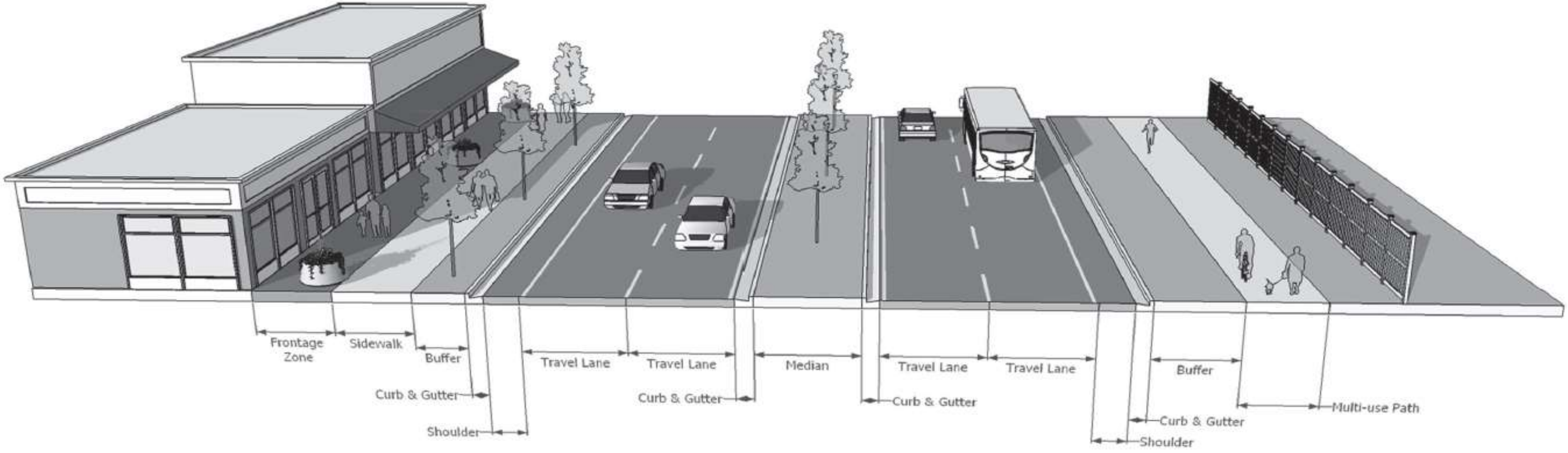
- **Functional Classification**
- **General land use**
- **Lane type**
- **Design speed**
- **Multimodal priority**

DESIGN CONSIDERATIONS:

NETWORK (Vehicles, freight, transit, bicycle, pedestrian)
CONTEXT (Land use, aesthetics, target speed, modal priority)
MOBILITY* (Level of Service, all modes)
QUALITY of SERVICE* (Accessibility*, convenience, reliability*)
SAFETY* (All modes)

**NCHRP 785 Performance Categories*

EXAMPLE: Urban Minor Arterial

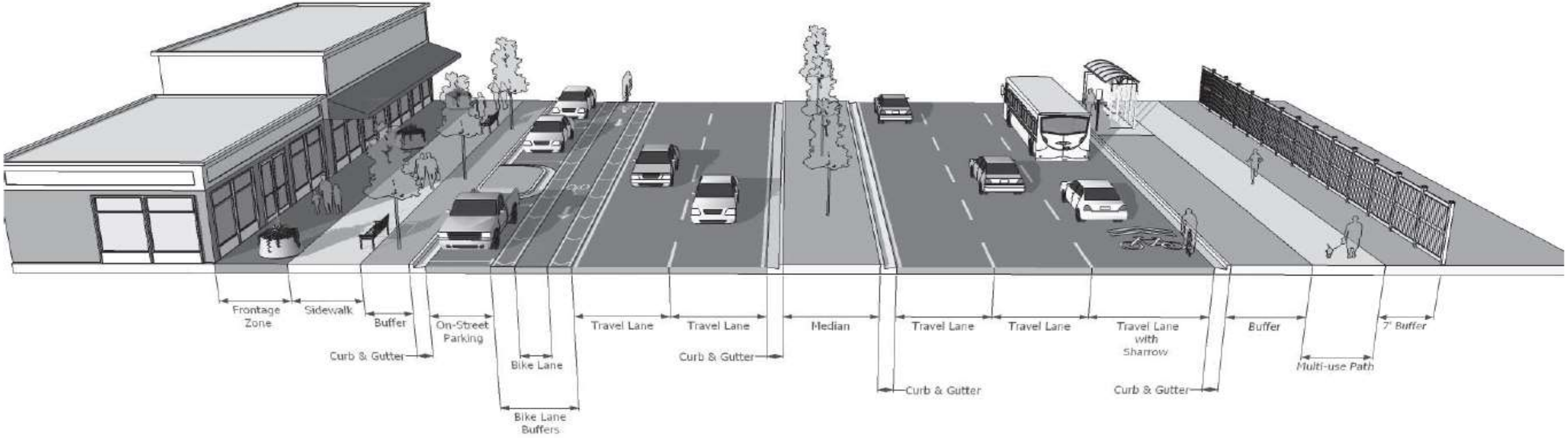


DESIGN CONSIDERATIONS:

NETWORK (Vehicles, freight, transit, bicycle, pedestrian)
CONTEXT (Land use, aesthetics, target speed, modal priority)
MOBILITY* (Level of Service, all modes)
QUALITY of SERVICE* (Accessibility*, convenience, reliability*)
SAFETY* (All modes)

**NCHRP 785 Performance Categories*

EXAMPLE: Urban-Suburban Minor Arterial



Project Schedule for Remaining Tasks

Phase II Recommended Work Plan Schedule

TASK	2016 TIMEFRAME
Task 6. Finalize Interim Report and Updated Work Plan	February
Task 7. Execute Updated Work Plan	February-March
Task 8. Prepare <u>preliminary</u> draft guidelines and final report	March-May
- Review by Panel and selected agencies*	June
- Meet with agency review teams for application feedback	July
- Revise draft guidelines and test against range of functional class, speeds and contexts	August
Task 9. Submit draft final guidelines and final report	September
- Revise/submit final guidelines and final report	October

*Recommended review agencies: GDOT, OreDOT, MnDOT

Closing Thoughts

- Panel members
- TRB Staff
- Research Team

Thanks!

Design and Liability

- Even though design flexibility has been available and encouraged in key design guidance, many designers have been reluctant to use it. Today’s design practice is moving towards more focus on “context” flexibility and less on use “generally accepted” standards and policy.

Key Guidance Exists

March 2012

NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM

Legal Research Digest 57

TORT LIABILITY DEFENSE PRACTICES FOR DESIGN FLEXIBILITY

This report was prepared under NCHRP Project 20-6, "Legal Problems Arising Out of Highway Programs," for which the Transportation Research Board is the agency coordinating the research. The report was prepared by Terri L. Parker, Esq. James B. McDaniel, TRB Counsel for Legal Research Projects, was the principal investigator and content editor.

The Problem and Its Solution

State highway departments and transportation agencies have a continuing need to keep abreast of operating practices and legal elements of specific problems in highway law. This report continues NCHRP's practice of keeping departments up-to-date on laws that will affect their operations.

Applications

In response to community and developmental demand, many state transportation agencies have modified their design policies to specifically require staff to consider historical, environmental, and other context-related elements during the design process rather than merely focusing on following "generally accepted" standards. This methodology allows the agency to give equal weight to aspects of the design of the road such as aesthetics, safety, and community concerns relating to parking and economics.

The NCHRP Legal Studies Committee realizes that there have been few if any tort liability cases brought on the grounds of what has been termed "flexible design" or "practical design" and encouraged through the principles of Context Sensitive Solutions (CSS). There is the lingering belief that the threat of tort claims continues in a number of states and that is having a dampening effect on designers' willingness to tailor designs to suit projects' unique contexts rather than designing projects that follow standard templates.

This research, which focuses on tort liability defense practices and cases involving the exercise of discretion in design, will hopefully provide a framework for determining successful strategies employed when defending design decisions made following the principles of CSS. This digest explores the concept of discretion as a defense to government tort liability, and defending these actions based on the designers' and policy-makers' discretion may be described by terms such as governmental immunity, official immunity, design immunity, or policy immunity. The existing law is relevant to analysis of tort legal defenses available to protect the decisions inherent in CSS. Many departments of transportation have adopted CSS principles or related concepts such as Practical Design to encourage flexibility in design decision-making. The digest's processes for documenting design decisions, articulating clearly the various factors considered in making a decision with a focus on decisions that involve design exceptions, should be of great help to attorneys, administrators, information officers, document retention officials, risk managers, planners, designers, and others responsible for such decisions.

TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

Create and file internal documentation that includes the rationale for your design decisions and any available facts/evidence to support those decisions.

Research Team Notes from February 3, 2016 NCHRP 15-48 Panel Meeting
9:00am-4:00pm, TRB Keck Center, Washington DC

Panel Members:

- Brent Story - Georgia DOT (Panel Chair) (participated by phone)
- Anne Benware -Capital District Transportation Committee
- David Hutchison - Springfield Public Works Department
- Yanxiao Jia - Iowa DOT (participated by phone)
- Michael King -Nelson/Nygaard Consulting Associates
- Brian Ho-Yin Lee – Puget Sound Regional Council
- Keith Harrison – FHWA (participated by phone)
- David Reynaud – TRB

Research Team Members:

- Marshall Elizer – Gresham, Smith and Partners (PI)
- Darren Torbic – MRIGlobal
- John Cock – Alta Planning + Design

Comments and Discussion Items

- The research team should identify gaps in knowledge as it relates to design guidance to serve all users in low- and intermediate-speed environments. We are not charged with recommending what type of research is needed to address the gap in knowledge.

- The guidelines should reference literature (research and/or best practices) supporting the recommended design guidance where possible.

- The design guidance where possible should be consistent with current AASHTO, FHWA, ITE and NACTO guidance, but we have the flexibility to recommend guidance that deviates from current policy if supported by research or if current policy does not address the issue.

- After much discussion about whether "roadside" is the correct term within the urban environment, most panel members were hesitant about using different terminology for the roadside between the urban and rural environments.

- Discussion addressed designing for 3 or 4 zones:
  - Vehicle zone
  - Pedestrian zone
  - Median (and potentially including transit)
  - Bike/parking/buffer zone

- Panel is comfortable with the direction of the research and the Interim Report. The schedule of the project should be driven by the development of the guidelines and not by restrictions of current POP. NCHRP is willing to extend the POP at a later date to accommodate development of the guidance document to provide the best available product, although a schedule had been developed that intends to complete the project by the current 10/31/2016 contract end date.

Research Team Notes from February 3, 2016 NCHRP 15-48 Panel Meeting
9:00am-4:00pm, TRB Keck Center, Washington DC

- Outline of Guidance Document
  - Ch. 1 (Introduction)
    - Discuss what the document addresses and does not address
    - How are the guidelines geared toward new construction vs reconstruction?
  - Ch. 2 (State of Knowledge and Practice)
    - Does not need to be included in guidance document.
    - Only include in final report.
  - Ch. 3 – 7
    - Consider merging into fewer chapters.
    - Remove redundancy/repetition
  - Merge Ch. 9 & 10 into a single chapter
    - Typical module/subsection should be structured as follows:
      - Design guidance / table
      - Relationship to AASHTO documents (GB, PED Guide, Bike Guide)
      - Supporting research
      - Application
    - Lane width
      - For 10 ft lanes, need to address drainage and other issues associated with narrower lanes
    - Section 10.10 Bus/Transit Stops
      - Needs to address ADA requirements
  - Ch. 11 (Intersection and Interchange Design Guidelines)
    - Keep separate from Chapter 9/10 (for now)

- General Comments on Guidance Document
  - Audience is the design engineer
  - Panel emphasized including illustrations / dimensions / typical sections / CAD drawings, e.g., images that speak best to the typical geometric design profession
  - Do not overwhelm with the amount of information presented
  - Need to address target versus design speed versus use of 85^{th} percentile speed
  - Need to address how to prioritize users
  - Guidance should address the most basic and the most vulnerable users
  - Need to address how best to assemble cross section elements
  - Address 40-44 ft sections and conversions (e.g., 3 and 4 lane roads)
  - Need to address not only street intersections but “sub” intersections as well as driveways
  - Should reference Roadside Design Guide (particularly Chapter 10) as needed
  - Need to keep up-to-date on changes to 13 controlling criteria
  - Guidance should allow for flexibility and use of engineering/professional judgment
  - Guidelines should include examples
  - Guidelines should address low- and intermediate-speeds and how guidance may differ, and full range of urban, suburban, and rural context
    - Priority should be given to most complex context/speeds
    - Only briefly address areas that are easier to address (e.g., rural 25 mph)
  - Consider including a section on “Mitigation” strategies in response to use of less than desirable criteria or elements

Research Team Notes from February 3, 2016 NCHRP 15-48 Panel Meeting
9:00am-4:00pm, TRB Keck Center, Washington DC

Action / Short Term Items:

By Mid-February

- Research team revises and resubmits Phase II work plan
    - Task 8 to include on-site, in-depth interviews with 3 selected agencies
    - Task 9 draft final report will be sent to 12-15 agencies and the panel for review and comment. (no longer part of Task 8)
- Research team revises and resubmits outline of guidance document with annotations
- Research team revises and resubmits draft subsection on lane width
- TRB distributes revised materials to panel for review

End of February

- TRB schedules conference call with panel to review and approve above action items/interim report

Early March

- Research team begins Phase II work plan upon approval

Research Team Notes
March 4, 2016 NCHRP 15-48 Panel Skype/Conference Call, 1:00-2:30pm Eastern

Panel Members Joining Call:

- Brent Story - Georgia DOT (Panel Chair)
- David Hutchison - Springfield Public Works Department
- Michael King -Nelson/Nygaard Consulting Associates
- Brian Ho-Yin Lee – Puget Sound Regional Council
- Richard Moeur – Arizona DOT
- Keith Harrison – FHWA
- David Reynaud – TRB

Research Team Members on Call:

- Marshall Elizer – Gresham, Smith and Partners (PI)
- Ingrid Potts and Darren Torbic – MRIGlobal
- Nick Falbo – Alta Planning + Design

Comments and Discussion Items

The Panel had been provided the attached submittal from the research team which included these revised elements of the Preliminary Interim Report (IR) for review:

- revised DRAFT Guidelines Table of Contents,
- revised sample section on lane widths, and
- revised Phase II Work Plan.

David Reynaud opened the meeting and provided the webinar connection for screen sharing by call participants. He then turned the discussion over to Marshall Elizer, Principal Investigator for the project. Marshall proceeded to overview the revised IR sections for Panel comments and suggestions.

Table of Comments Review
In general, the TOC was well received by the Panel since it had been shortened and simplified as requested by the panel. These specific comments were made on the revised Table of Contents (TOC) and will be addressed in development of the guidelines:

Chapter 2:
- look at combining sections 2c and 2f due to similar or overlapping topics
- look at combining sections 2h, 2n due to similar or overlapping topics
- add Target Speed to section 2h on speed relationships
- add section on design and control vehicles

Chapter 3:
- address issues related to traffic growth projections based on more recent travel growth trends
- review section 3c relationship to section 2i and adjust as needed

Chapter 4:
- evaluate sections 4.2h and 4.4e
- evaluate sections 4.3k and 4.3L, potentially remove to shorten document
- consider incorporating topics in section 4.4 into previous sections 4.1, 4.2, or 4.3

Chapter 5:
- add section on balancing user accommodation and trade-off process in intersections
- look at moving section 2e/2f/2g ahead of section 2d
- add discussion on intersection context

Chapter 6:
- define low and intermediate speed ranges

<u>Revised Lane Width Section Review</u>

In general, the Panel felt that the reduced amount of material was appropriate although it was noted that seven (7) pages will still be too many to keep the guidelines document at the desired size. Specific comments included:

- use designer-focused graphics where possible,
- focus material on speaking to the geometric design community,
- placing recommendations in the front of each section is good, and
- in the recommended lane widths table (10.2), consider segmenting the table first by speeds (low, moderate, high) rather than by multimodal priority.
- Need to describe or define multimodal user priority level scales (low, moderate, high) associated with table 10.2

Written comments from David Hutchinson to be addressed in Guidelines Development:

- Design vehicle is addressed on page 7, but is not in Table of Contents. That was addressed in today's discussion.
- Definition of multimodal often includes freight movement by truck, rail, air, and water. For discussion herein clarify for Table 10-2 (and other locations as appropriate) that the modes being discussed are walk, bike, other non-motorized devices, low-power slow-speed motorized devices, and transit using whatever terms best say that.
- Should the section on operating speed address the effect of "roadside" elements such as trees, utility poles, and tall buildings on operating speed?
- Percent trucks may be a consideration in the evaluation and selection of lane widths.
- Another consideration for selecting lane widths is that a minimum width through lane adjacent to a lightly-used two-way left turn lane may be acceptable adjacent to a minimum width bike lane because motor vehicles passing bicycles can use some of the space in the two-way left turn lane as they pass.
- I understand that seven pages for the Lane Widths section is still long, but I have no recommendation for making it shorter. I appreciate that you lost the four pages of discussion about how to interpret the green book language that was in the previous edition.

As of March 8, 2016, the only written comments addressing the revised Interim Report materials that the research team has received were from David Hutchinson by e-mail. The research team is still waiting to receive written comments provided by other panel members. We will consider and address these written comments when developing the draft guidelines document.

<u>Phase II Work Plan</u>

The Panel was comfortable with the Phase II work approach as presented.

This document is being provided to present revised sections of the NCHRP 15-48 Draft Interim Report based on feedback and suggestions from the Panel received at the Interim Report Panel meeting in Washington, DC on February 3, 2016.

Three revised products have been produced:

1. Revised DRAFT Table of Contents;

2. Revised Guidelines Sample Module for Section 10.1 Vehicle Travel Lane Widths; and

3. Revised Phase II Work Plan.

It is requested that TRB and the Project Panel review these revised documents in advance of a Panel conference call to be scheduled with the research team in late February or early March.

Once the material has been reviewed by the Panel and comments received, the Research team will update and insert them into and updated Interim Report. The research team will consider and address the other comments submitted by the panel on the Interim Report while developing the draft guidance document and draft final report.

1. REVISED PRELIMINARY Table of Contents Outline

The goal of the revisions to this section has been to address a number of comments made at the Panel meeting to shorten and simplify the contents. The revised DRAFT Table of Contents is as follows.

GUIDELINES FOR DESIGNING LOW- AND INTERMEDIATE-SPEED ROADWAYS THAT SERVE ALL USERS

PRELIMINARY TABLE OF CONTENTS

Chapter 1. Introduction (3-5 pgs)
(This chapter establishes the foundation for the purpose and use of the guidelines document.)

a. Purpose, Objectives and Organization of the Guidelines
b. Intended Users of the Guidelines
c. Range of Facilities Addressed in the Guidelines
d. Project Development and Design Process to Address All Users
e. Applicability of the Guidelines
f. Relationship to Other Design Guidance
g. References

Chapter 2. User Design Considerations in Low/Intermediate Speed Environments(15-20 pgs)
(This chapter discusses the range of considerations present in the design of roadways to effectively integrate and serve all types of users across the full range of contexts in 45 mph and less operating environments. Detailed information is provided on the designer's ability to select and use the most appropriate combination of AASHTO-supportive design controls, criteria and dimensions for the anticipated users in coordination with the surrounding context to achieve the desired operating conditions.)

a. AASHTO Design Controls and Criteria
b. Roadway User Definition, Characteristics and Human Factors
c. Functional System Considerations: Roadway, Bicycle, Pedestrian and Transit Networks
d. Separation and Integration of Modes
e. Understanding and Assessing Context
f. Context Sensitive Design Principles
g. Relationship between Functional Classification and Urban Street Typologies
h. Relationship of Design, Operating and Posted Speed to Context
i. Performance Metrics: Mobility, Quality of Service, Safety, Accessibility, Reliability
j. Flexibility in Application of Design Elements and Criteria
k. Bridge and Other Structure Considerations
l. Stormwater and Green Infrastructure
m. ADA Requirements
n. Design Exceptions and Liability Considerations
o. References

Chapter 3. Balancing User Service Levels in Low/Intermediate Speed Environments (12-15 pgs)
(This chapter provides guidance on establishing minimum and desirable accommodation for all users and considerations in combining and integrating accommodation alternatives based on key performance metrics.**)**

a. Design Volumes, Time Periods and Years (all users)
b. Capacity, Quality and Safety of Service Integration
c. Convenience, Accessibility and Reliability of Service
d. Relationship of Traveled Way, Roadside and Intersection Environments across Various Contexts
e. Multimodal Service Level Integration for Corridors, Segments and Intersections
f. Trade-Off Analysis Techniques
g. Recommended Service Level Approach by Facility Type, Context and Speed Range

h. Recommended Cross-Section Development Process
i. References

Chapter 4: Roadway and Roadside Design Guidelines (80-100 pgs)
(This chapter provides guidance on identifying users, user levels and facility design for the roadway traveled way and the roadside within the right-of-way. It addresses each of the key elements within the cross-section and how all users are considered and coordinated in the geometric design of those elements).

4.1 General Considerations
a. Roadway Uses, Users and Activities in Low/Intermediate Speed Environments
b. Roadway Width and Functional Requirements
c. Relationship Between Roadway and Roadside Realms
d. Considerations in Urban, Suburban and Rural Contexts
e. References

4.2 Roadside Design Guidelines
a. General Design Principles and Guidance
b. Pedestrian Accommodations
c. Bicycle Accommodations
d. Transit Service Accommodations
e. Driveway Access
f. Landscaping
g. Lighting
h. Traffic Control Devices
i. Traffic Barriers
j. Utilities
k. Recommended Roadside Design Practice Across Context and Speed Ranges

4.3 Roadway Design Guidelines
a. Vehicle Travel Lane Widths
b. Curbs and Shoulders
c. Medians
d. Bicycle Lanes/Accommodation
e. Parking Configuration and Width
f. Geometric Transition Design
g. Midblock Pedestrian/Bicycle Crossings
h. Pedestrian/Bicycle Refuge Islands
i. Integrated Transit Design
j. Transit
k. Stormwater Management
l. Snow Removal and Storage

4.4 Other Considerations
a. Speed Management
b. Access Management
c. One-Way Streets
d. Railroad-Highway Grade Crossings
e. Traffic Control Devices & Operations

4.5 References

Chapter 5 Intersection Design Guidelines
a. General Intersection Type/Layout
b. Intersection Alignment and Profile
c. Intersection Sight Distance
d. Vehicle Considerations
- Through Lanes
- Right and Left Turn Lanes

- Through Lane Offsets
- Curb Return Radii and Extensions

e. Pedestrian Considerations
f. Bicycle Considerations
g. Transit Considerations
h. Freight Considerations
i. Raised Intersections
j. Traffic Control Considerations
k. Special Considerations in Roundabouts
l. Special Consideration in Interchanges
m. References

Chapter 6: Design Examples

a. Urban Low-Speed Example
b. Urban Intermediate-Speed Example
c. Suburban Low-Speed Example
d. Suburban Intermediate-Speed Example
e. Rural Intermediate-Speed Example
f. Rural Low-Speed Example

Appendix 1. Key Terms and Concepts

2. REVISED Example Guidelines Section

10.1 Vehicle Travel Lane Widths

a. Current AASHTO Policy Guidance

The criteria provided in the AASHTO Green Book (x) describes design width values for through travel lanes, auxiliary lanes, ramps, and turning roadways. There are also recommended widths for special-purpose lanes such as continuous two-way left-turn lanes. AASHTO also provides guidance for widening lanes through horizontal curves to provide for the off-tracking requirements of large trucks. Lane width in the Green Book does not include shoulders, curbs, and on-street parking areas.

AASHTO criteria should be considered design policy guidance only except in the case of design on a National Highway System (NHS) facility where the Federal Highway Administration (FHWA) has adopted the Green Book as the design standard for those facilities.

AASHTO notes that speed is a primary consideration when evaluating potential adverse impacts of lane width on safety on high-speed two-lane highways because drivers may have more difficulty staying within the travel lane. On any high-speed roadway, the primary safety concerns with reductions in lane width are crash types related to lane departure, including run-off-road crashes.

Conversely, AASHTO notes that in a reduced-speed urban environment, the effects of reduced lane width are different and the design objective is often how to best distribute limited cross-sectional width to maximize safety for a wide variety of roadway users. Lane widths may be adjusted to incorporate other cross-sectional elements, such as medians for access control, bike lanes, on-street parking, wider sidewalks, transit stops, and landscaping. The recommended ranges for lane width in the urban, low-speed environment (less than 50 mph) provide adequate flexibility to achieve a desirable urban cross section without requiring a formal design exception.

The AASHTO Green Book policy guidelines for vehicle travel lane widths in urban low- and intermediate-speed contexts are summarized in Table 10.1.

Table 10.1
AASHTO Green Book Suggested Lane Widths for Urban Low/Intermediate Speed Facilities

Lane Type	All Classes	Local Urban Street		Urban Collector Street		Urban Arterial Street	
	Range	Minimum	Preferred	Minimum	Preferred	Minimum	Preferred
Through Lane	9-12 ft	9 ft	10-11 ft	10 ft	11-12 ft	10 ft	11-12 ft
Through Lane (Industrial)	11-12 ft	11 ft	12 ft	11 ft	12 ft	10 ft	11-12 ft
Left/Right Turn / Auxiliary Lane	10-12 ft	9 ft	10-12 ft	10 ft	11-12 ft	10 ft	11-12 ft
Two-Way Left Turn Lane	10-16 ft	n/a	n/a	10 ft	11-12 ft	10 ft	11-12 ft

b. Recommended Practice

Lane widths are impacted by a wide range of factors including the type of travel lane (through, left or right auxiliary, two-way left turn), functional classification of the facility, travel demand, the operating speed of the facility, the adjacent facilities in the right-of-way (e.g., medians, bicycle lanes, parking lanes, transit lanes, etc.), the presence and level of non-vehicle users and the context of the surrounding area (see Figure 10.1). Parking lanes and lanes incorporating transit operations are addressed in separate sections of this chapter.

Table 10.2 provides recommended lane widths for low- and intermediate-speed streets in the urban contexts for local, collector and arterial roadways. These recommendations are provided for three levels of non-motorized multimodal accommodation and three design speed ranges for each level. The recommended widths are for typical situations, and the designer should consider all relevant factors affecting their project before deciding what widths, and combination of widths, are most appropriate for their particular design situation.

Table 10-2
Recommended Lane Width Criteria for Urban Low/Intermediate Speed Facilities that Serve All Users

Multimodal User Priority Level	Design Speed Range MPH	Lane Type	Recommended Lane Widths (feet)				
			Local Urban Street (9-12 ft range)		Urban Collector Street (10-12 ft range)		Urban Arterial Street (10-12 ft range)
			Industrial	All Other	Industrial	Other	All
LOW Multimodal Priority	20-25	Through	11-12	9	11-12	10	10
		L/R Turn	11-12	9	11-12	10	10
		TWLTL	11-12	n/a	11-12	10	10
	30-35	Through	11-12	10	11-12	10	11
		L/R Turn	11-12	10	11-12	10	11
		TWLTL	11-12	10	11-12	10	11
	40-45	Through	11-12	n/a	12	11	12
		L/R Turn	11-12	n/a	12	11	12
		TWLTL	11-12	n/a	12	11	12
MODERATE Multimodal Priority	20-25	Through	11-12	9	11-12	10	10
		L/R Turn	11-12	9	11-12	10	10
		TWLTL	11-12	9	11-12	10	10
	30-35	Through	11-12	10	11-12	10	10
		L/R Turn	11-12	10	11-12	10	10
		TWLTL	11-12	10	11-12	10	10
	40-45	Through	11-12	n/a	12	11	11
		L/R Turn	11-12	n/a	12	11	11
		TWLTL	11-12	n/a	12	11	11
HIGH Multimodal Priority	20-25	Through	n/a	10	n/a	10	10
		L/R Turn	n/a	10	n/a	10	10
		TWLTL	n/a	10	n/a	10	10
	30-35	Through	n/a	10	n/a	10	10
		L/R Turn	n/a	10	n/a	10	10
		TWLTL	n/a	10	n/a	10	10
	40-45	Through	n/a	n/a	n/a	11	10
		L/R Turn	n/a	n/a	n/a	11	10
		TWLTL	n/a	n/a	n/a	11	10
NOTE: TWLTL is Two-Way Left Turn Lane; L/R is Left/Right							

c. Lane Width General Principles and Considerations

There are a wide range of potential considerations beyond those in Table 10.2 that may impact the selection of the appropriate lane widths for a specific design project. The following section discusses these considerations and provides guidance on the selection of travel lane width for the different types of travel lanes used in low- and intermediate-speed environments.

Where streets are designed in areas with a significant level of existing or planned use by non-motorized users, excessive street width can create barriers for pedestrians and encourage higher vehicular operating speeds. Wide streets can reduce the level of pedestrian interchange that supports economic and community activity. Wide streets discourage crossings for transit connections and the overall width of the street can affect the building height to width ratio, a vertical spatial definition that is an important visual design component of many urban streets.

While lane width is only one component of the overall width of the street, it is often cited as the design element that most adversely affects the comfort, convenience, and safety of pedestrian crossings. In fact, many factors affect pedestrian crossing safety and exposure, including the number of lanes, presence of pedestrian refuges, curb extensions, walking speed, and conflicting traffic movements at intersections.

In establishing the most appropriate vehicle lane width for a particular low- or intermediate-speed facility, the designer should consider the needs, safety, and operational impacts of alternative widths to all legal users of the roadway facility. In doing so, some of the key factors that affect lane width selection on a specific facility will include:

- **Total Travel Way Width**. The traveled way width should be adequate to accommodate through and turning traffic lanes, medians, curbs, and appropriate clearances from curb or barrier faces. The width of the traveled way, however, does affect users' perceptions of the speed and volume of the street. Wide streets with multiple travel lanes may be perceived as a barrier to crossing where frequent crossings are desired and encouraged. Wider lanes contribute to wider traveled ways and larger intersections which create longer crossing distances for pedestrians, increased pedestrian and bicycle crossing exposure time to vehicle traffic, and the need for longer traffic signal clearance intervals. The total number and width of travel lanes selected should be based on community objectives, the street's role in the overall network, and the existence or lack of parallel roadways across which traffic can be balanced.

- **Functional Classification**. The AASHTO Green Book states that "*while the accommodation of bicyclists, pedestrians, and transit users is an important consideration in the planning and design of highways and streets, the functional classification of a highway or street is primarily based on motor vehicle travel characteristics and the degree of access provided to adjacent properties.*" Higher-order classifications serving urban areas such as principal arterial, minor arterial and collector roadways often have multiple and even competing roles in the urban street system. The Green Book goes on to say that "*even though many of the geometric design values could be determined without reference to the functional classification, the designer should keep in mind the overall purpose that the street or highway is intended to serve, as well as the context of the project area*." It is for these reasons that the designer must be able to fully consider and balance design criteria such as travel lane width in consideration of the mobility, safety and convenience of all modes and users in the design process of these functional classifications across a broad range of network contexts and community priorities.

- **Design Vehicle**. Lane widths should obviously consider the selected design vehicle for a project. However, the safety and operational impacts of a selected lane width should be evaluated against the different types and sizes of vehicles expected and the frequency that they will use the facility. Some practitioners will conservatively select the largest design vehicle (WB 50 to WB 67) that could use a thoroughfare, regardless of the frequency although that is typically not the most cost-effective design solution in typical low- and intermediate-speed settings. Selecting too large a design vehicle can also serve to create wider cross-sections and intersections, creating negative impacts on other users, particularly crossing pedestrians and bicyclists. Consistent with AASHTO, Context Sensitive Solutions (CSS) emphasizes an analytical approach in the selection of a design vehicle, including evaluation of the trade-offs involved in selecting one design vehicle over another. The selection of a project design vehicle is addressed further in section 10.XX.

- **Vehicle Capacity**. Lane widths may affect vehicle capacity on some facilities. The HCM suggests that lanes narrower than 12 ft reduce vehicle capacity and therefore vehicle LOS on higher speed facilities, but recent studies have shown these impacts to be minimal or non-existent on low- and intermediate-speed roadways in urban settings when lanes are at least 10 ft wide (references to be added).

- **Lateral Clearance**. A wider lane width will provide more lateral clearance between vehicles traveling either in opposite directions on two-lane facilities or in the same direction on four-lane facilities. It also provides for more clearance to on-street parked vehicles, vertical curbs in outside lanes or raised medians, and fixed objects that may exist behind either of those curbed spaces.

- **Design Speed**. Design speed is a critical input to the design process for many geometric elements. For most of these elements, however, the relationship between the design speed and the actual operating speed of the roadway is weak or changes with the magnitude of the design speed. The relationships between lane widths and vehicle speed is complicated by many factors, including time of day, the amount of traffic present, and even the age of the driver. For higher design speeds (40-45 mph) within the low- to intermediate-speed range, it is generally recommended to utilize wider lane widths whereas narrower lanes are generally appropriate in the lower speed range (25-35mph). However, depending on context and the needs and safety of other users, it may be appropriate to use narrower 10 ft lanes even on 40-45 mph design speed facilities.

- **Operating Speed**. There is general agreement among design and traffic engineers with urban and suburban geometric design and operations experience that operating speeds tend to decrease as lane widths decrease to dimensions that create discomfort for drivers and make side-by-drive driving more difficult. While there is no definitive research that establishes the relationships between these two variables, a study conducted in 2000 (13) found that on suburban arterial straight sections away from a traffic signal, higher speeds should be expected with greater lane widths. NCHRP Project 15-18 identified several variables other than the posted speed limit that show some sign of influence on the operating speed on tangent sections. These variables include access density, median type, parking along the street, and pedestrian activity level.

- **Vehicle Safety**. In general, research studies have shown no effect of lane width on vehicle safety on urban and suburban roadways in low- and intermediate-speed settings, with only limited exceptions that may possibly represent random effects (add references). As a result, Chapter 12 (Urban and Suburban Arterials) of the Highway safety Manual (HSM) does not include a crash

modification factor (CMF) for lane width on urban and suburban arterials. On low- and intermediate-speed facilities the risk of lane-departure crashes is less and the design objective usually becomes how to best distribute limited cross-sectional width to maximize safety for a wide variety of roadway users. However, with vehicle mixes that contain substantial numbers of large trucks or buses, safety considerations would generally suggest a wider curb lane to more safely accommodate those wider vehicles.

- **Pedestrian Safety**. Many design professionals believe that, in general, pedestrian safety is improved as vehicle lane widths are reduced due to them contributing to shorter traveled way crossing distances (thereby reducing exposure time to vehicles) and reduced vehicle speeds induced by the narrower lane widths.

- **Bicycle Safety**. Bicycles experiences the same safety benefits as pedestrians related to shorter crossing and traffic exposure times from narrower lane widths. However, an equally if not more important consideration is the relationship of the travel lane to bicycle traffic in or adjacent to the outside travel lane. The AASHTO and NACTO bicycle facility design guides provide extensive guidance on the design of bicycle accommodation within the traveled way including recommended widths for both vehicle-bicycle shared lanes and striped bicycle lanes between the travel lane and vertical curb. When a parking lane is present, these lane width relationships become more sensitive and painted buffer strips are sometimes painted between the vehicle, bicycle and parking lanes.

- **Space for Other Facilities**. Using narrower lanes on urban and suburban arterials can provide space for incorporation of other features that are positive for operations and safety including medians, turn lanes, separate or shared bicycle lanes, parking lanes, bicycle lane buffers, wider sidewalks, enhanced border landscaping and context amenities.

Other potential considerations in the evaluation and selection of lane widths include:

1. Travel lane widths of 10 ft can provide a safe environment in urban settings while discouraging higher vehicle speeds.
2. Lanes greater than 11 ft should generally not be used on roadways with high levels of pedestrian and bicycle activity as they may cause unintended speeding and assume valuable right of way at the expense of other modes. This includes the use of wide outside lanes for bicyclist accommodation which are not considered an effective means of accommodating bicyclists in urban areas; rather, narrower travel lanes used in conjunction with bicycle lanes are preferred (Bahar et al., 2008; Hunter et al., 1999; McHenry and Wallace, 1985).
3. Roadways designated as major truck or transit routes through urban areas may require the use of wider lane widths for specific lanes, with 11 ft generally being the minimum width used.
4. Where adjacent lanes are unequal in width, the outside lane should be the wider lane to accommodate large vehicles and bicyclists (only where bicycle lanes are not practical), and facilitate the turning radius of large vehicles.
5. Where wider curb lanes are required, consider balancing the total width of the traveled way by narrowing turn lanes or medians to maintain the same overall pedestrian crossing width.
6. Additional lane width may also be necessary for receiving lanes at turning locations with tight curves, as vehicles take up more horizontal space at a curve than a straightaway.
7. Consider wider lanes along horizontal curves to accommodate vehicle off-tracking, based on a selected design vehicle. This measure is an alternative to providing wider lanes for the entire route. The AASHTO Green Book provides guidance on widening for vehicle off-tracking.

8. Many fire districts require a minimum 20-ft clear traveled way. This is usually achievable on urban roadways with 2 or more lanes without medians but may present challenges on streets with one travel lane in each direction separated by a median.
9. Curb lane widths should be measured to the face of curb unless the gutter and catch basin inlets do not accommodate bicycles and motor vehicles. To preserve the use of available width, inlets should be designed to safely accommodate bicycle and motor vehicle travel.
10. While it may be advantageous to use minimum dimensions under certain circumstances, combining minimum dimensions of adjacent elements to reduce street width may affect the safety of users. For example, avoid combining minimum-width travel lanes adjacent to a minimum-width parking/bicycle lane, a situation that significantly reduces the separation between vehicles and bicyclists.
11. If a network evaluation determines that sufficient capacity exists to accommodate corridor or area-wide traffic demands, consider reducing the number of travel lanes to accommodate the desired design elements in constrained right of way. On streets with very high turning movements, replacing through lanes (where turns are occurring from the inside through lane) with a turning lane can significantly improve traffic capacity.
12. Where there is insufficient network travel lane capacity and right of way to meet thoroughfare design objectives, consider converting two parallel streets into a pair of one-way streets (couplet) to increase capacity before considering widening thoroughfares. While sometimes the subject of debate and controversy, one-way couplets have appropriate applications under the right circumstances. Strive to keep the number of lanes in each direction to three or less. This measure requires a comprehensive study of the ramifications for pedestrian and bicycle safety, transit and vehicle operations, economic issues and so forth.

References

1. Bahar, G., M. Masliah, R. Wolff, and P. Park, *Desktop Reference for Crash Reduction Factors*, Report No. FHWA-SA-08-011, Federal Highway Administration, Washington, D.C., 2008.
2. NCHRP 03-112: *Operational and Safety Considerations in Making Lane Width Decisions on Urban and Suburban Arterials* (expected completion 2017)
3. NCHRP Report 783: *Evaluation of the 13 Controlling Criteria for Geometric Design* (2014)
4. NCHRP Report 766: *Recommended Bicycle Lane Widths for Various Roadway Characteristics* (2014)
5. *Highway Safety Manual* (2010 & 2014 Supplement)
6. *Urban Street Design Guide*, NACTO (2013)
7. *Urban Bikeway Design Guide, 2nd Edition*, NACTO (2012)
8. *Guide for Development of Bicycle Facilities,* AASHTO (2012)
9. *A Policy on Geometric Design of Highways and Streets,* 6th Edition, AASHTO (2011)
10. *Highway Capacity Manual*, TRB (2010)
11. *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach*, an ITE Recommended Practice, ITE (2010)
12. Potts, I. B., 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*, Transportation Research Board of the National Academies, Washington, D.C., 2007, pp. 63–82.
13. *Mitigation Strategies for Design Exceptions, Report* FHWA-SA-07-011, FHWA (July 2007)
14. Potts, I. B., D. W. Harwood, D. J. Torbic, K. M. Bauer, K. R. Richard, D. K. Gilmore, D. K. Lay, J. F. Ringert, J. D. Zegeer, D. L. Harkey, and J. M. Barlow, *Lane Widths, Channelized*

Right Turns, and Right-Turn Deceleration Lanes on Urban and Suburban Arterials, Final Report of NCHRP Project 03-72, Midwest Research Institute, August 2006.

15. *Guidelines for Geometric Design of Very Low-Volume Local Roads* (ADT ≤ 400), (2001)
16. Fitzpatrick, Kay et al, *Design Factors That Affect Driver Speed on Suburban Arterials*, Research Report 1769-3, Texas Transportation Institute (June 2000)
17. Project Summary Report 1769-S, *Project 0-1769: Identify Design Factors That Affect Driver Speed and Behavior*, Kay Fitzpatrick, P.E., Paul J. Carlson, P.E., Mark D. Wooldridge, P.E., and Marcus A. Brewer, Texas Transportation Institute, November, 2000
18. Hunter, W.W., J.R. Stewart, J.C. Stutts, H.H. Huang, and W.E. Pein. *Bicycle Lanes versus Wide Curb Lanes: Operational and Safety Findings and Countermeasure Recommendations*, Report FHWA-RD-99-035 (1999)
19. *A Comparative Analysis of Bicycle Lanes Versus Wide Curb Lanes: Final Report*, FHWA-RD-99–034 (1998)
20. TCRP Report 19, *Guidelines for the Location and Design of Bus Stops*, Transportation Research Board (1996) NCHRP Report 330: *Effective Utilization of Street Width on Urban Arterials* (1990)
21. McHenry, S.R., and M.J. Wallace. *Evaluation of Wide Curb Lanes as Shared Lane Bicycle Facilities*, Report No. FHWA-MD-85-06, Federal Highway Administration, Washington, D.C., 1985.

3. Revised Phase II Work Plan

Recommendations for Phase II Work Plan (Task 7)

The research team has developed a recommended approach and schedule to be executed in developing the guidelines document and project final report in Phase II of the project.

Step 1: Develop DRAFT Guidelines Document (Task 8) - March-May 2016

The research team will use the feedback and guidance provided by the Panel in their review of this document and the DRAFT Interim Report to develop the DRAFT Guidelines document consistent with the approved Table of Contents and example section module.

Step 2: DRAFT Guidelines Review by TRB, Panel & Three (3) Selected Agencies (Task 8) - June 2016

The DRAFT guidelines document will be simultaneously shared for review and comments with (a) TRB staff and the Project Panel, and (b) three (3) selected state or local roadway agencies. The research team will schedule day-long focused workshops with each of the three reviewing agencies to discuss their overall reaction to the effectiveness and usefulness of draft guidelines document. The workshops will also be designed to obtain more specific recommendations for how the guidelines can be more useful and beneficial to transportation designers in their agency.

Step 3: Revise DRAFT Guidelines to Preliminary FINAL Guidelines Document and Develop DRAFT Final Report (Task 8) - July 2016

In this step the Research team will update the DRAFT Guidelines document to reflect the feedback given by the Panel, TRB staff and the three workshop agencies. The resultant document will be the Preliminary FINAL Guidelines document.

Step 4: Preliminary FINAL Guidelines Review by TRB, Panel, and 12-15 Transportation Agencies (Task 9) – August 2016

In this step the Preliminary FINAL Guidelines document will be simultaneously shared for review by twelve (12) to fifteen (15) state DOT and local transportation agencies representing (a) a diversity of geographic and climatic conditions, and (b) having varying levels of advanced multimodal design experience and documentation. These agencies will be selected from those identified in the literature review and agency survey.

Step 5: Proposed Final Guidelines and Final Report Review by TRB and Panel (Task 9) – September-October 2016

In this step, the final proposed revised versions of the Guidelines and Final Report will be submitted for review. Comments will be addressed and the FINAL documents will be submitted to TRB for processing and publishing. The Final Report will develop a prioritized list of key gaps in knowledge associated with design guidance and performance measures across user types/modes.

NCHRP Project 15-48
Developing a Methodology for Designing Low and Intermediate Speed Roadways that Serve All Users
Panel Review Ballot Comments

Reviewer	Panel Review Comments	Research Team Response	Revision Location Chapter / Section / Page
1	No Comment		
2	1. The proposed title for the publication ("All Users Design Guide or AUDG") is short and simple; But, to me, it's a little too vague. I would suggest paring down the earlier version of the title to simply be "Guidelines for Designing Lower Speed Roadways That Serve All Users". Admittedly, that's still a little bit vague; But, at least the reader knows right away that we're designing roads not buildings and only for a specific subclass of speeds (further defined in the narrative).	We understand the comment and have proposed a title change "**Design Guide for Low-Speed Multimodal Roadways**" for these reasons: (1) The AASHTO Green Book defines low-speed design as 45mph and below, with high-speed design 50mph and above. It does not define an "intermediate speed" range. Given that distinction and the explanation in the introductory text of the document, we believe that using only "low-speed" in the title is acceptable; and (2) while "all users" is intended to describe all legal users of the roadway and right-of-way, we believe that "multimodal" is a well recognized term and is probably more readily understood in the profession than is "all users".	Title page and several locations throughout the document as shown in the Updated Draft version of the document.
2	2. The content still feels a bit "disconnected" in that the underlying framework of using the 15-52 Context Zones and Low/Medium/High priority sometimes get lost amongst discussion of other approaches like the ITE Walkable Thoroughfares guide with its own context zones.	We have attempted to identify and remove the "disconnected" sections and have made numerous edits that hopefully address that issue.	Revisions made throughout the document as shown in the Updated Draft.
2	3. There is a lot of information excerpted from other reference documents to the point that the document feels more like an NCHRP Synthesis and less like a Guidebook.	This point is understood and was a dilemma for the research team. When current guidance in other documents was deemed to represent the best practice in the literature for a certain aspect of design, we believed it was better to provide some portion that guidance directly, as referenced, to give credit to those sources rather than attempting to re-construct that information containing the same information and guidance. In some cases, the italicized text was used to validate, or support, the guidance provided. That said, we have identified several sections of the report where excerpted information has been reduced and summarized to address this concern.	Edits made throughout the Updated Draft to address this comment.
2	4. In many locations, the amount of material cut and pasted into this document is far too voluminous and/or far too detailed. Some of these excerpts span several pages and include very lengthy bulleted lists. I think the typical excerpt should be more like an Executive Summary, highlighting some germane points, including a sample paragraph or two and perhaps a graphic as well. It should serve as a "teaser" for the reader to go find the source document	As noted in the response to comment #3 above, several edits have been made throughout the document as summarize and reduce information included from source documents.	Edits made in "Track Edits" in these sections to address the comment:
2	5. Largely because of the breadth of reference material integrated into this publication, there is a lot of duplication. There are far too many repetitions of the need to consider all modes and to achieve an appropriate balance. That "Complete Streets" type message is important; But, it's repeated often enough (sometimes with slightly different wording) that it feels overdone.	We have attempted to reduce the amount of duplication as noted. However, with the assumption that many users will likely go to sections of interest and not read this document in its entirety, we felt that certain basic tenets of designing for all users needed to be restated as necessary to provide the intent of the various sections. Some edits have been made, however, to address this concern.	Edits made throughout the document in an attempt to avoid duplication of message except where a re-statement was deemed valuable.
2	6. The USDOT Policy on Bicycle and Pedestrian Accommodation is a persuasive document. But, it is given far too much emphasis and repeated more than once in its entirety. Cite it once and place the entire memo at the very end of the document if need be.	Understood and revisions made in locations as noted to reduce duplication of material.	Revisions made in Preface and Introduction sections.
2	7. The narrative in Chapter 3 needs to give greater emphasis on safety performance. Right now, it's presented in such a way that it repeatedly places sole focus on traffic operations (HCM and LOS). The Highway Safety Manual is included almost as an afterthought and is simply lumped in with a laundry list of other publications with no real acknowledgement of its uniqueness. Perhaps retitling the Chapter to substitute "Performance Goals" for "Service Levels" would help	The Research team agrees that safety is a critical element of performance to be considered in the design process. It is addressed in the lead section of Chapter 3 as one of the key performance metrics and specifically discussed in other parts of the chapter. That said, we have added text related to safety performance for all user types. **This should be discussed with the Panel.**	Revisions made in several areas of Chapter 3 as shown the "Track Edit" version of the document.
2	8. Chapter 6 includes case study examples "borrowed" from two other publications. I realize that it may be beyond the scope of this effort; But, I think not having an example (even if hypothetical) of using this document on a real-world example is a missed opportunity.	The Research Team felt that the examples provided addressed the use of the information in the document ranging from a more simple, qualitative project design process to a complex, quantitative performance-based process. Another example can be added, but there are many possible design scenarios that could be addresses. **It is recommended that this item be discussed further with the Panel.**	No changes made at this time other than clarifying edits to the case study text.
3	I like the name "All Users Design Guide". The report is well-organized. The table of contents presents information in a manner that is easy to find and like other engineering reference documents. As presented, it functions as a design document and a reference document. I was surprised how many new NCHRP reports and references I did not know about.	Based on comments from Reviewer #2, and agreement that "all users" may not be a term easily understood in the profession as "multimodal" is, a new name has been created for the document: "Design Guide for Low-Speed Multimodal Roadways." **This subject is important enough that it should be discussed with the Panel.**	Changes have been made throughout the document to reflect the new proposed document title.

3	Much of the language in Chapters 1, 2 and 3 of the All Users Design Guide identifies current practices, state of the art and evaluation processes. This language is important for the first edition of the All Users Design Guide. As the All Users Design Guide becomes the principle reference document for design of low and intermediate speed streets, reference to those topics can be reduced or removed for future editions.	The Research team agrees that the information and guidance for this area of design continues to evolve rapidly and the document should receive regular updates to capture the latest design guidance information developed by the profession.	No changes made at this time.
3	Page 5 and 11: I feel that the last paragraph in Section 1.E "The All Users Design Guide is also intended to: . . . " is the most important paragraph describing the document and should be the opening paragraph, or on the first page. It could be in a text box at the beginning of the document or between the 3rd and 4th paragraphs of Section 1.A.	We agree and this material has been added to Section 1.A. as suggested.	Section 1.A. has been revised.
3	Page 9: What is purpose of Exhibit 1.1. It says to me that all facility types and context zones 45 mph and under are addressed and those over are not. That can be said more simply and succinctly without the graphics. Consider a text box for highlight.	**This table can be removed if the Panel's decision is to do so.** The primary purpose of the table was to illustrate the basic interrelationships between functional classification, rural/urban areas, the more advanced context zone definitions, and design speed ranges.	No changes at this time.
3	Page 17: Second sentence, second paragraph in "Design Speed" change to "Design guidance in the All Users Design Guide is developed . . ."	Correction noted and made.	The second paragraph under the Design Speed section of 2.B. has been revised.
3	Page 17: 3rd paragraph, 3rd sentence in "Design Speed", consider changing "designed" to "intended" or "destined" "to become the posted speed limit."	Correction noted and made.	The third paragraph under the Design Speed section of 2.B. has been revised.
3	Page 19: 2nd paragraph, 1st bullet, I want to emphasize that the concept of design vehicle and control vehicle presented herein is very important for designing appropriately size streets. The design vehicle can use the entire portion of the roadway regardless of number of lanes going the direction intended without encroaching into opposing traffic and all vehicles intended to use the roadway need to be contained within the roadway, although occasional encroachment into opposing traffic may occur.	Agreed.	No changes made.
3	Page 21: The italic paragraph in section 2.C is also an important concept.	Agree.	No changes made.
3	Page 21: Within "Pedestrians" paragraph, should younger pedestrians be further described as having short stature and immature decision-making skills?	Agree. Text added to address this comment.	The Pedestrians section of section 2.C. has been revised to address this comment.
3	Page 22-26: It should be noted in Section 2.D or 2.E that all users are served with the general design of local roadways, which are normally low volume and slow speed. Bicyclists normally share lanes with motor vehicles within the traveled way. Pedestrians are served on sidewalks included in typical design. Intersections are simple meeting normal requirements of ADA and PROWAG. More policy and design is required on collector and arterial roadways to identify how each user would be served.	We agree that this is an important relationship to explain. We believe that the topic is best addressed in Section 2.D. and the text in that section has been edited to address this condition.	Section 2.D. has been edited to address this comment.
3	Page 25: Many roadways in suburban and general urban context areas are 4-6 lanes with speed limits of 40 -45 mph with medians or TWLTLs. These streets are not included in Exhibit 2.1: Urban Area Thoroughfare Type Descriptions. Exhibit 2.1 seems to address high and low speed roadways, and ignore intermediate speed roadways.	We agree that many urban and suburban thoroughfares have speeds in the 40-45mph range and are often designed with raised or flush medians and also two-way left-turn lanes. Exhibit 2.1 was adapted from the ITE/CNU Designing Walkable Urban Thoroughfares document which used 35mph as the maximum speed for a "walkable" roadway. Text has been added into this section to address this gap.	Section 2.E. has been edited to address this comment.
3	Page 25: second from last paragraph, add "raised or flush" to describe medians, and/or add TWLTL as an addition to "up to four" travel lanes. Again, some streets and avenues have six travel lanes.	Agree. Text has been added to address this comment.	Section 2.E. has been edited to address this comment.
3	Page 29 and 30 and page 104: The land use character is not adequately defined for suburban. Separated uses is the key descriptor. Could read: "Separated residential neighborhood and commercial clusters (includes town centers, commercial corridors, big box commercial, and light industrial) with most structures having a purpose use". For land use character for urban and urban core, the phrase "some mixed use structures (commercial lower level and residential or office above)" could be added. What does "closely mixed setbacks" for urban setbacks mean?	This table has been taken directly from the NCHRP 15-52 research report and we are concerned with editing this table as suggested, although the suggested changes are certainly reasonable. **We recommend this item be discussed further with the Panel.**	No changes made at this time.
3	Page 35-36: Roundabouts, chicanes, and slow points are also strategies to manage speed.	Good points. These items have been referenced n the text.	Section 2.K. has been edited to address this comment.

3	Page 80: Suggest for last sentence of second paragraph: "However, strict adherence to every design criteria contained in this All Users Design Guide may not always be obligatory for the low- and intermediate-speed roadways addressed herein."	Understood. Change made.	Section 3.F. has been edited to reflect this change.
3	Page 85: 4th line, "The USDG recognizes that . . ."	Change made.	Section 3.F. has been edited to reflect this change.
3	Page 92: Last sentence for 1st full paragraph, "See Section 3.B of the . . ."	Change made.	Section 3.G. has been edited to reflect this change.
3	Page 102: 1st bullet, "Block length: Development patterns with traditional urban, urban core and many rural town contexts usually have shorter block lengths with a network of closely-connected streets and possibly and alleys. Vehicle focused contexts such as suburban and some urban contexts tend to have larger block lengths, less street connections (fewer street connections) and often no alley access. These types of street patterns typically requires longer walking distances longer and will tend to generate lower pedestrian volumes." I disagree that longer blocks tend to generate demand for mid-block crossings except on higher volume streets. For low to intermediate volume streets, people cross where they want to cross regardless of block length.	Edits made to hopefully clarify and improve this paragraph.	Section 4.1.C. has been edited to reflect this change.
3	Page 102: Each bullet of Site Building Design except the second includes a description of how that characteristic effects the roadway. Bullet 2, Building width, includes only three elements of building width. Add a sentence describing how building width affects the roadway context. Also, there is a successive comma and semi-colon in the bullet.	Edits made to hopefully clarify and improve this paragraph.	Section 4.1.C. has been edited to address this comment.
3	Page 104: See comment for page 29	This table has been taken directly from the NCHRP 15-52 research report and we are concerned with editing this table as suggested, although the suggested changes are certainly reasonable. **We recommend this item be discussed further with the Panel.**	No changes made at this time.
3	Page 104: End of first line of 4.1.D should read "it is".	Agree.	Changes made to 4.1.D.
3	Page 108: Exhibit 4.5 is on three pages. Move Exhibit name to same page as start of table. Add column headings to top of second page of table. "Signalized Intersections" does not include all major intersections. Consider changing to "Major Intersections" or "Signalized Intersections and Roundabouts" or adding an additional line for "Other Major Intersections" and/or "Roundabouts".	Edits made to hopefully clarify and improve this table.	Changes made to Exhibit 4.5
3	Page 117: Consider for Exhibit 4.6 a different "context" illustration on one side of the roadway as the other similar to those contained in Exhibits 5.1-5.6.	The illustration has been changed as requested. The purpose of this exhibit is to simply illustrate the relationships of the traveled way, roadside and context realms in the design process. The type of context isn't a key aspect of the illustration, although the text has been edited to note changes in context and its relationship to the other realms.	Edits made to illustration and the beginning of Section 4.2.
3	Pages 120-125: The narrative for Section 4.2.B misses the mark for low speed roadways. Much of the narrative seems to apply to high-speed roadways and to a lesser extent intermediate-speed roadways. Most of the narrative is regarding shoulders whereas most low- and intermediate-speed roadways are edged by curb. The section should have little regarding hazards of curbs since they are a hazard primarily on high-speed roadways. The section should begin with and emphasize the use of curbs and their purposes for separating the travel-way and roadside, drainage control, parking positioning, speed management, etc. The section should be rewritten. The text regarding shoulders should be reduced and moved to the end as a way to also manage the edge of intermediate speed roadways.	The Research team agrees that additional information for curbed facilities would be beneficial. Edits have been made to address these concerns.	Edits made to Section 4.2.B.
3	Page 137: second line of second paragraph, change "bile" to "bike".	Correction made.	Change made in Section 4.2.D. Bicycle Lanes/Accommodation, under AASHTO Bike Guide
3	Page 142: On third line of third paragraph, change "mush" to "much". Among considerations for changing transit conditions are proximity of bus stops to signalized intersections and additional crosswalks including refuge islands and signals or beacons as transit volumes change.	Spelling correction made. Text edited to address other comments.	Change made in Section 4.2.D. Bicycle Lanes/Accommodation, under Transit Facilities on Roadways
3	Page 144: Regarding bus stop design, many transit agencies operate 30-foot buses with only one door for which a 6-10-foot landing area is acceptable.	Agree and will add that condition.	Change made in Section 4.2.D. Bicycle Lanes/Accommodation, under Bus Stop Design
3	Page 148: Second to last sentence of second paragraph, add space between Chapter 6 and outlines.	Edit made.	Edits made in 4.2.F.

3	Page 154: Fixed objects on the roadside is not considered an issue for low-speed roadways and a secondary issue for intermediate speed roadways. Rewrite the second paragraph under Trees and Landscaping in Medians to encourage placement of trees in medians and qualify the hazard of fixed objects in clear zone to roadways without curbs and with speeds greater than 40 mph.	Edits made to address this situation.	Edits made in 4.2.F.
3	Page 155: Last sentence: Yes! It is often preferable to cross streets where vehicles come from only two directions and sight distance is far enough that you can see all vehicles approaching while the person walking is in the roadway. Having to watch for vehicles entering intersections from four directions many of which the person walking cannot see until they are two or three seconds away is scary and dangerous.	Agree. No edits needed.	
3	Page 179: Remove the first bullet at the bottom of the page and let the text become a paragraph under Crosswalk and Ramp Placement introducing the bullet list.	Suggestion accepted. Edits made.	Edits made in 4.2.K.
3	Page 229: End of first line of 5.1.C should read "it is".	Edit made.	Edits made in 5.1.C.
3	Page 232: in second full paragraph, change "guide" to "RDG" in 3rd and 5th lines. Second sentence should begin "Designers are expected to use the RDG . . ."	Suggested edits made	Edits made in 5.1.D.
3	Page 233: On-street parking is listed as a roadside feature. While parking does function as a buffer, it is normally a part of the travelled way, not roadside.	Agree. Edits made.	Edits made in 5.1.D.
3	Page 233: In 5th line from bottom of page, "Install pedestrian refuge medians and/or channelized islands . . . "	Suggested edits made.	Edits made in 5.1.D.
3	Page 234: The bullet on bicycle racks is written for high-speed roadways. Bicycle racks are normally used on low-speed roadways as a part of normal street furniture and yielding design is not a consideration. Rewrite bullet to that effect.	Agree with comments and will make suggested changes.	Edits made in 5.1.D.
3	Page 234: The bullet on rumble strips has little relevance. Rumble strips are normally used on high-speed roadways. Remove bullet or rewrite to relate to intermediate speed roadways.	Agree. Revisions made.	Edits made in 5.1.D.
3	Page 235-236: Change numbers to bullets. In first bullet, change "usually" to "often" or "sometimes".	Suggested edit made.	Edits made in 5.1.E.
3	Page 236: In section on Main Streets, end first sentence of first paragraph with ". . . rural settings, urban cores, and urban neighborhood centers." In second sentence of second paragraph, add ". . . one to three stories, or taller in the urban core, and are oriented . . ." In 5th line of 3rd paragraph, separate 30 mph. In 4th line of 4th paragraph, add ". . . people to walk side by side and often pairs of people to pass one another."	Agree with suggestions and similar changes made to text.	Edits made in 5.1.E.
3	Page 238: It is important to convey that "All travelers are pedestrians at some point during their trip." In last sentence, introductory phrase is unnecessary in that pedestrians may share the road or use shoulders to complete a trip regardless of speed and volume of motor traffic. Speed and volume of motor traffic affects the safety of pedestrians that share the road or use shoulders.	Understand the point and edits have been made.	Edits made in 5.1.E.
3	Page 246: In last paragraph, detection for dynamic signs may also be by radar, cameras, and perhaps other methods.	Agree, edits made.	Edits made in 5.1.I.
3	Page 247: Suggest different contexts on each side of traveled way for Exhibit 5.15.	Agree. Changes made in exhibit.	Exhibit 5.15 revised.
3	Page 248: Delete "is" in first line of section 5.2.A.	Correction made.	Edits made in 5.2.A.
3	Page 253: In 4th paragraph from bottom of page, "An absolute minimum border area may be 5 feet clear of signs, utility poles, and other objects to accommodate . . ." Last sentence of 2nd paragraph from bottom of page could read: "Width of sidewalks may be increased in response to higher pedestrian activity . . ."	Good suggestions, edits made.	Edits made in 5.2.C.
3	Page 257: Keep Exhibit 5.18 on one page or add column headings on second page if split.	Agree, edits made.	Exhibit 5.18 revised.
3	Pages 263-273: Reference NACTO's Transit Street Design Guide as providing good information regarding pedestrian movements to and around transit stops and design of bikeways near transit stops. Reference Section 5.2.K on page 290/291 related to pedestrian and bicycle interaction near rails.	Agree, good suggestions. Edits made.	Edits made to section 5.2.E.
3	Pages 270-272: Numbers are inserted here and there not set off by brackets not for a purpose that I identify.	Corrections made.	Edits made to section 5.2.E.

3	Page 274: At end of 2nd paragraph, 3-foot high landscaping often impedes visibility. 3rd bullet on page 277 says 2 feet, which is a more practical height. In next to last line on page, do you mean "overhead" car doors?	Understand the points and edits have been made.	Edits made to section 5.2.E.
3	Page 275: In 2nd paragraph from bottom of page, "In areas with high pedestrian activity with limited walkway width, trees may be planted in tree wells covered by grates . . ." In many cases communities have found that grates come with their own sets of problems or chose to use the space around trees for planting.	Understood, edits made.	Edits made to 5.2.F.
3	Pages 278-280: Include conversation regarding storm water planters on steep grades. They work best where grades are relatively flat. On moderate to steep grades, the velocity and volume of water entering and leaving planters from the gutter during a heavy rain can wash away any ground cover material short of medium to large cobbles.	Good points, edits made.	Edits made to 5.2.F.
3	Page 281: The bullet list at top of page seems very prescriptive as though written for a specific community. "Shall" and "must" should be changed to "should" or "could" and "may". The last sentence of the last bullet could read: "Clamp-on brackets for banners or hanging planters may be attached to light poles."	Understand and edits made to address the comments.	Edits made to 5.2.G.
3	Page 284: In 2nd bullet, change "prevent" to "reduce probability of".	Agree, edits made.	Edits made to 5.2.H.
3	Page 285: At end of 2nd paragraph, why specify low speed? Desired spacing can be achieved on "all" roadways.	Agree, edits made.	Edits made to 5.2.I.
3	Page 286 and 288: Maximum recommended driveway width is stated to be 24 feet. 24 feet may be acceptable on low-speed roadways, but cars entering the driveway from the street when a car is exiting the driveway come to a virtual stop on the street and enter the driveway at less than 5 mph.	Understand the point. Edits made to address the situation.	Edits made to 5.2.I.
3	We have found 26-30 feet to be the most effective width on intermediate-speed roadways to allow motor vehicles to enter the driveway when there is a vehicle exiting. Granted they cross the sidewalk at a higher speed, but rear-end crashes are more prevalent than crashes with pedestrians on sidewalk crossing the driveway.	Understand, edits made to further address this issue.	Edits made to 5.2.I.
3	Page 287: Next to last line, "maximum" is superfluous.	Agree. Edits made.	Edits made to 5.2.I.
3	Page 293: The first signal phasing option for pedestrians should be fixed time operation or automatic pedestrian recall where volumes of pedestrian are moderate to high and block lengths are short and uniform, especially in urban core, neighborhood center, and town center contexts.	Agree that these are reasonable options and should be considered. Edits made.	Edits made to 5.2.L.
3	Page 294: The list near top of page is numbered instead of bullets. For number 6, ". . . intersection should have pedestrian signal heads." Ahead of Bicycle Signal Heads, discuss use of "BICYCLES USE PEDESTRAIN SIGNAL" sign where side paths or separated bikeways cross street intersections. That condition is referenced in 4th bullet under Bicycle Signal Heads.	**Not sure comment is understood. Need to discuss with reviewer or Panel.**	No changes made.
3	Page 295, 2nd line of Section 5.2.M, say ". . . opening up lanes for motor vehicles."	Agree, changes made.	Edits made to 5.2.M.
3	CHAPTER 6		
3	Design Case Studies A and C seem to lack sufficient detail or explanation, but are acceptable within available constraints. Design Case Studies B and D are confusing and difficult to follow. One has difficulty determining whether the author's notes are the author of the AUDG or NCHRP Report 785.	**Need to discuss with the Panel.** We are concerned about editing case studies taken from NCHRP 785, but edits have been made to hopefully clarify the "author's notes" sections.	Edits made in Case Studies A & C.
3	One has difficulty understanding whether the chapter/section references are to the AUDG or NCHRP Report 785, though one may assume the NCHRP report since they do not match the section designations contained herein. I also find the switching between italic and standard type confusing. Adding another set of author's notes to explain the existing author's notes would be more confusing. Why are the author's notes necessary? Could they be merged into the text?	Agree that edits are useful and have been made to hopefully address this situation.	Edits made to Case Studies A & C.
3	Could additional comments be added regarding selected cross sections and alternatives that were not considered? Many of the cross sections include 14-16-foot TWLTLs. Why does a lane that is occasionally used for slowing or standing traffic need to be wider than 11 feet?	**Need to discuss with Panel.** These studies have been used as examples from other documents and revising or adding to their analysis may be inappropriate.	No changes made.

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3	In Case Study D, why was no buffer put between the sidewalk and curb? Also in case study D, the north-south street against the protected forest-hillside with critical habitat would have no access on the west side of the roadway, a perfect location for a side path.	This case study has been taken from NCHRP 785 and we are concerned about editing it from its original context, other than clarifying comments where necessary. **Need to discuss with Panel.**	No changes made.
3	Page 316: Why is the matrix table contained in Exhibit 6-19 necessary? Since the same documents were used to evaluate each alternative, a list would convey the same information.	Generally agree with the comment, but we feel the NCHRP 785 content should not be edited. May need to discuss with Panel.	No changes made.
4	1. Charts and tables without gridlines are hard to read.	Charts and tables with clarity concerns have been reworked.	Edits made to all tables with clarity concerns.
4	2. Page 18 Paragraph 2: Many cities have arterial streets with narrow (10') lanes, but relatively high operating speeds (40+ mph). Note that lane width adjustments alone will not effect meaningful changes in speed.	Agree. Edits have been made to address this point.	Edits made to 2.B.
4	3. Page 19 Paragraph 3 Agencies may define design vehicle by policy - practitioner may not have input on the decision.	Agree.	Edits made to 2.B.
4	4. Page 22 Paragraph 6 Change "Bicyclists are a growing element" to "Bicyclists are a increasing element", since the bicyclists themselves aren't growing (unless they're young).	Agree, clarification made.	Edits made to 2.C.
4	5. Page 26 Paragraph 3Saying that designs should eliminate conflicts to the greatest extent possible is over simplistic, and creates a liability trap for agencies. At locations where travel paths cross, designers must make tradeoffs between conflicts based on likelihood of crashes and associated severity.	Understand and agree in general. Edits made to address this point.	Edits made to 2.F.
4	6. A weaving conflict can be less-severe than a crossing conflict, but attempting to eliminate both could be cost-prohibitive and not accepted by users (excessive delay, diversion from travel path, etc. Discuss trade-offs of conflicts, and don't use "possible" as it encompasses any solution, no matter the side effects or cost. Use the correct term "practical" or "practicable" instead.	Understand and agree in general. Edits made to address this point.	Edits made to 2.F.
4	7. Page 34 Paragraph 3This paragraph seems to duplicate earlier content, but in a different manner. Might be better to instead reference earlier text to reduce inconsistency.	Could not locate the duplication.	Edits made to 2.J. that may address the concern.
4	8. Page 123 2nd bullet The directive for wider lanes seems to contradict earlier guidance on lane width. A wider lane could affect speed, which affects other criteria.	Agree.	Edits made in 4.2.B.
4	9. Page 124 1st title Rumble Strips, not Stripes (rumble stripes are a distinctly different treatment).	Correction made.	Edits made in 4.2.B.
4	10. Page 128 Paragraph 2. This paragraph seems to duplicate earlier content, but in a different manner. Might be better to instead reference earlier text to reduce inconsistency.	Understood. Changes made.	Edits made to 4.2.C.
4	11. Page 128 Paragraph 4 Discuss how lateral clearance can affect travel speed (more clearance = higher speed, which affects other factors).	Agree, text added.	Edits made to 4.2.C.
4	12. Page 129-Several Paragraphs These paragraphs seem to duplicate earlier content, but in a different manner. Might be better to instead reference earlier text to reduce inconsistency.	Understood. Changes made.	Edits made to 4.2.C.
4	13. Page 131-Paragraph 5 Bike lanes are preferential, not exclusive. Other traffic commonly crosses, merges, and weaves across them.	Good point, changes made.	Edits made to 4.2.D.
4	14. Page 132 Also show and discuss buffer between bike lane and parking, which can reduce crashes with parked vehicles such as "dooring".	Agree, good point. Text added.	Edits made to 4.2.D.
4	15. Page 133 Paragraph 1 Recommended that contraflow bike lanes be placed in the traveled way where travel in that direction is expected; i.e. to the left of all regular-direction traffic. Drivers are conditioned to look in specific locations at intersections for conflicting traffic - this places contraflow bike traffic in those locations to facilitate detection.	**Need to discuss with Panel.** Our team's bicycle-focused consultant made this recommendation and there may be differences of opinion worth deliberating.	No changes made.
4	16. Pages 135-136 Do not use the term "protected" as it is a value-laden advocacy term and does not accurately describe operation (unless all of them are signalized, bicyclists aren't "protected" at conflict points)	**Need to discuss with Panel.** The term "protected" is used often within the profession, although I agree with the intent of the comment.	No changes made.

4	17. Page 151 Paragraph 2 Medians only function for crossing if they are wide enough to store a bicycle and bicyclist. A median too narrow for this can create a situation where the bicyclist crosses, stops in the median, and is then at risk due to partial exposure.	Good point. Edits made to address this.	Edits made to 4.2.F.
4	18. Page 178 Paragraph 4 Change "feasible" to "practical".	Agree, changes made.	Edits made to 4.2.K.
4	19. Pages 178-179 Discuss three-centered curve radii as a solution (more efficient than constant radius for reducing width).	Agree, edits made.	Edits made to 4.2.K.
4	20. Page 183 Paragraph 4 Change to "Two-Way Stop or Yield Control", and discuss use of yield per MUTCD guidance (not just in conjunction with mini-circles).	Agree, edits made.	Edits made to 4.2.K.
4	21. Page 259 Paragraph 1 Do not concur that sidepaths are safer on higher-speed facilities, as intersection conflicts can be less expected and more severe. Delete this statement, especially as this document is directed to lower-speed facilities.	See revised text in 5.2.D. **Panel may wish to discuss.**	Edits made to 5.2.D.
4	22. Pages 260-262 The biggest issue with sidepath operation is conflicts between turning and crossing traffic and "wrong way" bicyclists. Discuss this specific issue in detail, referencing AASHTO Bike Guide.	Understand. There are some conditions under which sidepaths do not operate well, and others where their use may be acceptable. Text has been added to address the comments, but the **Panel may wish to discuss the comment.**	Edits made to 5.2.D.
4	23. Page 294- 1st title and following paragraph Change "Bicycle Signal Heads" to "Bicycle Signal Faces".	Agree, edits made.	Edits made to 5.2.I.
5	1. This is a very well done document that incorporated the panel's direction to ensure the guidance, and supporting documentation, is fully consistent with federal law, FHWA and AASHTO guidance and "standards" while incorporating current research and guidance from additional resources such as ITE and NACTO. The panel emphasized that	Thank you.	No changes made.
5	2. A full TOC at the beginning of the document may be helpful to the document user and one that allows a user to click on specific sections/subsections, as many readers will utilize the digital version.	Agree, TOC added. The final on-line document produced by TRB will likely include the navigation tools suggested.	Table of Contents added.
5	3. If possible (and this would probably require a follow up project?) production of a condensed set of the guidelines themselves culled from the full document (with the full sections included as an appendix) would be most useful to practitioners and something that was discussed by the panel. The report provides a wealth of research cited and considerations a designer needs to think through which is very useful. However, the concern is the current length of the report, without a separate more condensed guidelines section, will be too daunting and the information won't be utilized as intended.	**We suggest that this comment be discussed with the Panel.** Multimodal design usually requires a very flexible approach to selecting and assembling design elements and criteria and therefore specific guidance was not provided in several areas where research-based guidance is currently unavailable. That said, a series of "best practice" or "current practice" tables could be developed for primary design elements, criteria and dimensions across the variables of functional classification, context, speed, volume and modal priority.	No changes made.
5	4. While the AUDG, on pg 17 states "In the AUDG, design speed is replaced with target speed ..." and "target speed then becomes the primary control for determining the values of the follow geometric design elements ...". The methods a designer should use to determine the target speed could be more strongly emphasized; the explanations are in the text but a full and careful reading is required.	Point understood, edits made to hopefully address this point.	Edits made to 2.B. and 4.1.F.

NCHRP Project 15-48
Developing a Methodology for Designing Low and Intermediate Speed Roadways that Serve All Users
Panel Comments and REsponses - Oct. 3, 2017 Conference Call

Reviewer	Panel Review Comments	Research Team Response	Revision Location Chapter / Section / Page
2	7. The narrative in Chapter 3 needs to give greater emphasis on safety performance. Right now, it's presented in such a way that it repeatedly places sole focus on traffic operations (HCM and LOS). The Highway Safety Manual is included almost as an afterthought and is simply lumped in with a laundry list of other publications with no real acknowledgement of its uniqueness. Perhaps retitling the Chapter to substitute "Performance Goals" for "Service Levels" would help	The Research team agrees that safety is a critical element of performance to be considered in the design process. It is addressed in the lead section of Chapter 3 as one of the key performance metrics and specifically discussed in other parts of the chapter. That said, we have added text related to safety performance for all user types. **This should be discussed with the Panel.**	Revisions made in several areas of Chapter 3 as shown the "Track Edit" version of the document.
2	8. Chapter 6 includes case study examples "borrowed" from two other publications. I realize that it may be beyond the scope of this effort; But, I think not having an example (even if hypothetical) of using this document on a real-world example is a missed opportunity.	The Research Team felt that the examples provided addressed the use of the information in the document ranging from a more simple, qualitative project design process to a complex, quantitative performance-based process. Another example can be added, but there are many possible design scenarios that could be addresses. **It is recommended that this item be discussed further with the Panel.**	No changes made at this time other than clarifying edits to the case study text.
3	I like the name "All Users Design Guide". The report is well-organized. The table of contents presents information in a manner that is easy to find and like other engineering reference documents. As presented, it functions as a design document and a reference document. I was surprised how many new NCHRP reports and references I did not know about.	Based on comments from Reviewer #2, and agreement that "all users" may not be a term easily understood in the profession as "multimodal" is, a new name has been created for the document: "Design Guide for Low-Speed Multimodal Roadways." **This subject is important enough that it should be discussed with the Panel.**	Changes have been made throughout the document to reflect the new proposed document title.
3	Page 9: What is purpose of Exhibit 1.1. It says to me that all facility types and context zones 45 mph and under are addressed and those over are not. That can be said more simply and succinctly without the graphics. Consider a text box for highlight.	**This table can be removed if the Panel's decision is to do so.** The primary purpose of the table was to illustrate the basic interrelationships between functional classification, rural/urban areas, the more advanced context zone definitions, and design speed ranges.	No changes at this time.
3	Page 29 and 30 and page 104: The land use character is not adequately defined for suburban. Separated uses is the key descriptor. Could read: "Separated residential neighborhood and commercial clusters (includes town centers, commercial corridors, big box commercial, and light industrial) with most structures having a purpose use". For land use character for urban and urban core, the phrase "some mixed use structures (commercial lower level and residential or office above)" could be added. What does "closely mixed setbacks" for urban	This table has been taken directly from the NCHRP 15-52 research report and we are concerned with editing this table as suggested, although the suggested changes are certainly reasonable. **We recommend this item be discussed further with the Panel.**	No changes made at this time.
3	Page 104: See comment for page 29	This table has been taken directly from the NCHRP 15-52 research report and we are concerned with editing this table as suggested, although the suggested changes are certainly reasonable. **We recommend this item be discussed further with the Panel.**	No changes made at this time.
3	Page 294: The list near top of page is numbered instead of bullets. For number 6, ". . . intersection should have pedestrian signal heads." Ahead of Bicycle Signal Heads, discuss use of "BICYCLES USE PEDESTRAIN SIGNAL" sign where side paths or separated bikeways cross street intersections. That condition is referenced in 4th bullet under Bicycle Signal Heads.	**Not sure comment is understood. Need to discuss with reviewer or Panel.**	No changes made.

3	Design Case Studies A and C seem to lack sufficient detail or explanation, but are acceptable within available constraints. Design Case Studies B and D are confusing and difficult to follow. One has difficulty determining whether the author's notes are the author of the AUDG or NCHRP Report 785.	**Need to discuss with the Panel.** We are concerned about editing case studies taken from NCHRP 785, but edits have been made to hopefully clarify the "author's notes" sections.	Edits made in Case Studies A & C.
3	Could additional comments be added regarding selected cross sections and alternatives that were not considered? Many of the cross sections include 14-16-foot TWLTLs. Why does a lane that is occasionally used for slowing or standing traffic need to be wider than 11 feet?	**Need to discuss with Panel.** These studies have been used as examples from other documents and revising or adding to their analysis may be inappropriate.	No changes made.
3	In Case Study D, why was no buffer put between the sidewalk and curb? Also in case study D, the north-south street against the protected forest-hillside with critical habitat would have no access on the west side of the roadway, a perfect location for a side path.	This case study has been taken from NCHRP 785 and we are concerned about editing it from its original context, other than clarifying comments where necessary. **Need to discuss with Panel.**	No changes made.
4	15. Page 133 Paragraph 1 Recommended that contraflow bike lanes be placed in the traveled way where travel in that direction is expected; i.e. to the left of all regular-direction traffic. Drivers are conditioned to look in specific locations at intersections for conflicting traffic - this places contraflow bike traffic in those locations to facilitate detection.	**Need to discuss with Panel.** Our team's bicycle-focused consultant made this recommendation and there may be differences of opinion worth deliberating.	No changes made.
4	16. Pages 135-136 Do not use the term "protected" as it is a value-laden advocacy term and does not accurately describe operation (unless all of them are signalized, bicyclists aren't "protected" at conflict points)	**Need to discuss with Panel.** The term "protected" is used often within the profession, although I agree with the intent of the comment.	No changes made.
4	21. Page 259 Paragraph 1 Do not concur that sidepaths are safer on higher-speed facilities, as intersection conflicts can be less expected and more severe. Delete this statement, especially as this document is directed to lower-speed facilities.	See revised text in 5.2.D. **Panel may wish to discuss.**	Edits made to 5.2.D.
4	22. Pages 260-262 The biggest issue with sidepath operation is conflicts between turning and crossing traffic and "wrong way" bicyclists. Discuss this specific issue in detail, referencing AASHTO Bike Guide.	Understand. There are some conditions under which sidepaths do not operate well, and others where their use may be acceptable. Text has been added to address the comments, but the **Panel may wish to discuss the comment.**	Edits made to 5.2.D.

5	3. If possible (and this would probably require a follow up project?) production of a condensed set of the guidelines themselves culled from the full document (with the full sections included as an appendix) would be most useful to practitioners and something that was discussed by the panel. The report provides a wealth of research cited and considerations a designer needs to think through which is very useful. However, the concern is the current length of the report, without a separate more condensed guidelines section, will be too daunting and the information won't be utilized as intended.	**We suggest that this comment be discussed with the Panel.** Multimodal design usually requires a very flexible approach to selecting and assembling design elements and criteria and therefore specific guidance was not provided in several areas where research-based guidance is currently unavailable. That said, a series of "best practice" or "current practice" tables could be developed for primary design elements, criteria and dimensions across the variables of functional classification, context, speed, volume and modal priority.	No changes made.