TECHNICAL REPORT STANDARD PAGE

1. Title and Subtitle
Development of Statewide Design Guidelines for Improving Pedestrian Safety on High-Speed Arterials in Louisiana

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5. Report No.
FHWA/LA.24/695

6. Report Date
May 2024

7. Performing Organization Code
LTRC Project Number: 22-3SA
SIO Number: DOTLT1000432

8. Type of Report and Period Covered
Final Report
Oct 2022 - Mar 2024

9. No. of Pages
168

10. Supplementary Notes
Conducted in Cooperation with the U.S. Department of Transportation, Federal Highway Administration

11. Distribution Statement
Unrestricted. This document is available through the National Technical Information Service, Springfield, VA 21161

12. Key Words
Pedestrian safety; high-speed arterials; statewide guidelines; countermeasure matrix; crash data analysis; national survey

13. Abstract

This study aimed to develop statewide guidelines for improving pedestrian safety on high-speed arterials in Louisiana, recommend which countermeasures are appropriate to improve pedestrian safety for various roadway characteristics, and suggest changes, as necessary, to the relevant Engineering Directives and Standards Manuals (EDSMs) of the Department of Transportation and Development (DOTD) and the Louisiana Revised Statutes (RS).

To achieve these goals, the research team employed several approaches, including: categorizing the roadway network on high-speed arterials in Louisiana; identifying crossing design features; surveying

professionals from state Departments of Transportation (DOTs) across the nation to document efforts to improve pedestrian safety on high-speed arterials; developing a matrix of design features for pedestrians' safe movement; examining conflicts with existing DOTD policies and guidelines; and developing statewide guidelines for pedestrian facilities on high-speed arterials.

The research focused on high-speed arterials in Louisiana, including intersections and midblock segments. Utilizing 2017-2021 crash data, GIS data from DOTD, and aerial views from Google Earth, the research team conducted a thorough analysis to identify design features and pedestrian safety measures aligning with the Safe System approach (SSA)—prioritizing safe roads, safe road users, and safe speeds. The crash data analysis revealed insights into the types and locations of pedestrian-involved crashes, emphasizing factors like speed limits, lighting conditions, and roadway characteristics. The survey responses from DOT professionals across the nation highlighted existing state laws, marked crosswalk practices, priorities in determining pedestrian facility necessity, safety analysis methods, and prevalent countermeasures on high-speed arterials.

The team developed a comprehensive matrix of design features and countermeasures for safe pedestrian movement, considering factors like land use, road configuration, Annual Average Daily Traffic (AADT), speed limit, intersection type, and median type. Recommended countermeasures include medians or pedestrian refuge islands, road diets, high visibility crosswalks, curb extensions, narrowing of lanes, pedestrian crossing signs, signal timing adjustments, and various other context-specific measures.

The review of policy documents and manuals identified several conflicts with existing guidelines. More detailed guidance is needed regarding treatments, such as leading pedestrian intervals (LPI) and pedestrian hybrid beacons (PHB), and design criteria, such as the narrowing of lanes or reduced curb radii. Furthermore, the team developed statewide guidelines featuring matrices and visuals to assist officials in selecting design features and countermeasures for high-speed arterials. The study highlights the importance of context-specific interventions and outlines areas for potential policy modifications to enhance the overall safety of pedestrians and road users.

Project Review Committee

Each research project will have an advisory committee appointed by the LTRC Director. The Project Review Committee is responsible for assisting the LTRC Administrator or Manager in the development of acceptable research problem statements, requests for proposals, review of research proposals, oversight of approved research projects, and implementation of findings.

LTRC appreciates the dedication of the following Project Review Committee Members in guiding this research study to fruition.

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LTRC Project No. 22-3SA
SIO No. DOTLT1000432

conducted for
Louisiana Department of Transportation and Development
Louisiana Transportation Research Center

May 2024

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Acknowledgments

The authors would like to thank the Louisiana Transportation Research Center (LTRC) and Louisiana Department of Transportation and Development (DOTD) for supporting this project. We would like to express our special thanks to the Project Review Committee, as well as LTRC's Safety Research Manager, Elisabeta Mitran, Ph.D., who gave us support and direction throughout the entire project.

In addition, we would like to acknowledge and express appreciation for the contribution of the state Department of Transportation (DOTs) professionals across the nation who participated in the online survey.

Implementation Statement

This study performed an in-depth analysis to develop statewide guidelines for improving pedestrian safety on high-speed arterials in Louisiana. The research team analyzed several datasets, including pedestrian-involved crashes from 2017-2021; categorized the roadway network; identified crossing design features; conducted a survey of DOT professionals across the nation; developed a matrix of design features for safe movement along and across roadways; and examined conflicts with existing DOTD policies and guidance.

The main objectives were to develop statewide guidelines on the provision of pedestrian facilities on high-speed arterials in Louisiana, recommend which pedestrian countermeasures are appropriate to improve pedestrian safety for various roadway characteristics, and make a proposal to modify, as necessary, DOTD's Complete Streets policy and relevant EDSMs.

The findings from this study provide transportation and traffic safety authorities in Louisiana with a matrix of design features for safe pedestrian movement along and across roadways. They also provide stand-alone statewide guidelines that can be used by transportation professionals for improving pedestrian safety on high-speed arterials in Louisiana.

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Introduction

The increase in pedestrian fatalities in the United States and across the globe is alarming [1]. According to the National Highway Traffic Safety Administration (NHTSA), 42,939 people were killed in traffic crashes in the United States in 2021, including 7,388 pedestrians [2]. The 35% increase in the national pedestrian mortality rate from 2015 to 2021, including a 73.5% increase in Louisiana, raises significant safety concerns for pedestrians. From 2020 to 2021 alone, pedestrian deaths increased 12.5% nationwide and 27.8% in Louisiana, a figure representing 184 pedestrian deaths statewide [2]. Louisiana ranks second in the nation in pedestrian fatalities per 100,000 residents [3].

The analysis of this data also revealed a higher number of pedestrian-involved collisions on urban roads in Louisiana without shoulders and sidewalks and on urbanized roads with high Average Daily Traffic (ADT) and no sidewalks [4]. Several existing national recommendations provide guidance on implementing pedestrian safety solutions along low-speed highways at both midblock and uncontrolled sites. However, guidelines on improving pedestrian safety on high-speed arterials (defined as roads having a posted speed limit of 40 mph or above) are limited. The land-use distribution of pedestrian high-speed roadway crashes reveals that approximately 71% of fatal crashes occurred on metropolitan roadway facilities, compared to 29% on rural roadways [4]. Previous studies also indicated that as traffic speeds increase, the risk of severe injury or death to pedestrians involved in a crash significantly increases. For example, the risk of severe injury or death increases from 10% when a pedestrian is struck at an impact speed of 23 mph to 75% at 50 mph, and further increases to 90% at 58 mph [5].

The Federal Highway Administration (FHWA) supports the implementation of the Safe System Approach (SSA) to eliminate crashes leading to fatality or severe injury. The SSA focuses on mitigating the impact of human mistakes and vulnerabilities, with a specific emphasis on reducing speeds for vulnerable users like pedestrians. Louisiana aligns with this approach in its efforts to reduce pedestrian fatalities and injuries. Prioritizing three Safe System elements (safe roads, safe road users, and safe speeds) can contribute to achieving meaningful reductions in pedestrian fatalities and injuries. The importance of the remaining Safe System elements, safe vehicle and post-crash care, is also acknowledged [6].

The primary objective of this study was to develop statewide guidelines for improving pedestrian safety on high-speed arterials in Louisiana. In addition, this study aimed to recommend which countermeasures are appropriate to improve pedestrian safety for various roadway characteristics, and suggest changes, as necessary, to the relevant Engineering Directives and Standards Manuals (EDSMs) of the DOTD and the Louisiana Revised Statutes (RS).

To achieve these goals, the research team employed several approaches, including: categorizing the roadway network on high-speed arterials in Louisiana; identifying crossing design features; surveying professionals from state Departments of Transportation (DOTs) across the nation to document efforts to improve pedestrian safety on high-speed arterials; developing a matrix of design features for pedestrians' safe movement; examining conflicts with existing DOTD policies and guidelines; and developing statewide guidelines for pedestrian facilities on high-speed arterials.

The next section reviews relevant literature on pedestrian safety on high-speed arterials, including studies on: 1) Vulnerable Road User (VRU) safety assessment; 2) factors affecting pedestrian safety, including vehicles, drivers, pedestrians and roadway infrastructure; 3) methodologies used in prior studies to categorize roadway networks and identify pedestrian crossing design features; and 4) existing guidelines and proven countermeasures to improve pedestrian safety.

Additionally, this report discusses the study's objectives, its scope, and the methodology employed to achieve its objectives, as well as presenting and discussing the outcomes of the project's tasks. This includes the results of roadway network categorization, which was conducted based on the average annual daily traffic (AADT), functional classification, land use, number of lanes, medians, and speed limits. This analysis is used to identify design features and safety measures to enhance pedestrian safety, aligning with the SSA elements of safe roads, safe road users, and safe speeds.

Furthermore, this report discusses the findings of the online survey conducted among state DOT professionals across the nation. This survey investigated the current policies and guidelines for pedestrian safety on high-speed arterials, assessed the effectiveness of the adopted pedestrian crossing treatments applied by different states, identified best practices related to the successful implementation of design features and pedestrian safety strategies, and identified cost-effective countermeasures adopted by DOTs across the nation to improve pedestrian safety on high-speed arterials.

This report also presents a matrix of design features and countermeasures for improving the safe movement of pedestrians. The suggested design features and countermeasures include pedestrian safety enhancements for signalized and unsignalized intersections and midblock crossings. Additionally, this report identifies where potential conflicts or gaps exist between current DOTD policies and guidance documents, as well as Louisiana Revised Statutes (RS), and the recommendations of the matrix of design features.

Finally, this report discusses the outline of the statewide guidelines that were developed for improving pedestrian safety on Louisiana's high-speed arterials. This statewide guideline, titled "Guidance for Pedestrian Safety Enhancements on High-Speed Arterials," was prepared as a stand-alone document to be used by state and local officials to improve pedestrian safety on high-speed arterials.

Literature Review

The research team conducted a comprehensive literature review of several relevant studies and manuals on pedestrian safety. The reviewed studies also included research reports, guidance documents, and other supporting documents. This section discusses the findings of this review and is divided into the following sections:

- Section 1: Vulnerable Road user (VRU) safety assessment
- Section 2: Factors affecting pedestrian safety (including vehicles, drivers, pedestrians, and roads)
- Section 3: Methodologies used to categorize roadway network and identify pedestrian crossing design features
- Section 4: Existing guidelines and proven countermeasures to improve pedestrian safety

Section 1: Vulnerable Road User Safety Assessment Guidance Memorandum

Vulnerable road users (VRU) include non-motorists such as pedestrians, bicyclists, or other cyclists. The FHWA issued guidance, titled "Vulnerable Road User Safety Assessment," on October 21, 2022, requiring states to conduct a data-driven VRU assessment every five years. This assessment is integral to the State Strategic Highway Safety Plan (SHSP) and aligns with 23 U.S.C. 148(l) under the Infrastructure Investment and Jobs Act [7].

The VRU assessment necessitates a quantitative analysis of VRU fatalities and injuries over the past five years, incorporating safety, crash, and demographic data. FHWA emphasizes data points such as VRU location, roadway details, volume, land use, and infrastructure indicators. Demographics, including race, ethnicity, income, age, and disability status (where available), must be considered, and collaboration with other agencies for data supplementation is encouraged. Identification of high-risk areas for VRUs is a key focus. States are required to employ methodologies like High Injury Network (HIN) analysis, predictive safety analysis, or systemic safety analysis. Collaboration with local entities and engagement with stakeholders, including local governments and planning organizations, is crucial to gaining insights into challenges and solutions. The VRU safety assessment mandates the development of a risk reduction program for high-risk areas. States should consider input from consultations and frameworks like the SSA, Complete Streets Design Model, and Americans with Disabilities Act (ADA) transition plans [7].

Section 2: Factors affecting pedestrian safety

Pedestrian safety is a complex issue shaped by many different factors. Previous studies have revealed the complex relationship between vehicle-related factors (e.g., size and speed of vehicle), driver-related factors (e.g., age, experience, and the influence of alcohol), and pedestrian-related factors (e.g., age, influence of alcohol, distractions, non-compliance with traffic rules) [8]. Additionally, physical environmental factors (e.g., pedestrian facilities such as sidewalks, crosswalks, adequate lighting, medians, etc.) contribute to a comprehensive understanding of the complexities involved in ensuring pedestrian safety [8]. The following paragraphs detail several studies discussing the ways in which these factors affect pedestrian safety.

Arias et al. (2021) examined the impact of vehicle speeds on bicycle and pedestrian safety on Georgia's arterial roads. A negative binomial model was developed using probe vehicle speed data. The findings revealed that high speeds, especially the difference between the 50^{th} and 85^{th} percentile speeds, significantly increased crash frequency. In addition, researchers observed a concentration of pedestrian and bicycle crashes in high-population segments [9].

Rosén et al. (2009) investigated pedestrian fatality risk related to car impact speed, using data from the German In-Depth Accident Study and other German national statistics (2003-2007). The sample involved 490 pedestrians, analyzed through logistic regression. The results demonstrated a strong correlation between vehicle speed and fatalities, with a risk increase of over two times at 50 kmph compared to 40 kmph, and five times compared to 30 kmph. The team also found that nearly half of pedestrian fatalities occurred at speeds between 50 kmph and 80 kmph [10].

In addition to these vehicle factors, there are several pedestrian-related factors that affect their safety as well. For instance, Nasser et al. (2008) conducted two studies to examine pedestrian distraction associated with mobile phone use. In the first study, 60 pedestrians participated, with 30 engaged in conversation calls and 30 in a non-conversation scenario. The results indicated that pedestrians noticed significantly more objects in the non-conversation scenario. The second study observed three intersections and also found a higher percentage of unsafe behavior among the mobile phone group, compared to the iPod or the no-use group [11].

Additionally, Schwebel et al. (2012) investigated how talking on the phone, texting, and listening to music impact pedestrians while crossing roads. This study, which involved 138 participants, categorized participants into distraction by call, text, music, or no distraction. Data were analyzed using linear, binary, and multivariate regression. The findings showed that the distracted groups looked away more than the undistracted group. The texting and music groups were also struck by the virtual vehicle more than the undistracted participants [12].

Numerous prior studies indicated that various physical infrastructure characteristics significantly impact pedestrian safety. For example, Abou-Senna et al. (2022) investigated the correlation between sidewalks and pedestrian safety in Central Florida using spatial analysis and GIS data. It was found that roadways without sidewalks were 1.67 times more likely to have pedestrian-involved crashes, with an increase in crash likelihood for every mile without sidewalks. Factors such as daily traffic volumes, average population within 0.5 miles of a crash location, and urban two-way divided arterials with four to six lanes also correlated with increased crashes [13].

Stipancic et al. (2020) evaluated pedestrian safety at signalized intersections in Montreal, analyzing injury records, inventory data, and count data. Researchers employed both the Full Bayes spatial Poisson Log-Normal model and INLA. The study identified correlations between increased vehicle and pedestrian volumes and a higher number of pedestrian injuries. Geometric features, such as raised medians and curb extensions, reduced injuries, while factors such as commercial entrances and lanes increased injuries [14]. In addition, Kim (2019) investigated the intersection-level correlation between physical conditions and elderly pedestrian safety in Los Angeles County. Using crash records from 2015 to 2017, multinomial logistic regression was developed. The findings revealed that features like parks, street trees, three-way intersections, and raised medians had a negative statistical relationship with pedestrian crashes involving the elderly. However, an increase in bus stops correlated with elevated pedestrian crashes involving the elderly [15].

Zeeger et al. (2012) conducted a study focusing on pedestrian crash trends and strategies to enhance pedestrian safety. The research identified vulnerable groups, emphasizing that children under 15, adults over 65, and pedestrians with disabilities faced higher fatality risks. Urban areas exhibited elevated crash rates, while rural areas experienced more fatalities. Factors contributing to high crash rates included nighttime incidents, vehicle speeds over 40 mph, and insufficient traffic infrastructure. Insights from Europe highlighted effective pedestrian facilities, stringent traffic law enforcement, and educational initiatives. Lessons from Australia emphasized innovative walk designs and road safety training, while China's success involved strict rules, improved roadway design, and environmental measures. India's approach included effective communication among stakeholders. The study proposed guidelines for enhanced pedestrian safety, covering aspects like pedestrian-friendly geometric design, traffic controls, funding for safety programs, improved bus stop design, enhanced law enforcement, encouragement of retroreflective materials, and the implementation of pedestrian-friendly intelligent systems. Limitations of the study include variations in local contexts and implementation challenges [16].

Jang et al. (2013) assessed pedestrian safety in San Francisco. Using data from 2002-2007, the study employed spatial kernel density estimation to identify crash hot spots. The results indicated higher pedestrian crash rates in central business districts and around the city. The injury severity analysis revealed associations with factors like alcohol consumption, age (under 15 and over 65), cell phone use, and environmental conditions (rainy weather, nighttime, and weekends). Larger vehicles were more likely to cause pedestrian injuries [17].

There have been several studies conducted specifically on high-speed arterials. For example, Digvijay et al. (2016) investigated critical gap estimation for pedestrians at uncontrolled midblock crossings on high-speed arterials. Using video recordings from crossings in Kohalpur and Mumbai, the study employed deterministic (Raff's and Ashworth's methods) and probabilistic approaches (Maximum Likelihood and Logit methods) to estimate temporal and spatial critical gaps. The results revealed lognormal distributions for both gaps, with vehicle speed significantly influencing spatial gap acceptance. The critical gap values from deterministic methods were smaller than those from probabilistic methods, ranging from 3.6 to 4.3 seconds temporally and 60 to 73 meters spatially, notably lower than HCM2010 standards [18].

Similarly, Zhou et al. (2011) conducted a case study on pedestrian safety along US 19 in Pinellas County, Florida, focusing on multi-lane high-speed arterials. The objective was to analyze crash data and infrastructure details from the specific corridor in 2003-2005 to recommend measures for reducing pedestrian-involved incidents. Data collection encompassed traffic volumes, roadway features, land use changes, and three years of pedestrian crash data from Florida DOT. Countermeasures, which were drawn from national and international studies, included engineering modifications to separate pedestrians from vehicles, enhance visibility, and reduce speeds. The results indicated that 54% of crashes occurred at non-signalized locations and 27% at signalized intersections. About half of the crashes that occurred at night were severe. Notably, 26% of crashes involved pedestrians aged 40-49, and 95% had impact speeds exceeding 35 mph [19].

Section 3: Methodologies used to categorize roadway network and identify pedestrian crossing design features

Several prior research studies provided valuable insights regarding the methodologies and techniques employed to assess and categorize the complex elements of road infrastructure and pedestrian crosswalk designs. These studies are discussed in the following paragraphs.

Road Function Classification (FHWA Safety November 2000) classifies roadways based on function into interstates, other arterials, collectors, and local roads. Interstates offer high mobility with uninterrupted long-distance travel, featuring speeds of 55 to 75 mph. Other arterials, connecting major areas, include multilane highways and freeways with speeds ranging from 50 to 70 mph. Collectors link local roads to arterials, offering moderate mobility with speeds of 35 to 55 mph. Local roads, with speeds between 20 to 45 mph, connect local areas, residences, and businesses [20].

Sun et al. (2021) analyzed pedestrian crashes on state-owned highways in Louisiana from 2015-2019. The data used in the analysis were classified by highway, land use elements, and socioeconomic factors. Socioeconomic factors were divided according to the number of households, unemployment percentage, population density, income, and households below the poverty line. The highway elements were divided into route, highway class, closeness to schools, closeness to parks, and shoulder type (e.g., curb and gutter, shoulder less than or more than 6 feet). The analyzed highway classes were categorized based on the number of lanes, presence of medians, and ADT, with certain subsections excluded due to fewer than 100 pedestrian crashes [21].

Current Louisiana Roadway Classifications are categorized using the functional system, with areas categorized as urbanized (50,000+ population), urban (2,500–49,999), or rural (less than 2,500). Major cities like New Orleans and Baton Rouge fall under urbanized areas, and surrounding regions are termed urban areas. Roads are further classified based on vehicular function into urbanized (arterials, collectors, local) and rural (arterials, collectors, local) categories [22].

Tobias et al. (2023) developed a Pedestrian Safety Countermeasure Tool based on the statewide systemic data analysis of pedestrian-involved crash data in Missouri. The study used systemic analysis, categorizing pedestrian-involved crashes into roadway segments, intersections, and roundabouts. Roadway segment characteristics considered factors like the number of lanes, land use type, road division, Annual Average Daily Traffic (AADT), speed limit, and length of pavement section. Intersections were assessed based on approach legs, entering volume, road division, signalization, and land use. Crash assignment followed peer group categorization for both segments and intersections, factoring in land use settings, number of lanes, and median type for segments, and land use, number of legs, and traffic control type for intersections. Distribution plots for AADT and speed limits were used to further partition peer groups into different volume and speed bins. Statewide systemic data analysis identified situational trends in pedestrian crashes. For road segments, traffic volume thresholds ranged from less than 5,000 vehicles per day (vpd) to greater than 20,000 vpd, while speed limit thresholds ranged from less than 25 mph to greater than 45 mph. The study provided a tool for interpreting results and applied speed ranges of 30 mph or less, 35 mph to 45 mph, and greater than 45 mph for practical use [23].

Codjoe et al. (2021) assessed pedestrian crossings on high-speed urban arterials, categorizing them based on street type and land use. The roadway network was classified into five categories (CAT1-CAT5) based on street names, and a second categorization considered urbanized and urban areas. Urban areas were further divided into urban centers, urban corridors, and urban residential, while urbanized areas included a central business district (CBD), urbanized centers, and urbanized residential. The study employed Data-Driven Safety Analysis (DDSA) to correlate roadway characteristics (pavement widths, AADT, sidewalk presence) with crash frequencies. The findings indicated higher crash densities on roadways with generic names like "Plaza" and "Expressway," with variations across CAT categories. Researchers found that urban areas experienced more pedestrian crashes on roadways lacking shoulders and sidewalks, while urbanized areas saw them on high-ADT roadways without sidewalks. Non-intersections had more frequent crashes than intersections, often involving a single motorist. Spatial hotspot analysis identified crash-prone areas, particularly around bus stops in large urban areas. Decision tree analysis revealed influential variables like pedestrian condition, distance to control, ADT, and day of the week. Location Movement Classification Method (LMCM) Analysis showed that most pedestrian crashes occurred when attempting to cross the first half of a roadway, with straight movements correlating most often with high pedestrian crash frequencies for motorists [4].

Manual on Uniform Traffic Control Devices (MUTCD) guidelines (Federal Highway Administration, 2003) emphasize crosswalk markings with solid white lines (6 to 24 inches) and advise a minimum spacing of 6 feet. Engineering studies, considering geometry, traffic, and pedestrian volume, are crucial for installation, especially in high-speed or high-traffic areas with four or more lanes [24].

DOTD's Marked Crosswalk General Information criteria for crosswalk installation include ADA compliance, adequate motorist-pedestrian visibility, restricted street parking 50 feet in advance, and connection to a sidewalk. Volume requirements for uncontrolled intersections and midblock crossings, speed limits exceeding 40 mph, and nearby crosswalk presence are considered. Controlled intersections require 20 pedestrians in a 2-hour period during an 8-hour period (presumably a typical workday or peak hours), and in the absence of volume requirements, engineering judgement can be considered. Engineering studies can incorporate speed, traffic and pedestrian volumes, sight distance, lighting, and road geometry [25].

Guidance for Installation of Pedestrian Crosswalks on Michigan State Trunkline Highways (2023) by Michigan DOT emphasizes a step-by-step procedure considering spacing criteria for uncontrolled crossings, with a minimum 300 feet from the nearest marked or signalized crossing. Waivers are allowed for shared-use paths and pedestrian crossing volumes exceeding twice the threshold, subject to engineering judgment. Urban areas with a 400-foot standard block length may consider a minimum 200 feet for pedestrian crossings, ensuring avoidance of turn lanes and interference with lane-changing vehicles, without impeding traffic near intersections [26].

Zeeger et al. (2002) assessed marked vs. unmarked crosswalk safety, building on Bruce Herms' 1972 study that raised concerns about marked crosswalks. Analyzing 1,000 marked and unmarked sites across 30 United States cities, the team employed both negative binomial regression and Poisson modeling. Their recommendations focused on signalized locations, school zones, and non-signalized areas, factoring in ADT, speed limit, and lanes. Guidelines for uncontrolled locations considered spacing, recommending marked crossings where 20 pedestrians (or 15 elderly adults and/or children) crossed per hour, with distances from signals determined by local engineers [27].

Dougald's (2004) guidelines for Virginia DOT aimed to develop statewide marked crosswalk guidelines. A literature review and collaboration with a task group led to criteria including peak hour pedestrian counts, spacing over 300 feet, and within sight distance. Special treatment levels ranged from standard crosswalks to advanced features like pedestrian-actuated signals and grade-separated crossings, with considerations for cost and crash risk [28].

Section 4: Existing guidelines and proven safety countermeasures

Numerous studies have explored existing guidelines and effective safety countermeasures, with many states successfully implementing these recommendations. The following section provides a concise overview of these guidelines and relevant literature.

The American Association of State Highway and Transportation Officials (AASHTO) guide provides information on planning, designing, and operating pedestrian facilities on streets, highways, and independent alignments. The guide focuses on pedestrian facilities in the public right-of-way and recommends site design and parking area design that accommodate these facilities. The guide offers three levels of design guidelines: (1) requirements established by legislation or standards like the ADA and MUTCD, (2) research-supported design guidance, and (3) design recommendations based on consensus and expert opinion when definitive guidance is lacking. Additionally, the guide addresses various types of pedestrian-involved crashes and suggests countermeasures to address these issues [29].

The Colorado Department of Transportation (CODOT) has developed the Pedestrian Crossing Guideline to aid transportation and traffic engineers in enhancing pedestrian crosswalks on the state highway system. This guideline ensures the consistent and transparent determination of appropriate treatments for pedestrian crossings while maintaining efficiency for all road users. Treatments include pedestrian median refuge, Rectangular Rapid Flashing Beacons (RRFB), Pedestrian Hybrid Beacons (PHB), pedestrian traffic signals, and crosswalk lighting. The guideline prioritizes locations with high pedestrian activity, such as school areas, transit stops, and roundabouts. Additionally, it serves as a reference for clarifying the legal rights of pedestrians and drivers in crosswalk scenarios [30].

As part of the Safe Transportation for Every Pedestrian (STEP) program, the FHWA has developed a guide to help transportation agencies in addressing pedestrian-involved crashes by promoting effective countermeasures, specifically at uncontrolled intersections. By focusing on uncontrolled intersection locations, state and local agencies can address a significant national safety issue and improve the pedestrian experience for people of all ages and abilities. The guide emphasizes six effective and low-cost countermeasures that communities can implement based on their specific needs, which include: (1) crosswalk visibility enhancements (such as high-visibility crosswalk markings, improved lighting, advance Yield/Stop Signs, and curb extensions), (2) raised crosswalks, (3) pedestrian refuge islands, (4) PHB, (5) Road Diet, and (6) RRFB [31].

The Roadway Design Manual by the Texas Department of Transportation (TxDOT) has a section devoted to pedestrian facilities, which aims to provide roadway designers with the necessary knowledge and tools to plan and design pedestrian facilities and other elements that can impact pedestrian safety and travel. The manual indicates that the design decisions must accommodate road users of all ages and abilities, including those who are not yet old enough to drive, those who cannot drive, and those who choose not to drive. The safety of pedestrians is the primary consideration in planning and designing roadway facilities. The manual includes criteria for basic design, for both new pedestrian facilities and for reconstructing or rehabilitating existing ones [32].

The FHWA has developed the “Pedestrian Facilities User Guide: Providing Safety and Mobility” to help improve the safety and mobility of pedestrians within the roadway’s right-of-way. The guide provides several tools, each of which focuses on a specific design criteria or topic, including pedestrian facility design, roadway design, intersection design, traffic calming, traffic management, signals and signs, and other measures. The guide also provides recommended guidelines for sidewalks, walkways, and crosswalks [33].

The “Pedestrians Facilities Guidebook” by the Washington DOT provides provisions on how to design pedestrian facilities (e.g., sidewalks, crosswalks, curb ramps, traffic calming and control devices, grade separated crossings, and wide shoulders, among other facilities). The guidebook is intended to provide traffic and transportation engineers, planners, designers, and developers with the tools and knowledge needed to improve pedestrian safety throughout the road network. The guidebook is divided into several toolkits, or chapters, each with a specific area of focus, such as accessibility, children and school zones, trails and pathways, sidewalks and walkways, intersections, crossings, traffic calming, and safety in work zones. These toolkits provide conditions that necessitate providing pedestrian facilities, then propose countermeasures that can be used to improve pedestrian safety at such locations [34].

The Ohio DOT's "Multimodal Design Guide 4—Pedestrian Facilities" in its Roadway Engineering Manuals and Design Standards offers directives and recommendations for shaping the state's pedestrian infrastructure. This comprehensive guide covers elements like sidewalk design, crosswalks, pedestrian signals, and ADA compliance. It emphasizes safety through adequate lighting, signage, and measures to reduce pedestrian-vehicle crashes. The guide also promotes pedestrian-friendly environments to enhance community life and reduce automobile dependence, ensuring compliance with state and federal regulations for uniformity and legal adherence in pedestrian infrastructure planning. Overall, it provides valuable insights and tools for creating safe, accessible, and interconnected pedestrian environments in Ohio [35].

The “Minnesota Statewide Pedestrian Safety Analysis Final Report” by the Minnesota DOT comprehensively evaluates factors contributing to pedestrian fatalities and injuries. Using statewide data, the study identifies key patterns, risks, and causal factors, emphasizing the SSA. Findings include concentrated crashes in urban areas, risks at intersections, higher-speed roadways, and nighttime. Contributing factors include age and drug and alcohol abuse. The recommendations focus on evidence-based measures like road diets, pedestrian crossings, visibility enhancements, and intersection improvements. The report advocates data-driven prioritization and educational initiatives for pedestrian safety. It is a crucial resource for policymakers and communities in Minnesota seeking to enhance pedestrian safety [36].

Veneziano et al. (2023) investigated year-round maintenance for pedestrian safety countermeasures, highlighting gaps in winter maintenance documentation. Ambiguities in responsibility, particularly during winter, led to snow accumulation issues, impacting pedestrian mobility. Phased snow removal strategies raised budget concerns, and curb ramp maintenance by property owners resulted in safety risks. The study recommended durable materials for crosswalks and addressed challenges with features like bulb-outs and curb extensions during snow removal. Tight radii at intersections and drainage for speed humps were identified as operational challenges. The report emphasized integrating maintenance considerations into pedestrian safety countermeasure design, emphasizing clear guidelines and defined responsibilities [37].

Objectives

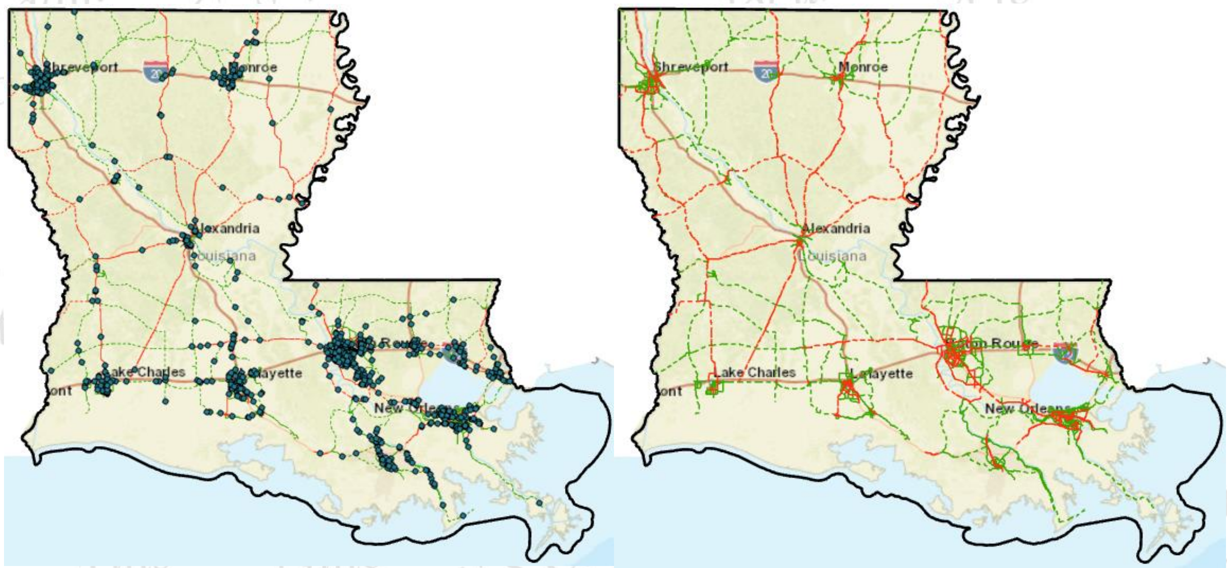
The primary objective of this study was to develop guidelines for improving pedestrian safety on high-speed arterials in Louisiana. Underlying this objective, this study also aimed to:

- Recommend which countermeasures are appropriate to improve pedestrian safety for various roadway characteristics.
- Identify conflicts with existing guidelines that may prevent the implementation of those countermeasures.
- Suggest changes, as necessary, to the relevant Engineering Directives and Standards Manuals (EDSMs) of the DOTD and the Louisiana Revised Statutes (RS).

Scope

The project scope included intersections and midblock roadway segments on high-speed arterial roads in Louisiana, defined as roads with posted speed limits of 40 mph or above. As shown in Figure 1, the study area included both principal (red dashed line) and minor (green dashed line) arterials in Louisiana. The figure also illustrates the distribution of pedestrian crashes (green circular dots) that occurred on high-speed arterials in Louisiana from 2017-2021 and used in the analysis of this study.

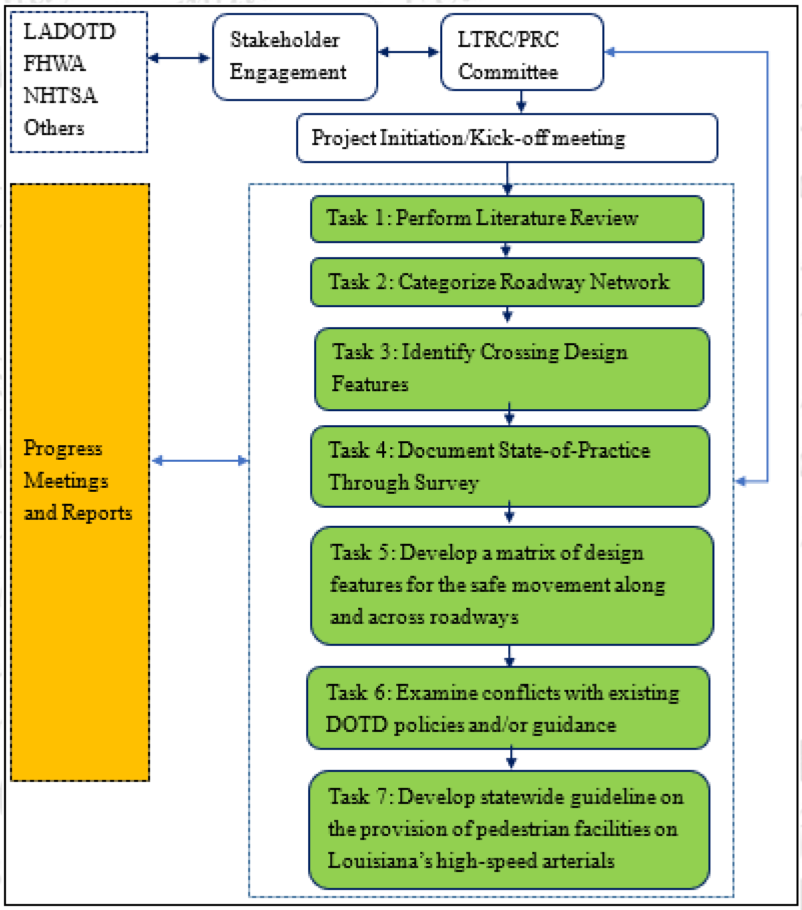
Figure 1. GIS maps showing the study area and distribution of pedestrian crashes on high-speed arterials



Methodology

This section summarizes the overall methodology employed in this project and discusses each task that was completed to achieve the project objectives. Figure 2 illustrates the overall approach and tasks implemented in this project.

Figure 2. Overall approach and tasks implemented in this project



Task 1: Perform Literature Review

In this task, an in-depth literature review was conducted, as discussed in Section 2 of this report. This review aimed to identify relevant studies, factors affecting pedestrian safety, methodologies used to categorize roadway networks and identify pedestrian crossing design features, best practices related to this research, as well as existing guidelines and proven countermeasures to improve pedestrian safety.

Task 2: Categorize Roadway Network

In this task, Louisiana's roadway network was systematically categorized based on factors like average daily traffic (ADT), functional classification, land use, number of lanes, medians, speed limits, and pedestrian facilities to identify high pedestrian risk factors. GIS analysis using ArcGIS Pro and Google Earth located and assigned high-speed arterial crashes from the last five years in intersections and midblock segments. Crash data were analyzed considering factors such as number of lanes, medians, total AADT, and speed limit. The resulting categorization formed peer groups for roadway segments and intersections, considering land use, number of lanes, median type, number of legs, and traffic control type. This approach laid the foundation for Task 3, focusing on identifying design features and safety measures to enhance pedestrian safety in alignment with the SSA.

Task 3: Identify Crossing Design Features

In this task, crossing design features were systematically identified based on diverse needs, risk factors, and conditions, specifically at midblock segments, signalized intersections, and unsignalized intersections. Utilizing the high-risk locations identified in Task 2, pedestrian-involved crashes were categorized by functional arterial classification (principal and minor) and divided and undivided approaches and legs. The analysis also established traffic volume and speed limit thresholds (ADT ranges, and 40, 45, 50, 55 mph and above) for detailed examination. This approach lays the foundation for developing crossing design features in line with the principles of the SSA—safe roads, safe road users, and safe speeds.

Task 4: Document State-Of-Practice Through Survey

In this task, in response to potential gaps in the literature review, the research team designed a survey to gather additional insights from various state DOT professionals across the nation. This comprehensive survey obtained feedback from nearly all state DOTs. Carefully incorporating feedback from the Project Review Committee (PRC), the survey focused on explaining current pedestrian safety policies, evaluating the efficacy of pedestrian crossing treatments implemented by various US states, identifying best practices in design features and safety strategies, and highlighting cost-effective countermeasures adopted to enhance pedestrian safety, specifically on high-speed arterials.

Task 5: Develop a Matrix of Design Features for the Safe Movement Along and Across Roadways

Based on the findings from Tasks 1-3, the research team developed preliminary matrices of design features and countermeasures for pedestrian safety on high-speed arterials. These matrices consider roadway characteristics and SSA principles, and they also underwent PRC/DOTD review. The team matched safety treatments to roadway segments and intersection peer groups, prioritizing Safe System elements (safe roads, safe road users, and safe speeds). The final matrices were then refined based on feedback from the PRC and the survey results, aiming to guide Louisiana in reducing traffic-related fatalities and injuries, aligning with Safe System principles.

Task 6: Examine Conflicts with Existing DOTD Policies and Guidance

Task 6 aimed to pinpoint potential conflicts or gaps in current DOTD policies, guidance documents, and Louisiana Revised Statutes (RS), based on Task 5 recommendations. Work zones and temporary traffic controls were not considered, as they fall outside the scope of this research. Pedestrian accommodations in these areas are project-dependent, and MUTCD 2009 Edition Part 6 addresses pedestrian considerations in such contexts. DOTD adopted the MUTCD 2009 Edition in 2011 to serve as the basis for its traffic control device policies. Relevant DOTD sources were scrutinized to align pedestrian safety recommendations with existing policies.

Task 7: Develop Statewide Guidelines on the Provision of Pedestrian Facilities on Louisiana's High-Speed Arterials

This task involves the development of statewide guidelines for enhancing pedestrian safety on Louisiana's high-speed arterials. The guidance document includes matrices, graphics, and visuals to assist state and local officials in selecting geometric design features and countermeasures that can enhance pedestrian safety.

Discussion of Results

This section summarizes the results of the tasks implemented in this study.

Task 2: Categorize Roadway Network

Roadway classification aids in determining the most important roadway needs and potential improvements. Since the primary purpose of this study was to improve the safety of pedestrians, pedestrian risk factors were determined based on the efforts to categorize the roadway network. First, the roadway network in Louisiana was categorized according to ADT, functional classification (principal or minor arterial), surrounding land use (urbanized, urban, and rural), number of lanes and total lengths, presence or absence of medians, speed limit, and presence or absence of pedestrian facilities. Second, roadway segments with high pedestrian-related risk factors were determined based on analysis of the last five years (2017-2021) of available pedestrian crash data in Louisiana. In this regard, crash frequency and rate were determined using GIS analysis of crash data for pedestrian-involved traffic collisions. This was accomplished by spatially joining the roadway GIS layers received from DOTD with the crash data. This was then used in Task 3 to identify design features and countermeasures that can improve pedestrian safety (i.e., reduce the number and severity of pedestrian-involved crashes), while considering the SSA elements of safe roads, safe road users, and safe speeds.

Arterials can be classified as major and minor based on the ADT and number of lanes. Major arterials connect cities and urban centers with minimum delay, connect traffic to the interstate system, and accommodate long and through trips, with ADTs of more than 15,000 and three or more lanes. Minor arterials connect activity centers within the city, connect traffic to principal arterials and interstate, and accommodate some long trips, with ADTs between 7,000 and 20,000 and two or more lanes [38].

For pedestrian volumes, prior studies have utilized socioeconomic elements to reflect the amount of pedestrian exposure along highways where pedestrian traffic count data are unavailable [39] [40]. Socioeconomic elements used in this study were retrieved from United States Census Bureau (USCB) data. They include the percentage of no-vehicle households, unemployment percentage, density percentage of households, and median household income below the poverty line.

To accomplish Task 2, a literature review of the most relevant studies was conducted to identify the methodologies used in prior studies to categorize the roadway network and identify risk factors. In this regard, this task included a close examination of two pivotal studies: an LTRC study titled "Evaluating Pedestrian Crossings on High-Speed Urban Arterials" [4] and "Missouri Systemic Countermeasures to Improve Pedestrian Safety" [23]. Considering the methodologies employed in these prior studies, this task was completed as follows:

Step 1 – Categorization of the Roadway Network in Louisiana

In this step, the roadway network was classified based on Functional Classification System (FCS). According to FCS, arterials are classified as principal arterials or minor arterials. DOTD makes state highway functional classification maps available at http://wwwsp.dotd.la.gov/Inside_LaDOTD/Divisions/Multimodal/Data_Collection/Mapping/Pages/Statewide_Highway_Functional_Classification_Maps.aspx. The FCS defines principal arterials as roadways with high traffic volumes that provide mobility between and within metropolitan areas and larger rural communities, whereas minor arterials are roadways with moderate traffic volumes that connect cities, towns, and local communities [22].

Next, cities were classified as either urbanized, urban, or rural areas using population values of 50,000 and above, between 2,500 and 49,999, and less than 2,500, respectively, similar to the limits used by United States Census Bureau [22]. The central zones of cities such as Shreveport, Baton Rouge, and New Orleans are classified as urbanized areas, while the surrounding areas are classified as urban areas. Roads were also classified as divided and undivided based on the presence or absence of medians.

Step 2 - Identify Roadway Segments and Intersections

In this step, ArcGIS Pro and Google Earth were utilized to locate and analyze crashes that occurred at high-speed arterials under investigation. First, using ArcGIS Pro, all pedestrian-involved crashes that occurred on high-speed arterials from 2017-2021 were located. High-speed arterials are typically roads with posted speed limits above 45 mph, though some studies considered them at 40 mph and above. After consulting with the PRC, this study defined high-speed arterials as roads with posted speed limits of 40 mph and above.

Crash data were provided by DOTD and uploaded on ArcGIS Pro; using spatial join, crashes that occurred only on high-speed arterials were extracted. Spatial join in ArcGIS Pro is a process of merging two datasets based on their spatial relationships. It involves combining attributes from crashes on a layer of functional class. The spatial join task was performed between the layer of functional class obtained from DOTD, which included information on principal arterials, minor arterials, collectors, and local roads. Crash data were used to determine the number of crashes that occurred on each road type, and all pedestrian-involved crashes that occurred on high-speed arterials were extracted and used in the analysis.

Subsequently, Google Earth was employed to determine crashes that occurred at roadways and intersections. Crashes that took place within a 150-foot radius of an intersection or roundabout were identified and assigned as crashes at intersections. The remaining crashes were assigned to roadway segments. Each crash was manually and thoroughly examined to determine if it occurred at an intersection or on a roadway. Table 1 shows the factors associated with intersections and roadway segments that were used in the analysis of this task.

Table 1. Description of factors associated with intersections and road segments.

Factor	Description
NUMBER_OF_LANES	Number of lanes per pavement record.
AREA_DESG_NAME	The name of the area designation for this record.
DIVIDED_UNDIVIDED	Indicates if the travel way is divided or undivided. A divided travel way is a travel way with any type of barrier or four-foot or greater flush median.
TOTAL_AADT	The volume for both sides of a travel way added together (divided and undivided).
TW_SPEED_LIMIT_CD	The speed limit assigned to the pavement record.
SIGNALIZED_FLAG	Indicates if this intersection is signalized.
NO_OF_APPRCH_LEGS	The number of approach legs for this intersection leg.
ENTERING_VOLUME	A range of entering volume for a particular intersection record.
LEG_DIVIDED_UNDIVD	Indicates if the travel way is divided or undivided.

These characteristics were used in the analysis for the following reasons [23]:

- **Number of Lanes:** Wide roadways with multiple lanes that pedestrians must cross without appropriate refuge are associated with a higher number of crashes. Therefore, this is an important factor to be included in the analysis.
- **Area Designated Name:** Used to develop peer groups.
- **Lanes Divided/Undivided:** Roads lacking suitable pedestrian refuges have a higher crash rate. As a result, it is crucial to consider this in the analysis.
- **Total AADT:** With increasing traffic volumes, the potential for pedestrian crashes increases. Therefore, this is an important factor to be included in the analysis.

- **Speed Limit:** It is crucial to consider speed limits in the analysis because the likelihood of a pedestrian being injured or killed when involved in a crash increases as speeds increase.
- **Signalized Flag:** Used to divide the intersections into two groups, signalized and unsignalized.
- **Number of Approach Legs:** More conflict points are associated with a higher number of crashes. Therefore, this is an important factor to be included in the analysis.
- **Leg Divided/Undivided:** Intersections near roadways without appropriate pedestrian refuges are associated with higher number of crashes. Therefore, this is an important factor to be included in the analysis.

Most of those variables (Number of Lanes, Lanes Divided/Undivided, Total AADT, Speed Limit) were provided in the crash data provided by DOTD, and the remainder of the required data (Signalized Flag, Number of Approach Legs, Leg Divided/Undivided) were extracted from Google Earth.

Step 3 - Assign Crashes to Intersections and Roundabouts

After the crash data were extracted from ArcGIS Pro containing only the crashes at high-speed arterials, the crashes were assigned to intersections and segments using Google Earth. Crashes within 150 feet of an intersection or roundabout were assigned to that intersection or roundabout. For each intersection with assigned pedestrian crashes, the number and severity of the crashes were recorded in a separate field for later analysis.

Step 4 - Assign Crashes to Roadway Segments

The crashes that remained after assigning them to intersections were assigned to the nearest segment of the roadway segment network using Google Earth. For each roadway segment with assigned crashes, the number and severity of crashes were estimated in a separate field for later analysis. The later analysis includes distributing crashes based on traffic volume (ADT) and speed limit. This was performed in Task 3.

Step 5 - Determine Peer Groups for Roadway Segments and Intersections

The roadway segments and intersections were categorized into peer groups. Peer groups represent homogeneous characteristics so that sites with similar safety risk profiles can be compared. Road segment peer groups were defined based on land use, number of lanes, and median type (divided or undivided). Intersections were defined based on land use, number of legs and traffic control type according to the following factors:

- Land Use (Rural, Urban, Urbanized);

- Number of Lanes (2, 4, 6, 8+);
- Median Type (Divided, Undivided);
- Number of Legs (3, 4, 5+); and
- Traffic Control Type (Signalized, Minor Leg Stop/Yield Control, All-Way Stop Control, Roundabout).

For the peer groups of roadway segments, each peer group was labeled using three letters. The first letter represents the land use setting, the second letter is the number of lanes, and the third letter indicates whether the segment is divided or undivided. For example, Z2U represents an Urbanized 2-Lane Undivided roadway segment. The levels under each of these three factors are shown in Table 2.

Table 2. Roadway classification based on land use, number of lanes, and median type.

Land Use Type	Number of Lanes	Median Type
Rural (R), Urban (U), Urbanized (Z)	2, 4, 6, 8+	Divided (D), Undivided (U)

For the intersections' peer groups, the first letter indicates the land use type, the second letter indicates the number of legs, and the third letter represents the control type. For example, U4S represents an Urban 4-legged Signalized Intersection. The levels under each of these three factors are shown in Table 3.

Table 3. Intersection classification based on land use, number of legs, and traffic control type.

Land Use Type	Number of Legs	Traffic Control Type
Rural (R), Urban (U), Urbanized (Z)	3, 4, 5+	Signalized (S), Minor Leg Stop Control (M), All-Way Stop Control (A), Roundabout (R)

Step 6 - Crash Data Analysis

The crash data provided by the DOTD included a total of 5,267 crashes involving pedestrians in the years 2017-2021. Since high-speed arterials were the focus of this study, only arterials with posted speed limits of 40 mph and higher were considered in the analysis. A total of 2,058 crashes were analyzed after eliminating those on roads with posted speed limits less than 40 mph. Among the 2,058 crashes, 1,307 pedestrian-involved crashes occurred on high-speed arterials. Based on GIS analysis, of the total 1,307 pedestrian crashes that occurred on high-speed arterials, only 1,172 had pedestrian injury information. As mentioned in Step 2, those crashes were identified with the help of the spatial join tool in ArcGIS Pro. The team performed a spatial join between a layer of functional class obtained from DOTD, which included information on principal arterials and minor arterials, and crash data to determine the number of crashes that occurred on each road type. Only crashes that occurred on high-speed arterials were extracted.

Data Analysis Results

First, with the help of ArcGIS Pro, all of the crashes that occurred on high-speed arterials (posted speed limits of 40 mph and above) were located. In ArcGIS Pro, the team performed spatial join. Crash data location and layer of functional class, both provided by DOTD, were merged in ArcGIS Pro, and only the crashes that were within 15 meters of the principal and minor arterial layer in the functional class layer were extracted for the study. The analysis focused on the trends in pedestrian-involved crashes and determined whether these crashes occurred at intersections or segments. Intersection crashes refer to crashes that happen within an intersection’s influence area (e.g., within 150 feet of each approach from the intersection stop line). Google Earth was used to measure the distance from each crash location to the intersection’s stop line based on crash coordinates. The study combined the crash data for rural, urban, and urbanized areas, resulting in a total of 1,307 crashes—1,172 crashes with known levels of injury severity and 135 with unknown levels of injury severity. A total of 1,361 pedestrians were involved in these crashes. Analysis of each crash location was conducted to confirm whether a crash occurred at an intersection or segment. Table 4 shows the distribution of crashes per location.

Table 4. Distribution of pedestrian crashes by crash location.

Crash Location	Crashes	Pedestrians Involved	Crash Percentage
At Intersections	828	862	63.4%
At Roadway Segments	479	499	36.6%
Total	**1,307**	**1,361**	**100%**

As shown in Table 4, of 1,307 pedestrian-involved crashes that were analyzed, 828 (63.4%) occurred at intersections, while the remaining 479 (36.6%) happened at roadway segments. Table 5 presents a breakdown of pedestrian crashes at different traffic control facilities located within the study area.

Table 5. Distribution of intersections related to pedestrian crashes by traffic control facility.

Traffic Control Facility	Count of Crashes at Location	Percentage
Stop/Yield Sign	475	57.4%
Signal Control	352	42.5%
Roundabout	1	0.1%
No Control	0	0.0%
Total	**828**	**100.0%**

The results indicate that the highest proportion of pedestrian-involved crashes at high-speed arterials occurred at intersections with "Stop/Yield Sign" control, accounting for 57.4% (475) of crashes, followed by "Signal Control" locations, with 42.5% (352) of crashes. Conversely, roundabout locations recorded the lowest number of crashes, with only 0.1% (1) of crashes.

Further analysis was conducted to examine pedestrian-involved crashes that occurred on intersections and roadway segments with sidewalks and shoulders present. All pedestrian-involved crashes occurring at intersections and roadway segments on high-speed arterials were examined. Table 6 shows the crash distribution based on pedestrian facility.

Table 6. Crash distribution by pedestrian facility.

Facilities presence on Roadways	Proportion of Pedestrian Crashes
Shoulder Present and No Sidewalk	520 (39.8%)
No Shoulder and Sidewalk Present	386 (29.5%)
No Shoulder and No Sidewalk	320 (24.5%)
Shoulder Present and Sidewalk Present	81 (6.2%)

As shown in Table 6, it was found that roads with shoulders and without sidewalks had the highest proportion of pedestrian crashes, with 39.8% (520) followed by roads without shoulders but with sidewalks, at 29.5% (386).

The crash distribution in rural, urban, and urbanized areas was estimated according to their AADT. Table 7 shows the crash distribution in rural, urban, and urbanized areas based on their respective AADT.

Table 7. Crash distribution based on land use and AADT.

Land-based Use and AADT	Crash Distribution
Rural	
AADT ≤ 10000 vpd	75 (5.74%)
> 10000 - ≤ 20000 vpd	24 (1.83%)
>20000 - ≤ 30000 vpd	8 (0.61%)
> 30000 vpd	0 (0.00%)
Urban	
AADT ≤ 10000 vpd	43 (3.29%)
> 10000 - ≤ 20000 vpd	41 (3.14%)
> 20000 - ≤ 30000 vpd	3 (0.23%)
> 30000 vpd	1 (0.08%)
Urbanized	
AADT ≤ 10000 vpd	238 (18.21%)
> 10000 - ≤ 20000 vpd	336 (25.71%)
> 20000 - ≤ 30000 vpd	295 (22.57%)
> 30000 vpd	243 (18.59%)
Grand total	**1,307**

As shown in Table 7, urbanized locations with AADTs above 10,000 vpd and up to 20,000 vpd had the highest proportion of pedestrian crashes, with 25.71% (336). In addition, Table 8 further shows the breakdown of urbanized roadways with AADTs above 10,000 vpd and up to 20,000 vpd with the presence or absence of shoulders and sidewalks.

Table 8. Crash distribution by pedestrian facility on urbanized roadways with AADT above 10,000 vpd and up to 20,000 vpd.

Facilities Present on Roadways	Proportion of Pedestrian Crashes
No Shoulder and Sidewalk Present	129 (38.4%)
Shoulder Present and No Sidewalk	93 (27.7%)
No Shoulder and No Sidewalk	83 (24.7%)
Shoulder Present and Sidewalk Present	31 (9.2%)

The distribution of crashes by pedestrian facility on urbanized roadways with AADTs above 10,000 vpd and up to 20,000 vpd shows that roads with sidewalks present and no shoulder had the highest proportion of crashes, with 38.4%. The crash distribution based on posted speed limit is shown in Table 9.

Table 9. Crash distribution based on posted speed limit.

Speed (mph)	Number (Percent) of Pedestrian Crashes
40	322 (24.6%)
45	588 (45.0%)
50	135 (10.3%)
55+	262 (20.1%)

As shown in Table 9, 45% of pedestrian crashes occurred on roads with posted speed limits of 45 mph. Roads with posted speed limits of 50 mph had the lowest proportion of pedestrian crashes, at 10.3%.

Next, the crashes were separated into peer group tables for intersections and roadway segments. Table 10 categorizes pedestrian-involved crashes by severity using the KABCO Scale: K for fatal, A for incapacitating/severe, B for non-incapacitating/moderate, C for possible/complaint, O for no injury/property damage only, and U for unknown injury severity level. Table 10 summarizes the peer groups for intersections with at least one pedestrian-involved crash and includes the distribution of these crashes by severity.

Table 10. Intersections peer groups and pedestrian crashes by severity.

Peer Group	Intersection Count	K	A	B	C	O	U	Total Pedestrians Involved	Number of Intersection Crashes	Percent	Crashes Per Count	Fatality Per Count
R3M	20	8	2	8	2	1	2	23	21	**2.5**	1.050	0.400
R3S	2	1	0	1	0	0	0	2	2	**0.2**	1.000	0.500
R4M	3	0	0	4	0	0	0	4	4	**0.5**	1.333	0.000
R4S	2	0	0	0	2	0	0	2	2	**0.2**	1.000	0.000
U3M	36	10	6	14	11	1	1	43	37	**4.5**	1.028	0.278
U3S	1	0	0	0	1	0	0	1	1	**0.1**	1.000	0.000

Peer Group	Intersection Count	K	A	B	C	O	U	Total Pedestrians Involved	Number of Intersection Crashes	Percent	Crashes Per Count	Fatality Per Count
U4M	3	0	0	2	0	0	1	3	3	**0.4**	1.000	0.000
U4S	6	0	0	4	1	2	0	7	6	**0.7**	1.000	0.000
Z2M	3	0	0	1	2	0	0	3	3	**0.4**	1.000	0.000
Z2S	3	0	3	0	0	0	0	3	3	**0.4**	1.000	0.000
Z3M	265	63	29	106	60	14	30	302	292	**35.3**	1.102	0.238
Z3S	38	8	10	6	8	1	8	41	40	**4.8**	1.053	0.211
Z4M	105	20	12	53	15	3	15	118	115	**13.9**	1.095	0.190
Z4R	1	0	0	1	0	0	0	1	1	**0.1**	1.000	0.000
Z4S	236	43	35	102	70	14	42	306	295	**35.6**	1.250	0.182
Z5S	3	0	0	3	0	0	0	3	3	**0.4**	1.000	0.000
Total	**727**	**153**	**97**	**305**	**172**	**36**	**99**	**862**	**828**	**100**	**1.139**	**0.210**

As shown in Table 10, Urbanized 4-legged Signalized Intersection (Z4S) had the largest number of pedestrian crashes (295), which represents 35.6% of total intersection crashes. This peer group was followed by Urbanized 3-legged Stop Control (Z3M), which accounted for 35.3% (292) of total intersection crashes. The table shows that Rural 4-legged Stop Control (R4M) had the highest crashes per count, and Rural 3-legged Signalized (R3S) had the most fatalities per count. It should be noted that only 5 intersections in the R4M and R3S peer groups had pedestrian-involved crashes.

The crashes were classified according to the type of arterials (principal and minor) and further categorized based on intersections for each type of arterial. Tables 11 and 12 show the pedestrian-involved crashes on principal arterials and minor arterials by severity for intersections. Table 11 shows that the Urbanized 4-legged Signalized (Z4S) peer group had the highest proportion of crashes among the principal arterials at intersections, accounting for 42.6% of all crashes. The second highest proportion of crashes occurred in the Urbanized 3-legged Stop Control (Z3M) group, accounting for 31% of all crashes on principal arterials at intersections.

Table 11. Intersections peer groups and pedestrian crashes by severity for principal arterials.

Peer Group	Crashes	K	A	B	C	O	U	Pedestrians Involved	Percent
R3M	9	4	0	4	1	0	1	10	**1.8**

Peer Group	Crashes	K	A	B	C	O	U	Pedestrians Involved	Percent
R3S	2	1	0	1	0	0	0	2	**0.4**
R4M	1	0	0	1	0	0	0	1	**0.2**
R4S	1	0	0	0	1	0	0	1	**0.2**
U3M	15	4	2	6	6	1	1	20	**3.6**
U4M	2	0	0	1	0	0	1	2	**0.4**
U4S	5	0	0	3	1	2	0	6	**1.1**
Z2M	3	0	0	1	2	0	0	3	**0.5**
Z2S	2	0	2	0	0	0	0	2	**0.4**
Z3M	164	37	20	60	28	8	17	170	**31.0**
Z3S	30	6	8	4	5	1	7	31	**5.6**
Z4M	65	14	5	26	11	1	8	65	**11.8**
Z4S	223	37	30	74	53	12	28	234	**42.6**
Z5S	2	0	0	2	0	0	0	2	**0.4**
Grand Total	**524**	**103**	**67**	**183**	**108**	**25**	**63**	**549**	**100**

Table 12. Intersections peer groups and pedestrian crashes by severity for minor arterials.

Peer Group	Crashes	K	A	B	C	O	U	Pedestrians Involved	Percent
R3M	12	4	2	4	1	1	1	13	**4.0**
R4M	3	0	0	3	0	0	0	3	**1.0**
R4S	1	0	0	0	1	0	0	1	**0.3**
U3M	22	6	4	8	5	0	0	23	**7.3**
U3S	1	0	0	0	1	0	0	1	**0.3**
U4M	1	0	0	1	0	0	0	1	**0.3**
U4S	1	0	0	1	0	0	0	1	**0.3**
Z2S	1	0	1	0	0	0	0	1	**0.3**
Z3M	128	26	9	46	32	6	13	132	**42.1**
Z3S	10	2	2	2	3	0	1	10	**3.3**
Z4M	50	6	7	27	4	2	7	53	**16.5**

Peer Group	Crashes	K	A	B	C	O	U	Pedestrians Involved	Percent
Z4R	1	0	0	1	0	0	0	1	**0.3**
Z4S	72	6	5	28	17	2	14	72	**23.7**
Z5S	1	0	0	1	0	0	0	1	**0.3**
Grand Total	**304**	**50**	**30**	**122**	**64**	**11**	**36**	**313**	**100**

Table 12 shows that Urbanized 3-legged Stop Control intersections (Z3M) had the highest percentage of crashes for intersections at minor arterials, with 42.1% of total crashes, followed by Urbanized 4-legged Signalized intersections (Z4S) group, with 23.7% of crashes.

Table 13 displays the roadway segment peer groups. It includes the total number of crashes per peer group as well as a breakdown of the total number of pedestrian-involved crashes by severity for each peer group.

Table 13. Roadway segments peer groups and pedestrian crashes by severity.

Peer Group	Segment Count	K	A	B	C	O	U	Total Pedestrians Involved	Segment Crashes	Percent	Crashes per Count	Fatality per Count
R2U	44	17	3	11	17	1	2	51	50	**10.4**	1.136	0.386
R4D	22	16	0	5	3	1	0	25	24	**5.0**	1.091	0.727
R4U	3	1	0	1	1	0	1	4	4	**0.8**	1.333	0.333
U2D	1	1	0	0	0	0	0	1	1	**0.2**	1.000	1.000
U2U	13	5	4	5	2	2	1	19	17	**3.5**	1.308	0.385
U4D	13	5	1	1	4	2	1	14	13	**2.7**	1.000	0.385
U4U	8	5	2	1	0	1	1	10	10	**2.1**	1.250	0.625
Z2D	6	1	3	1	1	0	0	6	6	**1.3**	1.000	0.167
Z2U	97	19	11	40	41	3	11	125	122	**25.5**	1.258	0.196
Z4D	67	31	13	28	17	4	7	100	99	**20.7**	1.478	0.463
Z4U	81	27	10	39	24	4	8	112	103	**21.5**	1.272	0.333
Z6D	18	9	2	8	1	2	3	25	23	**4.8**	1.278	0.500
Z6U	5	2	0	3	1	0	1	7	7	**1.5**	1.400	0.400
Total	**378**	**139**	**49**	**143**	**112**	**20**	**36**	**499**	**479**	**100**	**1.267**	**0.368**

Analysis of the roadway segments showed that there were 313 crashes on undivided roads and 166 crashes on divided roads. As shown in Table 13, the Urbanized 2-lane Undivided (Z2U) road segment peer group had the largest number of crashes (122), representing 25.5% of total segment crashes. This peer group was followed by Urbanized 4-lane Undivided (Z4U), which accounted for 21.5% (103) of total segment crashes and Urbanized 4-lane Divided (Z4D), which accounted for 20.7% (99) of total segment crashes. Table 13 shows that Urbanized 4-lane Divided (Z4D) had the highest crashes per count, and Urban 2-lane Divided (U2D) had the most fatalities per count, followed by Rural 4-lane Divided (R4D). It should be noted that the U2D peer group had only one segment with pedestrian-involved crashes.

The pedestrian-involved crashes were classified according to the type of arterials (principal and minor) and further categorized based on roadway segments for each type of arterial. Tables 14 and 15 show the pedestrian crashes at principal arterials and minor arterials by severity for roadway segments.

Table 14. Roadway segments peer groups and pedestrian crashes by severity for principal arterials.

Peer Group	Crashes	K	A	B	C	O	U	Pedestrians Involved	Percent
R2U	4	3	0	1	0	0	0	4	**1.6**
R4D	20	12	0	5	3	1	0	21	**8.0**
R4U	4	1	0	1	1	0	1	4	**1.6**
U2U	2	2	0	0	0	0	0	2	**0.8**
U4D	6	2	1	0	2	1	1	7	**2.4**
U4U	7	4	1	1	0	0	1	7	**2.8**
Z2D	3	0	2	0	1	0	0	3	**1.2**
Z2U	19	3	3	8	4	1	1	20	**7.5**
Z4D	84	26	11	24	17	3	4	85	**33.4**
Z4U	74	20	7	27	20	2	5	81	**29.5**
Z6D	21	9	1	8	1	2	2	23	**8.4**
Z6U	7	2	0	3	1	0	1	7	**2.8**
Grand Total	**251**	**84**	**26**	**78**	**50**	**10**	**16**	**264**	**100.0**

Table 14 shows that the Urbanized 4-lane Divided (Z4D) peer group had the largest number of crashes among the principal arterials at roadway segments, accounting for 33.4% of all crashes.

The second highest number of crashes belonged to the Urbanized 4 lane Undivided (Z4U) peer group, accounting for 29.5% of all crashes.

Table 15. Roadway segments peer groups and pedestrian crashes by severity for minor arterials.

Peer Group	Crashes	K	A	B	C	O	U	Pedestrian Involved	Percent
R2U	46	14	3	10	17	1	2	47	**20.2**
R4D	4	4	0	0	0	0	0	4	**1.8**
U2D	1	1	0	0	0	0	0	1	**0.4**
U2U	15	3	4	5	2	2	1	17	**6.6**
U4D	7	3	0	1	2	1	0	7	**3.1**
U4U	3	1	1	0	0	1	0	3	**1.3**
Z2D	3	1	1	1	0	0	0	3	**1.3**
Z2U	103	16	8	32	37	2	10	105	**45.2**
Z4D	15	5	2	4	0	1	3	15	**6.6**
Z4U	29	7	3	12	4	2	3	31	**12.7**
Z6D	2	0	1	0	0	0	1	2	**0.9**
Grand Total	**228**	**55**	**23**	**65**	**62**	**10**	**20**	**235**	**100**

Table 15 illustrates that for roadway segments at minor arterials, the Urbanized 2-lane Undivided road (Z2U) peer group had the highest proportion of crashes, accounting for 45.2% of total crashes, followed by Rural 2-lane Undivided (R2U), accounting for 20.2% of total crashes.

Task 3: Identify Crossing Design Features

In this task, crossing design features were identified based on variety of needs, risk factors, and conditions (midblock, signalized intersections, and unsignalized intersections) that, when implemented, can reduce pedestrian-involved crashes while considering the three elements of SSA: safe roads, safe road users, and safe speeds. The most important factor that influences the design of a pedestrian crossing is ensuring the safety of all pedestrians, but particularly those who have physical limitations. After identifying the locations with high pedestrian risk factors from Task 2, the following procedure was followed to identify crossing design features.

The locations of the pedestrian crossing were determined and divided into three distinct groups: midblock roadway segments, signalized intersections, and unsignalized intersections. Google Earth was used to identify crashes that occurred at roadway segments and intersections, as explained in the discussion of Task 2. For each category, pedestrian-involved crashes were further divided into two groups based on the functional categorization of arterials (principal and minor). The functional classification of arterials is a method used in transportation planning to categorize roads according to their intended purpose and function.

DOTD made GIS layers available that distinguished between major and minor arterials. Principal arterials are typically major roadways that serve as the primary routes for large volumes of traffic over long distances, connecting key destinations such as cities, airports, and major commercial and industrial centers. To facilitate the passage of large volumes of traffic, they are frequently designed with higher speed limits and multiple lanes. In contrast, minor arterials are typically minor roadways that connect local streets and residential areas to the principal arterials. They are intended to transport lesser volumes of traffic at slower speeds and typically include stop signs, traffic signals, and pedestrian crossings in order to facilitate local traffic and pedestrians. The signalized intersections group and the unsignalized intersections group were further separated into their respective subgroups according to whether the crashes happened on divided or undivided approaches and legs of the intersections. After analyzing the crashes, the most appropriate distributions for traffic volume and speed limit range were chosen. Table 16 shows the traffic volume and speed thresholds that are the most suitable for analysis:

Table 16. Traffic volume and speed limit thresholds.

Traffic volume (ADT)	Speed limits
≤ 10,000	40
> 10,000 - ≤ 20,000	45
> 20,000 - ≤ 30,000	50
> 30,000	55+

Based on the peer groups established during Task 2, the crashes were distributed according to traffic volume (ADT), speed limit, functional classification of arterials (principal and minor). This distribution is shown in Tables 17 through 21.

Table 17 shows the distribution of crashes on midblock roadway segments, revealing that most of the crashes occurred at segments with a speed limit of 45 mph. In addition, when there is a lower traffic volume (20,000 vehicles per day or less), most crashes take place on minor arterials.

However, as traffic volume increases, the majority of crashes take place on principal arterials, which further establishes the importance of classification of arterials. For midblock road segments, the Urbanized 2-lane Undivided (Z2U) roadway peer group had the highest number of pedestrian-involved crashes, with 122. Among the Z2U peer group, minor arterials had the most pedestrian-involved crashes, with 103 out of the 122 crashes. The next highest number of pedestrian crashes occurred on Urbanized 4-lane Undivided (Z4U) roadways, with 103 crashes, followed by Urbanized 4-lane Divided (Z4D) roadways, with 99 crashes. For both Z4U and Z4D, principal arterials had significantly more pedestrian-involved crashes than minor arterials, with 74 out of 103 crashes for Z4U and 84 out of 99 crashes for Z4D occurring on principal arterials. Urban 2-lane Divided (U2D) had the fewest number of crashes for midblock roadway segments, with only one crash.

Table 17. Distribution of pedestrian crashes per roadway segment peer group, volume, and speed

ADT Range (vpd)		**≤ 10000**				**> 10000- ≤20000**				**> 20000- ≤30000**				**> 30000**				**Grand Total**
Speed Range (mph)		**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	
Rural 2 lane Undivided (R2U)	**Total**	**1**	**5**	**2**	**34**	**1**			**7**									**50**
	Minor	1	4	2	31	1			7									46
	Principal		1		3													4
Rural 4 lane Divided (R4D)	**Total**				**10**		**2**		**9**				**3**					**24**
	Minor				2				2									4
	Principal				8		2		7				3					20
Rural 4 lane Undivided (R4U)	**Total**				**2**				**1**				**1**					**4**
	Minor																	
	Principal				2				1				1					4
Urban 2 lane Divided (U2D)	**Total**				**1**													**1**
	Minor				1													1
	Principal																	
Urban 2 lane Undivided (U2U)	**Total**	**2**	**7**	**2**	**4**		**1**		**1**									**17**
	Minor	2	6	1	4		1		1									15
	Principal		1	1														2

ADT Range (vpd)		≤ 10000				> 10000- ≤20000				> 20000- ≤30000				> 30000				Grand Total
Speed Range (mph)		**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	
Urban 4 lane Divided (U4D)	**Total**			**1**	**2**	**1**	**2**	**1**	**5**				**1**					**13**
	Minor				2	1	1	1	2									7
	Principal			1			1		3				1					6
Urban 4 lane Undivided (U4U)	**Total**	**1**	**1**		**1**		**4**	**1**	**2**									**10**
	Minor						2		1									3
	Principal	1	1		1		2	1	1									7
Urbanized 2 lane Divided (Z2D)	**Total**	**1**			**2**		**1**						**1**		**1**			**6**
	Minor	1			1		1											3
	Principal				1								1		1			3
Urbanized 2 lane Undivided (Z2U)	**Total**	**5**	**34**	**7**	**18**	**3**	**28**	**5**	**12**	**2**	**6**		**1**				**1**	**122**
	Minor	4	32	7	16	3	19	4	12	2	2		1				1	103
	Principal	1	2		2		9	1			4							19
Urbanized 4 lane Divided (Z4D)	**Total**	**3**	**1**		**6**	**1**	**14**		**5**	**1**	**17**	**5**	**13**	**1**	**9**	**17**	**6**	**99**
	Minor	2	1		4	1	3		1		2	1						15
	Principal	1			2		11		4	1	15	4	13	1	9	17	6	84
Urbanized 4 lane Undivided (Z4U)	**Total**	**5**	**8**	**2**		**10**	**15**	**3**		**12**	**16**	**9**	**7**	**2**	**11**	**2**	**1**	**103**
	Minor	2	5	2		7	4	2			3	1	2		1			29
	Principal	3	3			3	11	1		12	13	8	5	2	10	2	1	74
Urbanized 6 lane Divided (Z6D)	**Total**			**1**	**1**							**1**		**3**	**10**	**5**	**2**	**23**
	Minor				1										1			2
	Principal			1								1		3	9	5	2	21
Urbanized 6 lane Undivided (Z6U)	**Total**					**1**					**1**		**1**	**3**	**1**			**7**
	Minor																	
	Principal					1					1		1	3	1			7
Grand Total		**18**	**56**	**15**	**81**	**17**	**67**	**10**	**42**	**15**	**40**	**15**	**28**	**9**	**32**	**24**	**10**	**479**

Table 18 shows the distribution of crashes for signalized intersections with undivided approach legs. It reveals that the Urbanized 4-legged Signalized (Z4S) peer group had the highest number of crashes, accounting for 186 of 221 pedestrian-involved crashes, or 84.2%. Regarding the reference category, the principal arterials had the largest number of crashes, accounting for 132 of 186 pedestrian-involved crashes. In this regard, the speed limits of 40 mph and 45 mph had the highest number of crashes, with a combined 163 crashes out of 186. Three peer groups—Rural 4-legged Signalized (R4S), Urban 3-legged Signalized (U3S), and Urbanized 2-legged Signalized (Z2S)—had the lowest number of crashes, with only one crash in each group.

Table 18. Distribution of pedestrian crashes for undivided approach legs at signalized intersections.

ADT Range (vpd)		**≤ 10000**				**> 10000 - ≤ 20000**				**> 20000 - ≤ 30000**				**> 30000**				**Grand Total**
Speed Range (mph)		**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	
Undivided Legs																		
Rural 4 legged Signalized (R4S)	**Total**										**1**							**1**
	Minor																	
	Principal										1							1
Urban 3 legged Signalized (U3S)	**Total**		**1**															**1**
	Minor		1															1
	Principal																	
Urban 4 legged Signalized (U4S)	**Total**						**3**				**1**							**4**
	Minor						1											1
	Principal						2				1							3
Urbanized 2 legged Signalized (Z2S)	**Total**					**1**												**1**
	Minor																	
	Principal					1												1
Urbanized 3 legged Signalized (Z3S)	**Total**	**2**	**4**		**2**	**3**	**5**		**1**	**5**	**3**							**25**
	Minor	2	1		2	2	1		1									9
	Principal		3			1	4			5	3							16
Urbanized 4 legged	**Total**	**10**	**13**	**1**	**3**	**27**	**29**	**3**	**4**	**22**	**29**	**8**	**2**	**12**	**21**	**2**		**186**
	Minor	4	3		3	11	14	1	4	1	5	1		3	4			54

ADT Range (vpd)		≤ 10000				> 10000 - ≤ 20000				> 20000 - ≤ 30000				> 30000				Grand Total
Speed Range (mph)		40	45	50	55+	40	45	50	55+	40	45	50	55+	40	45	50	55+	
Signalized (Z4S)	Principal	6	10	1		16	15	2		21	24	7	2	9	17	2		132
Urbanized 5 legged Signalized (Z5S)	Total									**1**	**1**			**1**				**3**
	Minor										1							1
	Principal									1				1				2
Grand Total		**12**	**18**	**1**	**5**	**31**	**37**	**3**	**5**	**28**	**35**	**8**	**2**	**13**	**21**	**2**		**221**

Table 19 illustrates the distribution of crashes for signalized intersections with divided approach legs. It reveals that Urbanized 4-legged Signalized (Z4S) had the highest number of crashes, with 109 out of 131 (83.2%). Among those, most of crashes occurred at locations with traffic volumes more than 20,000 with 81 out of 109 crashes, and in principal arterials, with 91 out of 109 crashes. On the other hand, Rural 4-legged Signalized (R4S) intersections had the lowest number of pedestrian crashes, with only one crash.

Table 19. Distribution of pedestrian crashes for divided approach legs at signalized intersections.

ADT Range (vpd)		≤ 10000				> 10000- ≤ 20000				> 20000- ≤ 30000				> 30000				Grand Total
Speed Range (mph)		40	45	50	55+	40	45	50	55+	40	45	50	55+	40	45	50	55+	
Divided Legs																		
Rural 3 legged Signalized (R3S)	Total												**2**					**2**
	Minor																	
	Principal												2					2
Rural 4 legged Signalized (R4S)	Total	**1**																**1**
	Minor	1																1
	Principal																	
Urban 4 legged Signalized (U4S)	Total						**1**		**1**									**2**
	Minor																	
	Principal						1		1									2
	Total								**1**							**1**		**2**

ADT Range (vpd)		≤ 10000				> 10000- ≤ 20000				> 20000- ≤ 30000				> 30000				Grand Total
Speed Range (mph)		**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	
Urbanized 2 legged Signalized(Z2S)	**Minor**								1									1
	Principal															1		1
Urbanized 3 legged Signalized (Z3S)	**Total**	**2**	**1**	**1**		**1**	**3**				**2**			**2**	**1**	**1**	**1**	**15**
	Minor						1											1
	Principal	2	1	1		1	2				2			2	1	1	1	14
Urbanized 4 legged Signalized (Z4S)	**Total**	**4**	**6**			**11**	**4**	**2**	**1**	**9**	**16**	**1**	**3**	**11**	**24**	**13**	**4**	**109**
	Minor	1	2			2	2	2		2	2			2	2		1	18
	Principal	3	4			9	2		1	7	14	1	3	9	22	13	3	91
Grand Total		**7**	**7**	**1**		**12**	**8**	**2**	**3**	**9**	**18**	**1**	**5**	**13**	**25**	**15**	**5**	**131**

Similarly, Table 20 shows the distribution of crashes at unsignalized intersections with undivided approach legs. The results indicated that the majority of crashes happened in the Urbanized 3-legged Stop Control (Z3M) peer group, accounting for 208 of 345 crashes (60.3%). For this peer group, minor and principal arterials had almost a similar number of crashes, with 109 crashes on minor arterials and 99 crashes on principal arterials.

This peer group was followed by Urbanized 4-legged Stop Control (Z4M), with 80 crashes out of 345 (23.2%). For this section, Urbanized 4-legged Roundabout (Z4R) had the fewest number of pedestrian crashes, with only one crash.

Table 20. Distribution of pedestrian crashes for undivided approach legs at unsignalized intersections.

ADT Range (vpd)		≤ 10000				> 10000- ≤ 20000				> 20000- ≤ 30000				> 30000				Grand Total
Speed limit (mph)		**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	
Undivided legs																		
Rural 3-legged Stop Control(R3M)	**Total**		**4**	**1**	**9**		**1**		**1**									**16**
	Minor		3		6				1									10
	Principal		1	1	3		1											6
	Total	**2**					**1**											**3**

ADT Range (vpd)		≤ 10000				> 10000- ≤ 20000				> 20000- ≤ 30000				> 30000				Grand Total
Speed limit (mph)		**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	
Rural 4-legged Stop Control (R4M)	**Minor**	2																2
	Principal						1											1
Urban 3-legged Stop Control (U3M)	**Total**	**2**	**13**		**2**	**2**	**5**	**1**	**5**				**1**		**1**			**32**
	Minor	2	10		1	1	2		4									20
	Principal		3		1	1	3	1	1				1		1			12
Urban 4-legged Stop Control (U4M)	**Total**						**2**											**2**
	Minor																	
	Principal						2											2
Urbanized 2-legged Stop Control (Z2M)	**Total**					**1**								**1**		**1**		**3**
	Minor																	
	Principal					1								1		1		3
Urbanized 3-legged Stop Control (Z3M)	**Total**	**13**	**27**	**4**	**9**	**28**	**44**	**2**	**10**	**14**	**25**	**6**	**5**	**13**	**7**	**1**		**208**
	Minor	10	23	4	9	12	26	1	9	4	6	2	3					109
	Principal	3	4			16	18	1	1	10	19	4	2	13	7	1		99
Urbanized 4-legged Stop Control (Z4M)	**Total**	**8**	**11**		**5**	**10**	**17**	**2**		**6**	**7**	**2**	**1**	**6**	**4**	**1**		**80**
	Minor	7	10		4	5	8	2		3	1				1			41
	Principal	1	1		1	5	9			3	6	2	1	6	3	1		39
Urbanized 4-legged Roundabout (Z4R)	**Total**							**1**										**1**
	Minor							1										1
	Principal																	
Grand Total		**25**	**55**	**5**	**25**	**41**	**70**	**6**	**16**	**20**	**32**	**8**	**7**	**20**	**12**	**3**		**345**

Table 21 shows the distribution of pedestrian crashes for unsignalized intersections with divided approach legs. It reveals that Urbanized 3-legged Stop Control (Z3M) had the largest number of crashes, accounting for 84 out of 131 crashes (64.12%), with principal arterials having the majority of the crash distribution, with 65 crashes out of those 84 crashes. Apart from the Urbanized 3-legged Stop Control (Z3M) and Urbanized 4-legged Stop Control (Z4M), with 35 crashes, other peer groups (U3M, R3M, R4M and U4M) had five or less pedestrian-involved crashes.

Table 21. Distribution of pedestrian crashes for divided approach legs at unsignalized intersections.

ADT Range (vpd)		≤ 10000				> 10000- ≤ 20000				> 20000- ≤ 30000				> 30000				Grand Total
Speed limit (mph)		**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	**40**	**45**	**50**	**55+**	
									Divided legs									
Rural 3-legged Stop Control(R3M)	**Total**				**3**				**1**				**1**					**5**
	Minor				1				1									2
	Principal				2								1					3
Rural 4-legged Stop Control (R4M)	**Total**	**1**																**1**
	Minor	1																1
	Principal																	
Urban 3-legged Stop Control (U3M)	**Total**		**3**				**2**											**5**
	Minor		2															2
	Principal		1				2											3
Urban 4-legged Stop Control (U4M)	**Total**								**1**									**1**
	Minor								1									1
	Principal																	
Urbanized 3-legged Stop Control (Z3M)	**Total**	**5**	**8**		**3**	**6**	**5**	**1**	**6**	**4**	**9**	**5**	**7**	**2**	**12**	**7**	**4**	**84**
	Minor	2	5		3	1	1		3		1			1	2			19
	Principal	3	3			5	4	1	3	4	8	5	7	1	10	7	4	65
Urbanized 4-legged Stop Control (Z4M)	**Total**	**2**		**1**		**2**	**5**	**1**		**5**	**3**		**1**	**5**	**8**	**1**	**1**	**35**
	Minor	1		1		1	2							3	1			9
	Principal	1				1	3	1		5	3		1	2	7	1	1	26
Grand Total		**8**	**11**	**1**	**6**	**8**	**12**	**2**	**8**	**9**	**12**	**5**	**9**	**7**	**20**	**8**	**5**	**131**

Further analysis was conducted to examine lighting conditions during crashes. As shown in Table 22, 33.54% of the pedestrian-involved crashes occurred during daylight, while 30.04% of crashes occurred at night in the presence of continuous street light, and another 24.33% of crashes occurred at night with no street lights.

Table 22. Crash distribution based on lighting condition.

Lighting Condition	Frequency (Percentage)
Daylight	441 (33.54%)
Dark - Continuous Street Light	395 (30.04%)
Dark - No Street Lights	320 (24.33%)
Dark - Street Light at Intersection only	125 (9.51%)
Dusk	19 (1.44%)
Dawn	13 (0.99%)
Unknown	2 (0.15%)

The nighttime crashes without street lighting were further broken down by peer group in Table 23 to see the most impacted peer groups. The table shows that the roadway segment had 196 crashes, while intersections had 124 crashes. The findings reveal that among intersections, Urbanized 3-legged Stop Control (Z3M) experienced the highest number of nighttime crashes occurring at locations without street lighting, with 60 crashes, followed by Urbanized 3-legged Signalized (Z4S), with 24 crashes. In terms of roadway segments, Urbanized 2-lane Undivided (Z2U) segments had the highest number of nighttime crashes without street lights, with 60, followed by Urbanized 4-lane divided (Z4D), with 33 crashes, and Rural 2 lane Undivided (R2U), with 28 crashes. Based on this analysis, lighting as a countermeasure is suggested in Task 5 for affected peer groups.

Table 23. Distribution of nighttime crashes without street lights

Intersections		Midblock/Roadway segments	
Peer Group	**Crashes**	**Peer Group**	**Crashes**
R3M	12	**R2U**	28
R3S	1	**R4D**	15
R4M	1	**R4U**	2

Intersections		Midblock/Roadway segments	
Peer Group	**Crashes**	**Peer Group**	**Crashes**
U3M	7	**U2D**	1
Z3M	60	**U2U**	12
Z3S	6	**U4D**	6
Z4M	12	**U4U**	5
Z4S	24	**Z2D**	3
Z5S	1	**Z2U**	60
		Z4D	33
		Z4U	24
		Z6D	4
		Z6U	3
Total	124		196

Finally, Table 24 shows the distribution of pedestrian crashes based on pedestrian actions. Pedestrian actions include whether the pedestrians were crossing the road, walking along the roads (both walking along and against the traffic) or performing other actions, including actions such as sleeping in roadway, standing in roadway, getting on or off vehicle, pushing vehicle, and working on vehicle. Table 24 shows that among roadway segments, Urbanized 2-lane Undivided (Z2U) had the most pedestrian crashes while walking along the road, with 39, followed by Urbanized 4-lane Divided (Z4D), with 21 crashes, and Rural two-lane Undivided (R2U), with 16 crashes. For intersections, Urbanized 3-legged Stop Control (Z3M) had the most crashes, with 50, followed by Urbanized 4-legged Signalized (Z4S), with 22 crashes, and Urbanized 4-legged Stop Control (Z4M), with 19 crashes. There were 205 crashes where the pedestrian's action was unknown. Based on the pedestrian crashes that took place while pedestrians were walking along the road, it is suggested that those affected peer groups have sidewalks as a countermeasure in Task 5. Additionally, other criteria, such as the overall number of pedestrian-involved crashes, were examined to suggest sidewalks as a countermeasure.

Table 24. Distribution of pedestrian crashes based on pedestrian actions.

Peer Group	Crossing road	Walking along the road	Others	Unknown	Grand Total
	Midblock/Roadway segments				

Peer Group	Crossing road	Walking along the road	Others	Unknown	Grand Total
R2U	9	16	23	2	50
R4D	5	9	8	2	24
R4U	0	1	2	1	4
U2D	0	0	1	0	1
U2U	4	5	6	2	17
U4D	3	3	6	1	13
U4U	3	2	4	1	10
Z2D	2	2	2	0	6
Z2U	31	39	31	21	122
Z4D	46	21	17	15	99
Z4U	59	12	19	13	103
Z6D	11	2	6	4	23
Z6U	3	2	1	1	7
Subtotal	**176**	**114**	**126**	**63**	**479**
	Intersections				
R3M	7	4	7	3	21
R3S	1	0	1	0	2
R4M	4	0	0	0	4
R4S	2	0	0	0	2
U3M	16	8	11	2	37
U3S	1	0	0	0	1
U4M	1	1	0	1	3
U4S	5	0	1	0	6
Z2M	1	0	1	1	3
Z2S	1	0	1	1	3
Z3M	142	50	55	45	292
Z3S	21	5	4	10	40
Z4M	61	19	13	22	115

Peer Group	Crossing road	Walking along the road	Others	Unknown	Grand Total
Z4R	0	0	0	1	1
Z4S	184	22	33	56	295
Z5S	2	0	1	0	3
Subtotal	**449**	**109**	**128**	**142**	**828**
Grand Total	**625**	**223**	**254**	**205**	**1,307**

Task 4: Document State-Of-Practices Through Survey

This section discusses the results of a survey that was designed and conducted among state DOTs across the nation, including the Louisiana DOTD. The primary objectives of the survey were to: (1) investigate the current policies and guidelines for pedestrian safety at high-speed arterials; (2) assess the effectiveness of the adopted pedestrian crossing treatments applied by different state DOTs; (3) identify best practices related to the successful implementation of design features and pedestrian safety strategies; and (4) identify cost-effective countermeasures adopted by state DOTs across the nation to improve pedestrian safety at high-speed arterials.

Comments received from the PRC were carefully considered during the development of the survey questions, and they were revised accordingly based on this feedback. The survey was organized into two sections. The first section included questions regarding guidelines and specifications for pedestrian safety, while the second section focused on questions related to pedestrian safety.

To participate in this survey, state DOT professionals had to meet the following two requirements:

- Currently work at a state or local transportation agency in the United States or other United States transportation authority, such as the United States DOT (e.g., National Highway Traffic Safety Administration [NHTSA] or FHWA).
- Have at least three years of experience in the field of roadway design, traffic engineering, or pedestrian safety, and be familiar with his/her state and/or local pedestrian design and crossing policies.

The research team recognized that low response rates are often an issue with such surveys. For this reason, the team used its current contacts within each state DOT to quickly identify the appropriate personnel in every state. In addition, DOT professionals were reminded every Monday to respond to the survey.

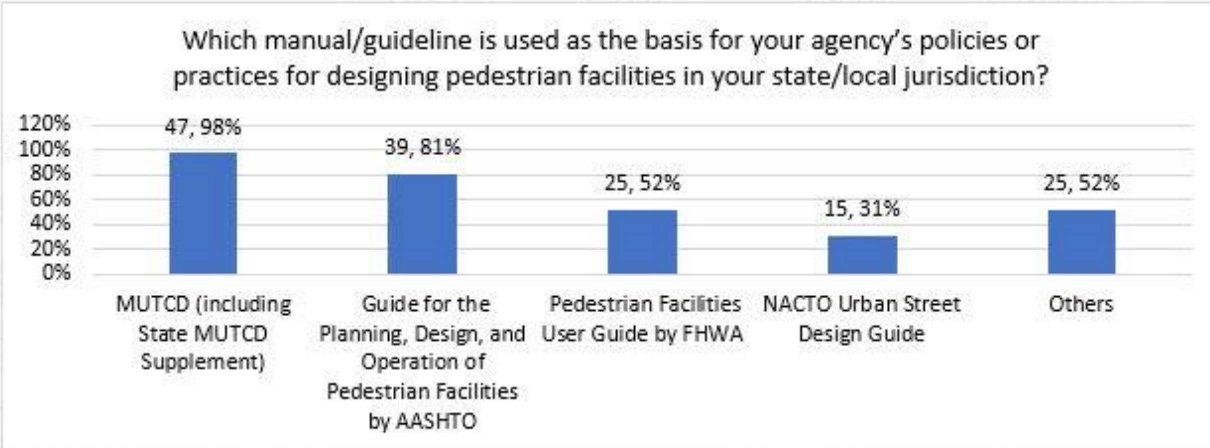
After many reminders via email and phone call to complete the survey, the team received responses from 48 state DOTs, including the District of Columbia (D.C.) and Puerto Rico. Several state DOTs submitted multiple responses from different departments; Connecticut, Massachusetts, New York, North Carolina, Tennessee, and Utah had two respondents each, while Florida had three respondents. After a thorough analysis, a combined response for each of the 48 states, including D.C. and Puerto Rico, was created for analysis.

Analysis of Survey Results

Each of the following figures shows responses to each survey question in terms of both frequency and percentage. When asked if a state or local jurisdiction has laws, statutes or ordinances, policies, and/or guidance for providing and designing pedestrian facilities on high-speed arterials, 81% (39) of state DOTs reported "Yes," while the remaining 19% (9) responded "No". Manuals, plans, and other documents provided by the respondents who answered "Yes" are provided in Appendix C.

Participating state DOTs were asked about the manual or guideline they used as the basis for their agency's policies for designing pedestrian facilities in their state or local jurisdiction. As shown in Figure 3, 98% (47) of participating state DOTs reported MUTCD as the guideline for their agency's pedestrian facility design policies. The AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities is the second most utilized document, adopted by 81% (39) of state DOTs. Additionally, 52% (25) of state DOTs reported using various other guidelines, including AASHTO Greenbook, AASHTO Guide for Transit Facilities, FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations, FHWA STEP Guide, Public Right-of-Way Accessibility Guidelines (PROWAG), and specific National Cooperative Highway Research Program (NCHRP) reports (562, 600, 948, and 926). These documents are also provided in Appendix C.

Figure 3. Guidelines used as basis for designing pedestrian facilities.



When participants were asked if their agency incorporated pedestrian safety countermeasures (e.g., marked crosswalks, PHB, etc.) into the Complete Streets policy, 69% (33) of state DOTs reported "Yes," while the remaining 31% (15) of state DOTs did not incorporate pedestrian safety countermeasures into the Complete Streets policy. For those state DOTs that responded "Yes," the pedestrian safety countermeasures incorporated into their Complete Streets policies include marked or high-visibility crosswalks, PHB, RRFB, road diets, and more. Several state DOTs provided links to their Complete Streets policies.

When asked if it is mandatory or common practice to provide sidewalks on high-speed arterials within their state or local jurisdictions, 33% (16) of state DOTs reported it was neither mandatory nor common, 31% (15) considered it common practice, and 4% (2) deemed it mandatory. Additionally, 31% (15) provided "Other" responses, citing factors such as state law adherence, context sensitivity, and engineering judgment.

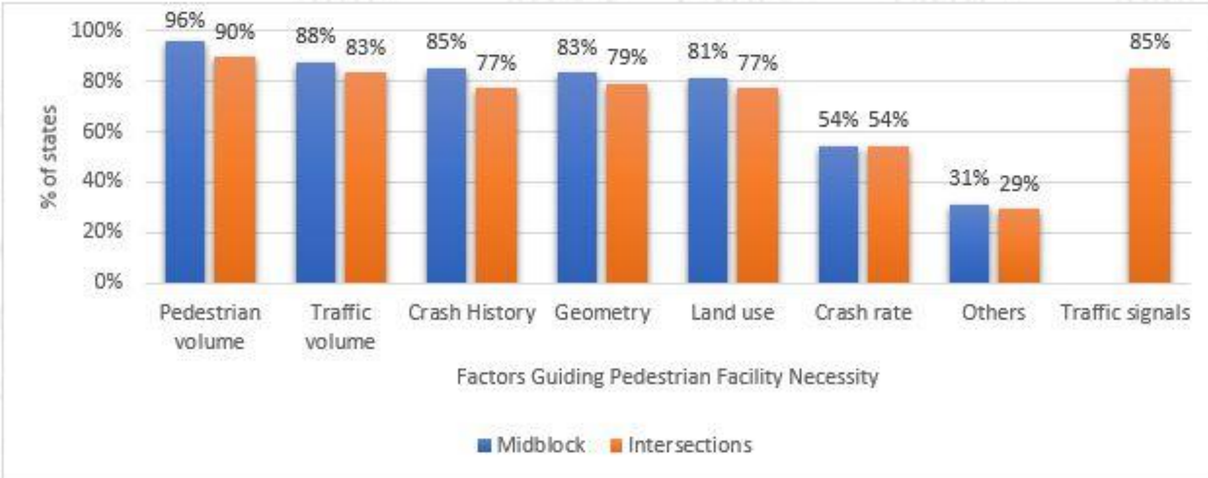
Another survey question related to the criteria for providing sidewalks. Responding to this question, 56% (27) of participants stated that their jurisdictions have established criteria, referencing manuals and reports from various state DOTs. Similarly, when asked whether it is mandatory or common practice to provide marked crosswalks at intersections on high-speed arterials in their state or local jurisdiction, 33% (16) of state DOTs considered it common practice, 27% (13) said it was neither mandatory nor common, and 8% (4) reported it as mandatory. The remaining 31% (15) offered "Other" responses, citing context-dependent practices and engineering judgment. For marked midblock crosswalks on high-speed arterials, 46% (22) of state DOTs reported having criteria, 21% (10) had none, and 33% (16) provided "Other" responses, emphasizing contextual considerations and reliance on engineering expertise.

Similarly, survey participants were asked if their agency has criteria that do not allow marked crosswalks above a particular speed for midblock locations. Only 25% (12) of participants indicated that they have such criteria. Among state DOTs that had the criteria, marked crosswalks were not allowed at midblock locations with speed limits of 45 mph or higher. Likewise, when asked if their agency had criteria that do not allow at-grade crosswalks above a particular speed for intersections, only 12% (6) of participants reported “Yes”. Among state DOTs that had such criteria, they reported that they prohibited at-grade crosswalks when the designated speed limit is 40 mph or higher.

Participants were asked about the factors that their agency considers to determine the necessity of pedestrian facilities on high-speed arterials at midblock segments. As shown in Figure 4, 96% (46) of state DOTs indicated that pedestrian activity is a key factor. Furthermore, 88% (42) of state DOTs prioritize traffic volume, and 85% (41) of state DOTs consider crash history. Roadway geometry is a determining factor for 83% (40) of state DOTs, while 81% (39) of state DOTs consider land use. An additional 54% (26) of survey participants consider crash rate, and the "Other" category encompasses varied considerations such as sight distance, future development, context class, travel speed, induced demand, and parking within a 20-foot radius.

Similarly, survey participants were asked another question regarding intersections. 90% (43) of state DOTs prioritize pedestrian activity, as shown in Figure 4. The presence of traffic signals is a significant factor reported by 85% (41) of state DOTs, followed by traffic volume by 83% (40), geometry by 77% (38), and location by 77% (37). Crash history is considered by 77% (37) of state DOTs, while 54% (26) of state DOTs consider crash rate. The "Other" category, selected by 29% (14) of state DOTs, includes considerations like pedestrian demographics, existing infrastructure, speed, the presence of pedestrian generators, and public transit availability, among others.

Figure 4. Factors agency considers for determining the necessity of pedestrian facilities on high-speed arterials



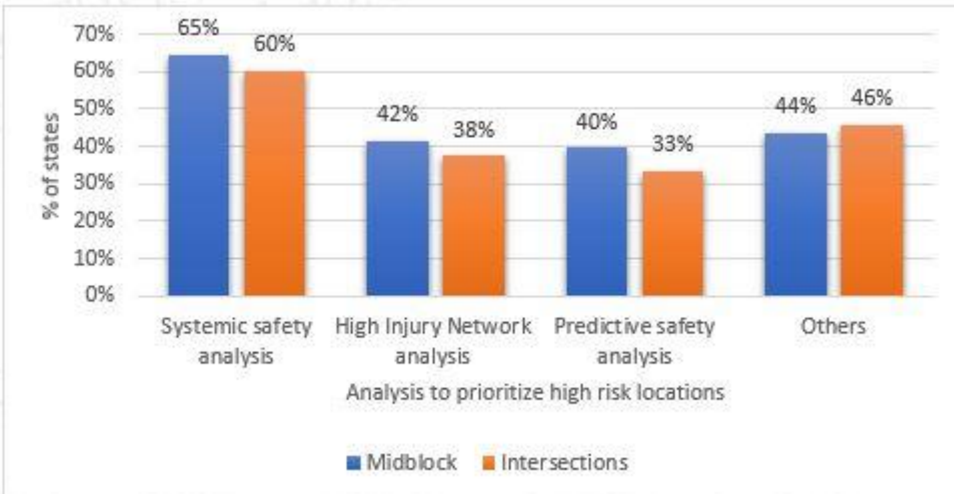
Likewise, survey respondents were asked if their agency has any pedestrian safety improvement programs or initiatives, such as the systemic approach to pedestrian improvements, pedestrian safety improvements, and the like. 75% (36) of state DOTs reported "Yes," while only 6% (3) state DOTs indicated "No". The remaining 19% (9) of state DOTs had "Other" responses, including Indiana's engagement in formulating safety regulations and plans for a pedestrian section in the Indiana Design Manual and Texas's prioritization of pedestrian safety within the Strategic Highway Safety Program.

When asked if their state agency identified high-speed arterial road segments, including midblock crossings, as an area of focus for pedestrian related traffic safety, 47% (22) of participants responded "Yes," emphasizing safety studies, road audits, and budget allocation, while 38% (18) of state DOTs responded "No". In addition, 15% (7) of state DOTs responded "Other," which included responses such as the process of creating the VRU Assessment Report in some state DOTs.

The subsequent question to participants related to the type of analysis their agency applies to identify and prioritize high-risk locations for pedestrian crashes on high-speed arterial segments. 65% (31) of state DOTs reported that they employ the systemic safety analysis approach, as shown in Figure 5. Furthermore, 42% (20) of state DOTs reported that they utilize HIN analysis, and 40% (19) stated that they apply the predictive safety analysis. In addition, 44% (21) of state DOTs reported that they utilize alternative methods, including network screening, Site-Specific Safety Analysis, pedestrian collision location/segment analysis, and pedestrian crash clustering and pattern analysis.

Participants were again asked a similar question regarding intersections. As shown in Figure 5, 60% (29) of state DOTs reported that they use systemic safety analysis. In addition, 38% (18) of the state DOTs said that they use HIN analysis, while 33% (16) of the state DOTs indicated that they utilize predictive safety analysis. On the other hand, 46% (22) of state DOTs reported using alternative analytic techniques.

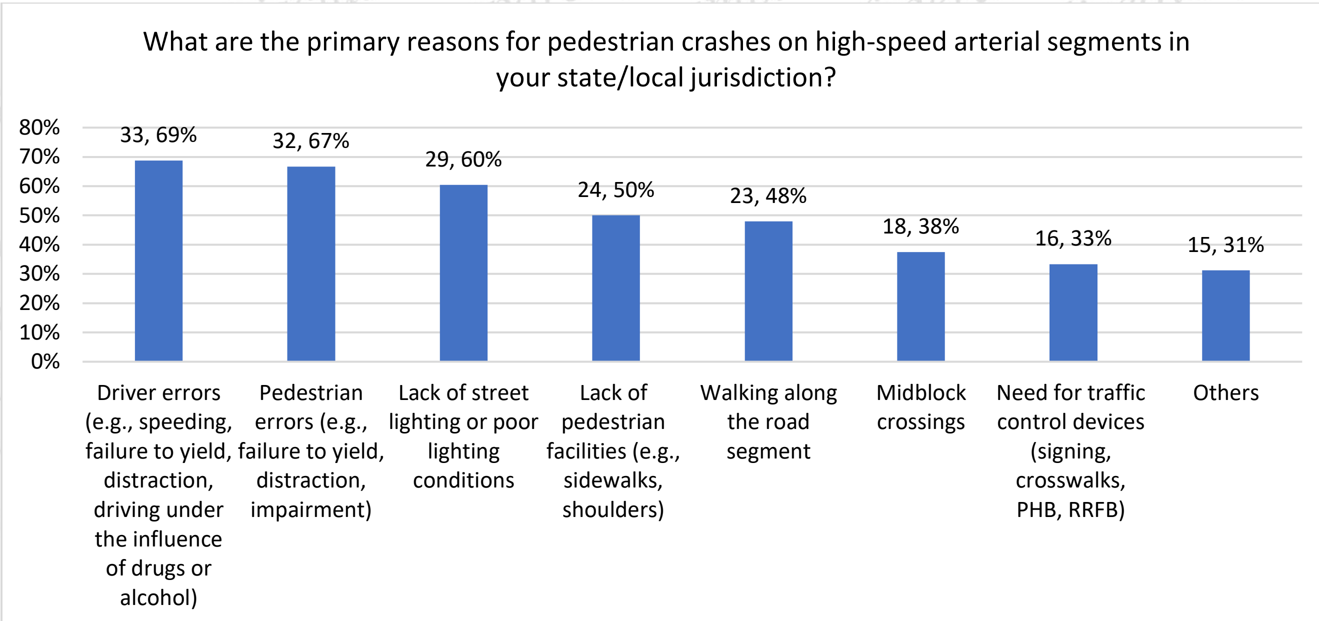
Figure 5. Analysis applied to identify and prioritize high-risk locations for pedestrian crashes on high-speed arterial road segments



In addition, participants were asked to identify the primary reasons for pedestrian-involved crashes on high-speed arterial segments in their state jurisdiction. As shown in Figure 6, the primary reasons included: 1) driver errors such as speeding, failure to yield, distraction, driving under the influence of drugs or alcohol (reported by 69% of participants); 2) pedestrian errors, such as failure to yield, distraction, and impairment (reported by 67% of participants); 3) the absence of street lighting (reported by 60% of participants); 4) lack of pedestrian facilities such as sidewalks and shoulders (reported by 50% of participants); 5) walking along the road segment (reported by 48% of participants); 6) midblock crossings (reported by 38% of participants); and 7) needs of traffic control devices (reported by 33% of participants).

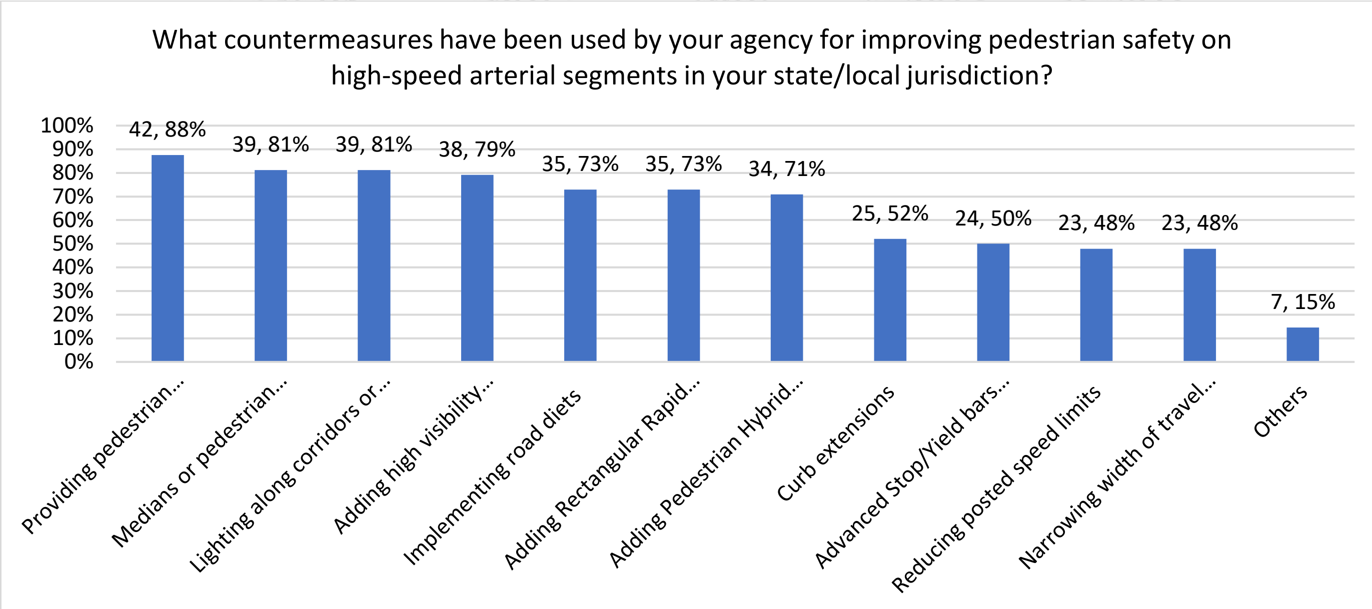
Other factors reported by 31% of participants included mobility issues due to seasonal maintenance, pedestrians on interstate facilities, and the distance between safe crossings.

Figure 6. Primary reasons for pedestrian crashes on high-speed arterial segments in your state/local jurisdiction



Participants were also asked about the countermeasures used by their agency for improving pedestrian safety on high-speed arterial segments. As shown in Figure 7, 88% of state DOTs reported providing pedestrian facilities, such as sidewalks and shoulders. Additionally, 81% of state DOTs utilized medians, and an equal percentage implemented lighting. High visibility crosswalks were adopted by 79% of state DOTs, while 73% implemented road diets and added RRFB. Furthermore, 71% of state DOTs incorporated PHB or High-Intensity Activated Crosswalk Beacon (HAWK) signals. Finally, 15% of state DOTs reported using several additional measures, such as removing right turn channelization and performing signal upgrades.

Figure 7. Countermeasures used by state DOTs for improving pedestrian safety on high-speed arterial segments in their state/local jurisdiction.



Participants were asked to report any conflicts with current guidelines that might prevent the implementation of pedestrian safety countermeasures on high-speed arterial road segments. 42% of respondents, or 20 state DOTs, reported that they had conflicts. Some state DOTs reported that they face challenges due to posted speed limits, especially with higher truck volumes, impacting the implementation of safety measures. Illinois disputes the effectiveness of reducing speed limits without geometric changes. Minnesota DOT's cost considerations conflict with guidance on treatment installation and maintenance. North Carolina faces legislative restrictions hindering funds for bicycle and pedestrian projects.

The survey findings indicated also that 56% (27) of state DOTs have implemented low-cost pedestrian safety measures on high-speed arterials, including advance warning signs, RRFBs, and road diets. North Carolina and New Jersey DOTs are conducting FHWA-funded research and systematically applying measures like temporary crossings and LPI. Ohio DOT has implemented various pedestrian safety countermeasures, particularly at the local level. However, 44%, or 21 state DOTs, confirmed that they have no low-cost countermeasures for improving pedestrian safety on high-speed arterial segments.

Those who applied low-cost countermeasures were asked about their effectiveness in improving pedestrian safety on high-speed arterial segments. Only 8% (4) of state DOTs indicated that they had evaluated the effectiveness of countermeasures. For example, in Seattle, the use of proactive crosswalk signs and lower speed limits were effective in reducing pedestrian related crashes. However, 71% (34) of state DOTs reported that no evaluation was performed.

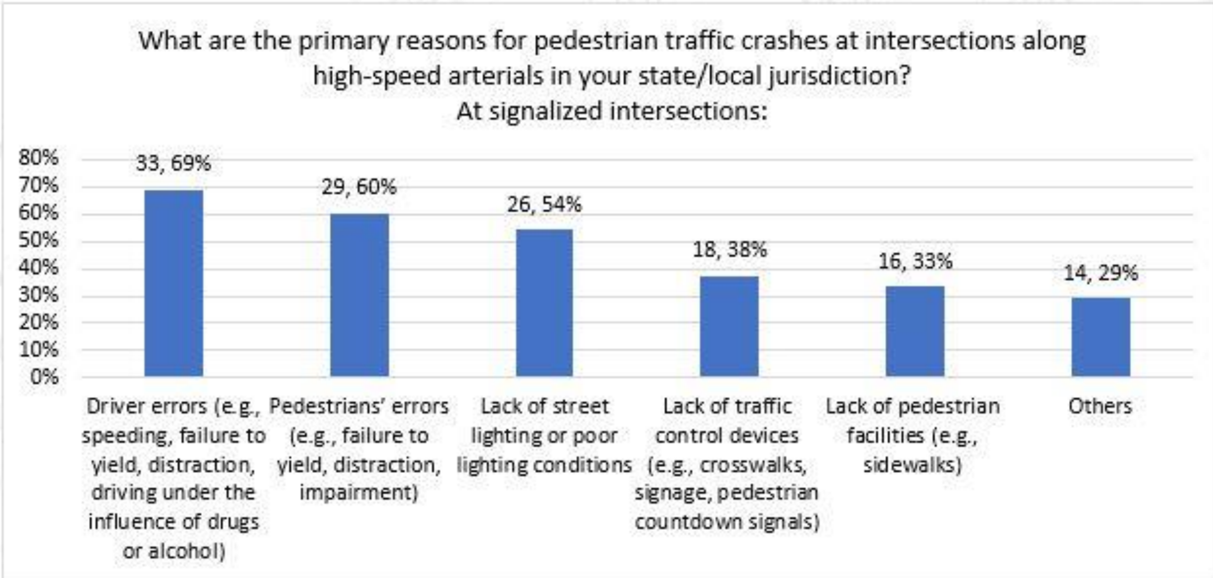
Similarly, participants were asked if their agencies evaluated the impacts of implementing pedestrian facilities on high-speed arterial segments in their state DOTs and local jurisdictions. Only 19% (9) of state DOTs reported “Yes”. On the other hand, 62% (30) of state DOTs reported that they have not performed an evaluation. The remaining 19% (9) of state DOTs selected the option “Other,” which included responses such as lack of awareness on particular assessments, ongoing reviews, and evaluations limited to signalized crossings with pedestrian facilities.

When asked if they found any countermeasures or programs to be most effective in improving pedestrian safety on high-speed arterial segments, 31% (15) of state DOTs reported having an individual countermeasure, or combination of countermeasures, that were effective. Those countermeasures included road diets, HAWK signals, PHBs, pedestrian islands, usage of pedestrian safety audits, sidewalks, crosswalks with PHBs at signalized intersections, speed management, and roundabouts. On the other hand, 54% (26) of state DOTs responded “No,” while the remaining 15% (7) of state DOTs responded “Other”. Those who selected “No” and “Other” indicated that the effectiveness of countermeasures varies based on circumstances, area, and geometry, with no universally applicable solution. Optimal approaches depend on specific conditions, and effectiveness is uncertain, requiring context-sensitive evaluation and ongoing investigation.

Participants were asked if their agencies have identified intersections on high-speed arterials as an area of focus for pedestrian-related traffic safety. 56% (27) of state DOTs have identified intersections as a focal point. These state DOTs conduct prioritization studies, leveraging programs like the SHSP and HSIP to pinpoint locations for potential pedestrian and bike crash reduction.

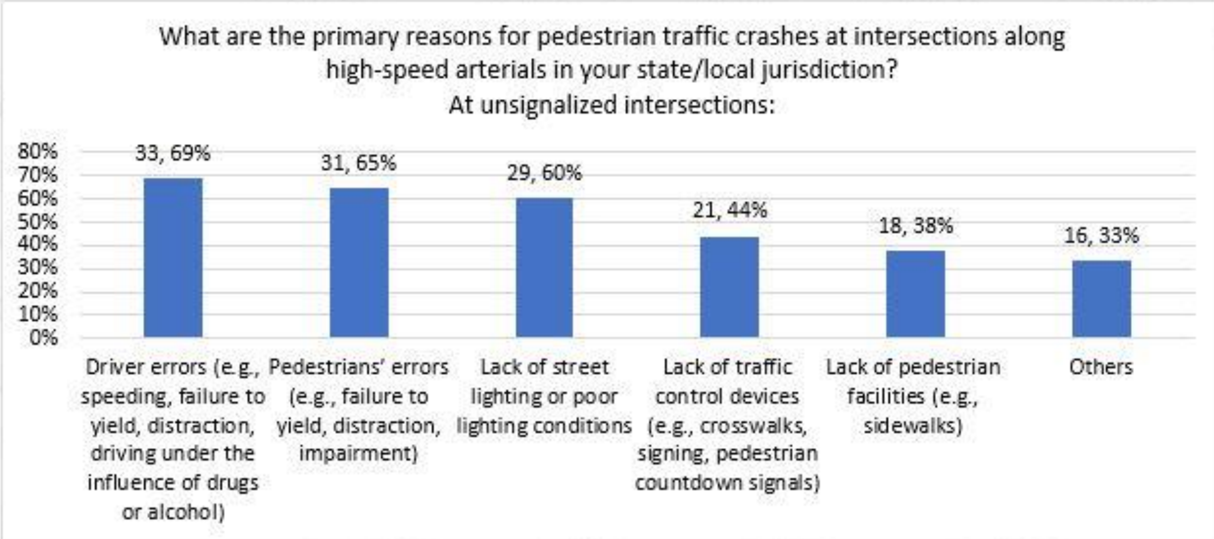
Participants were also asked to report the primary reasons for pedestrian-involved traffic crashes at signalized intersections along high-speed arterials. As shown in Figure 8, the primary reasons are driver errors (69%), pedestrian errors (60%), lack or poor quality of street lighting (54%), lack of traffic control devices (38%), and lack of pedestrian facilities (33%). In addition, 29% of state DOTs selected the "Other" option, including reasons such as long crossing distances, high-speed intersection design, seasonal maintenance, and a lack of available data during the VRU Assessment Report evaluation process. This comprehensive overview sheds light on the multifaceted factors contributing to pedestrian-involved crashes at signalized intersections along high-speed arterials.

Figure 8. Primary reasons for pedestrian traffic crashes at signalized intersections along high-speed arterials.



Likewise, participants were asked to determine the primary reasons for pedestrian-involved traffic crashes at unsignalized intersections. As shown in Figure 9, driver errors were identified by 69% of state DOTs. Pedestrian errors were reported by 65% of state DOTs. Concerns about lighting conditions emerged, with 60% of state DOTs highlighting the lack or poor quality of street lighting. Moreover, 44% of state DOTs identified the absence of traffic control devices as a contributing factor. The "Other" category, selected by 33% of state DOTs, encompassed reasons such seasonal maintenance, ongoing determination for the VRU Assessment Report, and a lack of available data.

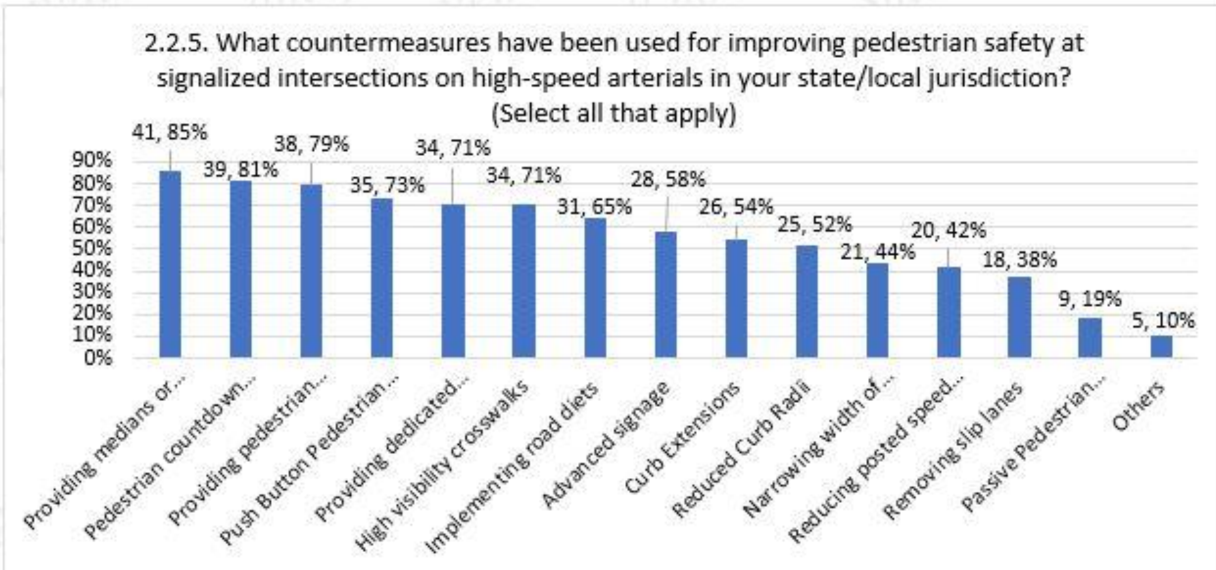
Figure 9. Primary reasons for pedestrian traffic crashes at unsignalized intersections along high-speed arterials.



Survey participants were asked if their agency analyzed data to determine what type of intersections have more pedestrian-involved crashes. 38% (18) of state DOTs indicated that they have conducted such analyses. The results revealed that signalized intersections tend to have a larger share of pedestrian-involved crashes, although they are often less severe in terms of injuries, notably left turn and right turn crashes. Conversely, uncontrolled marked crosswalks and midblock pedestrian crossings experience fewer crashes, but their severity tends to be higher due to vehicle speed. It was also reported that roundabouts, transitioning to signals and then to unsignalized intersections, exhibit a trend with more crashes at signals but fewer crashes per pedestrian, emphasizing the role of exposure. 62% of state DOTs reported that they have not analyzed intersections for pedestrian-involved crashes.

Participating state DOTs were asked to determine the countermeasures used to improve pedestrian safety at signalized intersections on high-speed arterials. As shown in Figure 10, the countermeasures included the provision of medians (85%), pedestrian countdown signals (81%), pedestrian facilities (79%), PPB Detection enabling pedestrians to request safe crossings (73%), LPI and high visibility crosswalks (71%), and road diets (65%), which aim to slow traffic by reducing travel lanes. Less frequently applied countermeasures included reducing posted speed limits (42%), removing slip lanes (38%), and passive pedestrian detection (19%). A notable 10% of state DOTs reported employing various "Other" countermeasures, including protected left turn phasing, truck aprons, turn restrictions, dynamic No Red Turn on Red Restrictions (RTOR) signage, and logic programming controllers.

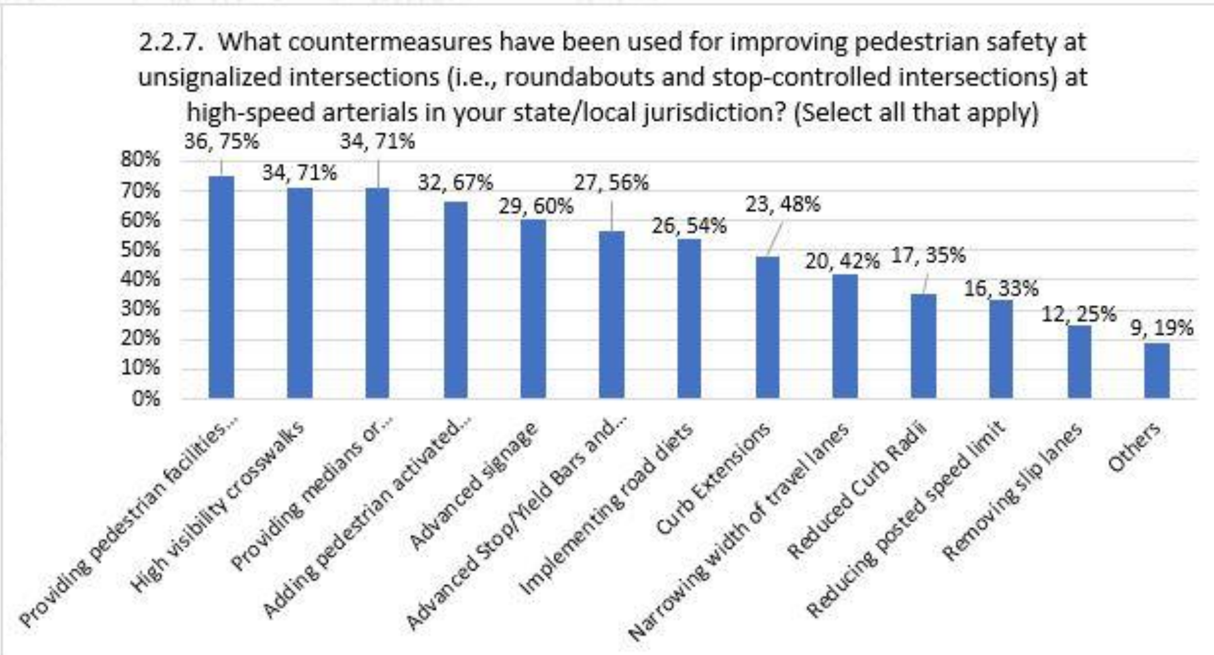
Figure 10. Countermeasures used for improving pedestrian safety at signalized intersections on high-speed arterials.



Survey participants were also asked to report any conflicts with the current state DOT guidelines that prevent the implementation of the countermeasures at signalized intersections suggested in the previous question. 17% (8) of state DOTs mentioned that there are conflicts. These conflicts manifest in various challenges, such as the need for clearer guidance on high visibility crosswalks, with Illinois undergoing legislative changes to address previous limitations on PHBs. Conflicts also arise from design standards impacting vehicle turning radii and reduced curb radii, potentially affecting signal timing adjustments. Historical design standards can restrict traffic calming measures like curb extensions, particularly in areas with significant truck traffic. Additionally, the absence of clear guidance and regional variations further complicates implementation. In contrast, 79% (38) of state DOTs reported no conflicts with current guidelines, while 4% (2) selected "Other".

Likewise, the survey participants were asked about countermeasures used to improve pedestrian safety at unsignalized intersections. As shown in Figure 11, 75% (36) of state DOTs provided pedestrian facilities. Additionally, 71% (34) of state DOTs have adopted high visibility crosswalks, and 71% (34), have implemented medians or pedestrian refuge islands. Furthermore, 67% (32) of state DOTs have introduced RRFB to enhance pedestrian visibility and safety, and 60% (29) utilize advanced signage to improve pedestrian awareness. Additionally, 19% (9) of state DOTs selected "Other," which included countermeasures such as illumination, exemplified by the South Carolina Pedestrian and Bicycle Safety Action Plan.

Figure 11. Countermeasures used for improving pedestrian safety at unsignalized intersections (i.e., roundabouts and stop-controlled intersections) at high-speed arterials.



Survey participants were asked if there are any conflicts with current state guidelines that prevent the implementation of the countermeasures suggested in the previous question to improve pedestrian safety at unsignalized intersections. 17% (8) of state DOTs stated that there are conflicts, including challenges such as the need for improved crosswalk guidance, historical ineffectiveness in reducing posted speed limits to enhance pedestrian safety, and restrictions on the use of curb extensions and various traffic calming measures, particularly on state roadways with speed limits exceeding 35 mph or in areas with a high volume of truck traffic. Additionally, the absence of clear guidance for informed decision-making in implementing pedestrian safety measures, including current design standards and crosswalk policies, poses challenges. Furthermore, regional preferences introduce variations in approaches and preferences across different areas. Meanwhile, 81% (39) of state DOTs reported that there was no conflict with the current guidelines to implement the countermeasures. The remaining 2% (1) selected "Other".

When asked if they used any low-cost countermeasures for improving pedestrian safety at intersections along high-speed arterials, 56% (27) of state DOTs responded “Yes”. These countermeasures include countdown pedestrian signals, high-visibility crosswalks, signage, pavement markings, LPIs, radar speed feedback signs, and pedestrian countdown timers. These measures have been implemented through various programs and initiatives, such as Caltrans' Pedestrian Systemic Safety Improvement Program and other state-specific efforts. However, it is important to note that while these countermeasures have been used, they have not always been systemically applied across all high-speed arterial intersections. Additionally, the specific locations and details of these implementations vary by state, and some countermeasures are still under development or are not typically applied to high-speed arterials. 44% (21) of state DOTs have not used any low-cost countermeasures for improving pedestrian safety at intersections along high-speed arterials.

State DOTs who used low-cost countermeasures for improving pedestrian safety at intersections along high-speed arterials were asked about the effectiveness of these countermeasures. Only 2% (1) reported that these countermeasures were effective in reducing pedestrian-involved crashes. 77% (37) of state DOTs stated that no evaluation was performed. 21% (10) of state DOTs selected “Other,” which included a range of responses, such as the need for further inquiry and evaluation of the data, reservations about fully endorsing the findings, ongoing assessment of the available data, and instances when the question was deemed not relevant.

Participants were also asked if their agency evaluated the impacts of implementing pedestrian facilities. It was found that only 6% (3) of state DOTs have evaluated the impacts for implementing pedestrian facilities at intersections on high-speed arterials, while 75% (36) of state DOTs have not. However, it is important to note that not all agencies have conducted formal evaluations, and in some cases, assessments are conducted on a case-by-case basis as part of improvement projects. Additionally, impacts are expected to be evaluated after the implementation of new policies and guidelines.

Finally, participants were asked about any individual or combination of countermeasures or programs that were most effective at improving pedestrian safety at intersections on high-speed arterials in their state/local jurisdiction. 25% (12) of state DOTs reported lighting, signage, sidewalks, crosswalks, pedestrian push buttons, pedestrian countdown timers, and striping to be effective. Additionally, road diets, HAWK signals, automated speed enforcement, curb extensions, refuge islands, LPIs, roundabouts, medians, and speed feedback signs were effective in enhancing pedestrian safety. Consistent application of countermeasures across corridors, reducing crossing distances, increasing visibility, and reducing the number and speed of conflict points were also successful. Moreover, evaluations and strategies included in the SHSP have contributed to improving pedestrian safety on highways. These diverse countermeasures and programs collectively address the unique challenges of pedestrian safety at intersections. However, 65% (31) of state DOTs indicated that they did not find any individual or combinations of countermeasures or programs to be most effective at improving pedestrian safety at intersections on high-speed arterials, while 10% (5) selected "Other," which included responses such as "further research and evaluation are needed." Others mentioned that all options are considered on a case-by-case, context-sensitive basis during the development of engineering scope documents, highlighting the absence of a universal solution.

Task 5: Develop a Matrix of Design Features for Safe Movement Along and Across Roadways

Using the findings from Tasks 1 through 4, the research team developed a series of preliminary matrices of design features and countermeasures for providing the safe movements of pedestrians along and across high-speed arterials, including rural, urban, and urbanized principal and minor arterials. The suggested design features and countermeasures included pedestrian safety enhancements for signalized and unsignalized intersections and midblock crossings. Each matrix incorporated the roadway classification and factors such as ADT, speed, and cross-sectional features (i.e., number of lanes and divided or undivided roadways). Considering the SSA, each matrix included features that separate pedestrians from vehicular travel, encourage reduced speeds, increase the visibility of pedestrians, and accommodate driver expectations for pedestrians. The team developed the preliminary matrices and provided them to the PRC and /DOTD for review and comment. A PRC meeting was held to discuss the preliminary matrices and obtain feedback. Based on the feedback received from PRC, the research team revised the preliminary matrices. The matrices will serve as the basis for identifying potential conflicts or gaps in policies or guidance documents, making recommendations for changes in these documents and state statutes, and developing the statewide guidance document.

In this task, the appropriate safety proven treatment options for each roadway and intersection peer group (identified in Task 3) were matched depending on the physical characteristics of the road (e.g., the traffic volume and speed range). Because Louisiana is focused on reducing traffic related fatalities and severe injuries, the research team considered the principles and elements of the SSA when identifying potential treatments. The SSA is a comprehensive approach to enhance road safety based on the premise that while humans make mistakes and are vulnerable, this should not result in death or injury. Countermeasures that consider Safe System elements (safe roads, safe road users, and safe speeds) to achieve reductions in fatalities and serious injuries were identified. For safe roads, countermeasures focusing on mitigating human mistakes, reducing impact forces, and encouraging safer behavior were suggested. For safe road users, countermeasures considered all modes of travel that enhance safe, responsible driving and behavior. As speeds increase, so does the potential for a crash to result in death or injury, so for safe speeds, countermeasures addressing speed management were suggested.

Suggest Appropriate Treatment Options

The initial list of countermeasures proposed in this task are evidence-based treatments proven to enhance pedestrian and other road user safety. The research sought to identify countermeasures adapted to specific locations and situations, with a focus on the safety of all pedestrians. In this step, a complete review of crash data, roadway characteristics such as traffic volume and speed limit range, and recommendations from previous relevant research were used to choose appropriate countermeasures. Proven safety countermeasures were suggested to deal with specific pedestrian safety issues and to improve overall road user safety. The goal was to prevent pedestrian crashes by implementing the elements of SSA related to safe roads, safe road users, and safe speeds.

First, the results of the statewide data analysis were analyzed for roadway segment and intersection peer groups to determine situational trends in pedestrian crashes in Louisiana. Three statewide priority peer group categories were suggested separately for intersections and midblock/roadway segments based on crash frequency and severity. Peer group categories with at least 20% of all pedestrian-involved crashes for a location type (intersection or midblock/roadway segment) on high-speed arterials are represented by Statewide Priority 1. Statewide Priority 2 refers to those peer groups that account for at least 10% but less than 20% of the statewide pedestrian-involved crashes for a location type (intersection or midblock/roadway segment) on high-speed arterials. Statewide Priority 3 peer groups account for at least 5% but less than 10% of the statewide pedestrian-involved crashes for a location type (intersection or midblock/roadway segment) on high-speed arterials. These should represent the statewide priorities for improving pedestrian safety.

Statewide Priority 1 Peer Groups:

- Midblock Road Segments:
  - — Urbanized 2-lane Undivided (Z2U)
  - — Urbanized 4-lane Divided (Z4D)
  - — Urbanized 4-lane Undivided (Z4U)

- Intersections:
  - — Urbanized 4-legged Signalized (Z4S)
  - — Urbanized 3-legged Stop Control (Z3M)

Statewide Priority 2 Peer Groups:

- Midblock Road Segments:
  - — Rural 2-lane Undivided (R2U)
- Intersections:
  - — Urbanized 4-legged Stop Control (Z4M)

Statewide Priority 3 Peer Groups:

- Midblock Road Segments:
  - — Rural 4-lane Divided (R4D)

These priority peer groups were further refined based on the number of pedestrian-involved crashes occurring at the various speed and ADT thresholds. As shown in Figures 12, 13 and 14, three separate countermeasure matrices were developed, one for each of the following types of roadway segments: midblock, signalized intersections, and unsignalized intersections, along with the various associated peer groups. The PRC recognized that conditions may exist at sites with characteristics that do not fall into the Statewide Priority Peer Groups, and it is important to provide guidance to agencies that allow them to address pedestrian safety issues at these locations. The research team revised the initial preliminary matrices to identify countermeasures for all peer group categories, including those outside of the Statewide Priority Peer Groups.

The Statewide Priority 1, Priority 2, and Priority 3 peer groups are highlighted in yellow, light blue and light green, respectively. Each preliminary countermeasure matrix was developed to identify appropriate countermeasures for the specific location type. The shaded countermeasures (in grey) should be considered during planning, but are not mandatory. An outlined unshaded number signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures (e.g., PHB). Even if a countermeasure is not included in the matrix, there is still a possibility that it might be used if the engineering study warrants it. An unshaded number in that matrix indicates that countermeasure could be considered for that particular cell of the peer group and speed and traffic volume. If there are no countermeasures suggested, it means those cells have low crashes related to ADT and speed range. For these cells, countermeasures could be suggested based on engineering judgement and availability of resources. Peer groups categories that have “NA” listed do not typically have lane configurations that are applicable for the site conditions; for example, low traffic volumes would not equate to 6- or 8-lane facilities.

The countermeasures suggested in this study were developed based on prior relevant studies such as the "Missouri Systemic Countermeasures to Improve Pedestrian Safety" [23], “Field Guide for Selecting Countermeasures at Uncontrolled Pedestrian Crossing Locations” [41], “NCHRP Report 893: Systemic Pedestrian Safety Analysis” [42], and the "Proven Safety Countermeasures" developed by the FHWA [43]. “Missouri Systemic Countermeasures to Improve Pedestrian Safety” aims to enhance pedestrian safety by identifying high-risk areas and systemically implementing countermeasures that have been shown to reduce pedestrian crashes. Based on crash data analysis of that study, countermeasures such as road diets, pedestrian countdown signals, high-visibility crosswalks, and better lighting were suggested. The "Field Guide for Selecting Countermeasures at Uncontrolled Pedestrian Crossing Locations" is similar to the Missouri study, offering a comprehensive approach to pedestrian safety that includes identifying high-risk locations and using proven countermeasures to prevent pedestrian crashes**.** The FHWA’s “Proven Safety Countermeasures” are a collection of evidence-based treatments to improve safety for all road users. Roundabouts, LPI, PHB, raised crosswalks, pedestrian refuge islands, and speed feedback signs are among some of the recommended countermeasures. These countermeasures are based on crash data analysis and are intended to address pedestrian safety.

5.1. Road Segment-Midblock Countermeasures

The midblock roadway segment countermeasures shown in Figure 12 includes peer groups along with the countermeasures for each cell of peer group per traffic volume (ADT) and speed. Figure 12 identified six statewide priority groups: three (Z2U, Z4D and Z4U) related to Statewide Priority 1 (highlighted in yellow), one (R2U) related to Statewide Priority 2 (highlighted in light blue) and one (R4D) related to Statewide Priority 3 (highlighted in light green). These priority peer groups were further refined based on the number of pedestrian crashes occurring at the various speed and ADT thresholds. The traffic volume and speed limit thresholds are similar to the ones used for the distribution in Table 17 in Task 3. The following is the list of identified countermeasures included in the matrix for midblock road segments. Each countermeasure is numbered accordingly. The number in the matrix is shaded if it should always be considered and outlined if it should be considered in conjunction with another treatment.

1. **High-Visibility Crosswalks with ADA Ramps and Pedestrian Crossing Signs in Advance/at Crosswalk, Parking Restrictions at Crosswalk Approach.** High visibility crosswalks are more visible to pedestrians and motorists than traditional transverse

crosswalks. They guide pedestrians to a preferred crossing location and alert motorists to the potential presence of pedestrians. They modify road user behavior, thus reducing the risk of vehicle/pedestrian conflicts [44]. ADA ramps should be installed at each end of the crosswalk (and at raised medians within the crossing) to provide access for all pedestrians when crossing the street. Street parking restricted to at least 50 feet in advance of the crosswalk will improve the sight distance of drivers to pedestrians. Due to the speeds or number of lanes, high visibility crosswalks require the installation of a traffic control treatment (e.g., PHB) for implementation. This should be supplemented with a pedestrian crossing sign in advance or at the crosswalk and street lighting at the crosswalk to further communicate the potential presence of pedestrians.

2. **Advanced Stop Bars and Signs.** These traffic control devices improve driver behavior and safety at midblock crosswalks by increasing stopping rates and reducing vehicle speed [45].
3. **Sidewalks and Walkways**. Providing sidewalks and walkways separates the pedestrian from vehicular traffic and can reduce pedestrian-involved crashes. The likelihood of a pedestrian crash along roadways with no sidewalk is 1.67 times greater than the likelihood of a crash with the presence of a sidewalk [13].
4. **Pedestrian Hybrid Beacon (PHB).** The PHB is used for midblock locations with posted speed limits of 40 mph or greater. It requires high-visibility crosswalks and signing. PHBs can reduce pedestrian crashes by 46% [46]. Street lighting is also recommended with the PHB. An engineering study should be performed to investigate this further.
5. **Curb Extensions.** Extending the curb line outward effectively reduces the street width. It requires the motorist to reduce the speed of their vehicles when turning toward the pedestrian crosswalk and decreases the crossing distance for the pedestrian. This reduces the potential for pedestrian crashes.
6. **Narrowing of Travel Lanes**. Vehicular speeds can be reduced by narrowing lanes of travel. This acts as a traffic calming measure. It reduces pedestrian crossing distances and exposure risk. This can be achieved through low-cost systemic restriping of the roadway. A minimum 10-foot lane may be used as traffic calming measure, although that is typically on urban roadways. Multi-lane roadways may use larger lane widths on the outside lanes to provide sufficient space for trucks and transit buses.
7. **Pedestrian Refuge Islands or Medians with Curb Cut**. A pedestrian refuge island or median with a refuge area reduces the crossing distance required of a pedestrian and provides an area that safely separates pedestrians from vehicles while waiting to cross the remaining portion of a multi-lane roadway. This countermeasure should be installed with a marked crosswalk. It is estimated that pedestrian crashes can be reduced by 56% [47].

8. **Road Diets/Road Reconfiguration**. Reducing the number of lanes or reconfiguring the roadway cross-section allows the roadway space to be utilized for other modes of travel. This countermeasure encourages slower speeds, reduces the crossing distance for pedestrians, and reduces crashes [23].
9. **Lighting**. Pedestrian crashes occur more often at night when the visibility of pedestrians is limited. This is particularly notable at midblock crossings. Lighting can reduce nighttime injury pedestrian crashes at intersections by up to 42%, and nighttime injury crashes on rural and urban highways by up to 28% [43]. Continuous lighting provides full coverage, and state agencies such as Delaware DOT have started installing lighting along arterial corridors to address pedestrian safety.

Based on the number of crashes from Table 17 in Task 3, proven safety countermeasures are suggested in Figure 12. For every peer group cell, a minimum of high visibility crosswalks with pedestrian crossing warning signs are suggested. It should always be considered during planning, but is not mandatory. Because crosswalks cannot be installed alone for roads with posted speed limits of 40 mph or greater, the PHB is recommended jointly [27]. In Figure 12, for example the following countermeasures are suggested for a cell in peer group Z2U having a traffic volume less than 10,000 at the speed limit 45 mph: 1 (high visibility crosswalks), 2 (advanced stop sign), 3 (sidewalks), 4 (PHB), 5 (curb extensions), 6 (narrow travel lanes), and 9 (lighting). This is because this peer group cell is relatively more vulnerable than the other group cells, as it has a higher number of crashes. Although the research suggests multiple countermeasures, it is important to note that their implementation should be evaluated in the context of the location's specific conditions and available resources. This requires considerable analysis and competent judgment on the part of transportation authorities and engineers. It is also critical to monitor and evaluate the efficiency of the selected countermeasures once they have been implemented. Also, some of the countermeasures are suggested only if they meet the criteria. For example, countermeasure 3 (sidewalks or walkways) is suggested in categories with higher numbers, recognizing that these need to be considered strategically. Countermeasure 6 (narrowing of lanes) is only suggested for roads with 4 lanes or less. Countermeasure 5 (curb extension) is suggested in urban and urbanized areas. Countermeasure 7 (medians with curb cut) is suggested for divided 2-lane roads and undivided roads with 4 lanes or more.

Note: An expanded and enhanced countermeasure matrix for roadway/midblock segments is available in Appendix D, categorized according to ADT groups.

Figure 12. Suggested Countermeasures for Roadway/Midblock Segments

ADT Range (vpd)	≤10000			
Speed Range (mph)	40	45	50	55+
Rural 2 lane Undivided (R2U)	1 2 4 6 9	1 2 3 4 6 9	1 2 4 6 9	1 2 3 4 6 9
Rural 4 lane Divided (R4D)	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9	1 2 3 4 7 9
Rural 4 lane Undivided (R4U)	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9
Urban 2 lane Divided (U2D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urban 2 lane Undivided (U2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urban 4 lane Divided (U4D)	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 6 7 9
Urban 4 lane Undivided (U4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 2 lane Divided (Z2D)	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9
Urbanized 2 lane Undivided (Z2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urbanized 4 lane Divided (Z4D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urbanized 4 lane Undivided (Z4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Divided (Z6D)	NA	NA	NA	NA
Urbanized 6 lane Undivided (Z6U)	NA	NA	NA	NA

ADT Range (vpd)	>10000- ≤20000			
Speed Range (mph)	40	45	50	55+
Rural 2 lane Undivided (R2U)	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9	1 2 3 4 6 9
Rural 4 lane Divided (R4D)	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9	1 2 3 4 7 9
Rural 4 lane Undivided (R4U)	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9
Urban 2 lane Divided (U2D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urban 2 lane Undivided (U2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urban 4 lane Divided (U4D)	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9
Urban 4 lane Undivided (U4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 2 lane Divided (Z2D)	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9
Urbanized 2 lane Undivided (Z2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urbanized 4 lane Divided (Z4D)	1 2 3 4 7 9	1 2 3 4 5 7 9	1 2 3 4 7 9	1 2 3 4 5 7 9
Urbanized 4 lane Undivided (Z4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Divided (Z6D)	NA	NA	NA	NA
Urbanized 6 lane Undivided (Z6U)	NA	NA	NA	NA

ADT Range (vpd)	>20000- ≤30000			
Speed Range (mph)	40	45	50	55+
Rural 2 lane Undivided (R2U)	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9
Rural 4 lane Divided (R4D)	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9
Rural 4 lane Undivided (R4U)	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9
Urban 2 lane Divided (U2D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urban 2 lane Undivided (U2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urban 4 lane Divided (U4D)	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9
Urban 4 lane Undivided (U4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 2 lane Divided (Z2D)	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9
Urbanized 2 lane Undivided (Z2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urbanized 4 lane Divided (Z4D)	1 2 3 4 7 9	1 2 3 4 5 7 9 9	1 2 3 4 5 6 7 9	1 2 3 4 5 7 9
Urbanized 4 lane Undivided (Z4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Divided (Z6D)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Undivided (Z6U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9

ADT Range (vpd)	>30000			
Speed Range (mph)	40	45	50	55+
Rural 2 lane Undivided (R2U)	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9
Rural 4 lane Divided (R4D)	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9
Rural 4 lane Undivided (R4U)	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9
Urban 2 lane Divided (U2D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urban 2 lane Undivided (U2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urban 4 lane Divided (U4D)	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9
Urban 4 lane Undivided (U4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 2 lane Divided (Z2D)	1 2 3 4 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 6 7 9
Urbanized 2 lane Undivided (Z2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urbanized 4 lane Divided (Z4D)	1 2 3 4 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9
Urbanized 4 lane Undivided (Z4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Divided (Z6D)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Undivided (Z6U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9

Statewide Priority 1 Statewide Priority 2 Statewide Priority 3

A. Land Use: Urbanized = population 50,000 and above, Urban = population between 2,500 and 49,999, and Rural = population less than 2,500.

B. # A shaded number denotes a countermeasure that should be always considered during planning but is not mandatory. The selection of a certain countermeasure should be documented by an engineering analysis or the use of engineering judgment.

C. # An outlined unshaded number signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.

D. # An unshaded number indicates a countermeasure that may be considered for that particular peer group, along with its speed and ADT ranges.

E. In a peer group cell, the lack of countermeasures number denotes a category with a low crash history related to the characteristics (i.e., ADT, speed). Based on engineering judgment, a higher-level countermeasure may be considered for low crash cells.

F. NA--Lane Configurations not applicable for ADT less than 20,000.

1. High Visibility Crosswalks with ADA Ramps and Pedestrian Crossing Signs in Advance/at Crosswalk, Parking Restrictions at Crosswalk Approach
2. Advanced Stop Bars and Signs
3. Sidewalks and Walkways
4. Pedestrian Hybrid Beacon (PHB)
5. Curb Extensions
6. Narrowing of Travel Lanes.
7. Pedestrian Refuge Islands or Medians with Curb Cut
8. Road Diets/Road Configuration
9. Lighting

5.2. Signalized Intersection Countermeasures

The signalized intersection countermeasures shown in Figure 13 include peer groups and countermeasures for each cell of peer groups according to traffic volume (ADT) and speed. The table identifies only one priority peer group (Z4S), Statewide Priority 1 (highlighted in yellow). These priority peer groups were further refined based on the number of pedestrian-involved crashes occurring at the various speed and ADT thresholds. The traffic volume and speed limit thresholds are similar to the ones used for the distribution in Tables 18 and 19 in Task 3. Tables 18 and 19 were separated for divided and undivided approach legs, while the countermeasure table combines both the divided and undivided approach legs.

The following is the list of identified countermeasures included in the matrix for signalized intersections. Each countermeasure is numbered accordingly, and the number in the matrix is shaded if it should always be considered.

1. **High-Visibility Crosswalks with ADA Ramps and Pedestrian Crossing Signs in Advance/at Crosswalk, Parking Restrictions at Crosswalk Approach.** High visibility crosswalks are more visible to pedestrians and motorists than traditional transverse crosswalks. They guide pedestrians to a preferred crossing location and alert motorists to the potential presence of pedestrians. They modify driving road user behavior, thus reducing the risk of vehicle/pedestrian conflicts [44].
2. **Signal Timing.** Modifying signal timing to prioritize the safety of pedestrians at signalized intersections can be accomplished by providing exclusive pedestrian phases, leading pedestrian intervals, pedestrian phase recall, reduced signal cycle, and permissive left turn phasing.
3. **Leading Pedestrian Interval (LPI).** This method of signal timing gives pedestrians a head start of 3 to 7 seconds before vehicles are given a green light. It reduces pedestrian crashes by up to 13% at intersections [23]. It can be supplemented with a NO RIGHT TURN blank out sign, which can restrict turning movements during the red phase and allow turning movements during the green phase. This allows a balance between pedestrian safety and movement of vehicles for capacity.

4. **Passive Pedestrian Detection.** Infrared, ultrasonic, microwave radar, video imaging, or piezometric sensors are passive pedestrian detection devices that provide an alternative way to activate pedestrian crossing traffic control devices. It may be used near schools, designated school crossings, and high-volume pedestrian crosswalks. A dedicated phase allowing for pedestrian crossings may not need actuation.

5. **Pedestrian Pushbutton (PPB) or Accessible Pedestrian Signals (APS).** Accessible pedestrian signals (APS) involve installing PPBs or APS in compliance with current MUTCD guidelines to increase pedestrian actuation usage. These may not be necessary at locations that include pedestrian phases in each cycle.

6. **Curb Extensions.** Extending the curb line outward effectively reduces the street width. It requires motorists to reduce the speed of their vehicles when turning toward the pedestrian crosswalk and decreases the crossing distance for the pedestrian. This reduces the potential for pedestrian crashes.

7. **Reduced Curb Radii**. When the curb radii are decreased, motorists need to reduce their speed when turning toward pedestrian crosswalks. This enhances pedestrian safety.

8. **Pedestrian Refuge Islands or Medians with Curb Cut.** A pedestrian refuge island or median with a refuge area reduces the crossing distance required of a pedestrian and provides an area that safely separates pedestrians from vehicles while waiting to cross the remaining portion of a multi-lane roadway. It helps protect pedestrians crossing the road. Extending existing medians and providing cut-throughs for divided roadways should be considered where appropriate. This countermeasure should be installed with a marked crosswalk. Pedestrian crashes are estimated to be reduced by 56% [47].

9. **Countdown Pedestrian Signals**. These traffic control devices show pedestrians the number of seconds remaining until the signal changes and help them better interpret pedestrian signals. Countdown timers also allow pedestrians to stop on a median refuge, where provided, and wait for the next signal phase if they believe that there is insufficient time for them to complete their crossing. MUTCD standards require new and upgraded pedestrian signals to count down.

10. **Lighting of Crosswalks at the Intersection.** Lighting can reduce injuries in nighttime pedestrian-involved crashes at intersections by up to 42% and in nighttime crashes on rural and urban highways by up to 28% [43].

11. **NO TURN ON RED Signing for Some or All Approaches.** Restricting right turning movements during the red phase of a traffic signal reduces the vehicle/pedestrian conflict

and allows the pedestrian to cross a signalized intersection safely. These should be considered especially when pedestrian activity may be frequent. NO RIGHT TURN blank out signs may be used to restrict turning movement during the red phase of a signal and allow turning movement during the green phase. This allows a balance between pedestrian safety and the movement of vehicles for capacity.

Based on the number of crashes from Tables 18 and 19 from Task 3, countermeasures are suggested in Figure 13. For every peer group cell, a minimum of high visibility crosswalks and push button pedestrian detection, except for intersections with a dedicated phase allowing for pedestrian crossing, are suggested. These should always be considered during planning, but they are not mandatory. In Figure 13, for example, the following countermeasures are suggested for a cell in peer group Z4S having a traffic volume of less than 10,000-20,000 at the speed limit 45 mph: 1 (high visibility crosswalk), 2 (signal timing), 3 (LPI), 4 (passive pedestrian detection), 5 (push button pedestrian detection), 6 (curb extensions), 7 (reduced curb radii), 8 (medians) and 9 (pedestrian countdown timers). This is because this peer group cell contains a relatively high number of pedestrian crashes compared to other group cells. Although multiple countermeasures are suggested, their implementation should be evaluated in context of the location and available resources. This should be supported by analysis and competent judgment on the part of transportation authorities and engineers. It is also important to monitor and evaluate the efficiency of the selected countermeasures once they have been implemented. If the peer group falls under Priority 1, then countermeasure 9 (pedestrian countdown timers) is also suggested. Also, some of the countermeasures are suggested only if they meet the criteria. For example, countermeasure 6 (curb extensions) is not recommended if the traffic volume (ADT) is less than 10,000, per the NCHRP research report. Countermeasure 3 (LPI) is suggested for peer groups with ADT 10,000-25,000 and speed limits less than or equal to 45 mph.

Note: An expanded and enhanced countermeasure matrix for signalized intersections is available in Appendix D, categorized according to ADT groups.

Figure 13. Suggested Countermeasures for Signalized Intersections

ADT Range (vpd)	≤10000				>10000-≤20000			
Speed Range (mph)	40	45	50	55+	40	45	50	55+
Undivided Legs								
Rural 4 legged Signalized (R4S)	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11
Urban 3 legged Signalized (U3S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 2 legged Signalized (Z2S)	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	**1 2 3 4 5 6 / 7 8 9 10 11**	**1 2 3 4 5 6 / 7 8 9 10 11**	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	**1 2 3 4 5 6 / 7 8 9 10 11**	**1 2 3 4 5 6 / 7 8 9 10 11**	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 5 legged Signalized (Z5S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Divided Legs								
Rural 3 legged Signalized (R3S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Rural 4 legged Signalized (R4S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 2 legged Signalized (Z2S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	1 2 3 4 5 6 / 7 8 9 10 11	**1 2 3 4 5 6 / 7 8 9 10 11**	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	**1 2 3 4 5 6 / 7 8 9 10 11**	**1 2 3 4 5 6 / 7 8 9 10 11**	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11

ADT Range (vpd)	>20000-≤30000				>30000			
Speed Range (mph)	40	45	50	55+	40	45	50	55+
Undivided Legs								
Rural 4 legged Signalized (R4S)	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11
Urban 3 legged Signalized (U3S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 2 legged Signalized (Z2S)	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	**1 2 3 4 5 6 / 7 8 9 10 11**	**1 2 3 4 5 6 / 7 8 9 10 11**	**1 2 3 4 5 6 / 7 8 9 10 11**	1 2 3 4 5 6 / 7 8 9 10 11	**1 2 3 4 5 6 / 7 8 9 10 11**	**1 2 3 4 5 6 / 7 8 9 10 11**	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 5 legged Signalized (Z5S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Divided Legs								
Rural 3 legged Signalized (R3S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Rural 4 legged Signalized (R4S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 2 legged Signalized (Z2S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	**1 2 3 4 5 6 / 7 8 9 10 11**	**1 2 3 4 5 6 / 7 8 9 10 11**	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	**1 2 3 4 5 6 / 7 8 9 10 11**	**1 2 3 4 5 6 / 7 8 9 10 11**	**1 2 3 4 5 6 / 7 8 9 10 11**	1 2 3 4 5 6 / 7 8 9 10 11

Note: No Priority group 2 and 3 peer group for this matrix

Statewide Priority 1   Statewide Priority 2   Statewide Priority 3

A. Land Use: Urbanized = population 50,000 and above, Urban = population between 2,500 and 49,999, and Rural = population less than 2,500.

B. # A shaded number denotes a countermeasure that should be always considered during planning but is not mandatory. The selection of a certain countermeasure should be documented by an engineering analysis or the use of engineering judgment.

C. # An unshaded number indicates a countermeasure that may be considered for that particular peer group, along with its speed and ADT ranges.

D. In a peer group cell, the lack of countermeasures number denotes a category with a low crash history related to the characteristics (i.e., ADT, speed). Based on engineering judgment, a higher-level countermeasure may be considered for low crash cells.

1. High visibility crosswalks with ADA Ramps and Pedestrian Crossing Signs in Advance/at Crosswalk, Parking Restrictions at Crosswalk Approach
2. Signal Timing
3. Leading Pedestrian Interval (LPI)
4. Passive Pedestrian Detection
5. Pedestrian Pushbutton (PPB) or Accessible Pedestrian Signals (APS)
6. Curb Extensions
7. Reduced Curb Radii
8. Pedestrian Refuge Islands or Medians with Curb Cut
9. Countdown Pedestrian Signals
10. Lighting of Crosswalks in the Intersection
11. NO TURN ON RED Signing for All Approaches

5.3. Unsignalized Intersection Countermeasures

Figure 14 illustrates the peer groups of unsignalized intersections along with the suggested countermeasures for each cell of peer group per traffic volume (ADT) and speed. The table identified two priority groups, one (Z3M) for Statewide Priority 1 (highlighted in yellow) and one (Z4M) for Statewide Priority 2 (highlighted in light blue). These priority peer groups were further refined based on the number of pedestrian crashes occurring at the various speed and ADT thresholds. Unsignalized intersections may be a combination of uncontrolled approaches on the major leg of the intersection with the minor legs as stop-controlled, 4-way stop condition, or roundabout. Uncontrolled approaches should be treated as midblock crossings.

The following is the list of identified countermeasures included in the matrix for unsignalized intersections. Each countermeasure is numbered accordingly. The number in the matrix is shaded if it should always be considered.

1. **High-Visibility Crosswalks with ADA Ramps and Pedestrian Crossing Signs in Advance/at Crosswalk, Parking Restrictions at Crosswalk Approach.** High visibility crosswalks enhance pedestrian and motorist visibility, reducing vehicle/pedestrian conflicts and guiding safe crossings [44]. Installing ADA ramps at crosswalk ends ensures accessibility, and restricting street parking 50 feet before the crosswalk improves driver sight distance. Consideration may be given to supplementing with advance pedestrian crossing signs, balancing visibility without sign clutter. For uncontrolled approaches, based on speeds of 40 mph or greater, marked crosswalks alone are not adequate and require a traffic control device (e.g., PHB, traffic signal) as well.
2. **Advanced Stop Bars and Signs.** These traffic control devices improve driver behavior and safety by increasing stopping rates and reducing vehicle speed [45].
3. **Sidewalks and Walkways**. Providing sidewalks and walkways separates pedestrians from vehicular traffic and can reduce pedestrian-involved crashes. The likelihood of a pedestrian crash along roadways with no sidewalk is 1.67 times greater than the likelihood of a crash with the presence of a sidewalk [13].
4. **Pedestrian Hybrid Beacon (PHB).** The PHB is used for locations in advance of an uncontrolled crossing with posted speed limits of 40 mph or greater. It requires high-visibility crosswalks and signing. PHBs can reduce pedestrian crashes by 46% [46]. An engineering study should be performed.
5. **Curb Extensions.** Extending the curb line outward effectively reduces the street width. It requires the motorist to reduce the speed of their vehicles when turning toward the

pedestrian crosswalk and decreases the crossing distance for the pedestrian. This reduces the potential for pedestrian crashes.

6. **Reduced Curb Radii.** When the curb radii are decreased, motorists need to reduce their speed when turning toward pedestrian crosswalks. This enhances pedestrian safety.
7. **Pedestrian Refuge Islands or Medians with Curb Cut.** A pedestrian refuge island or median with a refuge area reduces the crossing distance required of a pedestrian and provides an area that safely separates pedestrians from vehicles while waiting to cross the remaining portion of a multi-lane roadway. It helps protect pedestrians crossing the road. Extending existing medians and providing cut-throughs for divided roadways should be considered where appropriate. This countermeasure should be installed with a marked crosswalk. Pedestrian crashes are estimated to be reduced by 56% [47].
8. **Lighting of Crosswalks at the Intersection.** Lighting can reduce injuries in nighttime pedestrian-involved crashes at intersections by up to 42% and in nighttime crashes on rural and urban highways by up to 28% [43]. This should be added where pedestrian activity is anticipated, including where PHBs would be installed.
9. **Advance Pedestrian Warning Signs.** These signs provide additional communication to motorists where pedestrian crossing activity is anticipated.

Based on the number of crashes from Tables 20 and 21 from Task 3, several proven safety countermeasures are suggested, as shown in Figure 14. For every peer group cell, a minimum of high visibility crosswalks, PHB, and street lighting are suggested. This should always be considered during planning, but it is not mandatory. In Figure 14, for example, all countermeasures are suggested for a cell in peer group Z3M having traffic volume less than 10,000-20,000 at a speed limit of 45 mph. This is because this peer group cell contains a relatively high number of pedestrian crashes compared to the other group cells. Similar to countermeasures mentioned for midblock segments and signalized intersections, these countermeasures should be implemented based on location condition and availability of resources, which should be supported by analysis and competent judgment from transportation authorities and engineers. The efficiency of countermeasures should also be monitored and evaluated once they have been implemented. If the peer group falls under Priority 1 and 2, then countermeasure 2 (advanced stop bars or signs) is also suggested. Also, some of the countermeasures are suggested only if they meet the criteria. For example, countermeasure 6 (median) is recommended only for 4 or more lanes and undivided legs. Also, countermeasure 4 (curb extension) is not recommended if the traffic volume (ADT) is less than 10,000, per

NCHRP research report. Countermeasure 3 (LPI) is suggested for peer groups with ADT 10,000-25,000 and speed limits less than or equal to 45 mph.

Note: An expanded and enhanced countermeasure matrix for unsignalized intersection is available in Appendix D, categorized according to ADT groups.

Figure 14. Suggested Countermeasures for Unsignalized Intersections

ADT Range (vpd)	≤10000				>10000- ≤20000				>20000- ≤30000				>30000			
Speed Range (mph)	40	45	50	55+	40	45	50	55+	40	45	50	55+	40	45	50	55+
Undivided Legs																
Rural 3-legged Stop Control(R3M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Rural 4-legged Stop Control (R4M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Urban 3-legged Stop Control (U3M)	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 2-legged Stop Control (Z2M)	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 4 5 6 7 8 9	1 2 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Roundabout (Z4R)	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9
Divided Legs																
Rural 3-legged Stop Control(R3M)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Rural 4-legged Stop Control (R4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urban 3-legged Stop Control (U3M)	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9

Note: No Priority group 3 peer group for this matrix

Statewide Priority 1 Statewide Priority 2 Statewide Priority 3

A. Land Use: Urbanized = population 50,000 and above, Urban = population between 2,500 and 49,999, and Rural = population less than 2,500.

B. # A shaded number denotes a countermeasure that should be always considered during planning but is not mandatory. The selection of a certain countermeasure should be documented by an engineering analysis or the use of engineering judgment.

C. # An outlined unshaded number signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.

D. # An unshaded number indicates a countermeasure that may be considered for that particular peer group, along with its speed and ADT ranges.

E. In a peer group cell, the lack of countermeasures number denotes a category with a low crash history related to the characteristics (i.e., ADT, speed). Based on engineering judgment, a higher-level countermeasure may be considered for low crash cells.

1. High-Visibility Crosswalks with ADA ramps with Pedestrian Crossing Signs in Advance /at the Crosswalk, Parking Restrictions at Crosswalk Approach
2. Advanced Stop Bars and Signs
3. Sidewalks/Walkways
4. Pedestrian Hybrid Beacon (PHB)
5. Curb Extensions
6. Reduced Curb Radii
7. Pedestrian Refuge Islands or Medians with Curb Cut
8. Lighting of Crosswalks at the Intersection
9. Advance Pedestrian Warning Signs

Task 6: Examine Conflicts with Existing DOTD Policies and/or Guidance

The efforts of Tasks 1 through 5 resulted in a series of matrices, recommended design features, and countermeasures that can assist in providing for the safe movement of pedestrians on high-speed arterials. The objective of Task 6 was to identify where potential conflicts or gaps may exist with current DOTD policies and/or guidance documents, as well as with the Louisiana Revised Statutes (RS). Because work zones and temporary traffic control are not part of this research, documents related to pedestrian accommodations in work zones and temporary traffic control were not reviewed. Each location and project is unique, and consideration of pedestrians and the appropriate treatments to address their safe movement are dependent on the current available pedestrian accommodations, type of project, and construction operations and staging as a minimum. The MUTCD 2009 Edition Part 6 discusses pedestrian considerations in work zones and temporary traffic control.

In 2011, DOTD adopted the MUTCD 2009 Edition and uses it as the basis for its policies for traffic control devices installed on any public roadway. With the objective of Task 6 in view, the research team identified and examined several DOTD sources regarding the safe movement of pedestrians. These include:

1. **Engineering Directives and Standards Manual (EDSM)**

The EDSM is comprised of six individual volumes and consolidates all DOTD directives containing policies, procedures, standards, and guides which impact the engineering functions of the agency and its administration of the highway program. The EDSMs related to aspects involving safe movement of pedestrians include the following:

- EDSM II.2.1.9 Lighting of Roadway & Structures and Decorative Lighting of State Bridges, March 29, 2019. This policy establishes uniform procedures for constructing and maintaining new roadway lighting systems on state right-of-way. It indicates that roadway lighting shall be in accordance with "A Guide to Constructing, Operating, and Maintaining Highway Lighting Systems."
- EDSM II.2.1.14 Complete Streets, April 19, 2016. This directive's purpose is to establish policy for implementing the Complete Streets Policy in compliance with Louisiana state laws, referred to as Revised Statutes (RS). The referenced statutes are RS 32:1, RS 48:22.1, and RS 48:163.1. Definitions are included in this EDSM. Per this policy, DOTD will strive to accommodate pedestrians, bicyclists, and transit users by providing

appropriate safe crossings. DOTD updated its Minimum Design Guidelines to complement this EDSM. Preservation, rehabilitation, and replacement projects will only consider improvements that do not require the acquisition of right-of-way, relocation of utilities, or major construction to provide accommodations for pedestrians, bicyclists, or transit users. Improvements may include narrowing lanes or reconfiguring the roadway and restriping. It does indicate that the EDSM may not apply to minor projects, including those involving intersection improvements and turn lane projects, if pedestrian facilities do not exist. Priority is given to connecting pedestrian generators. The maintenance and liability for sidewalk facilities outside of the curb or barrier are the responsibility of the local jurisdiction, and if an agreement is not put into place, they will be excluded from a project. Specific to implementation, if a local entity has a Complete Streets plan, DOTD will determine if it is feasible to include facilities in the project. It also includes the process if a plan does not exist, or if the local entity chooses not to include facilities. This directive provides minimum consideration for when a 4-foot paved shoulder should be considered. These include available funding, roadway characteristics, and meeting the conditions of the policy. The directive allows for a waiver to be requested.

- EDSM IV.2.1.4 Median Openings on Divided Multi-Lane Roadways, June 2, 2014. This directive establishes policy for the planning, design, maintenance, permitting, and operation of medians and median openings on multi-lane roadways. All multi-lane roadways shall be designed with a median (raised or depressed area) that separates opposing directions of traffic.
- EDSM VI.1.1.2 Intersection Control Evaluation (ICE) Requirements, December 2, 2020. This directive requires an intersection control evaluation for projects involving a change in capacity, geometrics, traffic control or access. It does not apply to projects related to speed studies, signing studies, and signal timing studies, including those involving phase changes and upgrades.
- EDSM VI.3.1.2 Flashing Beacons and LED Flashing Signs, October 5, 2016. This directive supplements the MUTCD and establishes DOTD's policy for flashing beacons and LED flashing lights. It speaks to intersection control beacons, warning sign beacons, and stop beacons.
- EDSM VI.4.1.1 Pavement Markings, April 17, 2008. This directive supplements the MUTCD and establishes DOTD policy for permanent pavement markings. It also supplements DOTD's Standard Plan PM-01.

- EDSM VI.4.1.2 Marking No Passing Zone for Special Situations, April 17, 2008. This directive supplements the MUTCD and establishes a policy for marking no passing zones (NPZ) on state highways in situations not addressed in the MUTCD. The policy includes intersection approaches controlled by stop signs, yield signs, traffic signals, and flashing beacons.

2. Roadway Design Procedures and Details Manual, March 2009

The Roadway Design Procedures and Details Manual was issued in 2009 and includes updates to various chapters (e.g., Chapter 4 and 8) as recently as 2022. The manual provides guidance on the acceptable DOTD policies and procedures for roadway design to ensure consistency. It is applicable to state and local roadways.

- Chapter 5 of the manual discusses the policy requirements for cross section elements. It references DOTD's Minimum Design Guidelines (March 6, 2017) as well as requirements for sidewalks. The Minimum Design Guidelines were updated to complement the Complete Streets Policy and EDSM. It includes a section identified as Complete Streets Design Guide, which defines minimum acceptable facilities as well as preferred accommodations for pedestrians and bicyclists in urban and rural areas. The EDSM II.2.1.14 must be followed. Design speeds for urban arterials range from 30 mph to 60 mph, and from 45 mph to 65 mph for rural arterials.

  The Guide defines the preferred lane width for arterials as 12 feet in urban and rural areas. For urban areas, an acceptable width for through lanes on arterials is 11 feet when the design speed is 35 mph and greater and truck traffic is greater than 10%. An acceptable width for through lanes for arterials in rural areas is based on ADT and design speed, and ranges from 11 to 12 feet. For example, the acceptable lane width is 12 feet for a rural arterial roadway with an ADT greater than 2,000. Preferred and acceptable shoulder widths for urban and rural arterials are defined. For arterials in urban areas, the shoulder width is based on the presence of a curb. The acceptable width of shoulders for rural arterials is based on ADT and the number of lanes. There is not a preferred width for rural arterials. The preferred width for urban arterials is 1 foot (inside) and 4 feet (outside) if the roadway has a curb. If there is not any curb, then the preferred width is similar to the acceptable widths for rural arterials, which ranges from 4 feet to 8 feet based on the number of lanes and ADT. The acceptable range for shoulders on urban arterials is 1 foot if there is a curb and 2 feet if there is no curb.

The Complete Streets Design Guide indicates that a 5-foot sidewalk (urban and rural) and a 4-foot minimum shoulder width would meet the required Complete Streets accommodations. As referenced in item 6 in Section 6 (Implementation) of the EDSM II.2.1.14, the minimum 4-foot shoulder accommodation is considered only when a local entity does not have a Complete Streets plan in place or chooses to not make a recommendation regarding the need for Complete Streets facilities. Planning and coordination are essential to implementation. Sidewalks have a typical offset minimum of 2 feet from the back of a curb in urban areas; however, if the sidewalk is adjacent to the back of the curb, the sidewalk width would be increased to 7 feet. For rural areas, the acceptable offset of the sidewalk from the travel lane is defined as 8 feet. A roadway with an ADT less than 1,000 would require no special accommodations, and pedestrians and bicyclists can utilize the same travel lane as a vehicle.

- Chapter 6 discusses policy for at-grade intersections, including roundabouts. It includes intersection geometrics, signalization, and median openings. Except for the section on roundabouts, the chapter is silent on accommodations and the safe movement of pedestrians.

3. **<u>Traffic Engineering Manual, Revised April 2015.</u>**

The Traffic Engineering Manual (TEM) supplements the MUTCD through policies and guidance for the study and installation of traffic control devices. It does not provide any policy specific to pedestrian warning signs. Section 3B.2 of the TEM provides criteria for the installation of marked crosswalks at an uncontrolled approach at an intersection (3B.2.6), mid-block (3B.2.7), or a controlled approach at an intersection (3B.2.8), as well as a school zone (3B.2.5 and 7A.2). It includes information related to the approval, implementation, design, and maintenance, as well as pedestrian signs. 3B.2.1 references MUTCD Section 3B.18 Crosswalk Markings. Section 3B.2.2 describes the different types of marked crosswalks, and 3B.2.3 provides definitions for various terms associated with marked crosswalks. Section 3B.2.4 provides requirements for all crosswalks. Section 3B.2.9 discusses the requirement of a traffic engineering study and what may be included in the study, dependent on the location under review. Section 3B.3 of the TEM addresses policy for No Passing Zones, which includes any approaches controlled by a traffic signal or flashing beacon. Section 7A.2 addresses the policy for school zones.

4. **<u>Traffic Signal Manual, Version 3.0, July 1, 2020.</u>**

The Traffic Signal Manual provides policies, procedures, and guidance in the design and implementation of traffic signals. This manual, similar to the Traffic Engineering Manual, references the MUTCD.

5. **Sign Manual, September 1, 2020.**

This manual provides guidance beyond MUTCD, AASHTO Greenbook, and Louisiana EDSM, establishing policy on guide sign placement and design. It does not reference pedestrian signing.

6. **Standard Plans**

The Standard Plans provide further direction regarding policy and the application of various elements of a roadway. Items that are relevant to pedestrians moving safely across the road include Standards PED-01 Pedestrian Facilities (07-21-2022) and PM-08 Pedestrian/Bike Striping Layout (02-28-2019). There are not any special details relevant to pedestrians.

7. **Local Public Agency (LPA) Manual and Technical Memorandum No 1, Striped Crosswalks on Local Public Assistance Program Projects, January 12, 2016.**

The LPA Manual provides policy and guidance to LPAs for the planning, design, and construction of roadway projects. The technical memorandum is applicable to all projects with the design phase and establishes policy for the placement of crosswalks on state and local routes. It refers to the state statute, MUTCD, and the DOTD TEM Sections 3B.2.6, 3B.2.7, and 7A.2.3 for local roads, and 3B.2.1, 3B.2.4-8, 3B2.9, and 7A.2.3 for state routes. It requires documented justification regarding the need for a marked crosswalk at intersections on local routes, as well as the placement of the marked crosswalk, to meet MUTCD. For midblock crossings on local routes, an engineering study should be performed before a marked crosswalk is installed. For state routes, both the approval of the District Traffic Operations Engineer and an engineering study for the placement of new and existing crosswalks are required. Intersections of state routes and local roads are treated as state routes.

8. **Complete Streets Policy, April 19, 2016.**

The purpose of this policy is to create a comprehensive, integrated, and connected transportation system that balances access, mobility, and safety for all users. Through its leadership and implementation of this policy, DOTD will provide appropriate safe crossings and corridor continuity for pedestrians and bicyclists. It will not restrict access to pedestrians and bicyclists and will make reasonable attempts to mitigate negative impacts to these users.

9. **<u>A Guide to Constructing, Operating, and Maintaining Highway Lighting Systems, January 30, 2017.</u>**

This document establishes procedures to ensure the uniform construction and maintenance of new roadway lighting systems on state right-of-way. This is referenced in EDSM II.2.1.9 Lighting of Roadway & Structures and Decorative Lighting of State Bridges, March 29, 2019.

Louisiana Revised Statutes (RS) Title 32 includes laws related to motor vehicles and traffic regulations. Subpart H, Pedestrians' Rights and Duties, of Title 32 addresses pedestrians walking along and crossing the roadway. The laws relevant to pedestrians on high-speed arterials include the following:

1. RS 32:1, Definitions.
   (19)"Crosswalk":
   a. According to the state statute, a crosswalk is that part of a roadway at an intersection which represents the connection of the lateral lines of the sidewalks and/or shoulders from one side of the roadway to the opposite side, as measured from the curbs or edges of the roadway. If a sidewalk or shoulder is not present, then a crosswalk is the portion of the roadway at an intersection that would be included within the prolongation of the lateral lines of the sidewalk and/or shoulder on the opposite side of the street if there were a sidewalk or shoulder.
   b. The statute further defines a crosswalk as "any portion of a roadway at an intersection or elsewhere distinctly indicated for pedestrian crossing by lines or other markings on the surface."
2. RS 32:63, Establishing of speed zones.

   This state statute gives DOTD the authority to establish a reasonable and safe speed limit that is lower than the maximum speed set by statute based on an engineering and traffic investigation. This is pertinent in that it would allow DOTD, if justified, to reduce the speed limit on specific high-speed arterials to address pedestrian safety.
3. RS 32:211, Pedestrians subject to traffic regulations.

   "Pedestrians shall be subject to traffic-control signals at intersections as provided in R.S. 32:233 unless otherwise required by local ordinance, but at all other places pedestrians shall be accorded the privileges and shall be subject to the restrictions stated in this part" (Subpart H).

4. RS 32:212, Pedestrian right-of-way in crosswalks.

   "A. When traffic control devices are not in place or are not in operation, the driver of a vehicle shall stop and yield the right-of-way to a pedestrian crossing the roadway within a crosswalk when the pedestrian is upon the roadway upon which the vehicle is traveling or the roadway onto which the vehicle is turning. B. No pedestrian shall suddenly leave a curb or other place of safety and walk or run into the path of a vehicle which is so close that it is impossible for the driver to yield. C. Whenever any vehicle is stopped at a marked crosswalk or at any unmarked crosswalk at an intersection to permit a pedestrian to cross the roadway, the driver of any other vehicle approaching from the rear shall not overtake and pass such stopped vehicle."

5. RS 32:213, Crossing at other than crosswalks.

   "A. Every pedestrian crossing a roadway at any point other than within a marked crosswalk or within an unmarked crosswalk at an intersection shall yield the right-of-way to all vehicles upon the roadway. B. Between adjacent intersections at which traffic control signals are in operation pedestrians shall not cross at any place except in a marked crosswalk."

6. RS32:214, Drivers to exercise due care.

   "Notwithstanding the foregoing provisions of this part, every driver of a vehicle shall exercise due care to avoid colliding with any pedestrian upon any roadway and shall give warning by sounding the horn when necessary and shall exercise proper precaution upon observing any child or any confused or incapacitated person upon a highway."

7. RS 32:216, Pedestrians on highways or interstate highways.

   "A. Where sidewalks are provided, it shall be unlawful for any pedestrian to walk along and upon an adjacent highway. B. Where sidewalks are not provided, any pedestrian walking along and upon a highway shall, when practicable, walk only on the left side of the highway or its shoulder, facing traffic which may approach from the opposite direction."

8. RS 32:232, Traffic-control signals.

   "(1) (c) Unless otherwise directed by a pedestrian control signal as provided in R.S. 32:233, pedestrians facing any green signal, except when the sole green signal is a turn arrow, may proceed across the roadway within any marked or unmarked crosswalk." For a yellow indication, "(2) (b) Unless otherwise directed by a pedestrian control signal as provided in R.S. 32:233 a pedestrian facing a steady yellow signal is thereby advised that there is insufficient time to cross the roadway before a red signal is exhibited and no pedestrian shall then start to cross the roadway." In the situation when there is a flashing yellow condition, the vehicular traffic shall yield the right of way to a pedestrian that is lawfully in the crosswalk (Section 4). For a steady red indication, "(2) (d) Unless otherwise directed by a pedestrian-control signal as provided in R.S. 32:233, a pedestrian facing a steady circular red or red arrow signal shall not enter the roadway."

9. RS 32:233, Pedestrian-control signals.
   Whenever special pedestrian-control signals are exhibiting a Flashing or Steady WALK message, a pedestrian facing the signal may proceed across the roadway in the direction of the signal and shall be given the right-of-way by a driver of a vehicle. If facing the signal and seeing a Flashing or Steady DON'T WALK message, the pedestrian shall not start to cross the roadway in the direction of the signal, but a pedestrian who has partially completed his crossing on the "Walk" signal shall proceed to a sidewalk or safety island while the "Don't Walk" signal is showing.

Notable within these laws is that the pedestrian has the right of way at an intersection, regardless of the crosswalk being marked or unmarked. According to MUTCD Section 3B.18, crosswalk markings at midblock or "non-intersection" locations legally establish the crosswalk. Louisiana state law supports this and requires the pedestrian to stop and yield to the vehicle if crossing in a midblock area and there is not a marked crosswalk.

Based on the review of the policy and guidance documents and Louisiana state laws, the research team identified potential conflicts or gaps that may exist relative to the recommended design features and countermeasures for midblock crossings and signalized and unsignalized intersections on high-speed arterials in rural, urban, and urbanized areas. The following lists the policy, standards, and/or guidance documents, the potential conflict or gap, and the reason supporting this identification. The EDSM documents did not have any conflicts, as they primarily referred to the primary policy manual or guidance document. The primary conflict was related to the prohibition of the marking of pedestrian crosswalks for roads with posted speed limits over 40 mph. While engineering judgment is allowed in some cases, it appears this could be used to prohibit the installation of crosswalks. Gaps primarily related to the need for more detailed guidance related to the application of treatments such as LPI, pedestrian hybrid beacons (PHB), and design criteria, such as when narrowing of lanes or reduced curb radii should be applied.

An overview of the conflicts and gaps in pedestrian safety policy manuals is shown in Appendix E.

Task 7: Develop Statewide Guidelines on the Provision of Pedestrian Facilities on Louisiana's High-Speed Arterials

In this task, the research team developed a stand-alone document, titled "Guidance for Pedestrian Safety Enhancements on High-Speed Arterials," that can be used by state and local officials as the primary guideline for improving pedestrian safety on high-speed arterials. The outline of this state guideline is provided in Appendix F. The outline was initially presented to the PRC, and their feedback was considered before finalizing the guidelines.

Topics covered in this statewide guideline include:

- General issues and relationships of pedestrian safety to other factors (e.g., area, land use, location type, traffic volume, vehicle speed, time of occurrence, multimodal connections, and crossings)
- Pedestrian Safety Statewide Priorities on High-Speed Arterials
- Pedestrian Safety Countermeasures
- Site Assessment for Countermeasure Implementation
- Midblock Crossing Safety Countermeasure Implementation Criteria
- Unsignalized Intersection Pedestrian Safety Countermeasure Implementation Criteria
- Signalized Intersection Safety Countermeasure Implementation Criteria

Conclusions

The primary objective of the study was to develop statewide guidelines for improving pedestrian safety on high-speed arterials in Louisiana. In fulfilling this objective, the study aimed to recommend appropriate pedestrian facilities or countermeasures for various roadway characteristics and proposed modifications, as necessary, to DOTD's Complete Streets policy and relevant Engineering Directives and Standards Manuals (EDSMs). Various approaches were employed in the study, including categorizing the roadway network, identifying crossing design features, documenting the states-of-practice through a survey of state DOT professionals across the nation, developing matrices of design features for safe movement, examining conflicts with DOTD policies, and creating statewide guidelines for pedestrian facilities on high-speed arterials.

First, the research team reviewed relevant literature regarding pedestrian safety on high-speed arterials. This review found that states are mandated to conduct a data-driven VRU safety assessment every five years. The reviewed studies revealed different critical factors influencing pedestrian safety, such as vehicle and driver factors, pedestrian factors, and physical infrastructure factors. It also included reviewing various research studies and guidelines for categorizing roadway networks and identifying pedestrian crossing design features. The reviewed studies also highlighted diverse strategies and guidelines aimed at enhancing pedestrian safety.

Furthermore, the roadway network of high-speed arterials in Louisiana was categorized, and crossing design features were identified. Louisiana's roadway network was categorized based on average annual daily traffic (AADT), functional classification, land use, number of lanes, medians, and speed limits. Additionally, segments with high pedestrian-related risk factors were identified through a five-year analysis of crash data from 2017-2021.

Crash data analysis revealed that a total of 1,307 pedestrian-involved crashes involved 1,361 pedestrians. Among these, 63.4% occurred at intersections, with the highest proportion at "Stop/Yield Sign" control intersections (57.3%). Road segments accounted for 36.6% of crashes, with roads lacking shoulders and sidewalks having the highest proportion of incidents (39.8%). Urbanized locations with an AADT between 10,000 and 20,000 had the most crashes (336). The majority (45%) of crashes occurred at a posted speed limit of 45 mph, and 24.33% happened at nighttime with no street lights. Notably, 47.8% of crashes occurred while pedestrians were crossing the road, and 17% occurred while they were walking along the road.

Crashes were then categorized by peer groups, which revealed that, for intersections, Urbanized 4-legged Signalized Intersection (Z4S) had the most crashes, with 35.6% of total intersection crashes. For unsignalized intersections, Urbanized 3-legged Stop Control (Z3M) had the highest number of crashes. Among road segments, the Urbanized 2-lane Undivided (Z2U) category had the most crashes, with 25.5% of total segment crashes.

Furthermore, the research team conducted an online survey among professionals from state and local transportation agencies across the nation. The findings revealed that:

- 81% of states have laws or guidance to address and design pedestrian facilities on high-speed arterials.
- 98% of states use the MUTCD, including its State Supplement, as the basis for their agency's policies or practices for designing pedestrian facilities. This is followed by the AASHTO guide, used by 81% of states, and FHWA's Pedestrian Facilities User Guide, used by 52% of states.
- Marked crosswalks at high-speed arterial intersections: for 33% of states, it is a common practice; for 8%, it is mandatory; and for 27%, it is important to consider the specific context of the facility and relying on engineering expertise. Additionally, 12% of states have criteria prohibiting at-grade crosswalks on roads with posted speed limits over 40 mph.
- Determining pedestrian facility necessity: 96% of states prioritize pedestrian activity at midblock segments; 88% consider traffic volume; and 85% examine crash history. For intersections, 90% of states prioritize pedestrian activity, followed by traffic volume, geometry, and crash history.
- Pedestrian safety analysis methods: 65% of states use systemic safety analysis; 42% use HIN analysis; and 40% use predictive safety analysis for midblock segments. For intersections, 60% use systemic safety analysis; 38% use HIN analysis; 33% use predictive safety analysis; and 46% use alternative techniques.
- Key contributors to pedestrian crashes include driving errors, pedestrian errors, and insufficient street lighting in the majority of states.
- Pedestrian volume is a crucial factor for pedestrian facility necessity, along with considerations such traffic volume, crash history, and roadway geometry.
- Countermeasures on high-speed arterials include sidewalks, shoulders, medians, pedestrian refuge islands, high visibility crosswalks, road diets, and context-specific measures such as lighting, countdown signals, and RRFB.

- Despite countermeasures, conflicts with guidelines exist, posing challenges such as prioritizing pedestrian safety, access limitations, posted speed concerns, and legislative restrictions.

Additionally, a matrix of design features or countermeasures for safe movement along and across roadways was provided. The suggested design features and countermeasures included pedestrian safety enhancements for signalized and unsignalized intersections and midblock crossings based on AADT, speed limit, arterial type, and approach legs type. The countermeasures are thorough and were suggested based on priorities. They include: high visibility crosswalks, ADA ramps, pedestrian crossing signs, parking restrictions, signal timing adjustments, leading pedestrian intervals (LPI), pedestrian pushbuttons (PPB), curb extensions, reduced curb radii, medians with curb cut, and more.

Furthermore, the research team, after reviewing policy documents and Louisiana state laws, identified potential conflicts and gaps regarding recommended design features for midblock crossings and signalized and unsignalized intersections on high-speed arterials in rural, urban, and urbanized areas. EDSM documents showed no conflicts but referred only to the primary policy manual. A notable conflict involved the prohibition of marking pedestrian crosswalks on roads with posted speed limits over 40 mph, potentially limiting crosswalk installation. Further investigation determined that marked crosswalks could be installed on the high-speed arterials, but additional traffic control treatments such as a PHB would be required. Gaps were observed in the need for more detailed guidance on treatments like LPI, PHB, and criteria for applying measures such as lane narrowing or reduced curb radii.

In conclusion, this study developed a standalone statewide guideline for improving pedestrian safety on Louisiana's high-speed arterials. This comprehensive guidance, featuring matrices and visuals, will aid state and local officials in selecting design features and countermeasures to enhance the overall safety of pedestrians. While this study helps narrow potential countermeasures based on roadway characteristics and crash data, it is essential to recognize that each location presents unique circumstances. Therefore, a comprehensive engineering study and analysis will still be required to accurately pinpoint the most appropriate countermeasures for that location.

Recommendations

Based on the results of this research, it is recommended to focus on locations and corridors that meet the criteria of the statewide priorities when implementing countermeasures to improve pedestrian safety on high-speed arterials. It is also recommended to create a comprehensive database that includes an inventory of high-speed arterials and roadway features (e.g., shoulders/sidewalks, lighting, etc.). This would assist future studies in better identifying roadway segments and intersection types that are overrepresented for pedestrian-involved crashes, as well as select and prioritize effective countermeasures for improving pedestrian safety.

Additionally, based on the findings of all of project's tasks, the research team recommends future studies to:

- Evaluate the effectiveness of countermeasures after implementation
- Conduct longitudinal studies to assess the long-term impact of pedestrian safety measures

Future studies are recommended to continue evaluating the impact of different factors in Louisiana on pedestrian safety once missing information becomes available. Many variables have category 'unknown' in crash data. These include items such as types of driver violation, condition of driver, pedestrian actions, alcohol/drug involvement of both driver and pedestrians, vehicle movement before crash, and reason for movement. The inclusion of this information will further validate the results of this research.

Acronyms, Abbreviations, and Symbols

Term	Description
AADT	Annual Average Daily Traffic
AASHTO	American Association of State Highway and Transportation Officials
ADA	Americans with Disabilities Act
APS	Accessible Pedestrian Signal
DOT	Department of Transportation
DOTD	Louisiana Department of Transportation and Development
EDSM	Engineering Directives and Standards Manual
FCS	Functional Classification System
FHWA	Federal Highway Administration
GIS	Geographic Information System
HAWK	High-Intensity Activated Crosswalk
HCM	Highway Capacity Manual
HIN	High Injury Network
LPI	Leading Pedestrian Intervals
LTRC	Louisiana Transportation Research Center
mph	miles per hour
MUTCD	Manual on Uniform Traffic Control Devices
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
PHB	Pedestrian Hybrid Beacon
PPB	Pedestrian Push Button
PRC	Project Review Committee
RRFB	Rectangular Rapid Flashing Beacon
SSA	Safe System Approach
STEP	Safe Transportation for Every Pedestrian
TEM	Traffic Engineering Manual
TMC	Traffic Messaging Channel
USCB	United States Census Bureau
vpd	vehicles per day
VRU	Vulnerable Road User
ZIP	Zone Improvement Plan

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Appendix

Appendix A: IRB approval

LSU | Office of Research & Economic Development

TO:	Hany Hassan LSUAM | Col of ENGR | Civil and Environmental Engineering | CC00173
FROM:	Alex Cohen Chairman, Institutional Review Board
DATE:	15-Jun-2023
RE:	IRBAM-23-0708
TITLE:	Improving Pedestrian Safety on High-Speed Arterials
SUBMISSION TYPE:	Initial Application
Review Type:	Exempt
Risk Factor:	Minimal
Review Date:	15-Jun-2023
Status:	Approved
Approval Date:	15-Jun-2023
Approval Expiration Date:	14-Jun-2026
Exempt Category:	2b
Requesting Waiver of Informed Consent:	Yes
Re-review frequency:	Three Years
Number of subjects approved:	100
LSU Proposal Number:	AM221359
By:	Alex Cohen, Chairman

Continuing approval is CONDITIONAL on:

1. Adherence to the approved protocol, familiarity with, and adherence to the ethical standards of the Belmont Report, and LSU's Assurance of Compliance with DHHS regulations for the protection of human subjects*
2. Prior approval of a change in protocol, including revision of the consent documents or an increase in the number of subjects over that approved.
3. Obtaining renewed approval (or submittal of a termination report), prior to the approval expiration date, upon request by the IRB office (irrespective of when the project actually begins); notification of project termination.
4. Retention of documentation of informed consent and study records for at least 3 years after the study ends.
5. Continuing attention to the physical and psychological well-being and informed consent of the individual participants, including notification of new information that might affect consent.
6. A prompt report to the IRB of any adverse event affecting a participant potentially arising from the study.
7. Notification of the IRB of a serious compliance failure.
8. **SPECIAL NOTE: When emailing more than one recipient, make sure you use bcc. Approvals will automatically be closed by the IRB on the expiration date unless the PI requests a continuation.**

** All investigators and support staff have access to copies of the Belmont Report, LSU's Assurance with DHHS, DHHS (45 CFR 46) and FDA regulations governing use of human subjects, and other relevant documents in print in this office or on our World Wide Web site at http://www.lsu.edu/research*

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Appendix B: Survey Questionnaire Form

The following are the questions used for the survey. This section provides a comprehensive reference for the survey instrument employed in the study.

Survey on Improving Pedestrian Safety on High-Speed Arterials

You are invited to participate in a survey that aims mainly to improve pedestrian safety on high-speed arterials (roads with posted speed limits of 40 mph and greater). This survey has been developed by the researchers at Louisiana State University, USA, and is part of a Louisiana Transportation Research Center (LTRC) research project (LTRC Project 22-3SA) funded by Louisiana Department of Transportation and Development (DOTD).

The primary objectives of this survey are to:

- Investigate the current policies and guidelines for pedestrian safety at high-speed arterials;
- Assess the effectiveness of the adopted pedestrian crossing treatments applied by different states;
- Identify best practices related to successful implementation of design features and pedestrian safety strategies; and
- Recognize any cost-effective countermeasures adopted to improve pedestrian safety at high-speed arterials.

Inclusion Criteria

To participate in this study, you **MUST** meet the following two requirements:

- Currently work at a state or local transportation agency in the United States, or other US transportation authority, such as DOT, NHTSA, or FHWA.
- Have at least three years of experience in the field of roadway design, traffic engineering, or pedestrian safety, and be familiar with your state and/or local pedestrian design and crossing policies.

Questions about the Study

If you have questions or need more information about the study itself, the following members of the research team from Louisiana State University can be contacted.

Name	Role	Faculty	Department	Email address
Anish KC	Graduate Research Assistant	Engineering	Civil and Environmental Engineering	akc3@lsu.edu
Hany Hassan, Ph.D., PE	Principal Investigator	Engineering	Civil and Environmental Engineering	hassan1@lsu.edu

Screening Question

Having read the aforementioned information, I understand that by clicking the "Yes" button below, I agree to take part in this study under the aforementioned terms and conditions.

- Yes, I meet the inclusion criteria listed above and agree to participate in this survey.
- No, I do not meet the inclusion criteria listed above or do not agree to participate in this survey.

Please provide your name ____

Please provide name of agency you work for ______________________________

What Division/Section are you working at? ______________________________

Which city/state department are you working at? __________________________

Please provide your email ____

Please provide your official phone number _____________________________

Section 1: Guidelines and Specifications

1. Does your state/local jurisdiction have laws/statutes/ordinances, policies and/or guidance to address providing and designing pedestrian facilities on high-speed arterials?

— Yes

— No

— If yes, please provide link(s) (if available) to these documents: ________________

2. Which manual/guideline is used as the basis for your agency's policies or practices for designing pedestrian facilities in your state/local jurisdiction? (Select all that apply)

— Guide for the Planning, Design, and Operation of Pedestrian Facilities by American Association of State Highway and Transportation Officials (AASHTO)

— Pedestrian Facilities User Guide by Federal Highway Administration (FHWA)

— Manual on Uniform Traffic Control Devices (including State MUTCD Supplement)

— National Association of City Transportation Officials (NACTO) Urban Street Design Guide

— Other, please specify: ______________________________________

3. Does your agency incorporate pedestrian safety countermeasures (e.g., marked crosswalks, Pedestrian Hybrid Beacon, etc.) into a Complete Streets policy?

— Yes

— No

— If yes, please specify what pedestrian safety countermeasures and provide link to policy: ____

4. Is it mandatory or common practice to provide sidewalks or walkways on high-speed arterials in your state/local jurisdictions?

— Yes, Mandatory.

— Yes, Common Practice.

— No, it is neither mandatory nor common practice.

— Other, please specify: ____

— If yes, please provide more information (e.g., criteria, website): _________________

5. Are there criteria for providing sidewalks or walkways on high-speed arterials in your state/local jurisdictions?

— Yes

— No

— If yes, please specify: ____

—

6. Is it mandatory or common practice to provide marked crosswalks at intersections on high-speed arterials in your state/community?

— Yes, Mandatory.

— Yes, Common Practice.

— No, it is neither mandatory nor common practice.

— Other, please specify: ____

— If yes, please provide more information (e.g., criteria, website): ___________________

7. Are there criteria for providing marked midblock crosswalks on high-speed arterials in your state/local jurisdictions?

— Yes

— No

— Other, please specify: ____

— If yes, please provide more information (e.g., criteria, website): ___________________

8. Does your agency have criteria, guidance, or policies that do not allow marked crosswalks above a particular speed for midblock?

— Yes, please specify that speed (in mph): ____

— No

9. Does your agency have criteria, guidance, or policies that do not allow at grade crosswalks above a particular speed for intersections?

— Yes, please specify that speed (in mph): ______________________________

— No

10. What factors does your agency consider for determining the necessity of pedestrian facilities on high-speed arterials in your state/community? (Select all that apply)

- At midblock/roadway segments:

— Crash rate

— Traffic volume

— Location/Land use

— Pedestrian activity/volume

— Geometry of roadway segment

— Crash History

— Other, please specify: ______________________________

- At intersections:

— Crash rate

— Traffic volume

— Location

— Pedestrian activity/volume

— Presence of traffic signals to accommodate pedestrian crossing

— Geometry of the intersection

— Crash History

— Other, please specify: ______________________________

11. Does your agency have any pedestrian safety improvement programs or initiatives (e.g., systemic approach to pedestrian improvements, pedestrian safety improvements, leading pedestrian interval, etc.)?

— Yes

— No

— Other, please specify: ________________________________

— If yes, please provide more information (e.g., criteria, website): ____________________

Section 2: Safety

- **Roadway segments**

12. Has your agency identified high-speed arterial road segments, including midblock crossings, as an area of focus for pedestrian related traffic safety in your state/local jurisdiction?

— Yes, please elaborate: ________________________________

— No

— Other, please specify: ________________________________

13. What type of analysis does your agency apply to identify and prioritize high-risk locations for pedestrian crashes on high-speed arterial road segments? (Select all that apply)

— High Injury Network (HIN) analysis

— Predictive safety analysis

— Systemic safety analysis

— Other, please specify: ________________________________

14. What are the primary reasons for pedestrian related crashes on high-speed arterial segments in your state/local jurisdiction? (Select all that apply)

— Midblock crossings

— Walking along the road segment

— Lack of pedestrian facilities (e.g., sidewalks, shoulders)

— Need for traffic control devices (signing, crosswalks, PHB, RRFB)

— Lack of street lighting or poor lighting conditions

— Driver errors (e.g., speeding, failure to yield, distraction, driving under the influence of drugs or alcohol)

— Pedestrian errors (e.g., failure to yield, distraction, impairment)

— Other, please specify: ____

15. What countermeasures have been used by your agency for improving pedestrian safety on high-speed arterial segments in your state/local jurisdiction? (Select all that apply)

— Providing pedestrian facilities (e.g., sidewalks, shoulders, etc.)

— Adding high visibility crosswalks

— Reducing posted speed limits

— Curb extensions

— Advanced Stop/Yield bars and signs

— Narrowing width of travel lanes

— Implementing road diets

— Adding Rectangular Rapid Flash Beacon (RRFB)

— Adding Pedestrian Hybrid Beacon (PHB)/HAWK Signal

— Medians or pedestrian refuge islands

— Lighting along corridors or midblock crossing locations

— Other, please specify: ____

16. Is there any conflict with the current guidelines in your state to implement the countermeasures suggested in the previous question to improve pedestrian safety on high-speed arterial segments?

— Yes, please elaborate: ________________________________

— No

— Other, please specify: ________________________________

17. Has your state/local jurisdiction implemented any low-cost countermeasures for improving pedestrian safety on high-speed arterial segments? If yes, have they been implemented systemically?

— Yes, please specify: ________________________________

— No

18. If your agency has used any low-cost countermeasures, how effective were these countermeasures in improving pedestrian safety on high-speed arterial segments?

— They were effective in reducing the pedestrian related crashes.

— They were ineffective in reducing the pedestrian related crashes.

— No evaluation was performed.

— Other, please specify: ________________________________

19. Has your agency evaluated the impacts for implementing pedestrian facilities on high-speed arterial segments in your state/local jurisdiction?

— Yes, please elaborate: ________________________________

— No

— Other, please specify: ________________________________

20. Have you found any individual or package of countermeasures or programs to be most effective at improving pedestrian safety on high-speed arterial segments?

— Yes, please elaborate: ______________________________

— No

— Other, please specify: ______________________________

- **Intersections**

21. Has your agency identified intersections (signalized or unsignalized) on high-speed arterials as an area of focus for pedestrian related traffic safety in your state/local jurisdiction?

— Yes, please elaborate: ______________________________

— No

— Other, please specify: ______________________________

22. What type of analysis does your agency apply to identify and prioritize high-risk locations for pedestrian crashes at intersections on high-speed arterials? (Select all that apply)

— High Injury Network (HIN) analysis

— Predictive safety analysis

— Systemic safety analysis

— Other, please specify: ______________________________

23. What are the primary reasons for pedestrian related traffic crashes at intersections along high-speed arterials in your state/local jurisdiction? (Select all that apply)

- At signalized intersections:

— Lack of pedestrian facilities (e.g., sidewalks)

— Lack of traffic control devices (e.g., crosswalks, signage, pedestrian countdown signals)

— Lack of street lighting or poor lighting conditions

— Driver errors (e.g., speeding, failure to yield, distraction, driving under the influence of drugs or alcohol)

— Pedestrians' errors (e.g., failure to yield, distraction, impairment)

— Other, please specify: ________________________________

- At unsignalized intersections (i.e., roundabouts and stop-controlled intersections):

— Lack of pedestrian facilities (e.g., sidewalks)

— Lack of traffic control devices (e.g., crosswalks, signing, pedestrian countdown signals)

— Lack of street lighting or poor lighting conditions

— Driver errors (e.g., speeding, failure to yield, distraction, driving under the influence of drugs or alcohol)

— Pedestrian errors (e.g., failure to yield, distraction, impairment)

— Other, please specify: ________________________________

24. Has your agency analyzed data to determine what type of intersections (i.e., signalized, unsignalized, roundabouts, etc.) have more pedestrian related crashes? If yes, please identify which type(s) of intersection with more crashes and any trends related to that.

— Yes

— No

— If yes, please identify which type(s) of intersection with more crashes and any trends related to that: ________________________________

— If yes, please state the reason(s): ________________________________

25. What countermeasures have been used for improving pedestrian safety at <u>signalized intersections</u> on high-speed arterials in your state/local jurisdiction? (Select all that apply)

— Providing pedestrian facilities (e.g., sidewalks, raised crosswalk, etc.)

— Reducing posted speed limit

— Narrowing width of travel lanes

— Implementing road diets

— Pedestrian countdown signals

— Passive Pedestrian Detection

— Push Button Pedestrian (PPB) Detection.

— Curb Extensions

— Reduced Curb Radii

— Narrowing width of travel lanes

— Providing medians or pedestrian refuge islands

— Removing slip lanes

— Providing dedicated signal phasing for pedestrians at signalized intersections (i.e., Leading Pedestrian Interval)

— High visibility crosswalks

— Advanced signage

— Other, please specify: ________________________________

26. Is there any conflict with the current guidelines in your state to implement the countermeasures suggested in the previous question to improve pedestrian safety at signalized intersections on high-speed arterials?

— Yes, please elaborate: ________________________________

— No

— Other, please specify: ________________________________

27. What countermeasures have been used for improving pedestrian safety at unsignalized intersections (i.e., roundabouts and stop-controlled intersections) at high-speed arterials in your state/local jurisdiction? (Select all that apply)

— Providing pedestrian facilities (e.g., sidewalks, raised crosswalk, etc.)

— High visibility crosswalks

— Reducing posted speed limit

— Advanced Stop/Yield Bars and Signs

— Curb Extensions

— Reduced Curb Radii

— Narrowing width of travel lanes

— Implementing road diets

— Adding pedestrian activated flashing yellow lights (RRFB)

— Providing medians or pedestrian refuge islands

— Removing slip lanes

— Advanced signage

— Other, please specify: ___________________________________

28. Is there any conflict with the current guidelines in your state to implement the countermeasures suggested in the previous question to improve pedestrian safety at unsignalized intersections (i.e., roundabouts and stop-controlled intersections) at high-speed arterials?

— Yes, please elaborate: ___________________________________

— No

— Other, please specify: ___________________________________

29. Has your state currently used any low-cost countermeasures for improving pedestrian safety at intersections along high-speed arterials? If yes, have they been systemically implemented?

— Yes, please specify: ___________________________________

— No

30. If your state has used any low-cost countermeasures, how effective were these countermeasures in improving pedestrian safety at intersections along high-speed arterials?

— They were effective in reducing the pedestrian related crashes

— They were ineffective in reducing the pedestrian related crashes

— No evaluation was performed

— Other, please specify: ___________________________________

31. Has your agency evaluated the impacts for implementing pedestrian facilities at intersections on high-speed arterial segments in your state/local jurisdiction?

— Yes, please elaborate: ________________________________

— No

— Other, please specify: ________________________________

32. Have you found any individual or package of countermeasures or programs to be most effective at improving pedestrian safety at intersections on high-speed arterials in your state/local jurisdiction?

— Yes, please elaborate: ________________________________

— No

— Other, please specify: ________________________________

Final Thoughts and Comments:

Please use this space to share any additional thoughts or comments you may have regarding the survey topic. Thank you for your participation!

____

____

End of Survey

The research team would like to thank you for your time spent taking this survey.

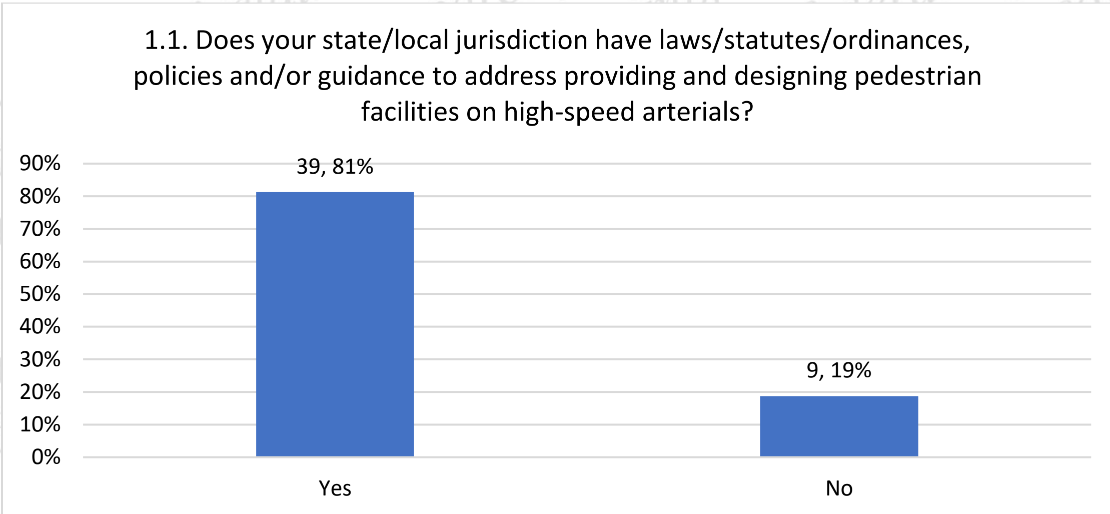
Appendix C: Survey Results

The following section illustrates the remaining survey findings for each question through corresponding figures, visually depicting the presented data.

Some of the manuals, plans, and other documents provided by the respondents who answered "Yes" when asked if the state or local jurisdiction have laws, statutes or ordinances, policies and/or guidance to address providing and designing pedestrian facilities on high-speed arterials (Figure 15) are:

- California Department of Transportation (Caltrans) Pedestrian Safety Countermeasures Toolbox (2019)
- Connecticut DOT's Highway Design Manual (January 2023)
- Connecticut Active Transportation Plan (January 2019)
- Connecticut Comprehensive Pedestrian Safety Strategy (January 2021)
- Connecticut's Pedestrian Safety Countermeasure Guidance at Marked Uncontrolled Crosswalks (2020)
- Florida FDOT Traffic Engineering Manual (Topic No. 750-000-005, 2023)
- Illinois DOT Policy TRA-23
- Louisiana Laws - Pedestrians on highways or interstate highways (RS 32:216, 2011)
- Minnesota Facility Design Guide, Non-Motorized Facilities (December 2021)
- Ohio Multimodal Design Guide (January 2023)
- Tennessee Multimodal Design (May 2023)
- New Jersey DOT Roadway Design Manual (BDC22MR-04, 2015)
- Utah DOT Safe Sidewalks Program (06C-20, 2015)
- Utah DOT Marked Pedestrian Crosswalks (06C-27, 2017)
- Wisconsin Facilities Development Manual (FDM 11-46-1, 2021)
- Wyoming DOT Pedestrian and School Traffic Control Manual (January 2014)

Figure 15. Presence of laws/statutes/ordinances, policies and/or guidance to address providing and designing pedestrian facilities on high-speed arterials.



Subsequently, participating states were asked about the manual or guideline they used as the basis for their agency's policies or practices for designing pedestrian facilities in their state/local jurisdiction as shown in Figure 3. 52% (25) of states stated that they use "Other," which included guidelines such as:

- AASHTO Greenbook
- AASHTO Guide for Transit Facilities
- FHWA Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations
- FHWA Safe Transportation for Every Pedestrian (STEP) Guide
- FHWA Lighting Guidelines for Mid-block Crosswalks
- Public Right-of-Way Accessibility Guidelines (PROWAG)
- Various NCHRP studies including NCHRP Reports 562, 600, 948, and 926

Some of the documents listed included publications produced by the DOT. Examples include:

- Arizona Roadway Design Guides (RDG)
- California Department of Transportation (Caltrans) Pedestrian Safety Countermeasures Toolbox
- Florida Design Manual (FDM)

- Rhode Island DOT's Safe Transportation for Every Pedestrian (STEP) Manual

When participants were asked if their agency incorporated pedestrian safety countermeasures (e.g., marked crosswalks, pedestrian hybrid beacon (PHB), etc.) into the Complete Streets policy, 69% (33) of states reported "Yes", as shown in Figure 16. Several states have provided links to their respective Complete Streets policies, ensuring pedestrian safety is a crucial aspect of transportation planning and design. Those policies or guidelines include:

- Indiana DOT's Complete Streets Program
- Kentucky Transportation Cabinet (KYTC) Complete Streets, Roads, and Highways Manual (August 2022)
- Michigan's Complete Streets legislation (Public Acts 134 and 135, 2010)
- Minnesota Complete Streets Handbook (August 2022)
- Minnesota Complete Streets Policy (February 2023)
- Nevada DOT Complete Streets Policy (June 2017)
- New Jersey DOT Complete Streets Policy (Policy No. 703, 2009)

Figure 16. States incorporating pedestrian safety countermeasures into Complete Streets Policy

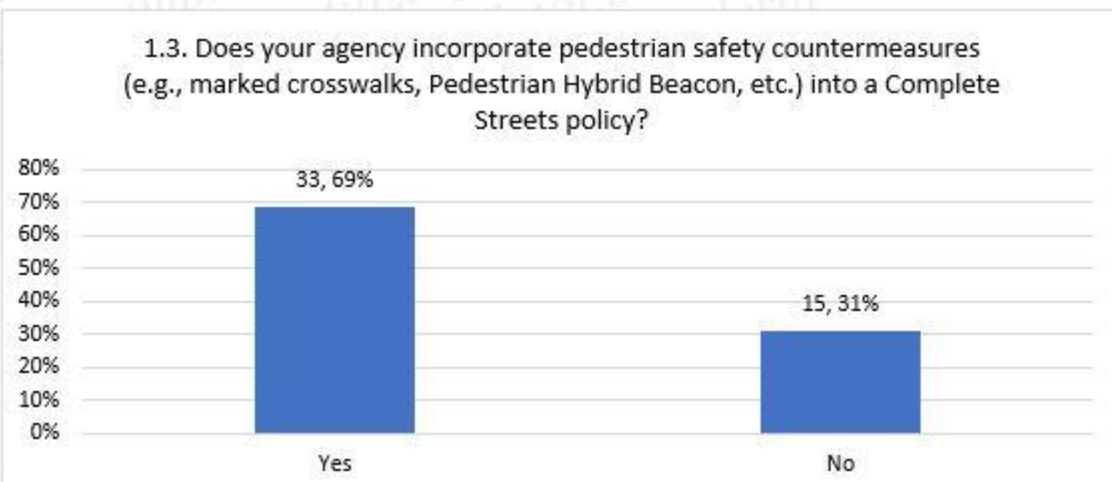
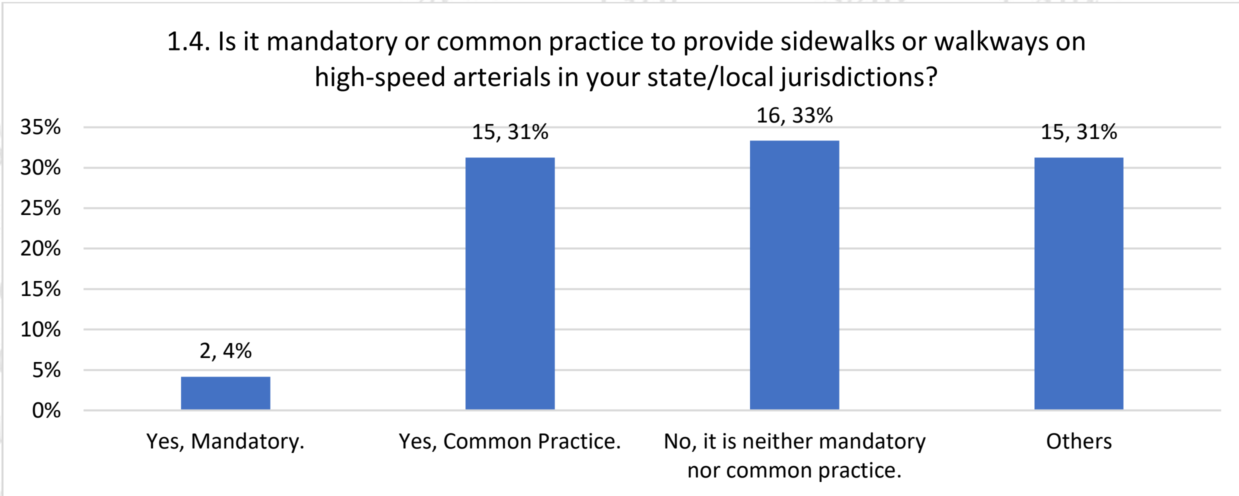


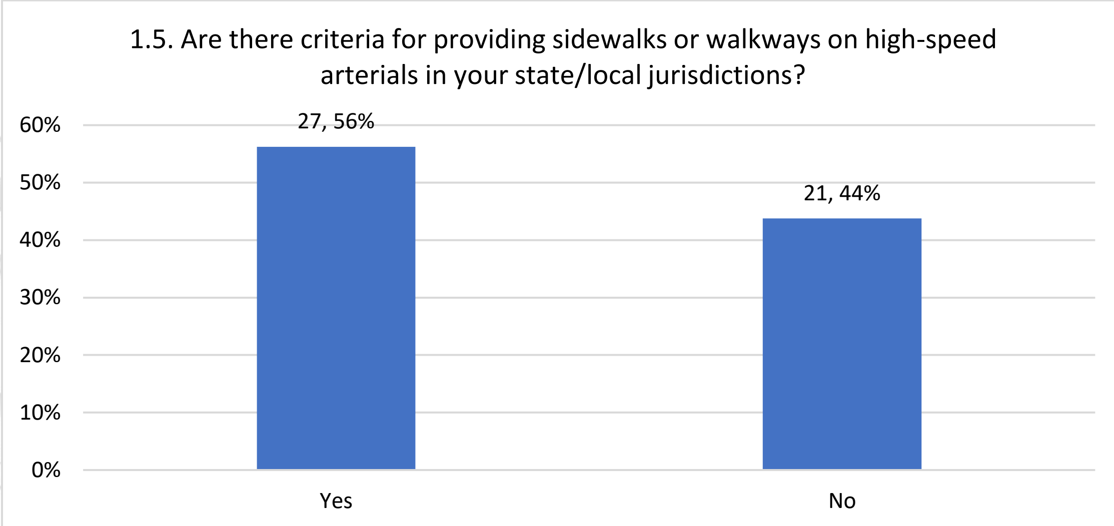
Figure 17. Provision of Sidewalks/Walkways on High-Speed Arterials



Additionally, participants were asked if there are criteria for providing sidewalks or walkways on high-speed arterials in their state or local jurisdictions. 56% (27) of participants indicated that there are such criteria, as shown in Figure 18. It was reported that there are several manuals and reports that provide criteria and guidelines for the construction of sidewalks or walkways on high-speed arterials, including:

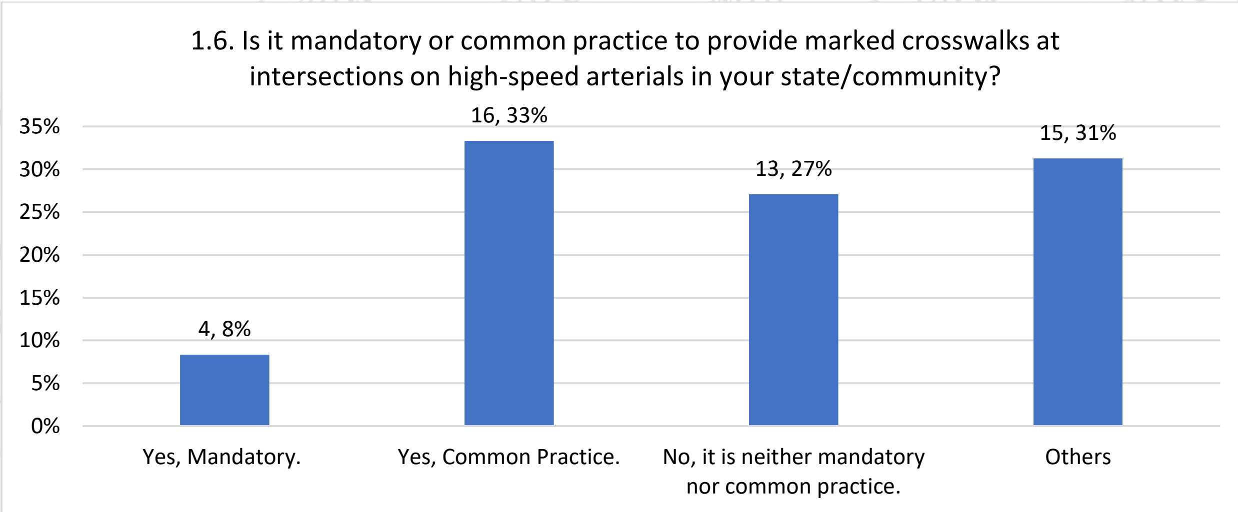
- Alaska DOT and Public Facilities have the Highway Preconstruction Manual, which states that it is common practice in urban areas, but not in rural areas
- Council of the District of Columbia Sidewalk installation requirements (Section 9–425.01, 2023)
- Massachusetts DOT Healthy Transportation Policy Directive (Policy P-13-0001, 2013)
- Minnesota Plan and Design Guide provides criteria to decide if sidewalks should be installed. They rely heavily on adjacent land use. They have this tool to estimate latent demand (https://mndot.maps.arcgis.com/apps/View/index.html?appid=1cc55aa66d3844a98402c84673f73d14)
- New York State DOT Critical Elements for The Design, Layout and Acceptance of Pedestrian Facilities (2021)
- Pennsylvania DOT Design Manual Part 2 Pedestrian chapter
- West Virginia DOT Design Directive (Report 813, 2014)

Figure 18. Criteria for providing sidewalks or walkways on high-speed arterials in state/local jurisdictions



Similarly, states were asked whether it is mandatory or common practice to provide marked crosswalks at intersections on high-speed arterials in their state or community, as shown in Figure 19. The inclusion of a crosswalk at a signalized intersection is a requirement, per the rules outlined in the MUTCD. These requirements are also emphasized in the FHWA Safety Training and Evaluation Process (STEP) handbook. However, it is important to note that the implementation of this requirement is not uniformly practiced. Instead, projects are assessed and evaluated on a case-by-case basis. Additionally, participants were asked to provide additional information, including specific criteria and the related website. The Alaska Traffic Manual (2016) was referenced, which asserts that the provision of crosswalks at signalized junctions is considered a standard practice. The Colorado DOT Statewide Bicycle and Pedestrian Plan (2015) highlights the importance of crosswalk markings at all legs of a signalized intersection. In accordance with the Florida Complete Streets policy, crosswalk markings should be ensured on all sides of signalized intersections, unless there are project-related reasons, such as physical limitations or safety concerns. Similarly, the KYTC Complete Streets, Roads, and Highways Manual (August 2022) emphasizes the provision of marked crosswalks. By contrast, the New Mexico DOT does not have a policy mandating marked crosswalks at intersections, although it is customary to have them at signalized intersections. Furthermore, the Vermont Guidelines for Pedestrian Crossing Treatments (August 2019) stipulate that the posted speed limit should be 40 mph or lower at unsignalized intersections.

Figure 19. Criteria for providing marked crosswalks at intersections on high-speed arterials in state/local jurisdictions.



Participating states were asked if they had criteria for providing marked midblock crosswalks on high-speed arterials in their states or local jurisdictions, as shown in Figure 20. When states were asked about additional information such as criteria and website sources, the following information was provided:

- Arizona STEP Guide Safe Transportation for Every Pedestrian
- Illinois DOT policy TRA-23
- Maine DOT Guidelines on Crosswalks (2019)
- MassDOT Engineering Directive (Report E-20-001, 2020)
- Oregon Traffic Manual (2023)
- Tennessee Multimodal (2023)
- Wyoming DOT Pedestrian and School Traffic Control Manual (Jan 2014)

Figure 20. Criteria for providing marked midblock crosswalks on high-speed arterials in state/local jurisdictions.

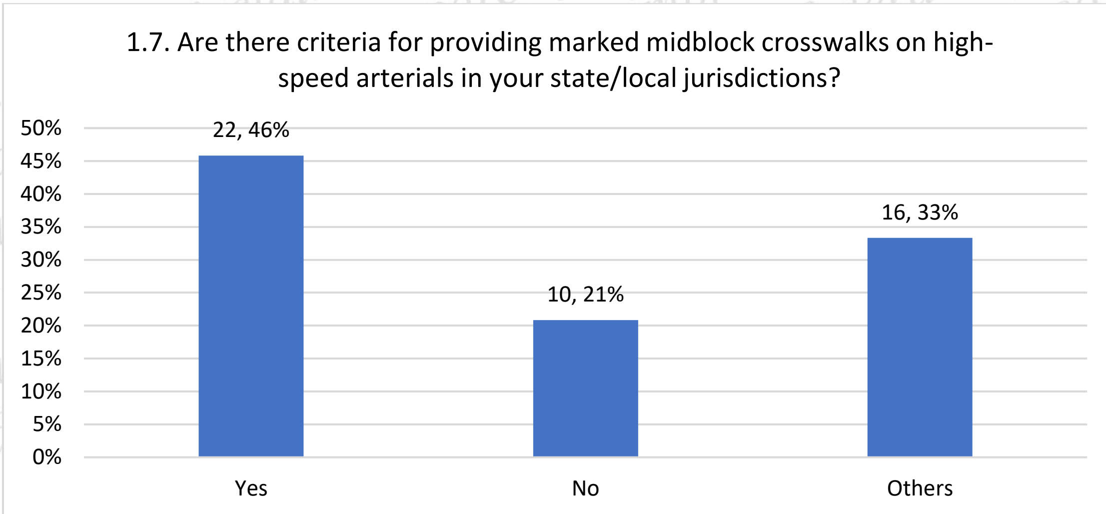


Figure 21. Criteria that do not allow marked crosswalks above a particular speed for midblock locations

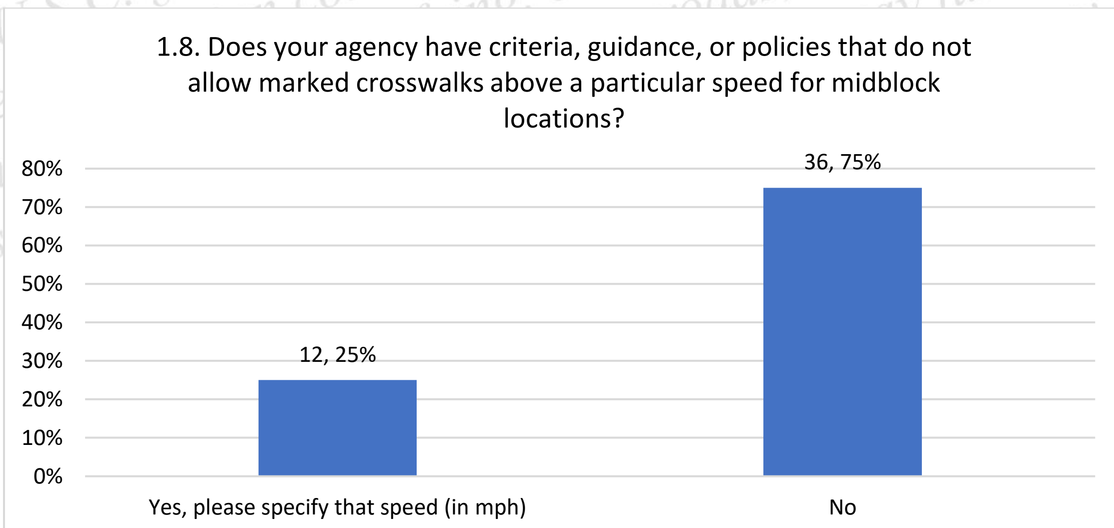
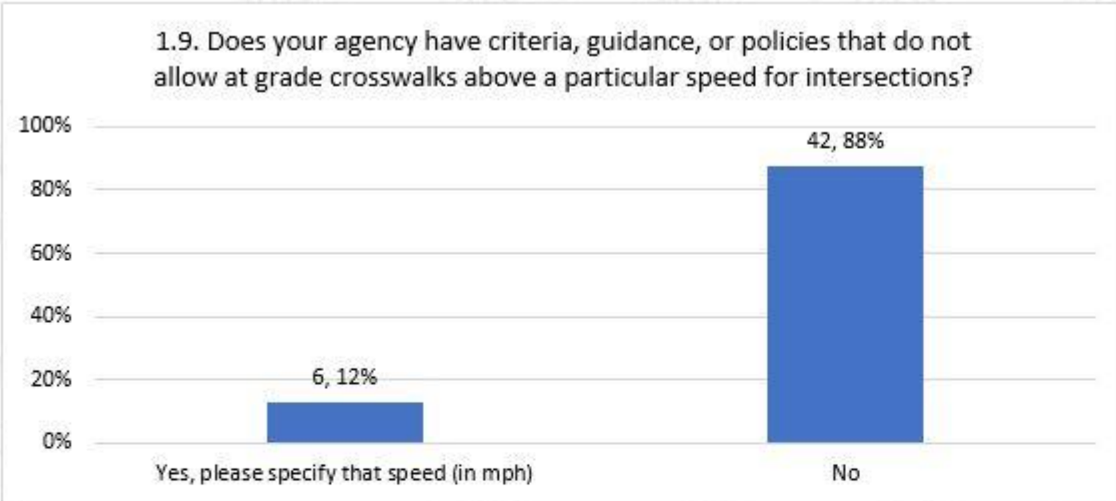


Figure 22. Criteria, guidance, or policies that do not allow at grade crosswalks above a particular speed for intersections



Likewise, survey respondents were asked if their agency has any pedestrian safety improvement programs or initiatives (e.g., systemic approach to pedestrian improvements, pedestrian safety improvements, leading pedestrian interval (LPI), etc.), as shown in Figure 23. 19% (9) of the states selected the option of "Other," which included responses such as:

- The Indiana DOT is now engaged in the formulation of pedestrian safety regulations and intends to include a pedestrian section in the Indiana Design Manual (IDM) in due course.
- Indiana DOT is in the process of establishing a Safety Scoring tool.
- Pedestrian-involved crashes have been identified as a focal point in the Texas Strategic Highway Safety Program. As a result, several initiatives aimed at enhancing pedestrian safety are eligible for financing under the Highway Safety Improvement Program (HSIP).
- Furthermore, the aforementioned material includes such as Arkansas Multimodal Planning, Connecticut LPI, Delaware Strategic Highway Safety Plan (SHSP), and Nevada SHSP.

Figure 23. Presence of any pedestrian safety improvement programs or initiatives (e.g., Systemic approach to pedestrian improvements, pedestrian safety improvements, leading pedestrian interval, etc.)

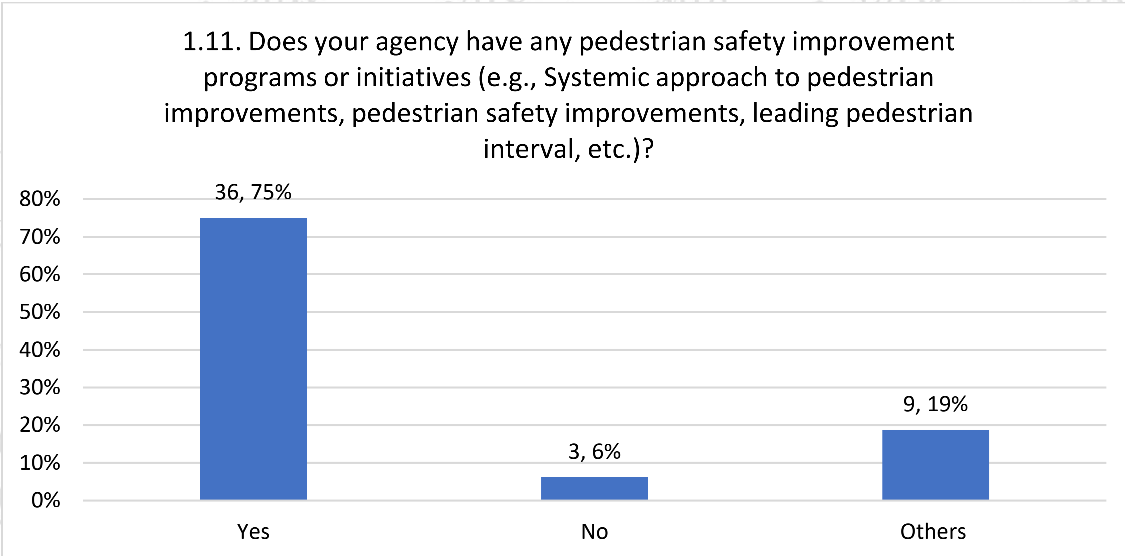


Figure 24. Identification of high-speed arterial road segments, including midblock crossings, as an area of focus for pedestrian related traffic safety in state/local jurisdiction.

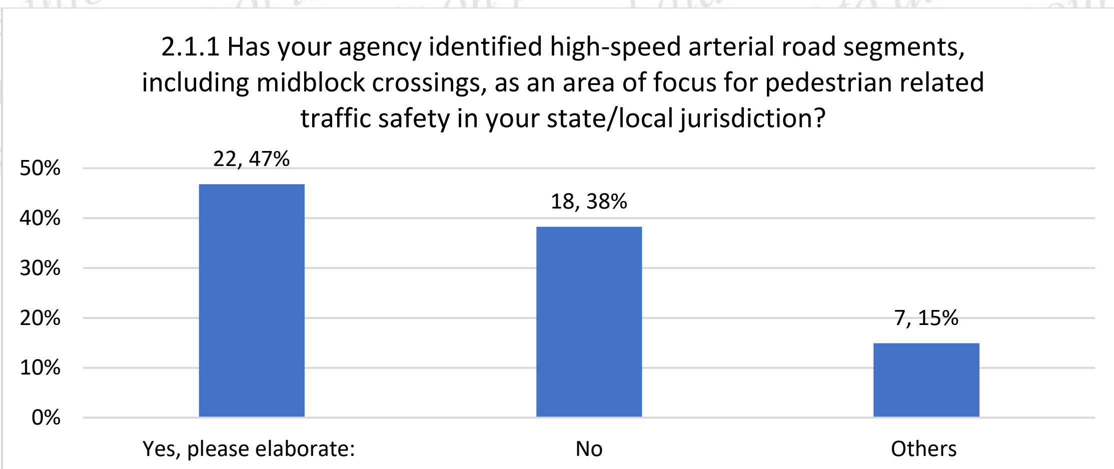


Figure 25. Conflict with the current guidelines in your state to implement the countermeasures suggested in the previous question to improve pedestrian safety on high-speed arterial segments

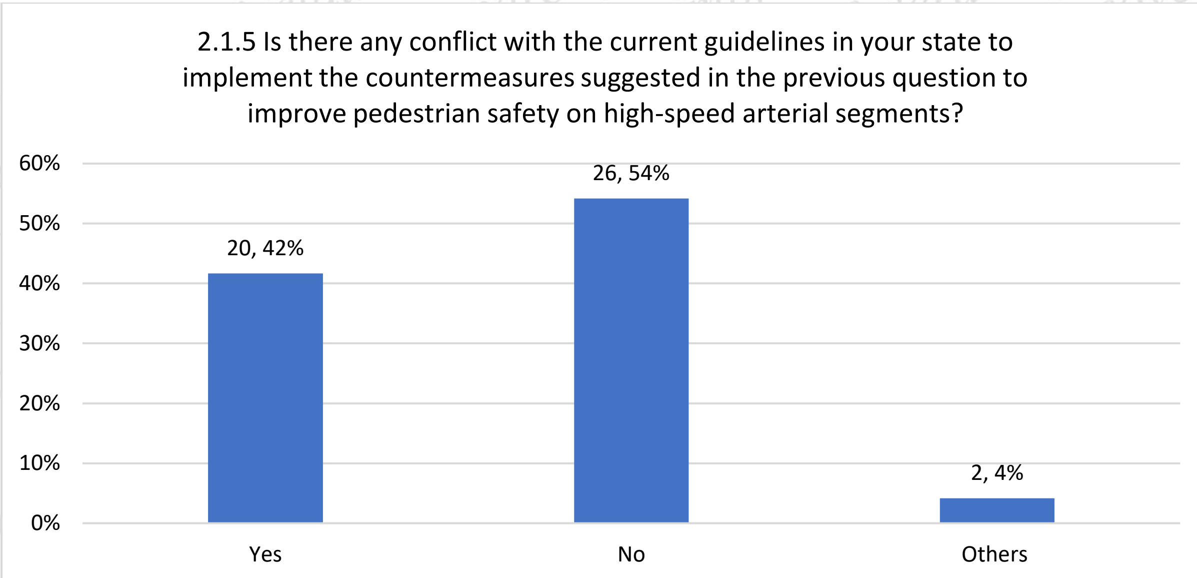


Figure 26.Implementation of any low-cost countermeasures for improving pedestrian safety on high-speed arterial segments

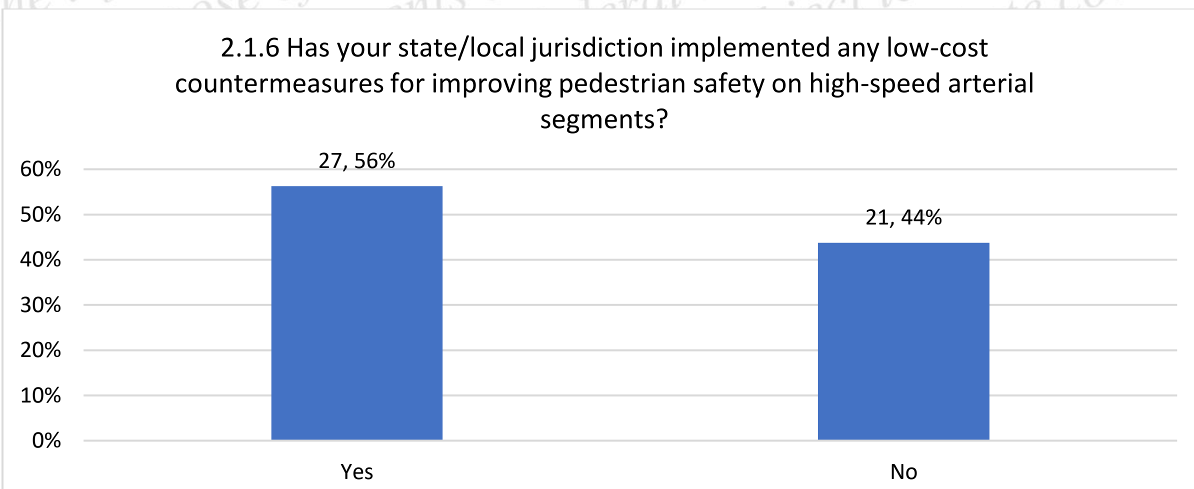


Figure 27. Effectiveness of low-cost countermeasures in improving pedestrian safety on high-speed arterial segments

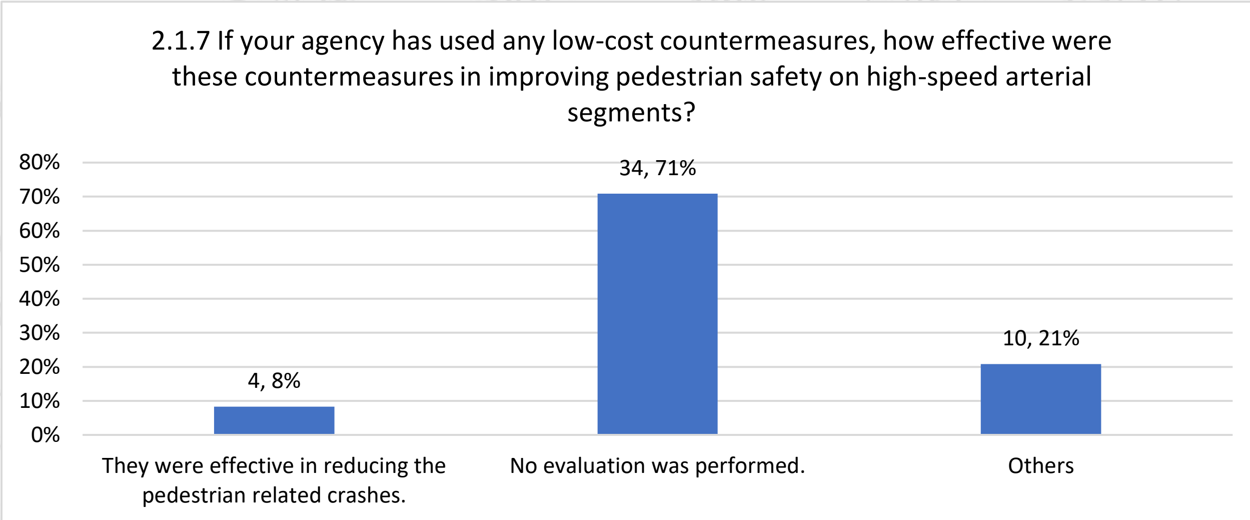


Figure 28. Evaluation of the impacts for implementing pedestrian facilities on high-speed arterial segments in state/local jurisdiction

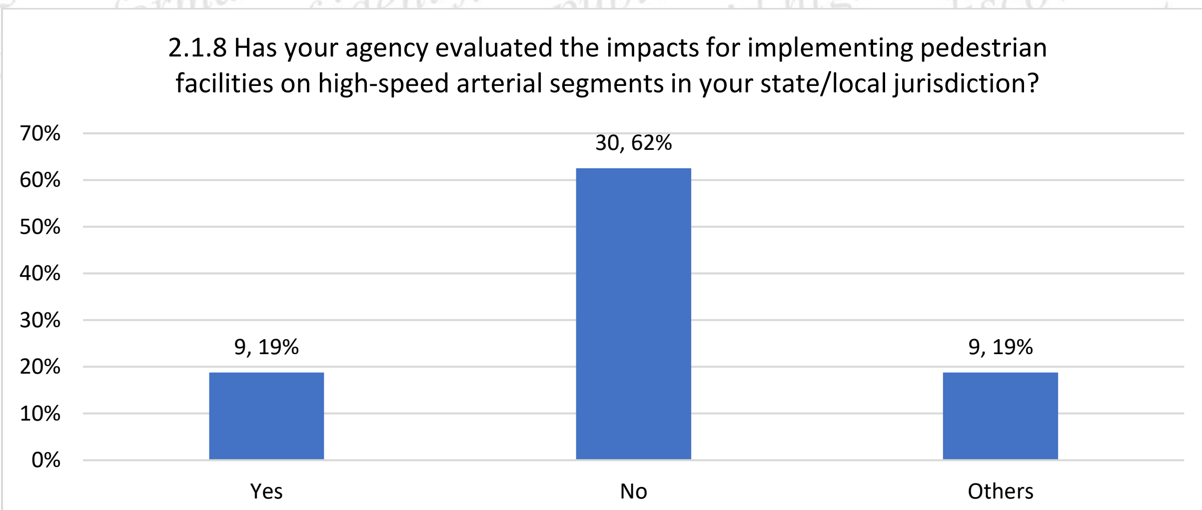


Figure 29. Effectiveness of any individual or package of countermeasures or programs at improving pedestrian safety on high-speed arterial segments

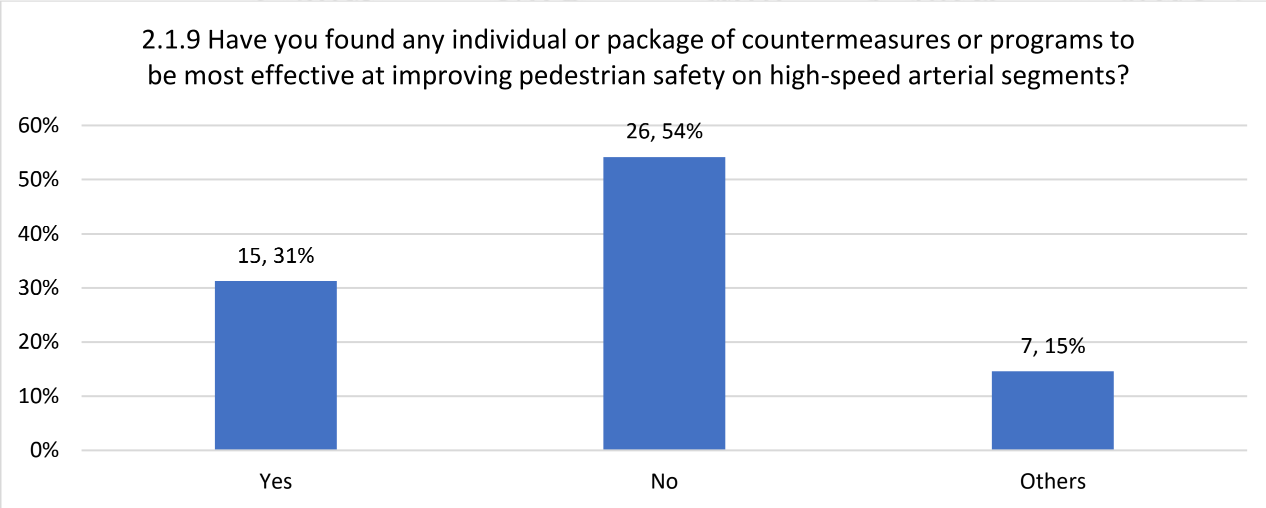


Figure 30. Identification of intersections (signalized or unsignalized) on high-speed arterials as an area of focus for pedestrian related traffic safety.

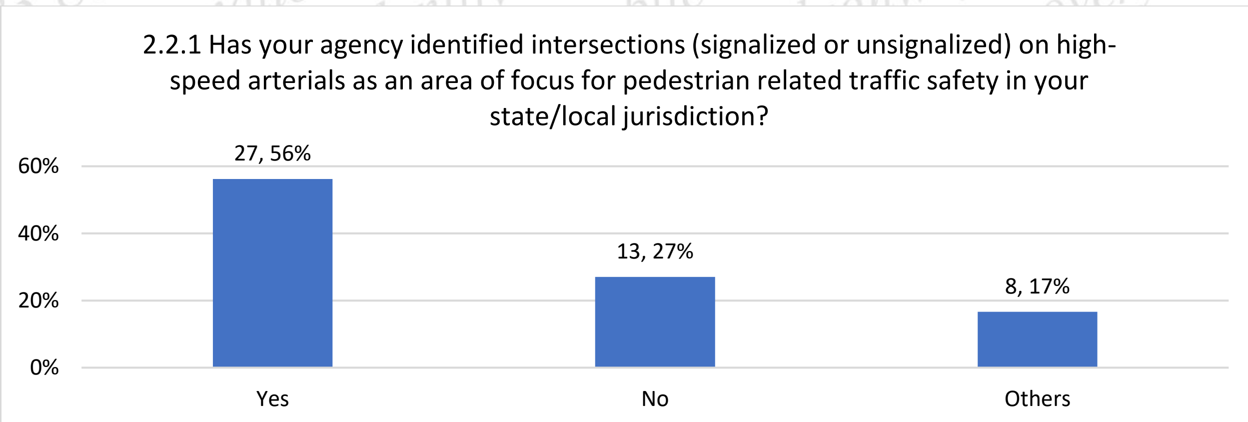


Figure 31. Analysis of data to determine what type of intersections have more pedestrian related crashes.

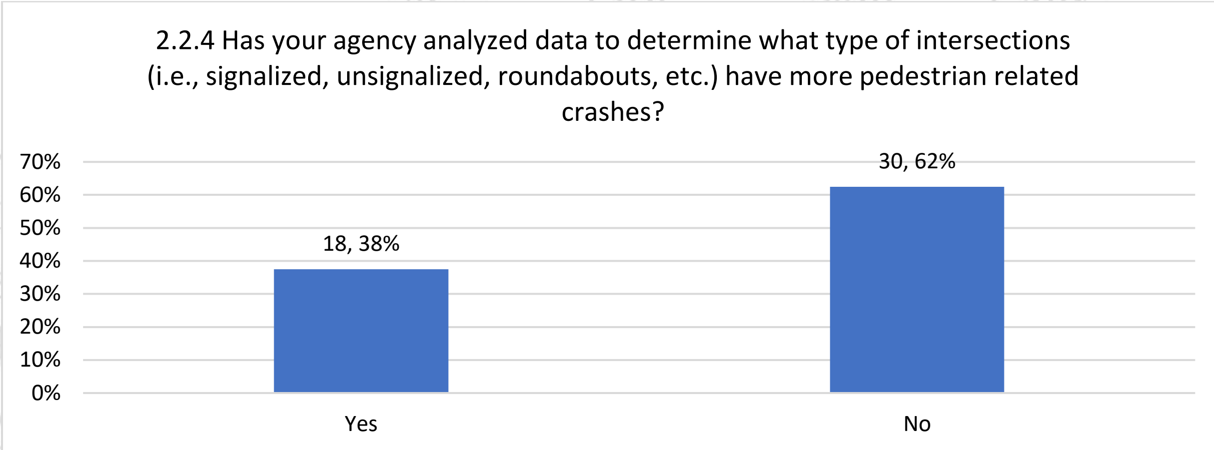


Figure 32. Conflict with the current guidelines in state to implement the countermeasures suggested to improve pedestrian safety at signalized intersections on high-speed arterials.

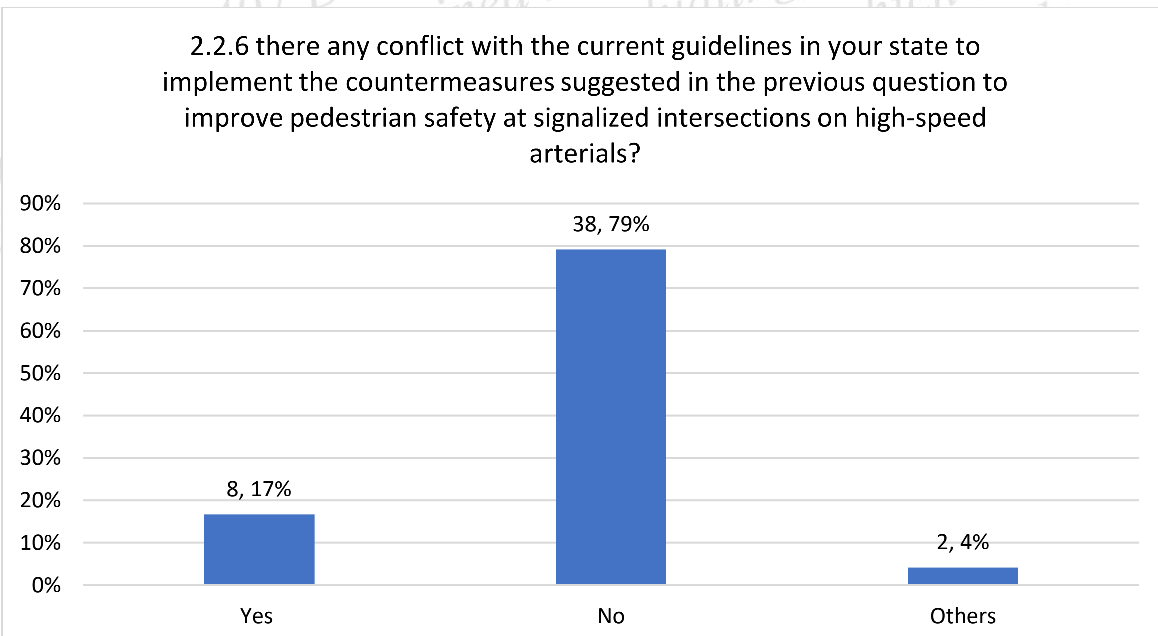


Figure 33. Conflicts with the current guidelines in your state to implement the countermeasures suggested in the previous question to improve pedestrian safety at unsignalized intersections.

Figure 34. Presence of low-cost countermeasures for improving pedestrian safety at intersections along high-speed arterials

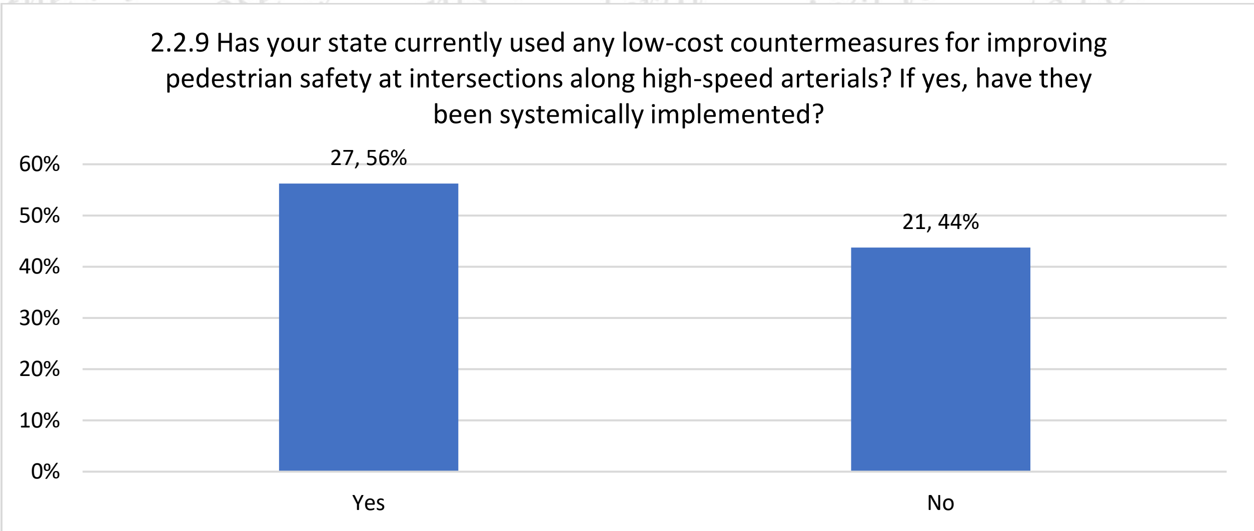


Figure 35. Effectiveness of countermeasures in improving pedestrian safety at intersections along high-speed arterials

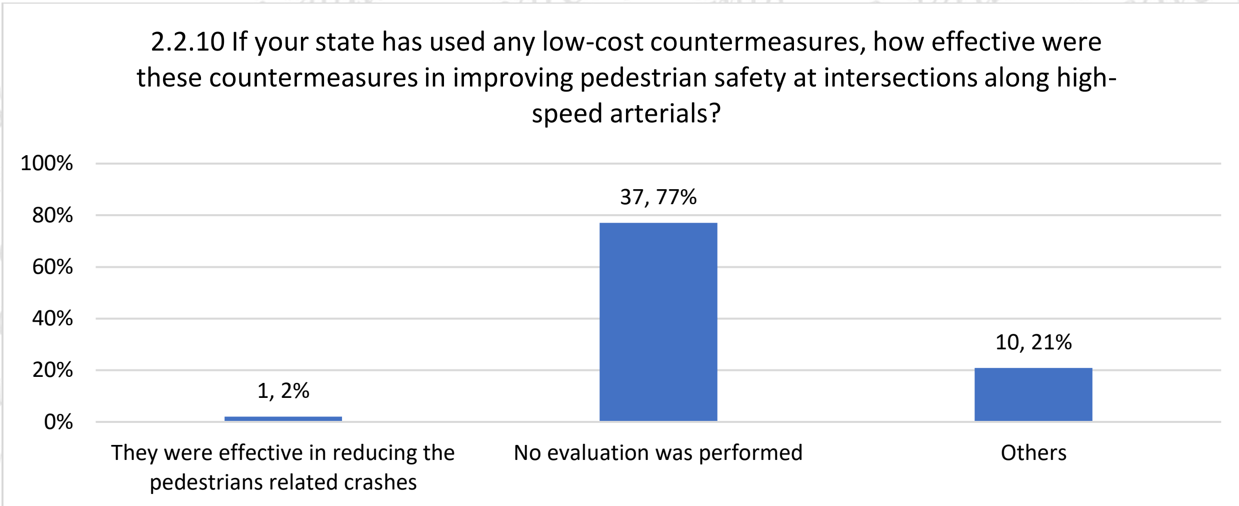


Figure 36. Evaluation of the impacts for implementing pedestrian facilities at intersections on high-speed arterial segments

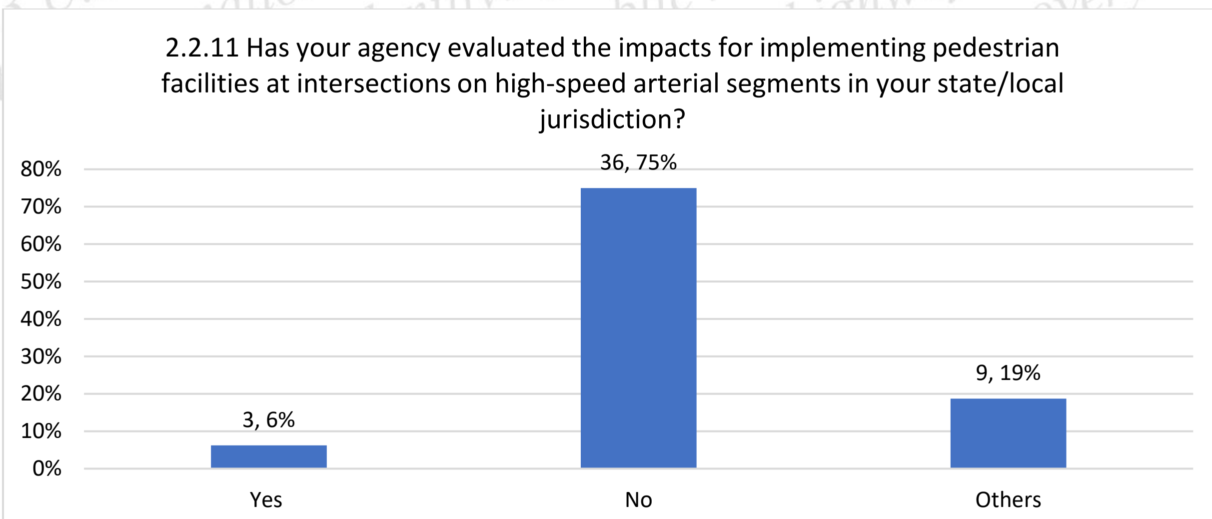
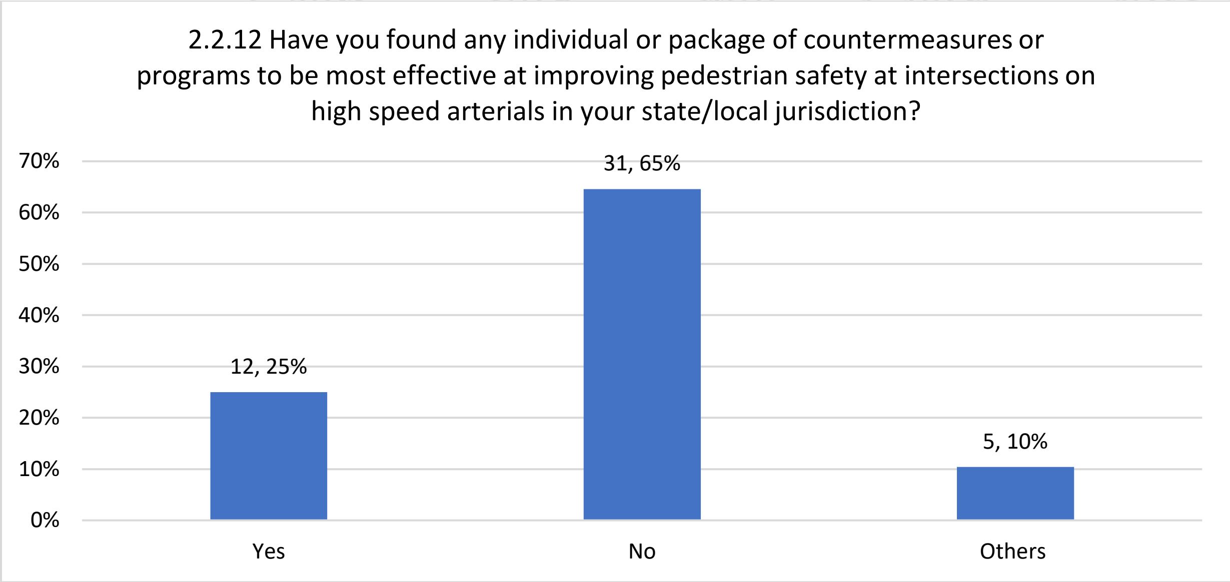


Figure 37. Presence of any individual or package of countermeasures or programs to be most effective at improving pedestrian safety at intersections on high-speed arterials.



Appendix D: Countermeasure Matrices

The following are the notes for the countermeasure matrices for roadway segments/midblock crossings on high-speed arterials, from Figures 38 to 41.

Statewide Priority 1 (yellow) Statewide Priority 2 (blue) Statewide Priority 3 (green)

A. Land Use: Urbanized = population 50,000 and above, Urban = population between 2,500 and 49,999, and Rural = population less than 2,500.

B. # A shaded number denotes a countermeasure that should be always documented during planning but is not mandatory. The selection of a certain countermeasure should be supported by an engineering analysis or the use of engineering judgment.

C. # An outlined unshaded number signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.

D. # An unshaded number indicates a countermeasure that may be considered for that particular peer group, along with its speed and ADT ranges.

E. In a peer group cell, the lack of countermeasures number denotes a category with a low crash history related to the characteristics (i.e., ADT, speed). Based on engineering judgment, a higher-level countermeasure may be considered for low crash cells.

F. NA--Lane Configurations not applicable for ADT less than 20,000.

1. High visibility crosswalks with ADA Ramps and Pedestrian Crossing Signs in Advance/at Crosswalk, Parking Restrictions at Crosswalk Approach
2. Advanced Stop Bars and Signs
3. Sidewalks and Walkways
4. Pedestrian Hybrid Beacon (PHB)
5. Curb Extensions
6. Narrowing of Travel Lanes.
7. Pedestrian Refuge Islands or Medians with Curb Cut
8. Road Diets/Road Configuration
9. Lighting

Figure 38. Countermeasures matrix for roadway segments/midblock crossings on High-Speed Arterials (ADT ≤10000)

ADT Range (vpd)	≤10000			
Speed Range (mph)	40	45	50	55+
Rural 2 lane Undivided (R2U)	1 2 4 6 9	1 2 3 4 6 9	1 2 4 6 9	1 2 3 4 6 9
Rural 4 lane Divided (R4D)	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9	1 2 3 4 7 9
Rural 4 lane Undivided (R4U)	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9
Urban 2 lane Divided (U2D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urban 2 lane Undivided (U2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urban 4 lane Divided (U4D)	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 6 7 9
Urban 4 lane Undivided (U4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 2 lane Divided (Z2D)	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9
Urbanized 2 lane Undivided (Z2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urbanized 4 lane Divided (Z4D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urbanized 4 lane Undivided (Z4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Divided (Z6D)	NA	NA	NA	NA
Urbanized 6 lane Undivided (Z6U)	NA	NA	NA	NA

Figure 39. Countermeasures matrix for roadway segments/midblock crossings on High-Speed Arterials (ADT >10000- ≤20000)

ADT Range (vpd)	>10000- ≤20000			
Speed Range (mph)	**40**	**45**	**50**	**55+**
Rural 2 lane Undivided (R2U)	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9	1 2 3 4 6 9
Rural 4 lane Divided (R4D)	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9	1 2 3 4 7 9
Rural 4 lane Undivided (R4U)	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9
Urban 2 lane Divided (U2D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urban 2 lane Undivided (U2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urban 4 lane Divided (U4D)	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9
Urban 4 lane Undivided (U4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 2 lane Divided (Z2D)	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9
Urbanized 2 lane Undivided (Z2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urbanized 4 lane Divided (Z4D)	1 2 3 4 7 9	1 2 3 4 5 7 9	1 2 3 4 7 9	1 2 3 4 5 7 9
Urbanized 4 lane Undivided (Z4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Divided (Z6D)	NA	NA	NA	NA
Urbanized 6 lane Undivided (Z6U)	NA	NA	NA	NA

Figure 40. Countermeasures matrix for roadway segments/midblock crossings on High-Speed Arterials (ADT >20000- ≤30000)

ADT Range (vpd)	>20000- ≤30000			
Speed Range (mph)	40	45	50	55+
Rural 2 lane Undivided (R2U)	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9
Rural 4 lane Divided (R4D)	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9
Rural 4 lane Undivided (R4U)	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9
Urban 2 lane Divided (U2D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urban 2 lane Undivided (U2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urban 4 lane Divided (U4D)	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9
Urban 4 lane Undivided (U4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 2 lane Divided (Z2D)	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9	1 2 3 4 6 7 9
Urbanized 2 lane Undivided (Z2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urbanized 4 lane Divided (Z4D)	1 2 3 4 7 9	1 2 3 4 5 7 9 9	1 2 3 4 5 6 7 9	1 2 3 4 5 7 9
Urbanized 4 lane Undivided (Z4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Divided (Z6D)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Undivided (Z6U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9

Figure 41. Countermeasures matrix for roadway segments/midblock crossings on High-Speed Arterials (ADT >30000)

ADT Range (vpd)	>30000			
Speed Range (mph)	40	45	50	55+
Rural 2 lane Undivided (R2U)	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9	1 2 4 6 9
Rural 4 lane Divided (R4D)	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9	1 2 4 7 9
Rural 4 lane Undivided (R4U)	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9	1 2 4 7 8 9
Urban 2 lane Divided (U2D)	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9	1 2 3 4 7 9
Urban 2 lane Undivided (U2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urban 4 lane Divided (U4D)	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9
Urban 4 lane Undivided (U4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 2 lane Divided (Z2D)	1 2 3 4 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 5 6 7 9	1 2 3 4 6 7 9
Urbanized 2 lane Undivided (Z2U)	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9	1 2 3 4 5 6 9
Urbanized 4 lane Divided (Z4D)	1 2 3 4 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9	1 2 3 4 5 7 9
Urbanized 4 lane Undivided (Z4U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Divided (Z6D)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Urbanized 6 lane Undivided (Z6U)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9

The following are the notes for the countermeasure matrices for signalized intersections on high-speed arterials, from Figures 42 to 45.

Note: There are no priority group 2 and 3 peer groups for the following matrices.

Statewide Priority 1 (yellow) Statewide Priority 2 (blue) Statewide Priority 3 (green)

A. Land Use: Urbanized = population 50,000 and above, Urban = population between 2,500 and 49,999, and Rural = population less than 2,500.

B. # A shaded number denotes a countermeasure that should be always documented during planning but is not mandatory. The selection of a certain countermeasure should be supported by an engineering analysis or the use of engineering judgment.

C. # An unshaded number indicates a countermeasure that may be considered for that particular peer group, along with its speed and ADT ranges.

D. In a peer group cell, the lack of countermeasures number denotes a category with a low crash history related to the characteristics (i.e., ADT, speed). Based on engineering judgment, a higher-level countermeasure may be considered for low crash cells.

1. High visibility crosswalks with ADA Ramps and Pedestrian Crossing Signs in Advance/at Crosswalk, Parking Restrictions at Crosswalk Approach
2. Signal Timing
3. Leading Pedestrian Interval (LPI)
4. Passive Pedestrian Detection
5. Pedestrian Pushbutton (PPB) or Accessible Pedestrian Signals (APS)
6. Curb Extensions
7. Reduced Curb Radii
8. Pedestrian Refuge Islands or Medians with Curb Cut
9. Countdown Pedestrian Signals
10. Lighting of Crosswalks in the Intersection
11. NO TURN ON RED Signing for All Approaches

Figure 42. Countermeasure matrix for signalized intersections on High-Speed Arterials (ADT ≤10000)

ADT Range (vpd)	≤10000			
Speed Range (mph)	**40**	**45**	**50**	**55+**
Undivided Legs				
Rural 4 legged Signalized (R4S)	1 2 3 5 6 7 9 10 11	1 2 3 5 6 7 9 10 11	1 2 3 5 6 7 9 10 11	1 2 3 5 6 7 9 10 11
Urban 3 legged Signalized (U3S)	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 2 legged Signalized(Z2S)	1 2 3 4 5 6 7 9 10 11	1 2 3 4 5 6 7 9 10 11	1 2 3 4 5 6 7 9 10 11	1 2 3 4 5 6 7 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 5 legged Signalized (Z5S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Divided Legs				
Rural 3 legged Signalized (R3S)	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11
Rural 4 legged Signalized (R4S)	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 2 legged Signalized(Z2S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11

Figure 43. Countermeasures matrix for signalized intersections on High-Speed Arterials (ADT >10000- ≤20000)

ADT Range (vpd)	>10000- ≤20000			
Speed Range (mph)	40	45	50	55+
Undivided Legs				
Rural 4 legged Signalized (R4S)	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11
Urban 3 legged Signalized (U3S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 2 legged Signalized(Z2S)	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 5 legged Signalized (Z5S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Divided Legs				
Rural 3 legged Signalized (R3S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Rural 4 legged Signalized (R4S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 2 legged Signalized(Z2S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11

Figure 44. Countermeasures matrix for signalized intersections on High-Speed Arterials (ADT >20000- ≤30000)

ADT Range (vpd)	>20000- ≤30000			
Speed Range (mph)	40	45	50	55+
Undivided Legs				
Rural 4 legged Signalized (R4S)	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11	1 2 3 5 6 / 7 9 10 11
Urban 3 legged Signalized (U3S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 2 legged Signalized(Z2S)	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11	1 2 3 4 5 6 / 7 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 5 legged Signalized (Z5S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Divided Legs				
Rural 3 legged Signalized (R3S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Rural 4 legged Signalized (R4S)	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11	1 2 3 5 6 / 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 2 legged Signalized(Z2S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11	1 2 3 4 5 6 / 7 8 9 10 11

Figure 45. Countermeasures matrix for signalized intersections on High-Speed Arterials (ADT >30000)

ADT Range (vpd)	>30000			
Speed Range (mph)	**40**	**45**	**50**	**55+**
Undivided Legs				
Rural 4 legged Signalized (R4S)	1 2 3 5 6 7 9 10 11	1 2 3 5 6 7 9 10 11	1 2 3 5 6 7 9 10 11	1 2 3 5 6 7 9 10 11
Urban 3 legged Signalized (U3S)	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 2 legged Signalized(Z2S)	1 2 3 4 5 6 7 9 10 11	1 2 3 4 5 6 7 9 10 11	1 2 3 4 5 6 7 9 10 11	1 2 3 4 5 6 7 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 5 legged Signalized (Z5S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Divided Legs				
Rural 3 legged Signalized (R3S)	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11
Rural 4 legged Signalized (R4S)	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11	1 2 3 5 6 7 8 9 10 11
Urban 4 legged Signalized (U4S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 2 legged Signalized(Z2S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 3 legged Signalized (Z3S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11
Urbanized 4 legged Signalized (Z4S)	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11	1 2 3 4 5 6 7 8 9 10 11

The following are the notes for the countermeasure matrices for unsignalized intersections on high-speed arterials, from Figures 46 to 49.

Note: There is no priority group 3 peer group for the following matrices.

Statewide Priority 1 (yellow) Statewide Priority 2 (blue) Statewide Priority 3 (green)

A. Land Use: Urbanized = population 50,000 and above, Urban = population between 2,500 and 49,999, and Rural = population less than 2,500.

B. [#] A shaded number denotes a countermeasure that should be always documented during planning but is not mandatory. The selection of a certain countermeasure should be supported by an engineering analysis or the use of engineering judgment.

C. [#] An outlined unshaded number signifies that crosswalk visibility enhancements should always occur in conjunction with other identified countermeasures.

D. # An unshaded number indicates a countermeasure that may be considered for that particular peer group, along with its speed and ADT ranges.

E. In a peer group cell, the lack of countermeasures number denotes a category with a low crash history related to the characteristics (i.e., ADT, speed). Based on engineering judgment, a higher-level countermeasure may be considered for low crash cells.

1. High-visibility crosswalks with ADA ramps with Pedestrian Crossing Signs in Advance /at the Crosswalk, Parking Restrictions at Crosswalk Approach
2. Advanced Stop Bars and Signs
3. Sidewalks/Walkways
4. Pedestrian Hybrid Beacon (PHB)
5. Curb Extensions
6. Reduced Curb Radii
7. Pedestrian Refuge Islands or Medians with Curb Cut
8. Lighting of Crosswalks at the Intersection
9. Advance Pedestrian Warning Signs

Figure 46. Countermeasures matrix for unsignalized intersections on High-Speed Arterials (ADT ≤10000)

ADT Range (vpd)	≤10000			
Speed Range (mph)	40	45	50	55+
Undivided Legs				
Rural 3-legged Stop Control(R3M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Rural 4-legged Stop Control (R4M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Urban 3-legged Stop Control (U3M)	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 2-legged Stop Control (Z2M)	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Roundabout (Z4R)	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9
Divided Legs				
Rural 3-legged Stop Control(R3M)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Rural 4-legged Stop Control (R4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urban 3-legged Stop Control (U3M)	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9

Figure 47. Countermeasures matrix for unsignalized intersections on High-Speed Arterials (ADT >10000- ≤20000)

ADT Range (vpd)	>10000- ≤20000			
Speed Range (mph)	40	45	50	55+
Undivided Legs				
Rural 3-legged Stop Control(R3M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Rural 4-legged Stop Control (R4M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Urban 3-legged Stop Control (U3M)	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 2-legged Stop Control (Z2M)	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Roundabout (Z4R)	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9
Divided Legs				
Rural 3-legged Stop Control(R3M)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Rural 4-legged Stop Control (R4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urban 3-legged Stop Control (U3M)	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9

Figure 48. Countermeasures matrix for unsignalized intersections on High-Speed Arterials (ADT >20000- ≤30000)

ADT Range (vpd)	>20000- ≤30000			
Speed Range (mph)	40	45	50	55+
Undivided Legs				
Rural 3-legged Stop Control(R3M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Rural 4-legged Stop Control (R4M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Urban 3-legged Stop Control (U3M)	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 2-legged Stop Control (Z2M)	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Roundabout (Z4R)	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9
Divided Legs				
Rural 3-legged Stop Control(R3M)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Rural 4-legged Stop Control (R4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urban 3-legged Stop Control (U3M)	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9

Figure 49. Countermeasures matrix for unsignalized intersections on High-Speed Arterials (ADT >30000)

ADT Range (vpd)	>30000			
Speed Range (mph)	40	45	50	55+
Undivided Legs				
Rural 3-legged Stop Control(R3M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Rural 4-legged Stop Control (R4M)	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9	1 2 4 8 9
Urban 3-legged Stop Control (U3M)	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9	1 2 3 4 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 2-legged Stop Control (Z2M)	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9	1 2 3 4 5 6 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 4 5 6 7 8 9	1 2 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Roundabout (Z4R)	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9	1 3 7 8 9
Divided Legs				
Rural 3-legged Stop Control(R3M)	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9	1 2 3 4 5 7 8 9
Rural 4-legged Stop Control (R4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urban 3-legged Stop Control (U3M)	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9	1 2 4 5 7 8 9
Urban 4-legged Stop Control (U4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 3-legged Stop Control (Z3M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9
Urbanized 4-legged Stop Control (Z4M)	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9	1 2 3 4 5 6 7 8 9

Appendix E: Conflicts and Gaps in Pedestrian Safety Policy Manuals

Table 25. Overview of Conflicts and Gaps in Pedestrian Safety Policy Manuals

Item	Policy/ Manual	Date	Section	Conflict/ Gap	Reasoning
1	Traffic Engineering Manual	Revised 04/2015	3B.2 Marked Crosswalk General Information.	Conflict: 3B.2.5 School. Refers to Section 7A.2 for school crosswalks which states that school crosswalks shall not be installed: where approach speeds exceed 50 mph.	Potential conflict if DOTD intends to use the pedestrian guidance to include school zones. Speed for crosswalks would be exceeded. Overrepresentation of pedestrian crashes occurs within ¼ mile of schools.
2	Traffic Engineering Manual	Revised 04/2015	3B.2 Marked Crosswalk General Information.	Conflict: 3B.2.6 Uncontrolled Approach At An Intersection. Includes a minimum pedestrian volume and gap in traffic for installation. It also states to not install a marked crosswalk if posted speeds exceed 40 mph.	An uncontrolled approach does not have a signal, flashing beacon or stop sign. The matrix uses midblock and unsignalized intersection, not "uncontrolled." We will make the clarification in the guidance document. The matrix was not built on a foundation of minimum number of pedestrians. This restricts use of crosswalks at higher speeds greater than 40 mph, which conflicts with the recommendations in the matrices/study. Per DOTD, the purpose of this part of the manual is to state that you cannot mark a crosswalk and provide no other measures such as traffic control devices on roads of 40 mph and greater. This will be clarified in the guidance document.

Item	Policy/ Manual	Date	Section	Conflict/ Gap	Reasoning
3	Traffic Engineering Manual	Revised 04/2015	3B.2 Marked Crosswalk General Information.	Conflict: 3B.2.6 Uncontrolled Approach at An Intersection. Do not install on a roadway with 4 or more lanes without a raised median or crossing island that has (or will soon have) an ADT of 12,000 or more.	This conflicts with recommendations to use crosswalks at volumes higher than 12,000 for 4 or more lanes without a median. MUTCD Section 3B.18 Crosswalk Markings paragraph 09 states: "New marked crosswalks alone, without other measures designed to reduce traffic speeds, shorten crossing distances, enhance driver awareness of the crossing, and/or provide active warning of pedestrian presence should not be installed across uncontrolled roadways where the speed limit exceeds 40 mph…." and provides the ADT criteria. This initial statement is not included in DOTD TEM. Per DOTD, the purpose of this part of the manual is to state that you cannot mark a crosswalk and provide no other measures such as traffic control devices on roads of 40 mph and greater. This will be clarified in the guidance document. The use of a PHB with a marked crosswalk and signing would meet MUTCD requirements and is recommended by FHWA.
4	Traffic Engineering Manual	Revised 04/2015	3B.2 Marked Crosswalk General Information.	Conflict: 3B.2.6 Uncontrolled Approach at An Intersection. Do not install on a roadway with 4 or more lanes with an ADA compliant raised median or crossing island that has (or will soon have) an ADT of 15,000 or more.	This conflicts with recommendations to use crosswalks at volumes higher than 15,000 for 4 or more lanes with a median. The same criteria as Item 3 above, the same MUTCD statement applies. Similarly, the initial statement of the MUTCD is not included in DOTD TEM. Per DOTD, the purpose of this part of the manual is to state that you cannot mark a crosswalk and provide no other measures such as traffic control devices on roads of 40 mph and greater. This will be clarified in the guidance document. The use of a PHB with a marked crosswalk and signing would meet MUTCD requirements and is recommended by FHWA.

Item	Policy/ Manual	Date	Section	Conflict/ Gap	Reasoning
5	Traffic Engineering Manual	Revised 04/2015	3B.2 Marked Crosswalk General Information.	Conflict: 3B.2.7 Mid-Block Crosswalks. Criteria for a when a midblock crossing may be installed includes 40 or more pedestrians during a one hour period or 25 or more cross per hours for 4 consecutive hours and fewer than 5 gaps in traffic during the peak 5 minute period. It also includes and ADT (2-way) above 3500.	The matrix does not include criteria for the number of pedestrians crossing in order to install a marked crosswalk. These values will be considered when developing the guidance document.
6	Traffic Engineering Manual	Revised 04/2015	3B.2 Marked Crosswalk General Information.	Conflict: 3B.2.7 Mid-Block Crosswalks. Do not install if another crosswalk exists within 600'.	The matrix does not place restrictions or limitations on when a crosswalk should or should not be installed. In order to not conflict with this policy criteria, the guidance document would need to include this criterion. The guidance document would be used in tandem with the matrices/study (provided in task 5).
7	Traffic Engineering Manual	Revised 04/2015	3B.2 Marked Crosswalk General Information.	Conflict: 3B.2.7 Mid-Block Crosswalks. Do not install if posted speeds exceed 40 mph.	This policy criteria restricts the use of marked crosswalks at midblock crossings for roadways with posted speed limits greater than 40 mph. This conflicts with the recommendations in the matrices/study (provided in task 5). The TEM should allow marked crosswalks if implemented with other treatments/countermeasures.
8	Traffic Engineering Manual	Revised 04/2015	3B.2 Marked Crosswalk General Information.	Conflict: 3B.2.8 Controlled Approach at An Intersection. There are a minimum of 20 pedestrians crossing in a 2 hour period during any 8 hour period.	A controlled approach includes a signal, flashing beacon or stop sign. We will make the clarification in the guidance document. The matrix/study (provided in task 5) does not rely on pedestrian volumes. As such, this is a gap or conflict with the policy criteria.

Item	Policy/ Manual	Date	Section	Conflict/ Gap	Reasoning
9	Traffic Engineering Manual	Revised 04/2015	7A.2 Policy for School Areas	Conflict: 7A.2.3 School Crosswalks A School Crosswalk shall not be installed where approach speeds exceed 50 mph.	See Item 1 above. The matrix does not distinguish the difference between a standard crosswalk and a school crosswalk nor locations by the presence of schools. This policy currently presents a potential conflict if DOTD intends to use the pedestrian guidance to include school zones as the speed limit for crosswalks would be exceeded. Overrepresentation of pedestrian crashes occurs within ¼ mile of schools.
10	LPA Technical Memorandum No 1	2016	NA	Conflict: The referenced DOTD TEM Sections 3B.2.6, 3B.2.7, and 7A.2.3 for local roads and 3B.2.5-8 and 7A.2.3 for state routes.	The referenced DOTD TEM Sections 3B.2.6, 3B.2.7, and 7A.2.3 for local roads and 3B.2.5-8 and 7A.2.3 for state routes identified in this LPA conflict with recommendations in the matrix. Refer to items 1-9 in this table for more detail specific to the appropriate conflicts (40 mph threshold, pedestrian volume, ADT, etc.).
11	Traffic Signal Manual	Release Version 3.0 7/1/2020	NA	Gap: Leading Pedestrian Interval (LPI)	The policy only refers to MUTCD and does not provide any guidance as to when LPI would be permissible to use. The matrix included this as a recommended treatment. Additional guidance is needed to fill the gap in the policy.
12	Traffic Signal Manual	Release Version 3.0 7/1/2020	NA	Gap: Pedestrian Hybrid Beacon	The policy only refers to MUTCD and does not provide any guidance as to when PHB would be permissible to use. The matrix included this as a recommended treatment. Additional guidance is needed to fill the gap in the policy.
13	Roadway Design Procedures and Details Manual	March 2009	Chapter 5, Cross Section Elements	Gap/Conflict: The policy states the minimum lane width is 11 feet. It is silent on road diets.	Based on the recommendations, clarification would be needed to ensure lanes would not be reduced below 11 feet. Guidance may be needed on when a road diet is appropriate.

Item	Policy/ Manual	Date	Section	Conflict/ Gap	Reasoning
14	Roadway Design Procedures and Details Manual	March 2009	Chapter 6, At-Grade Intersections	Gap: This chapter is silent on pedestrians except for roundabouts.	Pedestrian accommodations should be addressed for intersections beyond roundabouts.
15	Standard Plans	PM-08 2/28/2019	Pedestrian/Bike Striping Layout - Signalized and unsignalized intersections, midblock crossings, and bike lanes with right turn lanes.	Conflict: Signalized Intersection. This striping detail uses traditional longitudinal striping for the crosswalk. It includes optional white/red RPM at 2’-0” O.C. (place 2’ behind the edge of crosswalk). The channelized right turn lane does not have a stop bar or yield bar prior to the crosswalk.	The standard is in conflict in that it uses the traditional longitudinal striped crosswalk while the matrix indicates a high visibility continental crosswalk. The matrix does not include the optional white/red RPM at 2’-0” O.C. (place 2’ behind edge of crosswalk)-major leg identified in the standard. The standard should add a stop bar or yield bar prior to the crosswalk. The guidance document will include.
16	Standard Plans	PM-08 2/28/2019	Pedestrian/Bike Striping Layout - Signalized and unsignalized intersections, midblock crossings, and bike lanes with right turn lanes.	Gap: Unsignalized Intersection. This striping detail includes optional white/red RPM at 2’-0” O.C. (place 2’ behind edge of crosswalk).	The matrix does not include the optional white/red RPM at 2’-0” O.C. (place 2’ behind edge of crosswalk)-major leg identified in the standard. This can be added in the guidance document.

Item	Policy/ Manual	Date	Section	Conflict/ Gap	Reasoning
17	Standard Plans	PM-08 2/28/2019	Pedestrian/Bike Striping Layout- Signalized and unsignalized intersections, midblock crossings, and bike lanes with right turn lanes.	Conflict: Midblock Crossing. This striping detail uses high-visibility continental ladder style crossing. It shows a stop bar on each side of the crossing. It includes optional white/red RPM at 2'-0" O.C. (place 2' behind edge of crosswalk) as well as NO PASSING Zone (NPZ) requirements.	The standard includes criteria for a NPZ; however, the matrix does not include NPZ as a recommendation. Furthermore, while the matrix includes crosswalks for speeds greater than 40 mph and this standard has a 85th percentile or speed limit criteria for NPZ that goes to 70 mph, the two are in conflict with the current DOTD TEM policy of not to exceed 40 mph limitation for a crosswalk. The matrix recommends the Advanced Pedestrian Warning signs for the midblock crossing, but the standard does not include them, thus is in conflict.
18	Standard Plans	PM-08 2/28/2019	Pedestrian/Bike Striping Layout- Signalized and unsignalized intersections, midblock crossings, and bike lanes with right turn lanes.	Conflict: General Note stating an Engineering Study and Justification are required for crosswalk markings.	The matrix recommends crosswalks as a countermeasure as a blanket safety treatment for all ADT levels and speeds 40 mph and greater. The general note requiring an engineering study for marking of a crosswalk would conflict with the matrix. It needs to be determined when engineering judgement is acceptable, and an engineering study would not be required. Paragraph 08 from Section 3B.18 of the 2009 MUTCD states "An engineering study should be performed before a marked crosswalk is installed at a location away from a traffic signal or an approach controlled by a STOP or YIELD sign." This is a "should" statement and would require a design exception from the DOTD chief engineer to omit from the proposal of a midblock crossing. As a minimum, the midblock would need an engineering study because of the recommendation to use a PHB.

Item	Policy/ Manual	Date	Section	Conflict/ Gap	Reasoning
19	Standard Plans	PM-08 2/28/2019	Pedestrian/Bike Striping Layout-Signalized and unsignalized intersections, midblock crossings, and bike lanes with right turn lanes.	Gap: There are not specific pedestrian crosswalk details that apply to roundabouts.	This should be considered and added.
20	A Guide To Constructing, Operating, And Maintaining Highway Lighting Systems	1/30/2017	Introduction, Lighting on State Highways	Conflict: INTRODUCTION statement: Although the highways are designed to be safe without fixed roadway lighting, fixed roadway lighting may provide increased visibility, better obstacle recognition at higher speeds, and increased driving comfort. This is expected to result in more efficient traffic flow, greater driver security, and economic growth. LIGHTING ON STATE HIGHWAYS statement. "The department does not normally provide fixed lighting on state highways because fixed lighting is not essential for safety."	These two statements are in conflict. Furthermore, FHWA has recognized lighting as a proven safety countermeasure for addressing pedestrian safety. The matrix recommends lighting for pedestrian safety whereas the guidance document does not. The guide is silent on lighting for pedestrian safety, specifically at intersections, midblock, unsignalized and corridor lighting on arterials. The goal of crosswalk lighting should be to illuminate with positive contrast to make it easier for a driver to visually identify the pedestrian. This involves carefully placing the luminaires in forward locations to avoid a silhouette effect of the pedestrian. The nighttime fatality rate is three times the daytime rate. Lighting can reduce nighttime injury pedestrian crashes 28-42%.

Appendix F: Outline of Guidelines

This section presents the detailed outline of statewide guidelines on the provision of pedestrian facilities on Louisiana's high-speed arterials.

Outline

Chapter 1: Introduction—This provides information regarding the intent of the guidance document. It includes also a process flowchart for guidance implementation.

Chapter 2: Factors Influencing Pedestrian Safety—This speaks to the general issues and relationship of pedestrian safety to each of the items.

- Area (i.e., rural, urban, urbanized)
- Land Use (e.g., schools, shopping, housing)
- Location Type (e.g., midblock, intersection) and Traffic Control Type— (speak to signalized, 4-way stop, 2-way stop, no control)
- Traffic Volume (e.g., higher volumes—more traffic lanes)
- Pedestrian Volume
- Geometrics (number of legs at intersection, number of lanes, medians, availability of sidewalk/shoulder coverage)
- Vehicle Speed (e.g., higher speeds—increase in pedestrian injury/fatality)
- Time of Occurrence (e.g., nighttime, lighting)
- Multimodal Connections and Crossings (e.g., transit stops)

Chapter 3: Safety Analysis and Pedestrian Safety Statewide Priorities on High-Speed Arterials—This chapter includes the following sections.

- Steps to Safety Analysis
  - ➢ Identify Network/Location for Analysis
  - ➢ Identify and Compile Data for Analysis
  - ➢ Analyze Data and Identify Factors Influencing Pedestrian Safety.
  - ➢ Select Potential Countermeasures
- Identify Network/Location for Analysis.
- Analyze Data and Identify Factors Influencing Pedestrian Safety.
- Select Countermeasures.

Chapter 4: Pedestrian Safety Countermeasures Selection and Implementation—This chapter includes the following sections:

- Speed Management.
- Pedestrian Countermeasure Matrices
- Countermeasures
  - High-Visibility Crosswalks with ADA Ramps
  - Pedestrian Crossing Signs
  - Parking Restrictions
  - Advanced Stop Bars and Signs
  - Sidewalks and Walkways
  - Pedestrian Hybrid Beacon (PHB)
  - Curb Extensions
  - Narrowing of Lanes
  - Pedestrian Refuge Islands or Medians
  - Road Diets/Reconfiguration
  - Lighting
  - Signal Timing
  - Leading Pedestrian Interval
  - Passive Pedestrian Detection
  - Pedestrian Pushbutton (PPD) or Accessible Pedestrian Signals (APS)
  - Curb Extensions
  - Reduced Curb Radii
  - Pedestrian Countdown Signals
  - NO TURN ON RED Signing

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Appendix: Matrices

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