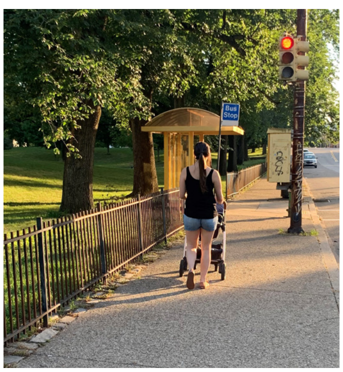
PEDESTRIAN AND BICYCLIST ROAD SAFETY AUDIT (RSA) GUIDE AND PROMPT LIST



U.S. Department of Transportation
Federal Highway Administration

SEPTEMBER 2020

Technical Documentation Page

<table>
<tr><td>1. Report No.
FHWA-SA-20-042</td><td>2. Government Accession No.</td><td colspan="2">3. Recipient's Catalog No.</td></tr>
<tr><td colspan="2" rowspan="2">4. Title and Subtitle
Pedestrian and Bicyclist Road Safety Audit (RSA) Guide and Prompt Lists</td><td colspan="2">5. Report Date
September 2020</td></tr>
<tr><td colspan="2">6. Performing Organization Code</td></tr>
<tr><td colspan="2">7.Author(s)
Elissa Goughnour, Matt Albee, Libby Thomas, Dan Gelinne, and Joe Seymour</td><td colspan="2">8. Performing Organization Report No.</td></tr>
<tr><td colspan="2" rowspan="2">9. Performing Organization Name and Address
VHB
940 Main Campus Drive, Suite 500
Raleigh, North Carolina 27606
University of North Carolina
Highway Safety Research Center
Chapel Hill, North Carolina 27599</td><td colspan="2">10. Work Unit No.</td></tr>
<tr><td colspan="2">11. Contract or Grant No.
DTFH61-16-D-00005</td></tr>
<tr><td colspan="2" rowspan="2">12. Sponsoring Agency Name and Address
Federal Highway Administration Office of Safety
1200 New Jersey Ave., SE
Washington, DC 20590</td><td colspan="2">13. Type of Report and Period
Final Report, June 2018 – June 2019</td></tr>
<tr><td colspan="2">14. Sponsoring Agency Code
FHWA</td></tr>
<tr><td colspan="4">15. Supplementary Notes
The Contracting Officer’s Task Manager (COTM) was Tamara Redmon (FHWA Office of Safety).
This guide is an update of the Pedestrian Road Safety Audit Guidelines and Prompt Lists (http://www.pedbikeinfo.org/cms/downloads/PedRSA.reduced.pdf) developed in 2007 and the Bicycle Road Safety Audit Guidelines and Prompt Lists (https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa12018/) developed in 2012.</td></tr>
<tr><td colspan="4">16. Abstract
This guide is intended to support agencies that are interested in conducting pedestrian- and bicycle-focused RSAs and includes information on safety risks for both modes, the RSA process, necessary data, and the roles and responsibilities of the RSA Team. Also included are updated prompt lists for pedestrians and bicyclists to use in the field. This guide will aid practitioners understand pedestrian and bicyclist issues in their jurisdiction and potentially achieve other goals in addition to safety, like enhancing quality of life, improving community health, or increasing pedestrian and bicycle mode share.</td></tr>
<tr><td>17. Key Words:
road safety audit, road safety assessment, RSA, pedestrian, bicycle, safety, multimodal, prompt lists, Vision Zero, Safe System, micromobility</td><td colspan="3">18. Distribution Statement
No restrictions.</td></tr>
<tr><td>19. Security Classif. (of this report)
Unclassified</td><td>20. Security Classif. (of this page) Unclassified</td><td>21. No. of Pages
73</td><td>22. Price</td></tr>
</table>

Form DOT F 1700.7 (8-72) Reproduction of completed pages authorized

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
		NOTE: volumes greater than 1000 L shall be shown in m^3		
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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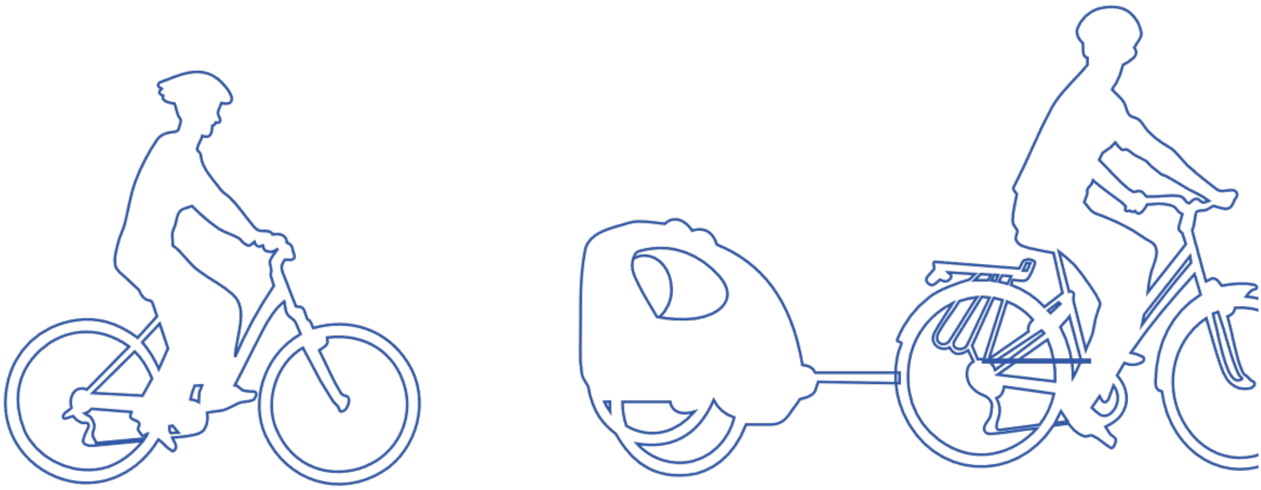
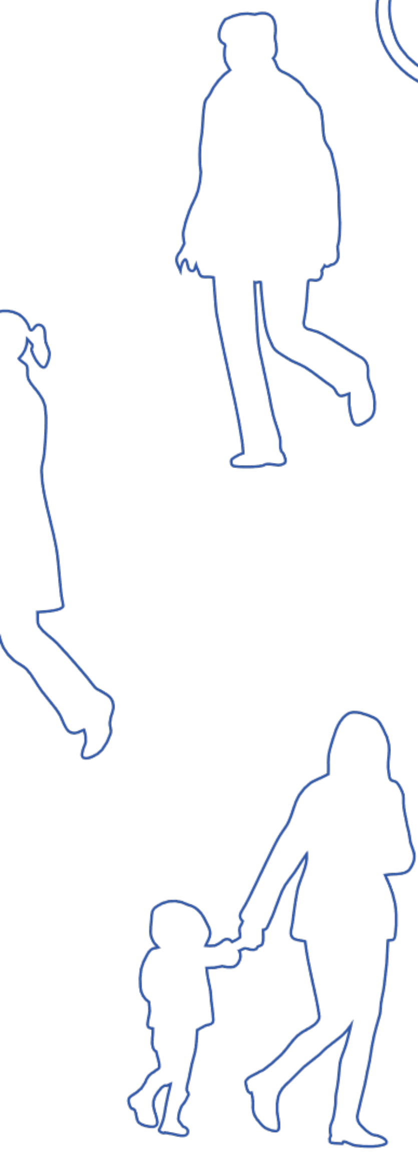
List of Acronyms

AADT	Average Annual Daily Traffic
AASHTO	American Association of State Highway Transportation Officials
ADA	Americans with Disabilities Act
B/C	benefit/cost
BRT	bus rapid transit
CMF	crash modification factor
CRF	crash reduction factor
DOT	Department of Transportation
EMS	Emergency Medical Services
FARS	Fatality Analysis Reporting System
FHWA	Federal Highway Administration
LRT	light rail transit
LTAP/TTAP	Local/Tribal Technical Assistance Program
MUTCD	Manual on Uniform Traffic Control Devices
NACTO	National Association of City Transportation Officials
NCHRP	National Cooperative Highway Research Program
NHTSA	National Highway Traffic Safety Administration
PBCAT	Pedestrian and Bicyclist Crash Analysis Tool
PBIC	Pedestrian and Bicycle Information Center
PHB	pedestrian hybrid beacon
PROWAG	Proposed Rights-of-Way Guidelines
RRFB	rectangular rapid-flashing beacon
RSA	road safety audit
SLM	shared lane marking, or “sharrow”





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Publication Number: FHWA-SA-20-042

Introduction

Road Safety Audits (RSAs) are a proactive, formal safety performance examination of an existing roadway or future roadway project and its surrounding area. An independent and multi-disciplinary team conducts the assessment with the intent of improving safety—and may be focused particularly on pedestrian and bicyclist safety. The RSA Team considers how roadway, traffic, environmental, and human factors impact safety, within the context of mobility, access, surrounding land use, and aesthetics.

While transportation professionals have collectively made progress in improving roadway safety, there are still stark differences in safety for particular modes. Notably, increases in pedestrian and bicyclist fatalities have outpaced those of other modes, increasing by 51 percent in the 10-year period between 2009 and 2018. During that same time period, total traffic fatalities increased by 8 percent.[(1)] In 2018 (the most recent year for which complete data is available), the National Highway Transportation Safety Administration (NHTSA) reported that while there was a 2.4 percent reduction in overall fatalities from the previous year, fatalities among pedestrians and bicyclists increased by 3.4 percent and 6.3 percent, respectively. Not only can walking and biking be an enjoyable way to travel, it can also help individuals and agencies reach environmental, physical, and mental health goals. With the increases in walking and bicycling throughout the U.S., it is imperative that transportation professionals support those modes by improving safety. As such, RSAs can be a useful tool for enhancing the operating environment and improving safety for these non-motorized modes.

In 2008, the Federal Highway Administration (FHWA) Office of Safety recognized RSAs as a Proven Countermeasure in reducing serious injuries and fatalities. FHWA encourages widespread implementation of RSAs by State, Tribal, and local transportation agencies.[(2)] FHWA's *Road Safety Audits: An Evaluation of RSA Programs and Projects* showed a significant reduction in crashes after implementing five RSAs in the study. Total crash reductions ranged from 10 to 50 percent. For most RSA projects, benefit/cost (B/C) ratios—which compare the benefits derived from crash reduction to the cost of conducting the RSA and implementing the countermeasures—were calculated as an additional measure of the project's success. All of the evaluated RSA projects had a B/C ratio greater than 1.0, meaning the project benefits outweighed the project costs.[(3)]

This guide serves as an update to the *Pedestrian Road Safety Audit Guidelines and Prompt Lists* (2007) and *Bicycle Road Safety Audit Guidelines and Prompt Lists* (2012). However, as pedestrian- and bicycle-focused RSAs are oftentimes conducted simultaneously, this new guide provides the content in one concise document.

While this guide is written to address both pedestrians and bicyclist safety, it is important to remember that walking and bicycling are distinct transportation modes with unique safety concerns. Bicyclists travel at higher speeds compared to pedestrians and may use the roadway like a motorized vehicle (with or without shared bicycle markings) and/or have facilities dedicated for their use adjacent to motorized vehicle travel lanes, (e.g., bicycle lanes, bike boxes). Pedestrians, conversely, travel at lower speeds, on facilities that are separate from vehicular travel lanes (e.g., sidewalks, shared use paths), and usually enter the travel lane only when crossing the street. However, when pedestrian facilities are absent, like in many residential or rural locations, pedestrians may be forced to use the travel lane or shoulder.

Walking, biking, taking transit, and driving each play a role in how individuals travel daily. It is important to view the transportation system as a whole—how motorists, pedestrians, and bicyclists, and other modes interact with each other from both a behavioral and infrastructure perspective. Improvements to one mode can enhance or detract from the safety of other modes, so it is important to think holistically and consider all possible outcomes as a result of suggested improvements.

This guide is intended to support agencies that are interested in conducting pedestrian- and bicycle-focused RSAs and includes information on safety risks for both modes, the RSA process, necessary data, and the roles and responsibilities of the RSA Team. Included in the Appendices are sample materials, prompt lists to use in the field, and additional resources. Agency staff can use this guide to understand pedestrian and bicyclist safety issues in their jurisdiction and achieve other goals in addition to safety, like enhancing quality of life, improving community health, or increasing pedestrian and bicycle mode share.

Linking RSAs with Zero Deaths Based Initiatives and the Safe System Approach

RSAs can be used in alignment with various initiatives or goals, such as Vision Zero, Toward Zero Deaths, or the Safe Systems Approach. These initiatives all recognize that roadway users misjudge risks or make mistakes, and it is necessary to design a transportation system that reduces the number and severity of consequences resulting from these actions. Towards Zero Deaths and Vision Zero approaches state that roadway deaths are unacceptable, and many State and local agencies have adopted plans and policies to reach zero deaths. Both approaches typically combine a systemic and site-specific approach to identify locations for improvement. RSAs are a perfect tool for identifying those site-specific safety needs.

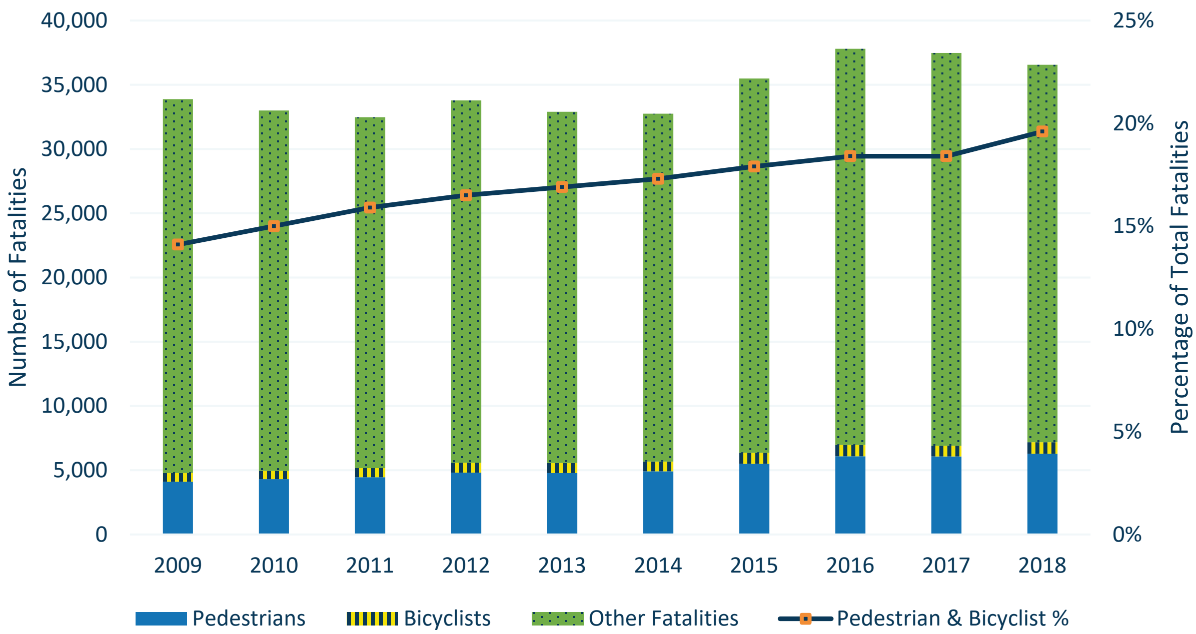
The Safe Systems Approach requires analysts, designers, and transportation leaders to understand the interaction among five key elements:

- *Road users.*
- *Roadways and roadsides.*
- *Vehicles.*
- *Speed.*
- *Incident management.*

This approach embraces the philosophy that if one part of the system fails, the other parts should still protect transportation system users. The RSA approach allows agencies to investigate these interactions and diagnose potential safety issues through observations of modal behavior by stakeholders from various disciplines.

Pedestrian and Bicyclist Crash Trends

The number of pedestrian and bicyclist fatalities in the U.S. has steadily increased since 2009. In the years between 2009 and 2018, pedestrian fatalities increased by 53 percent and bicyclist fatalities increased by 37 percent. These increases far outpaced the increase in total traffic fatalities over the same time period, which saw only an 8-percent increase. As a result, pedestrians and bicyclists accounted for an increasing share of roadway fatalities over the past decade. Together, these vulnerable road users accounted for 20 percent of all fatalities in 2018, up from 14 percent in 2009. The two-year average for 2016-2017 is 41 percent higher than the two-year average for 2008-2009. Meanwhile, the two-year average for fatalities, exclusive of pedestrians and bicyclists, was approximately the same for 2015-2016 compared to 2008-2009.(4)



Source: 2018 NHTSA.

Figure 1. Graphic. Fatalities over the past 10-years in the U.S.(4)

Note: Pedestrian fatalities do not include people using micromobility devices such as skateboards or stand-up scooters.

Micromobility Crash Trends

The Fatality Analysis Reporting System (FARS) data captures "personal conveyance" traffic deaths, but does not include which device was being used (e.g., roller skates, inline skates, skateboards, baby strollers, scooters, toy wagons, motorized skateboards, motorized toy cars, Segway-style devices, motorized and non-motorized wheelchairs, and scooters for those with disabilities).[5] As a result, data for micromobility devices or "personal conveyance" may be limited and therefore difficult to quantify the safety performance of these modes. Agencies vary in how they capture crashes involving micromobility devices, like e-scooters, with some adding new vehicle types, while others include them in the bicycle category or do not record them at all due to crash reports lacking an appropriate field.

Overall trends can be useful for understanding the scale and scope of the problem. Transportation agencies can then use details captured in crash reports to gain more insight into the factors contributing to pedestrian and bicyclist death and injury at specific locations. Though non-fatal crash data is not readily available nationally, many States have detailed records of all crashes involving pedestrians and bicyclists. Using these sources, practitioners can gain an understanding of common characteristics that may contribute to crashes involving pedestrians and bicyclists. The following sections summarize some of these factors, including types of locations where crashes occur, the role of road user separation, and the importance of visibility and conspicuity.

Location Types

Between 2009 and 2018, pedestrian fatalities increased by 69 percent in urban areas and increased by 0.1 percent in rural areas. During this same period, bicyclist fatalities increased by 48 percent in urban areas and decreased by 8.9 in rural areas. These numbers and proportions are similar year-to-year, but annual differences, as well as differences by region, may relate to changes in land uses and density that are not fully reflected in the definitions of rural/urban in the data. Other trends may affect the rural and urban trends, including regional weather patterns affecting the amounts of riding and walking, changes in population numbers, demographics, health-related characteristics, infrastructure, fleet characteristics, and types and amounts of urban and rural activity. These trends are not, at present, well-understood.

A majority of pedestrian and bicyclist fatalities occur in urban areas;

79 percent of pedestrian fatalities and 75 percent of bicyclist fatalities in 2018 occurred in urban areas.

While intersections are common locations for pedestrian crashes, both rural and urban areas across the country observe more pedestrian and bicyclist fatal and injury crashes at non-intersection locations (along segments) according to national fatal crash data (see references 6 and 7) and total crash data from North Carolina (see references 8 and 9). Overall, nearly 50 percent of pedestrians and about 38 percent of bicyclists are killed in urban areas at non-intersection locations across the U.S.[1,5] National trends do not apply to every jurisdiction, so agencies are encouraged to analyze local data to better understand the variation within their transportation system. For example, Virginia found that 57 percent of pedestrian fatal crashes occurred at intersections.[10] An analysis of data from 2014 to 2016 for fatal pedestrian crash locations is shown in figure 2 and for fatal bicyclist crash locations in figure 3.

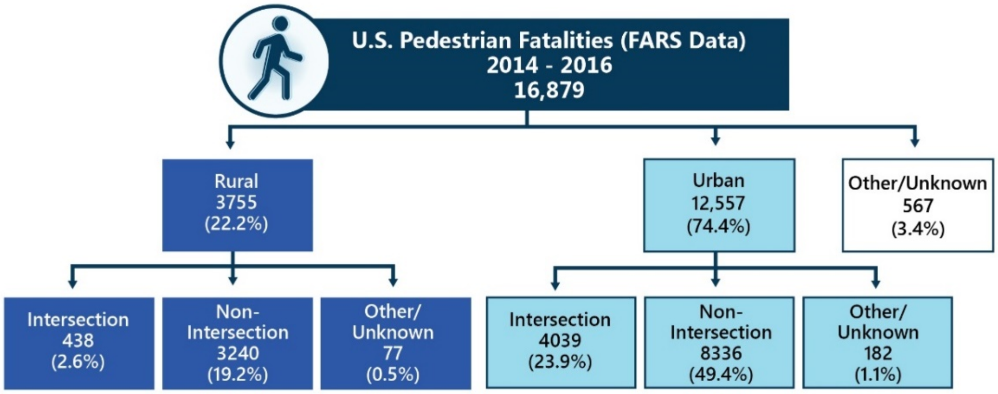


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Figure 2. Graphic. Analysis of pedestrian fatalities by location from 2014-2016. [4]

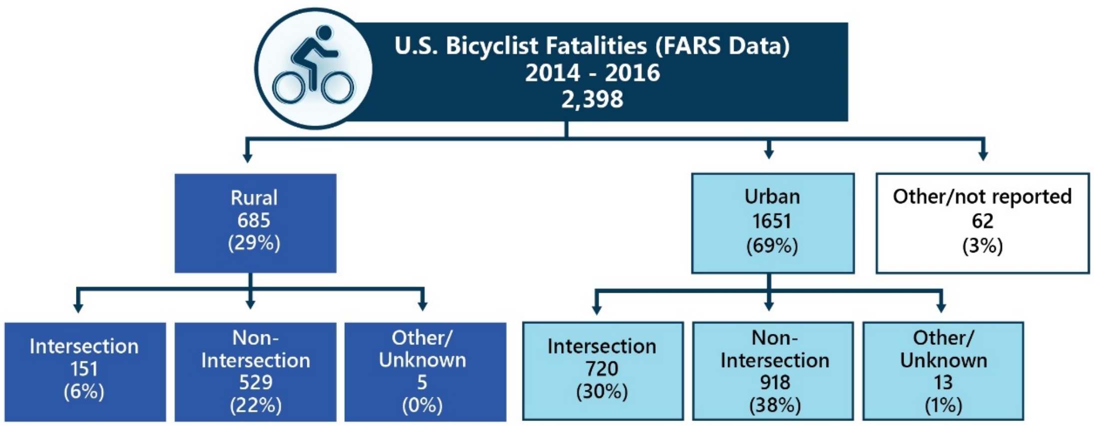

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Figure 3. Graphic. Analysis of bicycle fatalities by location from 2014-2016. [4]

Separation of Road Users

The number one type of collision leading to fatalities and injuries for bicyclists involves motorists overtaking bicyclists from behind (see figure 4). This type of crash led to 28 percent of all U.S. bicyclist fatalities as reported nationally. As with all crash types, there may be variation in observed trends by agency. For example, in North Carolina, overtaking bicyclists from behind represents a higher percentage of fatal and disabling (or severe) injury crashes, even in urban areas of the State. However, this type is not among the top crash types in data from Boulder, Colorado, where separated paths and bike lanes are more prevalent than in many jurisdictions across the U.S. FHWA's *Bikeway Selection Guide* shows that separated bike lanes, with or without protected intersections, all but eliminate overtaking crashes.[9,13,14]

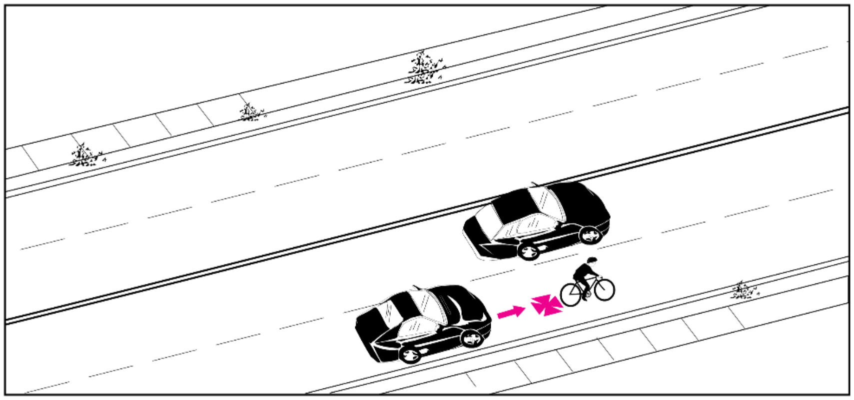

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Figure 4. Graphic. Motorist overtaking crash type.[11]

While bicyclist fatalities in urban areas also commonly occur at signalized and other intersections, many "crossing path" type fatalities occur at intersections that lack traffic controls, such as crossing the uncontrolled leg of a two-way stop-controlled intersection. Other frequent crash types involve motorists turning left or right across the paths of bicyclists who are on a parallel path or involve bicyclists riding out from stop-controlled side streets where the motorist faces no traffic control (see figure 5 and figure 6). At signalized locations, the phasing may not separate turning and through movements.[9]

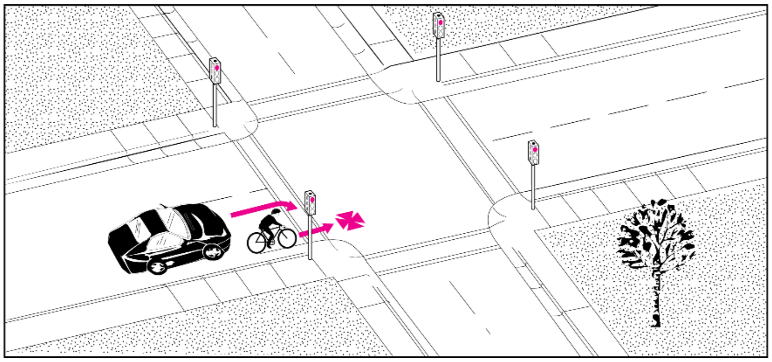

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Figure 5. Graphic. Motorist and bicycle turning conflict at an intersection. [11]

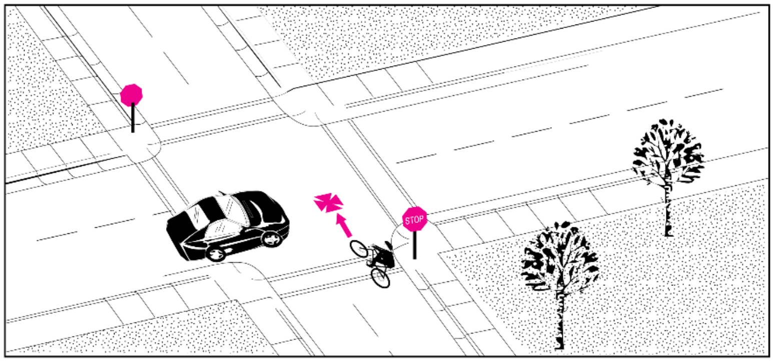

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Figure 6. Graphic. Motorist and bicycle crossing path conflict at an intersection. [11]

For pedestrians, 22 percent of crashes that result in fatalities or serious injuries—more than any other type—involve a pedestrian crossing a street and a through-traveling vehicle at both intersection and non-intersection locations. In 80 percent of those crashes, there is no traffic control present (i.e., no stop sign or signal) for the motorist.[15,8] Agencies should analyze local data as these percentages will vary among jurisdictions. For example, in New York (outside of New York City), 62 percent of urban crashes occurred when a pedestrian was crossing the road.[12]

What these types of frequently serious crashes have in common is that they typically occur at locations where the pedestrians and bicyclists are not separated in space through physical means, or in time through traffic controls or operational features.

A study from the Baltimore and Washington, D.C. area showed that crash type trends can also change over time in the same area—likely for a variety of reasons that may include changes in demographics, population, land use, travel patterns, and infrastructure, but which are not well-understood.[16]

Visibility and Conspicuity

The above types of crash patterns and conditions are especially prevalent at night or at other times and locations where pedestrians and bicyclists are difficult for motorists to see. Around half of all bicyclist fatalities, and more than three-fourths of pedestrian fatalities occur at night, dawn, or dusk. Data from FARS show that the percentage of pedestrians who were killed in nighttime crashes has increased steadily for more than 10 years. In addition, bicyclists and pedestrians are typically traveling along the outer margins of roadway space where they may be blocked from view by traffic in other lanes, or by buildings, vehicles parked in close proximity to crossings, and other objects. Other factors, not well-studied, may also affect conspicuity—for example, headlights of opposite direction traffic may reduce conspicuity of pedestrians and bicyclists at night.[9] There is some evidence that fluorescent colors during daytime, and lighting and reflective biomotion materials (e.g., reflective wrist and ankle bands that highlight human motion) at night, may improve driver detection of pedestrians and bicyclists, but crash effects are less certain.[17,18,19] Adaptive headlight beams may also increase the distance of detection of pedestrians and bicyclists but crash effects have not yet been documented since these were only approved for use in the U.S. in late 2018.[20]

Transit Interactions

Analyses from Seattle, Washington and a few other jurisdictions have found that transit activity can increase the risk of pedestrian collisions. It is important to understand that transit use can have a positive impact on road user safety. However, the combination of increased pedestrian volumes and the reactions of drivers to transit vehicle stops, can lead to an increase in pedestrian crashes. These factors can be worsened by conspicuity issues and other factors.[8,21]

The National Cooperative Highway Research Program (NCHRP) 893 *Systemic Pedestrian Safety Analysis* noted that the presence of transit stops and the number of stops along a segment are both associated with pedestrian crash risk along segments.[22] Other transit activity measures, such as the number of buses stopping along a segment and increasing numbers of passengers boarding or alighting at a stop, were associated with an increase in pedestrian crash risk.

The various types of transit come with different considerations for pedestrian and bicycle safety; however, any transit boarding and alighting area needs to accommodate all types of users with all types of abilities, should not block general pedestrian activity, and should be well-defined with a sufficiently sized waiting area and paths that access the waiting area. The following is a brief discussion of specific considerations for bus, bus rapid transit (BRT), light rail transit (LRT), and commuter rail.

Bus

Agencies identify bus stop locations that will maximize ridership and operate reliably. Within this framework there is flexibility in choosing stop locations—all of which can affect pedestrian and bicyclist safety. A far-side stop encourages pedestrians to cross behind the bus but can create sight distance issues for vehicles traveling in the opposite direction of the bus. A near-side stop allows passengers to access the bus closest to the crosswalk but can obscure curb signals and cause sight distance issues for drivers and pedestrians. A mid-block stop can reduce congestion at passenger waiting areas and minimize sight distance problems at intersections, but pedestrians must increase walking distance to crosswalks with the potential for an uncontrolled mid-block crossing. One should also consider bus transfers when placing bus stops. Placing stops on the same quadrant of the intersection eliminates the need for pedestrians to cross the road to transfer.

Bus stops should have good linkages to the existing pedestrian network through the use of sidewalks, curb ramps, and crosswalks. Bus activity should be a consideration when combining transit corridors with on-street bicycle facilities (see figure 7). For example, heavy transit corridors may not be suitable corridors for shared or on-street bicycle facilities.

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Figure 7. Photo. Bus approaching a bus stop by crossing a bicycle lane.

Bus Rapid Transit

The placement of BRT stops come with unique considerations. BRT stops may look like a curb side stop served by a local bus route and should be designed on local bus route principles as previously noted. BRT platforms are sometimes located at-grade in the median between travel lanes. Because of this, it is important to consider surrounding traffic speeds, pedestrian refuge space, connections to crosswalks, pedestrian control devices and timing, and transfer activity.

Light Rail Transit

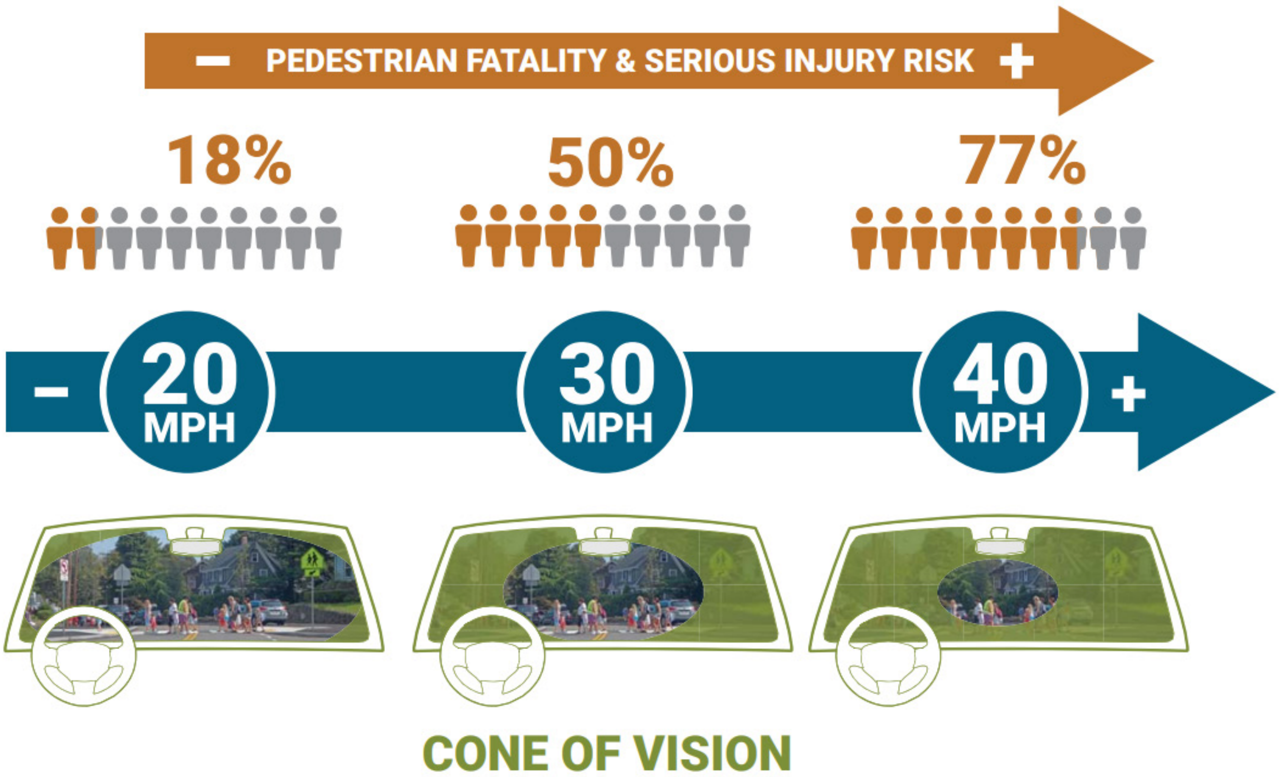
Pedestrian crossings should be clearly marked with pedestrian signals linked to the signals for the light rail and general traffic. Signs can provide warnings to pedestrians and bicyclists about LRT crossings—flashers and gates may be used to warn pedestrians and bicyclists of approaching trains or to prevent crossings.

Commuter Rail

Rail stations are large and can be a convergence of private vehicles, bicycles, buses, and pedestrians. Pedestrian facilities need to accommodate pedestrian surges (e.g., sidewalk width, crosswalk width) and should provide well-defined crossings.

Risks for Crashes

Prior analytic studies tell us that certain factors, such as roadway characteristics, increase the risk of collisions for pedestrians and bicyclists. ***The first and foremost risk is the amount of all types of traffic, but the relationships can be nuanced.*** As vehicle traffic increases, pedestrians may be discouraged from walking, especially in areas with poor infrastructure and higher speeds. In such cases, there may be relatively few collisions. Low crash numbers certainly do not indicate these locations are relatively safe and they may have a relatively high risk of severe collisions in the future. On the other hand, busy commercial areas and urban cores may have many people traveling by all modes. While collisions may be more frequent in such locations, the population-level risk of fatalities and serious injuries may be lower than in other areas. This is because traffic speeds are generally lower, and drivers may have a higher expectation to encounter pedestrians. At lower speeds, drivers also have a greater visual field and peripheral vision, as illustrated in figure 8.



Source: 2016 FHWA.

Figure 8. Graphic. Relationship between vehicle speeds, pedestrian injury outcomes, and cone of vision. [23]

Besides traffic, pedestrian and bicyclist crash risk may increase with the following:

- Increasing number of lanes (including turn lanes) presenting more conflict points.
- Increasing pedestrian crossing distance and roadway width, leading to greater exposure to traffic.
- Decreasing separation in time, such as allowing free-flow turns or right-turn-on-red movements.
- Decreasing availability of sidewalks or other facilities that separate pedestrians from motor vehicle traffic.[8]

Risks for Severity

In addition to the crash risk relationships for pedestrians and bicyclists, certain factors increase the potential for more serious injuries when a crash occurs.

Pedestrian and bicyclist injury severity may increase with the following:

- Higher speeds at impact. A pedestrian’s chance of survival is exponentially greater at lower vehicle speeds, as seen in figure 8. At higher speeds, a driver may not have enough time or distance to react and stop their vehicle.
- Pedestrian age (which is likely due to associations with increasing frailty and perhaps slower crossing times).
- Heavier vehicles (even light trucks and sport utility vehicles compared with cars).
- Nighttime.

- Alcohol use by either the driver or person walking or biking.
- Higher speed limits (by association with travel speeds).

Principles of Pedestrian and Bicyclist Safety

The RSA Team should include an expert(s) on pedestrian and bicyclist safety and facility design (e.g., sidewalks, bicycle lanes, Americans with Disabilities Act [ADA] requirements). However, other members of the team should have a basic understanding of the principles of pedestrian and bicycle safety and what to consider while conducting the RSA. Additional information on RSA Team members can be found in the RSA Team section of the guide. While this document is not intended to serve as a comprehensive resource on pedestrian and bicyclist design principles, the following information provides a summary to help prepare the RSA Team and provide a base-level of understanding. Readers should refer to the references provided to learn more about pedestrian and bicyclist safety and design.

Principles of Pedestrian Safety

Some of the factors that may influence a pedestrian's decision to walk (or not to walk) include the following:

Distance and access to desired destinations. Pedestrians should have direct and connected walking routes to desired destinations that are accessible to and usable by individuals with disabilities. The pedestrian network should be direct between key destinations, but also appropriate for characteristics of the surrounding conditions. An agency should understand pedestrians' "desire lines" and seek to accommodate pedestrians in these locations. The pedestrian network should not have gaps or abrupt changes, as seen in figure 9.

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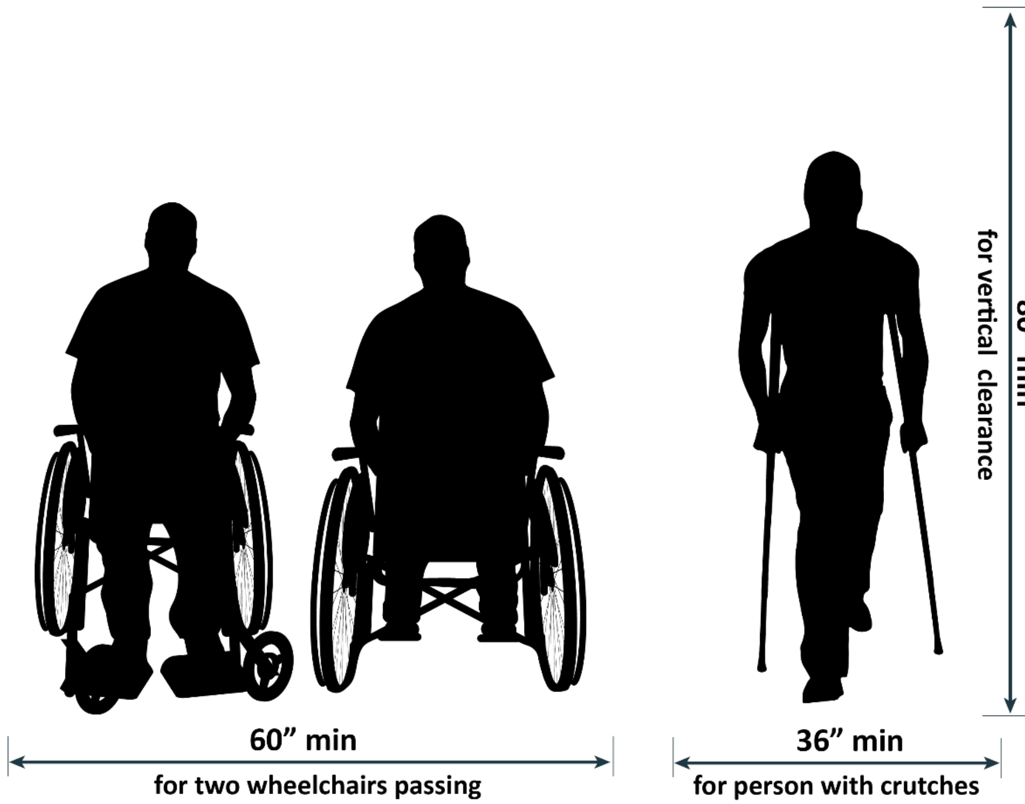
Figure 9. Photo. Pedestrians walking in the grass due to sidewalk discontinuity.

Accessibility and Space. Readers should refer to the ADA standards established by the Department of Justice (see reference 24). While these requirements are technically only applicable to newly designed, constructed, or altered facilities, agencies and designers should strive to provide the most accessible facilities possible. The space requirements below address general pedestrian needs as well as those to ensure accessibility.

At a minimum, a 4-foot sidewalk can accommodate a single pedestrian using crutches, and pedestrian facilities need to be at least 5 feet wide to accommodate passing or walking side-by-side, as shown in figure 10. Overhead clearance to tree limbs or signs of at least 80 inches is needed to avoid injury to pedestrians.

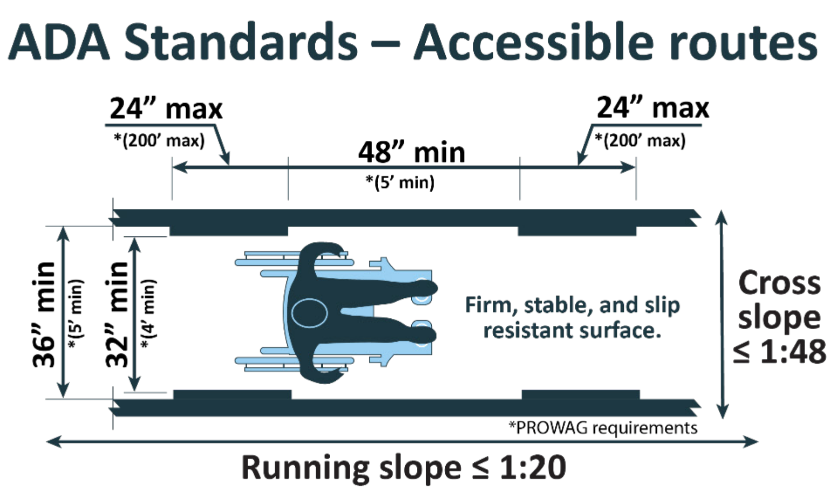
However, minimums are often inadequate to meet the needs of pedestrians. When large groups of pedestrians are present on the sidewalk, and sufficient space is not provided, pedestrian traffic will move slowly, causing some people to walk in the street, or cross to the other side of the street, violating driver expectancy. Even in less crowded areas, pedestrians may walk in the street if the sidewalk is not wide enough, or they may decide to cross the street at an unsafe location to reach a sidewalk with less traffic. Since walking is often a social activity, many pedestrians traveling in pairs or groups will walk in the street or along the grass in order to stay side by side with others.



Source: 2020 FHWA.

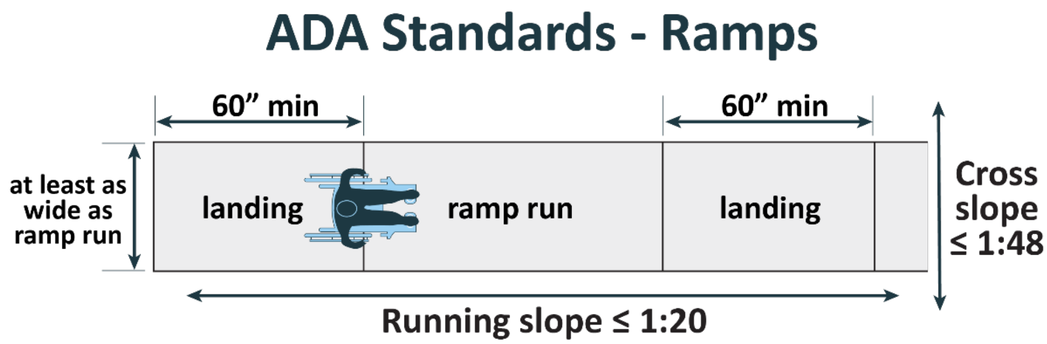
Figure 10. Graphic. Minimum space for two wheelchairs passing, person with crutches, and vertical clearance.[24]

Figures 11, 12, and 13 show ADA and Proposed Rights-of-Way Guidelines (PROWAG) requirements for accessible routes, ramps, and for when a change of direction is needed, respectively.



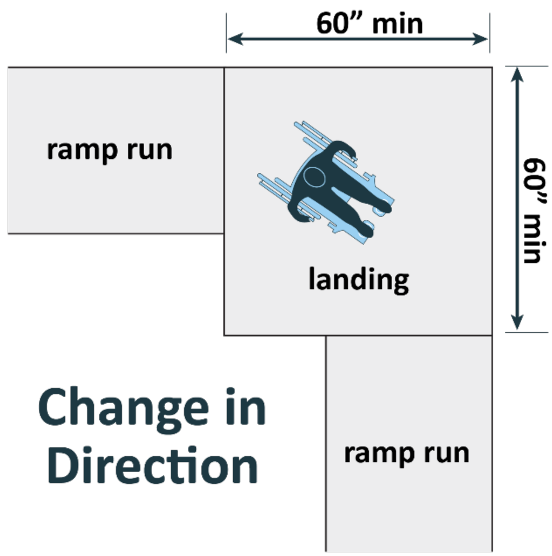
Source: 2010 Department of Justice.

Figure 11. Graphic. ADA standards and PROWAG requirements for accessible routes.[24]



Source: 2010 Department of Justice.

Figure 12. Graphic. ADA Standards for ramps.(24)



Source: 2010 Department of Justice.

Figure 13. Graphic. ADA Standards for change in direction.(24)

Intersection safety. Pedestrians may decide not to walk due to inadequate provisions at intersections for crossing safely. The provision of high-visibility marked crosswalks, pedestrian signals with accessibility features, median refuges to break up long crossings, limitations on right-turns-on-red, and other features may make intersections safer and more comfortable for pedestrians.

Necessity. People may walk because they do not have access to vehicles or may not have the physical and/or cognitive ability to drive.

Safety and comfort. Some variables that may impact a pedestrian's decision not to walk include high-speed traffic, lack of separation from vehicles, inadequate crossing facilities (see figure 14), lighting conditions, and poor quality of the walking experience. A facility may meet all design standards, but a pedestrian may feel uncomfortable and perceive the road as dangerous, especially if they are walking in close proximity to traffic. This highlights the importance of conducting field observations to note potential safety issues—both actual and perceived. The condition of the surface is a key factor in whether the facility is usable.

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Figure 14. Photo. Pedestrian waiting to cross a road without sidewalks or a marked crossing.

Health. Pedestrian facilities like sidewalks and multi-use paths provide opportunities to be physically active, which can improve health and overall quality of life.[29]

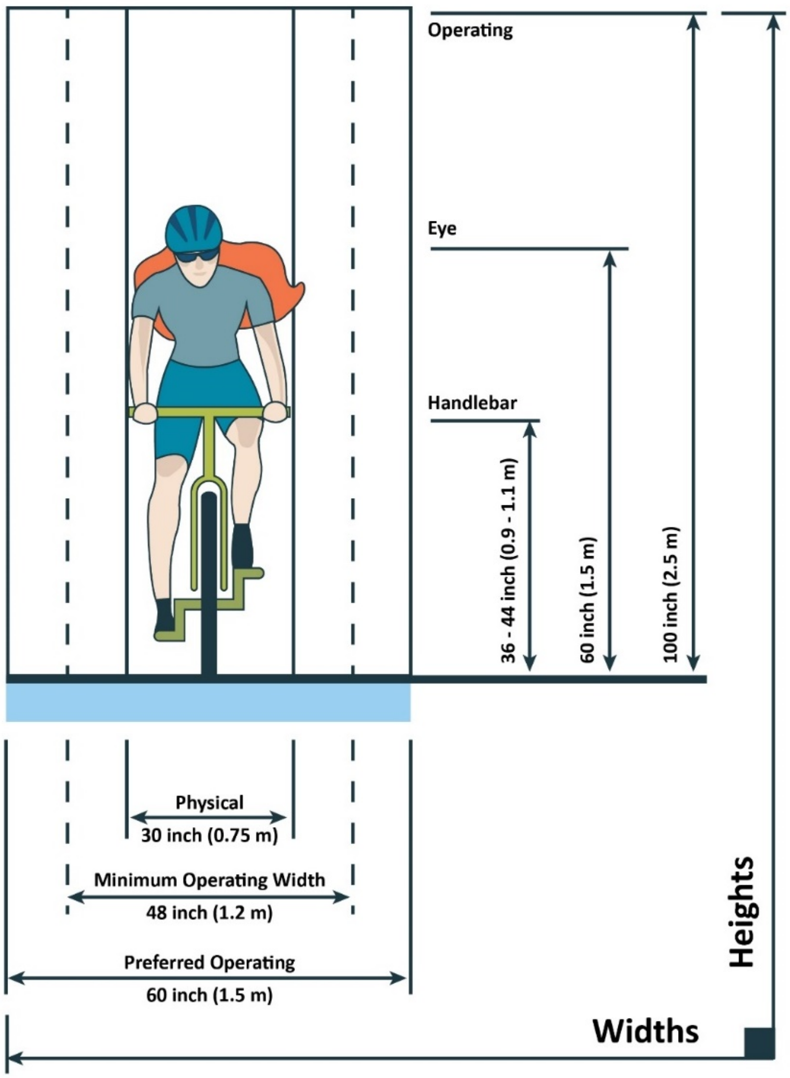
Pedestrians have a wide range of ages and abilities, both physical and cognitive. Understanding the different needs of pedestrians will add to the RSA findings. Some individual characteristics that influence safety for pedestrians along the roadway and at crossings include walking speed, spatial needs, mobility, vision, cognitive abilities (e.g., young or old age, illness, substance impairment, distraction), and behaviors in crossing choices and waiting times.

Principles of Bicyclist Safety

Characteristics of the roadway have an effect on bicyclist safety. Some considerations are the presence and type of existing bicycle facility, traffic volumes and traffic vehicle mix (e.g., trucks, buses, heavy vehicles), presence or absence of parking turnover and curbside activity, driveway/intersection frequency, vehicle speeds, surrounding land use, populations of children and older adults, lighting, lane configuration, and network connectivity.

Some of the bicycle facility design factors that influence a bicyclist's safety include the following:

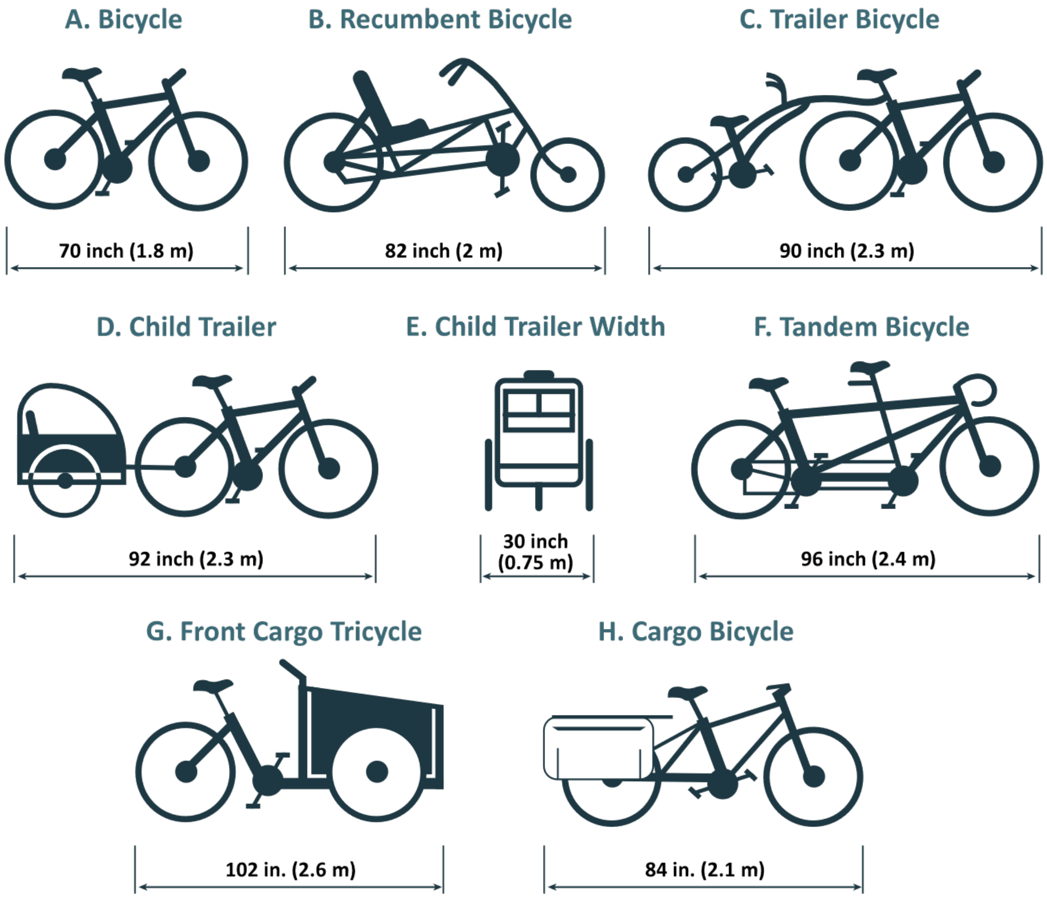
Space. A bicyclist needs a minimum operating width of 48 inches (60 inches is preferred) and height of 100 inches. Figure 15 is adapted from the American Association of State Highway Transportation Officials (AASHTO) *Guide for the Development of Bicycle Facilities* and the FHWA *Bicycle Road Safety Audit Guidelines and Prompt Lists* to show needed bicyclist operating space. [30,31]



Source: 2012 FHWA.

Figure 15. Graphic. Bicyclist operating space [31]

Length. Bicycles can come in a variety of configurations and sizes. Facilities that accommodate these ranges of bicycle types will result in higher levels of bicyclist comfort and safety. Figure 16 shows common bicycle configurations and dimensions and was adapted from the AASHTO *Guide for the Development of Bicycle Facilities* and the FHWA *Bicycle Road Safety Audit Guidelines and Prompt Lists*.[30,31]



Source: 2020 FHWA.

***Figure 16. Graphic. Variation in bicycle dimensions. Adapted from FHWA.*[31]**

Stability. Bicyclists must maintain adequate speeds to be stable and avoid "zigzagging" at lower speeds, which increases space needed to safely operate. Surface condition of the roadway is important for bicyclist stability as well.

Speed, deceleration, and stopping. Uphill and downhill gradients can affect speeds and therefore distances needed to decelerate and stop, or to accelerate from a stop, and time needed to cross an intersection. Bicyclist speeds are also important for line-of-sight considerations at intersections.

Network (facilities). The following are factors that should be considered in all contexts to provide safe accommodations for bicyclists:

> **Directness**. The bicycle network should be direct between key destinations, but also appropriate for characteristics of the surrounding conditions. An agency should understand bicyclists' "desire lines" and seek to accommodate bicyclists in these locations.
>
> **Continuity and connectivity**. The bicycling network should not have gaps or abrupt changes besides the beginning and end terminals of a bicycle facility. These transition areas typically occur when land use changes and should be clearly defined with signage or pavement markings.

Comfort. A bicyclist's behavior may be influenced by the perceived risk and level of comfort. Factors affecting comfort levels can include degree of separation from vehicular traffic, lighting, roadway condition, and a rider's confidence in ability. NCHRP 941 found that bicyclists rated facilities having a higher degree of separation from drivers more positively, with protected/separated bike lanes and multi-use paths being the best. The study also showed that parking was a clear deterrent for comfort, perceived safety, and willingness to bicycle.(32)

RSA Overview and Process

The FHWA definition of an RSA is:

An RSA is a formal safety performance examination of existing or future roads or intersections by an independent audit team. The RSA Team considers the safety of all road users, qualitatively estimates and reports on road safety issues, and identifies opportunities for safety improvement.

The primary focus of an RSA is safety while working within the context of mobility, access, surrounding land use, and/or aesthetics. RSAs enhance safety by bringing together a multidisciplinary team that identifies potential safety issues affecting all road users under all conditions and suggests measures for consideration by the design team or responsible agency.

While all RSAs should include a review of multimodal safety, a pedestrian- and bicyclist-focused RSA strives to improve identified safety issues that may have resulted from changes in land use and mode choice over time or inadequate consideration of walking and cycling in previous planning and design processes.

The aim of an RSA is to answer the following questions, which will also apply to pedestrian- and bicyclist-focused RSAs:

- What elements of the road may present a safety concern: to what extent, to which road users, and under what circumstances?
- What opportunities exist to eliminate or mitigate identified safety concerns?

An RSA is not simply a standards check. Although important, standards checks are included in the design process to confirm adherence to the design standards applicable to the project. The RSA Team may identify safety issues by comparing items of concern to standards and to key industry guidance publications. The general intent of an RSA is to identify areas where applied designs may interact with road user behaviors to generate a potential safety issue. Agencies may also use field observations to conduct other activities, like inventorying sign condition or other assets along a corridor or intersection.

When Should RSAs be Considered?

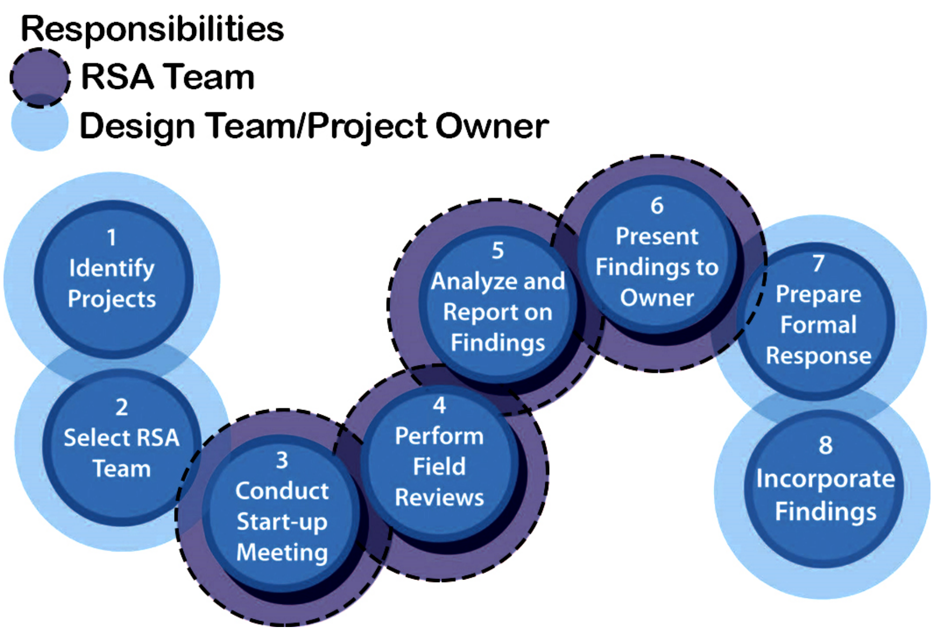
RSAs can occur at any stage of a project:

- Pre-construction (planning, preliminary design, final design).
- Construction (work zone traffic control plan, pre-opening).
- Post-construction (existing roads open to traffic).

While an RSA can occur at any stage of a project, agencies should strive to start an RSA at the earliest feasible stage. An RSA in the early stages of planning and design can identify issues when they can most easily be rectified. RSAs on existing projects are helpful in identifying pedestrian and bicyclist safety issues, in that, many agencies devote less resources to understanding such issues. Therefore, they may be unaware of problems or may not be experienced with detailed facility designs. It is a common perception that a pedestrian or bicyclist safety issue may not exist based on a review of reported crashes. However, many bicycle and pedestrian crashes go unreported, or the absence of facilities like sidewalks and bicycle lanes may suppress walking and biking. An RSA can help to overcome these challenges by identifying safety issues that are not identified in the data and opportunities to enhance the walking and biking environment.

Pedestrian- and Bicyclist-Focused RSA Process

This section describes the eight steps recommended by FHWA to conduct an RSA, along with suggestions for adequately considering pedestrians and bicyclists in the process. Figure 17 illustrates the progression of these steps. The responsibilities of the project owner/design team and the RSA Team may vary during an RSA.



Source: 2012 FHWA.

Figure 17. Graphic. Eight-step RSA process.

Step 1 – Identify Project or Existing Road for RSA

The project owner (i.e., the person or agency that owns or is responsible for the project or facility) identifies the project(s) to be audited. The owner should develop clear parameters for the RSA. ***Evaluating the safety of both pedestrians and bicyclists may require looking beyond the specific roadway or project to include parallel pedestrian and bicycle paths, routes, and connections that may affect bicyclist and pedestrian safety.*** The parameters should define the RSA scope, schedule for completion, RSA Team requirements, required tasks and requirements on the content and format of the RSA report, and how responses to the RSA report will be handled.

During this step, the project owner can use crash data to identify locations with the highest crash frequencies or severities to include in the RSA study area. Locations that do not have crash histories but have similar characteristics to high-crash locations, may also be considered in the study area because of these shared risk factors. Data can help support anecdotal evidence from the general public, pedestrian and bicycle advocacy groups, local officials, local school staff (e.g., principal, transportation director, superintendent), and other stakeholders to confirm locations that are considered more dangerous for pedestrians and bicyclists. Because data has limitations, conducting field observations provides valuable insights in roadway users' behaviors and interactions that are not found in a database. See the Data Analysis section for detail on data analysis sources and methods.

Step 2 – Select Independent and Multidisciplinary RSA Team

The project owner is responsible for selecting the RSA Team or the RSA Facilitator/Team Leader. To make sure there is no conflict of interest and a fair and unbiased evaluation will be conducted, the RSA Team must be independent of the operation and design of the location(s) being assessed and cannot include members of the party charged with the development of the original plans or the facility owner. The project owner may select a set of qualified individuals from within its own organization, another transportation agency, or contract with an outside group. If a non-independent assessor wishes to evaluate the pedestrian or bicyclist safety elements of a project, the process may still be valuable but should not be considered a formal RSA.

The project owner should select an RSA Team that possesses a combined set of skills that address the most critical aspects of the project. For pedestrian and bicyclist RSAs, the team members should be aware of constraints and issues that affect those non-motorized users and have a background in (1) road safety; (2) traffic operations; (3) road design; (4) accessibility needs for pedestrians with disabilities; (5) bicycling safety, operations, or planning (or someone who understands the skills necessary for bicycling on the road with traffic); (6) transit operations; (7) enforcement (e.g., bike patrol officer); or (8) emergency medical services (EMS).

Since the independence of the audit team is a requirement of an RSA, local agencies are encouraged to contact the State Department of Transportation (DOT), the Local/Tribal Technical Assistance Program (LTAP/TTAP) center, FHWA Division Offices, or the FHWA resource center for assistance in finding team members.[26,27] The local agency may also find it helpful to contact neighboring local agencies directly to assemble an independent team. The owner should consider including individuals from local cycling organizations or bicycle and pedestrian committees, as they may provide valuable insights and detailed knowledge of the local area. Also consider inviting diverse members of the disability community to represent key disability perspectives (e.g., hearing, vision, cognitive, and mobility).

The size of the RSA Team may vary. Small teams typically provide the greatest ability for team members to significantly contribute insights during the audit but may be limited in experience with the various areas of expertise. While three members may be adequate for some projects, that size may be insufficient for larger, more complex projects. The best practice is to have the smallest team that brings all the necessary knowledge and experience to the process.

Step 3 – Convene RSA Team Meeting

The purpose of the RSA Team meeting is to make sure all RSA participants introduce themselves and their area of expertise, understand the RSA process, review the RSA data packet material (e.g., area map, crash data), provide an overview of schedule/logistics, and assign roles and responsibilities. RSA participants should be given a packet with relevant information (data, maps, schedule/logistics) to have in the field. Materials for this packet are discussed in the *Logistics* section and Appendix A. This meeting helps establish lines of communication between the RSA Facilitator/Team Leader and the project owner. At the end of the meeting, all parties should have a clear understanding of the scope of the RSA and each of their roles and responsibilities.

Specific topics of discussion should include:

- RSA scope and objectives.
- Pedestrian and bicyclist data (e.g., crash data, volumes, peak and off-peak hours of travel, locations of key pedestrian and bicycle generators, and citizen requests and complaints).
- Context of the study area through sources like crash and volume data, maps/aerials, future transportation plans, transit accommodations, and surrounding land use.
- Design constraints, standards used, ADA Transition Plan, bicycle plans, and findings of previous studies (if applicable).
- Local laws/statutes describing rights and duties of all road users. Key laws may include where bicycles are legally allowed to operate (i.e., sidewalk or street) and yield versus stop requirements for motorists at crosswalks.

Preferably, any available data should be provided to the participants for review and analysis prior to the RSA Team meeting. This enables the team to familiarize itself with the location, understand potential safety issues, and ask more focused questions.

Step 4 - Perform Field Reviews

The RSA Team should review the entire site (as well as plans if conducting an RSA of a design), documenting potential safety issues and project constraints (e.g., available right-of-way, impact on adjacent land). Issues identified during the review of the supplied data should be verified in the field. A thorough field review for an RSA should consist of the following:

- **Include a walk- or ride-through**. The RSA Team should review the site during the daytime and nighttime to experience conditions from the perspective of all roadway users, with a focus on pedestrians and bicyclists. The RSA Team should walk, bicycle, and drive on or along the roadway (and on the pedestrian and bicycle facilities, if available) and note potential issues with the physical elements, as well as the behavior of cyclists, pedestrians, and other road users (see figure 18). The field review should also include visits during both peak and non-peak traffic conditions, as well as the afternoon when schools are let out, if applicable to the study area. Pedestrian and bicyclist safety, mobility, and access are heavily influenced by traffic conditions and issues may change depending on the time of day.

- **Consider a wide range of abilities**. A wide range of pedestrian and bicyclist experiences and capabilities should be accommodated. Pedestrian and bicyclist facility designs should accommodate children who lack experience and cognitive development judging vehicles and safe gaps for crossing and lane positioning, as well as adults with differing hearing, vision, cognitive, and mobility levels.

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Figure 18. Photo. RSA Team conducting site observations.

- **Consider visibility of pedestrians and bicyclists, especially at night**. There are several reasons why the visibility of pedestrians and bicyclists may be limited. People do not only walk and bike for exercise but also choose those modes to run errands, travel to work, or for any other daily task. As such, they may not be wearing bright or reflective clothing. Additionally, the smaller profile of pedestrians and bicyclists reduces their conspicuity to motorists. During dark conditions, the smaller profiles combined with the lack of bright headlights and the placement/type of overhead lighting, can exacerbate the visibility and conspicuity issue. These factors increase the risk of collision, especially in situations where drivers are watching for potentially conflicting vehicles, such as where right-turns-on-red are permitted.
- **Examine the treatment and transition of bicyclist and pedestrian facilities.** Pedestrian and bicyclist facilities should be designed with attention to connecting facilities throughout the project area and during construction. Discontinuities in pedestrian facilities can result in pedestrians being forced into the roadway, exposing them to increased risk of collisions. Alternatively, facility discontinuities for bicyclists can cause confusion for both motorists and bicyclists on lane position.
- **Consider pedestrian, bicyclist, and driver behavior beyond the project limits.** Designs outside of the project limits may have a significant effect on users' behaviors. An example of this is a traffic calming project that diverts traffic from a neighborhood, increasing the volume on main streets. If this diverted volume leads to congestion, it could change the site conditions for both drivers and pedestrians.

Key elements to observe include:

- Site characteristics (e.g., road geometry, sight distance, clear zones, drainage, surface condition, signing and marking, lighting, barriers).
- Traffic characteristics (e.g., traffic/pedestrian/bicycle volumes, movements, speeds).
- Human factors issues (e.g., road user behavior and deviations from normal, interactions between modes).
- Surrounding land uses (e.g., bicycle, pedestrian, and vehicle trip generators).

The prompt lists in Appendix B are designed to be used during the field review to remind the RSA Team of numerous aspects of pedestrian and bicyclist safety. This includes a review of the prompt lists by the RSA Team in the field for each type of facility encountered, annotating any issues on paper and with photographs.

Step 5 - Analyze and Report on Findings

Following the field review, the RSA Team should convene to discuss observations made in the field. The team should work together to identify positive features throughout the study area and safety issues based on data from the field visit and pre-audit material. Identification of safety issues should not be solely based on pedestrians and bicyclists; safety issues affecting all roadway users should be acknowledged and considered in this process. Issues should not be noted for traffic operations, like delay or queue lengths, unless there is a clear link to safety. For each identified safety issue, there should be a corresponding recommendation. These recommended improvements should be identified in various areas like engineering, education, enforcement, Emergency Medical Services (EMS), or any other areas that may be beneficial to user safety on the facility. It can be beneficial to the implementing agency if the RSA Team categorizes the recommendations into short-, mid-, or long-term timeframes. Seeing a complete list of recommendations may be overwhelming to an agency as it may not seem clear how to proceed. Noting timeframes can help the implementing agency begin to plan and program funding toward these projects.

These findings are compiled into a report. The resulting RSA report is a concise document, that includes a brief description of the project, a list of the RSA Team members, materials used in conducting the RSA, and a summary of findings and suggestions for improvement. The report includes pictures and diagrams that may be useful to illustrate points made. An example report outline is provided in Appendix A. Other resources can be found on FHWA's RSA webpage.[(28)]

In addition to timeframe, the safety issues may also be prioritized by the RSA Team based on the documented risk (through crash data or exposure analyses) or perceived risk. Perceived risk may be based on the expected crash frequency and the expected severity of a crash. Expected crash frequency is qualitatively estimated by expected exposure (i.e., how many road users will likely be exposed to the identified safety issue) and probability (i.e., how likely is it that a collision will result from the identified issue). Expected crash severity is qualitatively estimated based on such factors as anticipated speeds, expected collision types, and the likelihood that vulnerable road users will be exposed. These two risk elements (frequency and severity) may be combined to obtain a qualitative risk assessment based on the matrix shown in table 1.

Table 1. Prioritization matrix.

Frequency of Crashes	**Severity of Crashes**			
	Possible/Minor Injury	**Moderate Injury**	**Serious Injury**	**Fatal**
Frequent	Moderately High	High	Highest	Highest
Occasional	Middle	Moderately High	High	Highest
Infrequent	Low	Middle	Moderately High	High
Rare	Lowest	Low	Middle	High

Step 6 – Present RSA Findings to Project Owner

The RSA Team may present their findings and recommendations for improvement in various ways depending on the project. The presentation can take place in-person or as an online meeting, as a slideshow or preliminary report. The findings and recommendations may either be draft or final at this time. The purpose of this meeting is to finalize the RSA report and to make sure the report will adequately address the scope and objectives of the RSA. The project owner may ask questions to seek clarification on the RSA findings or suggest additional/alternative mitigation measures. At the conclusion of this step, the RSA Team provides a final review of the RSA report.

Step 7 - Prepare Formal Response

After reviewing the RSA report, the project owner should prepare a written response that outlines what actions the project owner will take with respect to each safety concern listed in the RSA report. To build support for the findings and the overall RSA process, the RSA findings may be presented in a public meeting or the report could be made available to the public. The timeframe for making this information public may vary for each agency.

Step 8 - Incorporate Findings

After the response to the RSA report is prepared, the project owner should work to implement the agreed-upon safety measures or create an implementation plan. Implementation of the suggested measures is at the discretion of the project owner and appropriate staff based on their project schedules and available funds.

Data Sources

There are numerous primary and secondary sources of information that can support the RSA Team's preparation for the field review and throughout the report drafting process. These sources include information on crashes, roadway characteristics, land use, proposed site plans and roadway improvements, transit, and community observations. Each type of data provides valuable insights into how bicyclists and pedestrians are experiencing—or will experience—the corridor as well as safety performance and potential safety improvements.

Crash Data

If available, crash data for bicyclists and pedestrians can aid in identifying locations or situations where safety is a concern. The infrequency of bicyclist and pedestrian crashes compared to only vehicle-to-vehicle crashes necessitates multiple years of data to see any trends; a minimum of 3 years of crash data is recommended, but 5 to 10 years is ideal. Crash data should be geolocated or contain location information to be processed for inclusion on crash diagrams. FARS does not capture crashes that do not involve vehicles, so hospital and urgent care records (e.g., intakes of blunt force trauma) can be a useful source of injury data.

Crash data is critical to the RSA process. However, there are limitations related to under-reporting. Additionally, certain contributing circumstances for crashes can be difficult to capture because it requires drivers and pedestrians to self-report violations, such as distraction, drowsiness, and substance impairment.

Crash reports also provide valuable insight into circumstances surrounding a crash. The narratives provided in these reports explain driver or pedestrian behaviors that resulted in the crash. This information, however, varies by crash and may not be practical to analyze for each crash within the study area. For smaller RSA areas with fewer pedestrian crashes, it may be beneficial to review individual crash reports to identify trends or patterns in behavior. It can also be beneficial to have one or two sets of these crash reports on-hand during the RSA to provide a deeper understanding of how the site is functioning. The FHWA Pedestrian and Bicyclist Crash Analysis Tool (PBCAT) can help practitioners in the analysis of crash typologies.[(33)] This tool enables users to develop a database of details associated with crashes between motor vehicles and pedestrians or bicyclists. PBCAT users can analyze the data, produce reports, and select countermeasures to address the problems identified by the software.

The process for obtaining crash data is dependent on the jurisdiction; while some local agencies maintain crash databases, the respective State DOT may manage that information. Enough time should be allotted for requesting data, as requests may require disclosure forms and other requirements. If possible, the crash data should include the reporting law enforcement officer's crash narratives and diagrams and should also be supplemented with hospital admittance records to assist in understanding contributing crash factors and injury outcomes. Also, crash data for vehicular crashes may be considered in the analysis, since such crashes provide insights into common safety issues like elevated vehicle speeds, low yielding rates, turning vehicle conflicts, and access management issues that affect all users.

In addition to crash data, secondary sources of data can be obtained about near misses or perceived safety/access issues through pedestrian and bicycle advocacy groups, community surveys, crowd-sourced data, online forums, or complaint hotlines.

Roadway and Traffic Data

Information on roadway geometry, posted speeds, lane configuration, parking utilization, bicycle and pedestrian facilities, lane/shoulder widths, signalized intersection operation (e.g., signal phasing, turn restrictions), history of improvement projects, and multimodal volumes are essential inputs prior to the field review. Many of these data needs can be met by the local liaison or host agency, and sufficient time should be considered when requesting data. If certain roadway information is not available, review of aerial maps and other mapping resources and discussions with RSA Team members may be sufficient.

Gathering volume data for all modes and types of vehicles is important to better understand the context of the RSA area. If available, important information to obtain within the study area include traffic volumes (e.g., Average Annual Daily Traffic [AADT], short-term counts, video log) for various modes (e.g., vehicles, pedestrians, bicyclists), truck and heavy vehicle usage percentages, intersection turning movement counts, and transit stop locations with boardings and alightings. If exposure data is unavailable—especially for bicycle and pedestrian activity—secondary sources of data can be obtained through pedestrian and bicycle advocacy groups, community surveys, crowd-sourced data, or online forums for a qualitative understanding of volumes and routes.

Observational Data

While not a primary source of data, observations from the community and local RSA Team members are critical in understanding the RSA study area. Such observations may include speed studies and/or 85th percentile speed, vehicle yielding rates, bicycle and pedestrian behaviors, and perspectives on perceived unsafe locations. Sources of observational data may include the local bicycle and pedestrian committees, local cycling groups, and neighborhood or chamber of commerce organizations.

Land Use and Trip Generation Data

Understanding land use and its effect on pedestrian and bicyclist mobility and safety is foundational to preparing for the RSA field review. Different land uses impact the amount, time, and pattern of bicycle and pedestrian trips. For example, a commercial district with shopping and grocery stores will likely experience heavy pedestrian and vehicle volumes during the evening and weekend hours, whereas a school location will see higher volumes of younger pedestrians and turning vehicles (for pick up and drop off) during the morning and mid-afternoon periods. Additionally, employment centers with shift-based work will likely experience peaks of pedestrian activity during low-light conditions that deserve special consideration during the nighttime field review. Land use information may also guide data on pedestrian and bicycle counts; certain land use combinations, like schools and parks, are anticipated to generate higher volumes of pedestrian activity.

Relevant Plans and Policies

Review of site plans, infrastructure designs, other improvement projects, and related policies for the RSA study are of high priority before the field review. In some instances, the RSA itself may have been initiated based on anticipated pedestrian and bicyclist activity from the redevelopment of an area. Policies and standards are also important for understanding the study area and potential improvements to address safety issues. Relevant plans and policies to consider include:

- Local capital improvement plans.
- Plans for roadway or safety improvements.
- ADA Transition Plans.
- Bicycle, pedestrian, and greenway plans.
- Corridor and small area plans.
- Plans for changes in land use/property access.
- Transit short- and long-range operations plans.
- Site plans for parcels of significance.
- State Transportation Improvement Plan projects.
- Regional transportation plans (Metropolitan Transportation Plan, Comprehensive Transportation Plan, or equivalent).
- Complete Streets policies.
- Safe Routes to School or School Zone policy.
- Roadway design standards.
- Curbside activities, policies, and schedule (e.g., street cleaning, trash collection, EMS access).
- Planned maintenance activities (e.g., repaving, mowing, sign replacement).

Data Limitations

The RSA Team should fully understand constraints related to each data source, especially for crash data and crash diagramming. The review of crash data alone is generally not sufficient to comprehensively identify and address pedestrian and bicyclist safety issues in large part because of the factors that contribute to a crash, which are not always captured in a crash report. The RSA Team should consider that the reported crashes only represent a portion of the crashes that have occurred. Law enforcement-collected crash data typically only contain crashes involving motorized vehicles. Research shows a consistent underreporting of pedestrian and bicyclist crashes. ***As many as 55 percent of pedestrian crashes and even more bicyclist crashes may be missing from police-reported crash data.***[(1)] *The under-reporting of these crashes may be due to a variety of factors, including crash reporting thresholds related to damage and the fact that police only collect crash data that involves collision with a motor vehicle. Although more difficult to obtain, the RSA Team should consider seeking other sources of data, such as hospital or emergency department records or indications of bicycle crashes from self-reports to area agencies. Seeking input from community groups, such as local cycling groups, may help provide information on cycling conditions and "close calls." The team should also focus on conflicts and conditions that are likely to have contributed to unreported crashes.*

Analysis Methodologies

Once the data are assembled, the RSA Facilitator or Host may conduct analyses to identify focus areas, modify the RSA study area, or add as additional background to guide the study team during the RSA process. There are several approaches to analyzing the data sources above to inform the RSA. These include the analysis methods below, which may be used in combination to provide a complete review of bicyclist and pedestrian safety issues.

Hot Spot and Crash Diagramming

Hot spot or crash cluster analysis involves the mapping of individual crash events over the period of study (i.e., at least 3 years of crash data). Mapping these locations will reveal notable locations where crashes have occurred in high frequencies. These areas may include corridors and intersections that share common features or similar land uses. Crash severities should also be considered, especially deeper investigation into the contributing factors and behaviors of fatal and serious injury crashes. Grouping crashes can show areas with potential for bicycle and pedestrian improvements. If police reports are available (or if the crash data provide sufficient detail), creating crash diagrams can also illustrate the details surrounding bicycle and pedestrian crash events, such as the position of the pedestrian or bicyclist and angle of the vehicle.

Systemic Analysis

Systemic analysis can complement hot spot analysis. Systemic analysis can reveal locations that have high crash risks but currently display low bicycle and pedestrian crash frequencies or rates. This type of analysis is particularly important for bicyclists and pedestrians as there is proven under-reporting and if a hot spot analysis was solely used, the smaller amount of crash data may limit the RSA Team's understanding of true locations of concerns. This methodology looks at the crash data as a whole and identifies associated factors, such as roadway design and traffic controls, lighting presence (or absence), vehicle speeds, and pedestrian destinations. Combinations of these factors can help identify countermeasures to address and reduce the risk of bicycle and pedestrian crashes. FHWA's Systemic Safety website provides more information on the systemic approach to safety, including a tool for systemic project selection.(34,35)

Network Connectivity

Assessing the connectivity of the pedestrian and bicycle network can reveal gaps along roadways and at midblock and intersection locations. The RSA Team should consider existing and planned improvements when evaluating the level of connectivity within the study area. In situations where the main roadway has high vehicle volumes, high speeds, or few dedicated pedestrian and bicycle facilities, the study team should include parallel roadways in the network connectivity review, as such routes may provide increased comfort and reduced vehicle conflicts.

Roles and Responsibilities

The following section will discuss the logistics of conducting an RSA, including a discussion of team members' duties, recommended materials for meetings, field visits considerations, and the use of innovative technologies and resources.

Project Owner

The project owner is the person/agency that owns or is responsible for the project or facility that will be audited. The owner should develop clear parameters for the RSA that define the RSA scope, outline a schedule for completion, highlight the recommendations of the RSA Team, plan for field observation, outline content and format of the RSA report, and determine how responses to the RSA report will be handled. The project owner may also assume some (or all) of the responsibilities of the RSA Host.

RSA Host

The RSA Host is responsible for the planning and logistics of the RSA. The project owner may also be the RSA Host, but if these roles are separated, this person may be responsible for the initial selection of the project area, securing an event date, reserving a meeting location, reserving field visit vehicles (if applicable), recruitment of and communication to the RSA Team, preparing/printing RSA Team packet materials, and assembling field visit materials.

RSA Facilitator/Team Leader

The RSA Facilitator/Team Leader must be deeply familiar with the RSA process and each participant's roles and responsibilities. This person is responsible for developing and leading the RSA workshop presentation, facilitating the field visit, and preparing the report. The Facilitator/Team Leader may also be responsible for refining the project area, preparing the agenda, and creating map packet contents.

RSA Team

The goal is to form an independent and multidisciplinary team that will draw upon deep and skilled knowledge of their discipline to share complementary perspectives of the study area. The variety of disciplines that make up a diverse team can include the following:

Essential members

- **Transportation Engineer -** Roadway designers and can weigh-in on how designs relate to standards and plans for the agency. Traffic operations engineers can provide insights into design standards and potential changes to the roadway environment or signal timing.
- **Transportation Planner** – Planners can weigh-in on long-range plans and how land use may change and influence mode choice, mode shift, and pedestrian and bicyclist activity.
- **Safety Specialist** – These staff could include planners, traffic engineers, or others that have specialized in safety. These stakeholders can provide a perspective on quantitative safety and the use of tools and techniques to estimate the expected safety performance in terms of crash frequency and severity across the various modes.

- **Transportation pedestrian and bicyclist expert** – While the information provided in this guide provides an overview, it is important to have a team member who is intimately knowledgeable on transportation safety considerations for bicyclists and pedestrians and who understands the needs of pedestrians with disabilities. One person may be able to fill this role, or it may require several individuals.
- **Law enforcement/first responders** – Law enforcement officers are on the streets every day and can provide their observations and insights into the crash reports, as well as information on crashes that may not have met the reporting threshold or where citations were issued. First responders can also provide information on crashes that may not have been reported but where they responded to a crash. It is helpful if these members can stay for the entire RSA. However, given time constraints they may only be able to participate for a portion of the time. Either way, their insights are invaluable to the RSA process.
- **Public works and maintenance** – These staff provide the perspective on construction and maintenance of the facilities. Participation in the RSA can provide them with an understanding of some regular maintenance to improve non-motorized access and safety.

Optional Members

- **Pedestrian and bicycle advocacy/vendors** – These organizations and businesses—such as local bicycle shops or rentals—have an intimate knowledge of the transportation network, how it is working, and specific concerns/suggestions identified by their members/customers. These perspectives are important, and a representative can be involved in the RSAs or can provide input at the kickoff meeting or a separate meeting. If it is possible to incorporate a bicycle ride, then members of these organizations may be helpful in leading the ride or organizing bikes for participants.
- **Community development** – Representatives from community development or business districts may be able to provide insights from their members and community. Sometimes these conversations can lead to public-private partnerships for implementing improvements or disseminating messaging.
- **School representatives** – If there is a school located within the study area, involve them in the process. Some considerations include how students and staff access the school and provide opportunities for walking and biking. Crossing guards may have insight into safety issues and the interactions and behaviors between students and drivers. If possible, involve students in future efforts to encourage and improve safety for walking and biking.
- **Community leaders** – Community representatives and leadership can provide feedback from community members, at least during the kickoff meeting or a separate meeting.
- **Public transit** – If public transit is present within the study area, understanding the transit types and how transit riders access stops are all important to pedestrian and bicyclist safety.
- **Accessibility representative** – Some of the essential team members should have expertise in ADA requirements for pedestrians and bicyclists. However, it may be beneficial to involve a specialist in this area or members from the accessibility community. The RSA is not a standards check, but having this perspective confirms the facilities work for users of all abilities.

Based on the RSA site and special features or considerations important to the agency, the participant list may vary from those listed above. It is the responsibility of the RSA Team to be active participants throughout the RSA process. This includes gathering field data (e.g., compiling notes and taking pictures or video of both positive features and potential issues related to the infrastructure, roadway users' behaviors, and maintenance activities), sharing unique perspectives and expertise to the group, asking questions, and contributing to and reviewing the final report.

Logistics

As outlined in the eight steps, the RSA has many components like setting a date and meeting location, assembling the RSA Team, compiling and analyzing data, conducting a field visit, recommending solutions, and preparing a final report. The RSA Facilitator and RSA Host are responsible for coordinating these activities for a successful RSA. The following sections should be considered when planning and conducting the RSA.

RSA Team Packets

The RSA Facilitator should develop packet contents to provide the relevant data and instruction for a productive RSA. These materials can include site maps, crash data tables/summaries, crash diagrams, prompt lists, and other supporting RSA materials. For certain material, like maps and aerial imagery, it should be printed in a way that the RSA Team can write notes and/or draw on the aerial imagery and maps in the field. Ensure that all materials and meetings are accessible to individual team members with disabilities.

Field Visit Locations

The RSA Facilitator should predetermine the sequence of locations where RSA participants can safely meet to begin review of the site or segment. If the RSA area is large, then the RSA Team may be split up for adequate coverage. The area should be well defined and communicated to the RSA Team to make the best use of time and minimize time where observations are not being made.

Meals

The Facilitator should coordinate with the RSA Team how to address meals throughout the RSA field visit so observations are ongoing by at least some RSA Team members. For example, the mid-day lunch rush is an important time to observe pedestrian and bicyclist activity, so lunch breaks for the RSA Team members should be staggered in a way so that observations are continuous during the whole lunch peak.

Vehicles

Depending on the size of the RSA area, the location of the pre-field meetings, and if the RSA Team will be split up across the study area, the RSA Team may need to drive to reach the desired locations. In the case where driving is required, the RSA Facilitator/Host should coordinate vehicle use, whether that is one vehicle, shared vehicles, or a combination of vehicles.

General Field Review Considerations

The RSA Facilitator and RSA Host must understand the site and known concerns and consider overall health and safety of the review team.

If there are locations that are unsafe to observe field conditions, the RSA Team should still experience the site in whatever method possible (such as driving through the site but not getting out and observing as a large group). Consider gathering other observational data from other means, such as setting up a video camera.

The RSA Facilitator and Host should discuss the range of likely weather conditions for the RSA and inform the participants of the recommended clothing, footwear, and personal protective equipment (if applicable). Discussing weather may also shape how and when the RSA is conducted and contingencies should weather not cooperate. It may be difficult to spend long periods outdoors in high heat or cold conditions and weather events may change the types of users on the road and how they behave. However, in areas where it snows frequently, that may not deter pedestrians and bicyclists and those observations can make clear what parts of the roadway are used. It is important to get an accurate observation of road users in a way that is safe for the RSA Team.

The RSA Team should have the following materials during the field review:

Essential

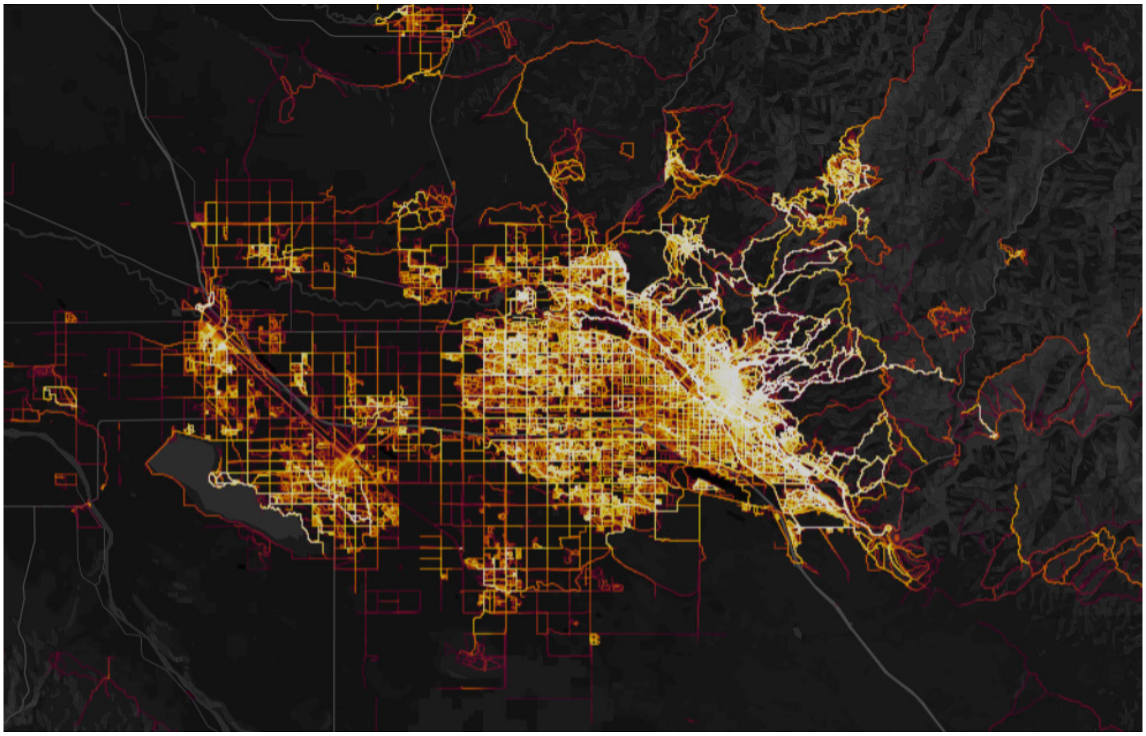
- Safety vests.
- Camera/smartphone.
- Chargers/batteries (for phones, tablets, cameras).
- Team packets with clipboards.
- Writing utensils (e.g., pen, marker, highlighter).
- Clipboards or rigid notepads.
- Measuring wheel/tape.
- Water bottle.
- Weather protection (e.g., hats, sunglasses, sunscreen, gloves, coats).

Optional

- Flashlight.
- Light meter.
- Radar gun to measure speeds.

Innovative and Advanced Technologies and Resources

Technology can be a useful tool to gather additional data and supplement the findings with camera or video footage. For example, mobile applications can be developed for smartphones and tablets to geolocate pictures taken in the field and add captions or notes. Other mobile applications can track movements of pedestrians and bicyclists and could be a source of data to indicate common routes and origins and destinations of trips. Figure 19 shows a screenshot of Strava heatmap data available for free from their website. Data from sources such as this may not be indicative of every type of user; however, it can help inform an RSA Team’s knowledge about users and how they travel through the study area.



©2019 Strava.

Figure 19. Graphic. Strava bicycle and pedestrian heatmap data for Boise, Idaho.

Cameras mounted on a vehicle as seen in figure 20 capture footage while driving through the study area. This footage confirms aerial imagery and roadway inventory databases, like seen in figure 21. Screenshots of the footage can also be used in the final report to show safety issues.

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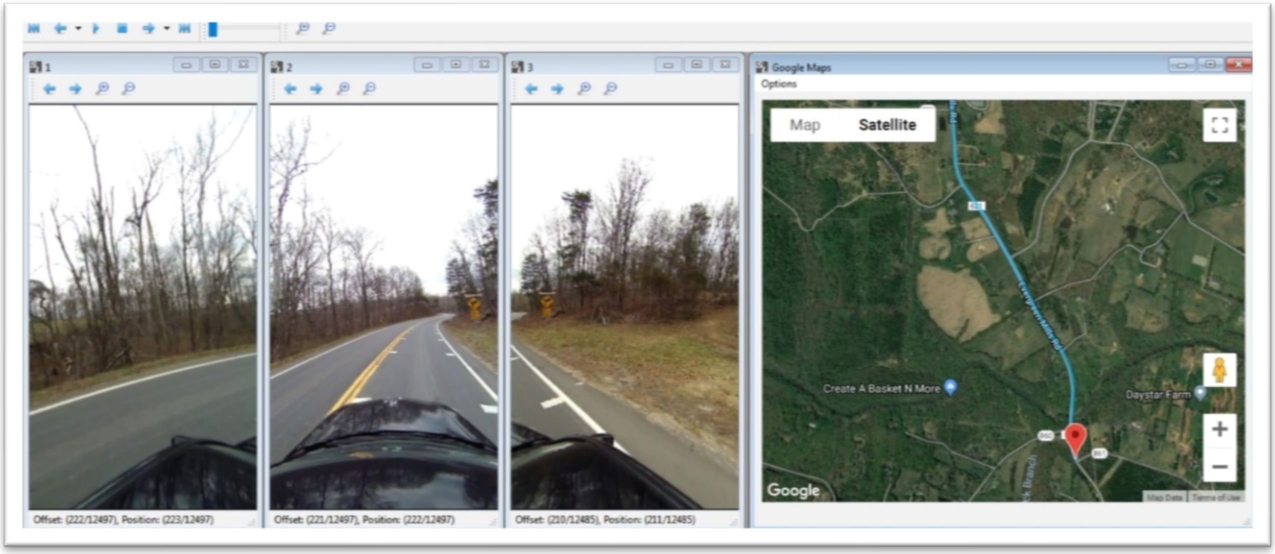
Figure 20. Photograph. Camera-mounted vehicle.



©2019 VHB.

Figure 21. Photograph. Google Earth footage.

The RSA Team can set up video cameras at a single location or intersection to capture pedestrian and bicyclist activity for a longer duration than feasible in the RSA field observation, as seen in figure 22 and figure 23. This is useful in areas where pedestrian or bicycle activity is low or is more prevalent late in the night.

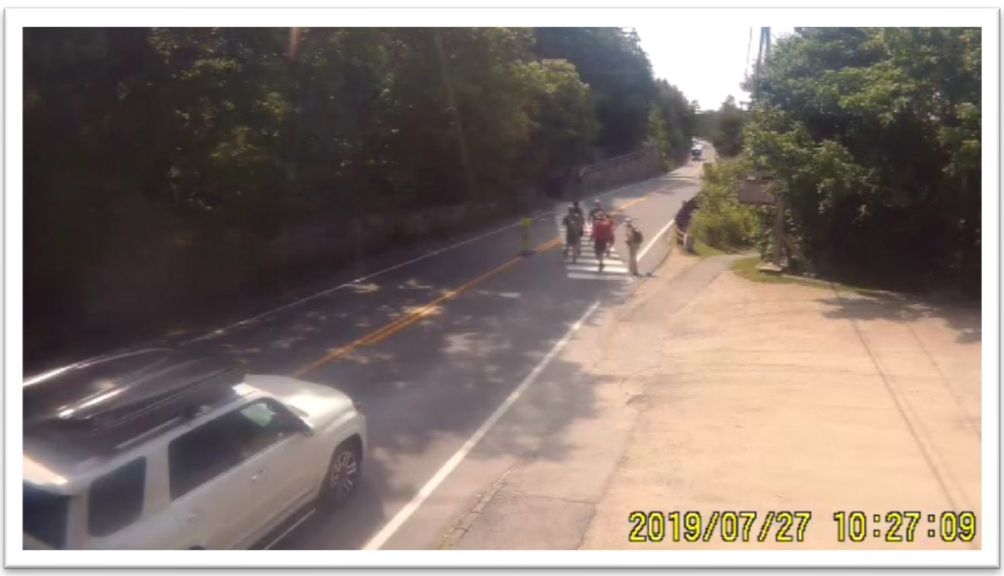


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Figure 22. Photograph. Example of video footage monitoring crosswalk use.

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Figure 23. Photograph. Additional video footage showing transit access.

Exploring Alternatives to In-Person RSAs

In response to the national pandemic in 2020, many agencies restricted in-person travel and working/gathering in groups. Additionally, other travel restrictions due to budgets and specific staffing time constraints can limit in-person meetings and events. Regardless, there is an ongoing need for identifying and implementing necessary safety improvements. While in-person RSAs are always ideal, many transportation agencies created virtual solutions to maintain momentum. Notably, the City of Albuquerque conducted a remote RSA with stakeholders and partners, including FHWA, the New Mexico Department of Transportation, Albuquerque Police Department, Mid-Region Council of Governments, and other stakeholders. The following are tools and tips used to overcome the potential challenges of a remote RSA.

- ***Use technology to enhance communication and understanding:*** *Any virtual event relies heavily on available technology, and this RSA was no different. The team maximized technology to collect data prior to the RSA and to gather collectively, which helped the team understand the site better and to feel connected to the rest of the RSA Team. The RSA Team used drones (see figure 24 and figure 25) to capture footage of the corridor from various vantage points, hosted a web room with video capabilities and screen sharing, and requested that participants turn on their video as much as possible during discussions. The video component helped participants to connect with one another throughout the meetings.*
- ***Prepare and collect data in advance:*** *RSAs always require advance data gathering, such as assembling and analyzing crash and traffic data; however, the remote RSA required even more upfront work. In preparation for the RSA, City of Albuquerque staff gathered additional information about the corridor and community experiences, which included walkability audits prior to the RSA, interactions with community groups, collection of the drone footage and speed data, and photos of the corridor. The data and information collected provided the RSA Team a fuller understanding of the experiences and needs along the corridor.*

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Figure 24. Photograph. Sample drone footage from the Albuquerque RSA.

- ***Communicate with team members and stakeholders:*** *Every RSA participant brings a unique set of skills and experiences that are valuable to the RSA Team. As with all RSAs, it was important to establish an environment where all felt comfortable sharing their thoughts and to provide opportunities for each team member to speak. Verbal and non-verbal communication was fostered using web-cameras through the process. Facilitators and local organizers also asked pointed questions to specific participants to hear their thoughts or experiences. The chat function in the virtual meeting room also allowed members of the team to share links, thoughts, and questions with all participants. The entire RSA Team in Albuquerque was engaged throughout the process.*
- ***Incorporate in-person components:*** *In-person components are vital to the success of an RSA. Despite advances in technology, there are still many elements that can only be fully understood by an in-person review of the study area. The City of Albuquerque performed advanced in-person field reviews and after the first day of the RSA, some local staff walked the study area, took additional photos, and made observations. The photos and experiences conveyed the characteristics of the study area to the RSA Team and helped all team members better understand the safety issues.*

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Figure 25. Photograph. Sample drone footage from the Albuquerque RSA.

Definitions

Figure 26 shows some of the various bicycle and pedestrian facilities and accommodations that are mentioned in this section. The graphic is for illustrative purposes only and does not represent design standards. The image is not to scale and shows optional combinations of facilities and accommodations.

Source: 2020 FHWA.

Figure 26. Graphic. Illustration of various bicycle and pedestrian facilities and accommodations (not to scale).

Bicycle—A device propelled solely by human power having two or more wheels in tandem, including children's bicycles, except a toy vehicle intended for use by young children such as a tricycle. Some bicycles may have electric components or pedal assists. Definitions and laws regarding bicycles, and those with electric components, and use of bicycle facilities vary between agencies.

Bicycle Boulevard—A street segment (or series of contiguous street segments) that has been modified to accommodate through bicycle traffic but discourage through motor traffic.

Bicycle (Bike) Box—A defined and/or colored area at a signalized intersection provided for bicyclists to pull in front of waiting traffic. The box is intended to reduce car-bike conflicts, particularly involving right-turning movements across the path of a bicyclist, and to increase bicyclist visibility.

Bicycle Facility—A general term denoting infrastructure and provisions to accommodate or encourage bicycling, including parking and storage facilities and shared roadways specifically designated for bicycle use.

Bicycle (Bike) Lane—A portion of a roadway that has been designated by striping, pavement markings, and signs for the preferential or exclusive use of bicyclists.

Bicycle (Bike) Path—A facility that is intended for the exclusive use by bicyclists, where a separate, parallel path is provided for pedestrians and other wheeled users. Most pathways are shared between bicyclists and other uses (see Shared Use Path).

Bikeway—A generic term for any road, street, path, or traveled way that is in some manner specifically or legally designated for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.

Buffered Bicycle Lane—bicycle lanes with a painted buffer to increase lateral separation between bicyclists and motor vehicles.

Bus/Bikeway—A marked lane for exclusive use by buses and cyclists. May also be referred to as a bus/bicycle lane.

Complete Streets—Roadways that are designed with the safety of all users in mind, including but not limited to motorists, pedestrians, bicyclists, and transit users.

Contraflow Bicycle Lane—A bicycle lane that allows bicyclists to travel the opposite direction of motor vehicle traffic on a one-way street.

Controlled Pedestrian Crossing—A pedestrian crossing where motorists are required to stop by either a STOP sign, traffic signal, or other traffic control device.

Crash Modification Factor (CMF)—A multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure. If available, calibrated or locally developed State estimates may provide a better estimate of effects for the State.

Crash Reduction Factor (CRF)—The percentage crash reduction that might be expected after implementing a given countermeasure at a specific site.

Curb Extensions—A roadway edge treatment where the curb line protrudes out toward the middle of the roadway to narrow the width of the street. Curb extensions are sometimes called "bulbouts" or "neckdowns."

Cyclist (Bicyclist, Rider or Bike Rider)—A person who is riding a bicycle.

High Visibility Crosswalk—A pedestrian crossing location marked by patterns such as wide longitudinal lines parallel to the flow of traffic as described by the Manual on Uniform Traffic Control Devices (MUTCD).

Loop Detector—An inductive (wire) loop embedded in the pavement that detects the presence of a vehicle at a signalized intersection to activate a signal change. Diagonal quadruple loops typically provide the best bicycle detection.

Marked Crosswalk—A pedestrian crossing that is delineated by crosswalk pavement markings in accordance with the MUTCD.

Mid-Block Location—A non-intersection location where nonmotorized users cross the roadway. Mid-block locations may or may not be a marked crossing for pedestrian or bicyclist activity.

National Bike Routes—A national network of bike routes that may span multiple States or have national or regional significance.

On-Road Accommodation—A facility that is part of the roadway or traveled way that is typically used by bicyclists and/or motor vehicles such as a wide curb lane, bicycle lane, or bikeable shoulder.

Off-Road Accommodation—A facility that is separate from the roadway used by motor vehicles. This may parallel a roadway or may be separate from a road on an independent alignment. This separate facility can be separated from pedestrian traffic (bicycle path) or shared with pedestrian traffic (shared use path).

Parking Restriction—Parking restrictions can include the removal of parking spaces, or the installation of new signs and markings that prohibit parking in specific areas.

Paved Shoulder—The portion of the roadway contiguous with the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of sub-base, base, and surface courses. Use by cyclists may be allowed or prohibited based upon specific State and local laws.

Pedestrian—Any person afoot or using a wheelchair (manual or motorized) or means of conveyance (other than a bicycle) propelled by human power, such as skates or a skateboard.

Pedestrian Hybrid Beacon (PHB)—A traffic control device with a face that consists of two red lenses above a single yellow lens. Unlike a traffic signal, the PHB rests in the dark until a pedestrian activates it via a pushbutton or other form of detection. PHBs are also known as "HAWK" beacons, which is an acronym for High-intensity Activated crossWalK beacons.

Protected Intersection—Modeled after Dutch intersection design, a protected intersection brings physical protection as bicyclists ride through the crossing. A protected intersection has four main elements, (1) a corner refuge island, (2) a forward stop bar for bicyclists, (3) a setback bicycle and pedestrian crossing, and (4) a bicycle-friendly signal phasing.

Raised Crosswalk—Raised crosswalks are crosswalks that have been elevated to the level of the sidewalk and span the entire width of the roadway. They are often placed at midblock crossing locations to reinforce pedestrian priority to drivers.

Rectangular Rapid-Flashing Beacon (RRFB)—RRFBs are pedestrian-actuated conspicuity enhancements used in combination with a pedestrian, school, or trail crossing warning sign to improve safety at uncontrolled, marked crosswalks. The device includes two rectangular-shaped yellow indications, each with an LED-array-based light source, that flash with high frequency when activated. RRFBs are placed on both ends of a crosswalk. If the crosswalk contains a pedestrian refuge island or other type of median, an RRFB should be placed to the right of the crosswalk and on the median (instead of the left side of the crosswalk). The flashing pattern is pedestrian-activated by pushbuttons or automated detection and is unlit when not activated.

Refuge Island— Space within a curbed median or channelizing island where pedestrians can wait to continue crossing a roadway. This countermeasure is sometimes referred to as a crossing island or pedestrian island.

Road Diet—A roadway reconfiguration that can result in a reduction in the number or width of travel lanes. The space gained is typically put to other uses and travel modes.

Roadway—The portion of a highway, including the shoulder, that is improved, designed, or ordinarily used for vehicular travel.

Separated Bicycle Lane—A separated bicycle lane is an exclusive facility for bicyclists that is located within or directly adjacent to the roadway and that is physically separated from motor vehicle traffic with a vertical element. Separated bicycle lanes can be one-way or two-way and the physical separation can be curbs, flex posts, or on-street parking. One-way separated bicycle lanes, especially those with a physical curb, have been shown to reduce injury risk and increase bicycle ridership due to their greater actual and perceived safety and comfort.

Shared Lane—A lane of a traveled way that is open to bicycle travel and motor vehicle use.

> **Narrow Lane**—A travel lane less than 14 feet in width, which therefore does not allow bicyclists and motorists to travel side-by-side within the same traffic lane and maintain a safe separation distance.
>
> **Wide Curb Lane**—A travel lane at least 14 feet wide, adjacent to a curb, which allows bicyclists and motorists to travel side-by-side within the same traffic lane.

Shared Lane Marking (SLM or "Sharrow")—A pavement marking symbol that assists bicyclists with lateral positioning in lanes that are too narrow for a motor vehicle and a bicycle to travel side-by-side within the same traffic lane.

Shared Roadway—A roadway that is open to and legally permits both bicycle and motor vehicle travel; any existing street where bicycles are not prohibited.

Shared Use Path—A bikeway physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent right-of-way. Shared use paths may also be used by pedestrians, skaters, wheelchair users, joggers, and other non-motorized users. Such facilities are often referred to as "trails" or "multi use path."

Sidepath—A facility for pedestrian and bicyclist use that is physically separated from the travel lanes using elements such as a curb, flex post, or on-street parking. Sidepaths are designed to support and encourage pedestrian use where an on-road bicycle facility, like a separated bicycle lane, exists.

Sidewalk—The portion of a street or highway right-of-way reserved for preferential or exclusive use by pedestrians.

Signed Shared Roadway (Signed Bike Route)—A shared roadway that has been designated by signing as a preferred route for bicycle use.

Traffic Calming—A way to design or retrofit streets to encourage slower and more uniform vehicle speeds.

Traveled Way—The portion of the roadway, excluding shoulders, bike lanes, and sidewalks, to be used for the movement of vehicles.

Two-Stage Turn Queue Boxes—These designated areas in an intersection provide a safe way to make left turns at from a right-side bicycle lane, or right turns from a left side bike lane.

Uncontrolled pedestrian crossing—An established pedestrian crossing that does not include a traffic signal, pedestrian hybrid beacon, or STOP sign to require that motor vehicles stop before entering the crosswalk.

Vehicle Queue—A line of stopped vehicles in a single travel lane, commonly caused by traffic control at an intersection.

Appendix A: Sample Materials

Sample Agendas

The following are sample RSA agendas for varying lengths from one to two days in length. The time needed for an RSA will depend on the size of the study area and the number of sites or specific times needed for observation. For example, for a location with a school, it will be important to view both the beginning and end of the school day. Times may also vary depending on peak periods, but also make sure to observe during off-peak times as well. When developing the RSA agenda, be sure to build in time to drive, walk, and, for bicycle-focused RSAs, bike the site.

Key

■ **General meeting** – all need to attend especially "roadway owners" (i.e., persons responsible for development of plans and/or facility owner).

● **RSA team activity** – all who are interested in participating in the site visits and developing suggestions (excluding facility owner).

▲ **Optional RSA team activity** – not required, but welcomes all who are interested in participating.

Sample #1 - Full day RSA

■	9:00 – 9:30 AM	RSA Kickoff Meeting: Introduction to the Project and RSA process
■	9:30 – 10:30 AM	RSA Kickoff Meeting: Review Background Data and Field Packets
●	10:30 AM– 4:00 PM	Field Observations - Lunch breaks (staggered to not miss lunch activity)
●	4:00 – 5:00 PM	Audit Findings Workshop/Debrief - Summarize observations - Potential recommendations
■	5:00 – 6:00 PM	Preliminary findings meeting
▲	Evening*	Optional night field observations

Sample #2 – 1 ½ Day RSA (PM and AM Field Observations)

	Day 1	
■	1:00-1:30 PM	RSA Kickoff Meeting: Introduction to the Project and RSA process
■	1:30-2:30 PM	RSA Kickoff Meeting: Review Background Data and Field Packets
●	3:00-6:00 PM	Field Observations
▲	Evening*	Optional Night Observations
	Day 2	
●	7:00 AM -12:00 PM	Morning Field Observations
●	1:00-4:00 PM	Audit Findings Workshop
■	4:00-5:00 PM	Preliminary Findings Meeting

Sample #3 – 2-day RSA

	Day 1	
■	9:00 – 9:30 AM	RSA Kickoff Meeting: Introduction to the Project and RSA process
■	9:30 – 10:30 AM	RSA Kickoff Meeting: Review Background Data and Field Packets
●	10:30 AM– 5:00 PM	Field Observations - Lunch breaks (staggered to not miss lunch activity)
▲	Evening*	Optional night field observations (timing based on sunset)
	Day 2	
●	7:00 AM -12:00 PM	Morning Field Observations
●	1:00-4:00 PM	Audit Findings Workshop
■	4:00-5:00 PM	Preliminary Findings Meeting

Sample Crash Diagram

Figure 27 and figure 28 are two examples of crash diagrams. There are many ways to create the diagrams and how to summarize/display the information. These examples uses symbols to represent crash types and a combination of color and smaller symbols to denote injury severity, speed, weather, and light condition.

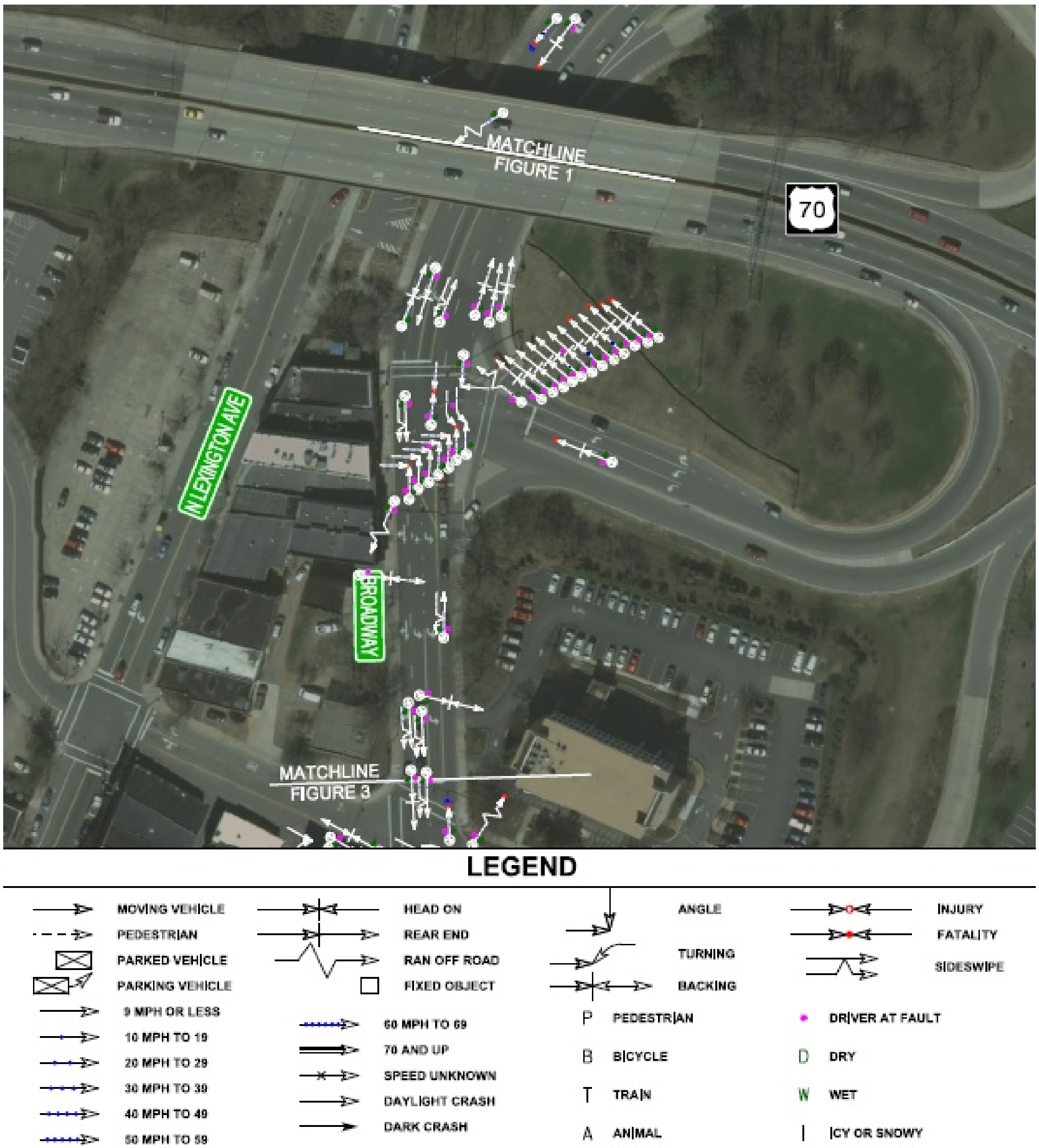

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Figure 27. Graphic. Collision diagram.

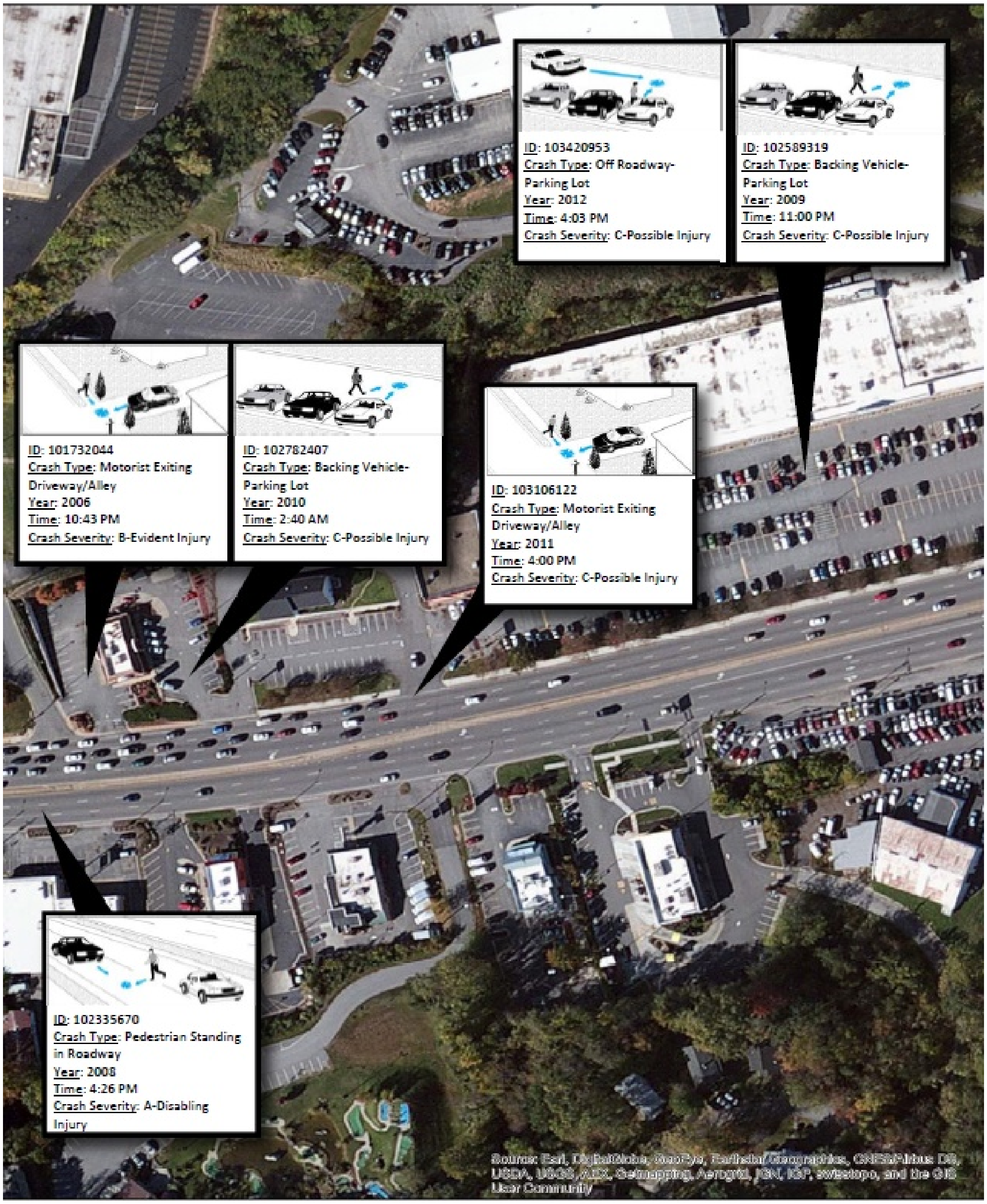

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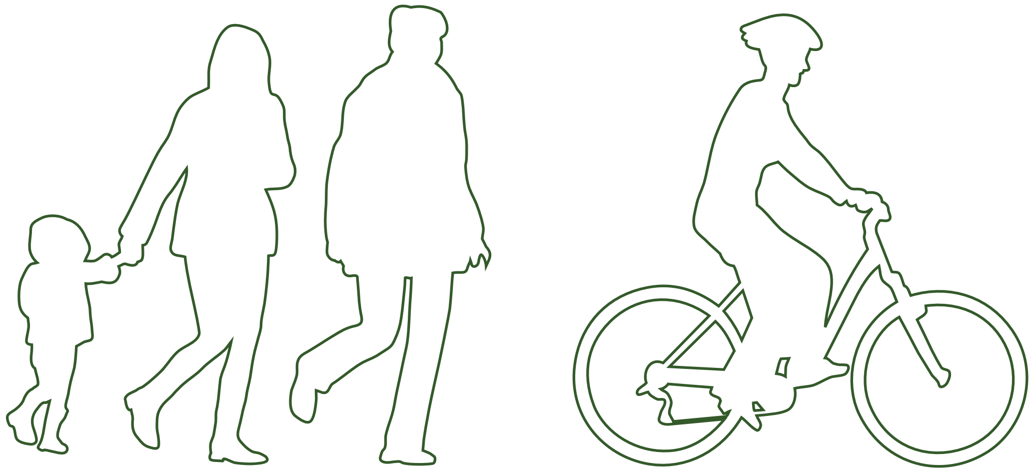
Figure 28. Graphic. Collision diagram with pedestrian crash details.

Sample Field Packet

- Agenda/schedule.
- General overview map of study area (e.g., aerial view of roadway, crash summary, Severity Index, speed limit, transit summary, ped/bike/vehicular volumes, major destinations or traffic generators, special considerations [schools, hospitals, homes for the aging], crash severity profile, 3-year average).
- An aerial with crash diagram and crash summary for each focus/hot spot location.
- Blank notes page.
- Maps of vehicular crashes.
- Prompt lists (not necessary for each person).
- Crash reports (1-2 copies for the group to share).
- Supplemental information could include:
    - Pedestrian or bicycle plan or route maps.
    - Traffic signal plans.
    - Future/planned development.

RSA Report Outline

1. Introduction
    a. Background on study area
    b. Objective of RSA
    c. Relationship to other efforts (Pedestrian and Bicycle Safety Action Plans, Vision Zero)
2. RSA site locations
3. Geometric conditions and multimodal volume summary
    a. Vehicle traffic
    b. Pedestrian and bicyclist traffic
    c. Transit
4. Crash history
    a. Pedestrian and bicyclist crash history
    b. Vehicle crash summary
5. RSA Team members and roles/areas of expertise
6. Assessment findings
    a. Positive existing features
    b. Vehicle capacity analysis (if applicable)
        i. Alternative 1
        ii. Alternative 2
    c. Identified safety issues and suggestions for improvements (include pictures or illustrations)
7. Improvements suggested for consideration and implementation timeframe (near- to long-term)
    a. Signalized intersection A
    b. Intersection B
    c. Mid-block C
    d. Potential crosswalk D
    e. Signalized intersection E
    f. Mid-block F
8. Conclusions



Appendix B
Prompt List

Appendix B: Prompt List

Location	Physical Environment / Infrastructure					
	Presence/Placement	Quality/Condition	Connectivity/ Consistency	Visibility	Lighting	Transit
Universal Considerations for Study Area	• Do facilities address ped and bike needs, including those with disabilities? • If future changes are proposed to the transportation system or surrounding land use, will those needs still be met?	• Are ped and bike facilities in good condition and accommodate users with disabilities?	• Are safe, continuous, and convenient ped and bike routes provided throughout the study area?	• Do obstructions block the view of roadway users? • What obstructions block the view of pedestrian and bicycle facilities (e.g., crosswalks, traffic control devices, signs)? • Does the sun create visibility issues at certain times of day?	• Are ped and bike facilities well-lit? • Can peds and bikes be seen by motorists during dark conditions?	• How does transit infrastructure interact with ped and bike facilities?
Along Street (including driveways)	• How are peds and bikes accommodated on both sides of the road? • Are facilities shared, separate, or buffered? • What is the comfort level for users? • Are ped and bike facilities appropriate for the adjacent land use? • Do parked vehicles obstruct ped paths? • Does parking adversely affect bike safety?	• Are the bike/ped facilities in good condition and well-maintained? • Are there obstacles (e.g. utility poles or signs) in the pedestrian travel path? • Are the sidewalks wide enough for two people to walk together? • Does vegetation or debris infringe on pedestrian or bicyclists facilities? • Is the pavement free of obstacles (e.g., potholes, drainage grates, longitudinal joints)?	• How are peds accommodated at driveways/ access points? • Are ped walkways continuous? • Are bike routes continuous?	• Are there obstructions blocking the driver's view of peds and bikes? • Are driveways designed with peds and bikes in mind (e.g., less driveway density, access management, proper signage, pavement markings)?	• Are sidewalks and bicycle facilities adequately lit?	• Are there sufficient boarding areas (5 feet along curb, 8 feet perpendicular to curb line) and visibility at transit stops? • Do ped and bike facilities connect to transit stops?

Location	Physical Environment / Infrastructure					
	Presence/Placement	Quality/Condition	Connectivity/ Consistency	Visibility	Lighting	Transit
Mid-Block Crossing (marked)	• Are there crossing enhancements? • What are the distances between the mid-block crossing and other marked crosswalks?	• Are signs and pavement markings in good condition and visible/legible?	• Does this crossing lead to/from a ped/bike generator?	• Are there obstructions blocking the view of signs or pavement markings? • Does roadway curvature (horizontal and/or vertical) impede adequate sight distance between drivers and peds/bikes?	• Are pedestrian crossings adequately lit?	• Is there a transit stop located mid-block? • Are transit users crossing mid-block to get to/from the transit stop?
Observed Mid-Block Crossings (unmarked)	• Are crossings isolated or a frequent route used by pedestrians or bicyclists?	N/A	• How far is it to the nearest controlled crossing? • Why are peds/ bikes crossing mid-block and not at the closest marked crossing? • Are there generators that lead to pedestrians and bicyclists crossing mid-block?	• Are there obstructions blocking the view of pedestrians and bicyclists?	• Does this section of roadway have lights?	• Are mid-block crossings occurring near transit stops?

Location	Physical Environment / Infrastructure					
	Presence/Placement	Quality/Condition	Connectivity/ Consistency	Visibility	Lighting	Transit
Intersections	• How are peds and bikes accommodated (accessible ped signal, bike box, crosswalks, bike signal)? • What intersection characteristics increase/decrease ped and bike safety (e.g., channelized right turns, large cub radii, wide crossing distances, right-turn-on-red)?	• How many legs have a crosswalk? In what condition? • Are ped push buttons accessible, with a locator tone, properly located and connected to the walkway, and functioning correctly? • Are curb ramps in good condition and ADA-compliant for each crosswalk or does a single curb ramp serve both crosswalks?	• Are intersection enhancements to signs, pavement markings, and signals consistent across intersections in the study area? • Do crosswalks line up with sidewalks?	• Can peds, bikes, and drivers see each other at all legs? • Are there utility poles, signs or other objects blocking the view of traffic? • Do skewed intersections divert drivers' focus from peds?	• Is the lighting adequate at all corners of the intersection?	• Do ped and bike facilities connect to transit stops? • Are transit stops on the near or far side of the intersection?
Shared Use Paths and Grade-Separated Crossings	• Do bicyclists have adequate space to ride comfortably (e.g., horizontal and vertical clearance at tunnels and bridges, construction zones, guardrails, fences)? • Do pedestrians have sufficient width to walk comfortably and is access to the facility accessible to individuals with disabilities? • Are bollards present?	• Does condition of the facility promote personal safety? • What material is the structure (freeze/thaw)? • Are the grades and cross slopes accessible to individuals with disabilities? • Is there adequate drainage? • Does wildlife affect comfort levels? • Are sideslopes adequate for bikes to return to the roadway if lane departure occurs? • Are facilities properly maintained (free of vegetation, snow)? • Are bollards appropriate height, well-marked, provide enough room for accommodations of users with disabilities, and set back far enough from roadway?	• Are bike facility transition areas designed appropriately with logical termini or do they end abruptly, potentially contributing to sudden and difficult merges, uncontrolled crossings, or behaviors such as wrong-way riding? • How is access provided to destinations if grade-separated? • Is the facility connected to other ped facilities in the area?	• Does poor visibility compromise personal safety? • Does the speed of users affect their ability to see and react to shared use path connections?	• Is adequate lighting provided?	• Are connections to transit provided?

Location	Traffic Control Devices		
	Signs and Pavement Markings	Signals	Compliance?
Universal Considerations for Study Area	• Are signs and pavement markings for pedestrian and bicycle facilities present and effective?	• Are pedestrians and bicyclists accommodated at signals through adequate signal timing and phasing? • Are pedestrian push buttons accessible, with a locator tone, properly located and connected to the walkway, and functioning correctly?	• Do motorists, pedestrians, and bicyclists follow traffic laws?
Along Street (including driveways)	• Are bicycle pavement markings adequate?	N/A	N/A
Mid-Block Crossing (marked)	• Are crossing points for pedestrians properly signed and/or marked? Are curb ramps provided? • Are there signage enhancements for the crossing, such as RRFBs or flashing beacons?	• Are there any devices (i.e., PHB or signalization) to control the crossings? • If so, are pedestrian push buttons accessible, with a locator tone, properly located and connected to the walkway, and functioning correctly?	• Are drivers, pedestrians, and bicyclists compliant with traffic control devices? • Are drivers yielding to pedestrians? • Are bicyclists yielding to pedestrians?
Intersections	• Is paint on stop bars and crosswalks worn, or are signs worn, missing, or damaged? • Are there sign or pavement marking enhancements?	• How long is the pedestrian or bicycle signal? Is there enough time to cross? • Is there a pedestrian countdown and/or bicycle signal? • Do pedestrians and bicyclists use push buttons to actuate a crossing? • Is there a leading pedestrian interval (LPI)? Is it accessible to pedestrians with vision disabilities? Are bikes allowed to utilize the early start? • Are there restrictions on turning-movements, like no right-turn-on-red? • How long do pedestrians have to wait in between signals? • Do vehicles have protected or permitted left-turn control?	• Are drivers, pedestrians, and bicyclists compliant with traffic control devices? • Are drivers yielding to pedestrians (especially at right-turn)? • Are bicyclists yielding to pedestrians?
Shared Use Paths and Grade-Separated Crossings	• Do signs provide wayfinding or advance warning of at-grade intersections?	N/A	N/A

Location	Operations / Interactions / Behaviors		
	Characteristics	Mode Behavior	Interactions of Modes
Universal Considerations for Study Area	• Are design, posted, and operating traffic speeds compatible with pedestrian and bicyclist safety? • Is the safety of children in school zones adequately considered?	• Do pedestrians or motorists regularly misuse or ignore pedestrian facilities? • Are drivers, pedestrians, and bicyclists behaving in a safe, compliant manner? • Are behaviors systemic across the network or at isolated locations?	• Do roadway users look/scan for other travel modes? • Are drivers and bicyclists yielding to pedestrians at crossings? • Do drivers allow extra space or reduce speeds when overtaking or driving near bicyclists? • How do pedestrians and bicyclists interact with transit facilities?
Along Street (including driveways)	• Do scooters, bicycles, skateboards, or non-motorized vehicles create hazards for pedestrians (e.g., operating or parking on sidewalk)? • Are vehicles traveling at appropriate speeds?	• If available, are bicyclists using their dedicated facilities?	• Are drivers yielding to pedestrians at driveways? • Are there conflicts between bicycles and pedestrians on sidewalks?
Mid-Block Crossing (marked)	• What are vehicle speeds? • What are traffic volumes?	• Are people using the mid-block crossing? • Are drivers yielding to pedestrians or bicyclists in the crosswalk?	• Are the physical environment and traffic control devices adequate for a safe crossing?
Observed Mid-Block Crossings (uncontrolled)	• What are vehicle speeds?	• Are pedestrians and bicyclists waiting for gaps?	• Are drivers expecting crossing pedestrians or bicyclists?
Intersections	• What are vehicle speeds? • What are vehicle, pedestrian, and bicycle volumes at the intersection?	• Are drivers stopping in the crosswalk? • Are pedestrians crossing with or against the pedestrian signal, if present? • Do pedestrians and bicyclists use push buttons to actuate a crossing?	• Is it clear between roadway users who has the right-of-way and is there compliance? • Do drivers yield to pedestrians and bicyclists when turning right or left?
Shared Use Paths and Grade-Separated Crossings	• Is there a mix of grade-separated and at-grade crossings?	• Do pedestrians walk in a way that blocks the path for other users? • Are bicyclist speeds too fast for conditions? • Does a mix of grade-separated and at-grade intersections influence behavior (e.g., higher speeds, less expectancy of crossing conflicts)?	• Are there pavement markings that separate users? How are such separations communicated to pedestrians with vision disabilities? • What are the levels of comfort for users?

Appendix C: Resources

Planning and Performance Measurement Resources

A Resident's Guide for Creating Safer Communities for Walking and Biking (FHWA) https://safety.fhwa.dot.gov/ped_bike/ped_cmnity/ped_walkguide/residents_guide2014_final.pdf

Achieving Multimodal Networks: Apply Design Flexibility and Reducing Conflicts (FHWA) https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/fhwahep16055.pdf

ActiveTrans Priority Tool (PBIC) http://www.pedbikeinfo.org/topics/tools_apt.cfm

Bike Network Mapping Idea Book (FHWA) https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/bikemap_book/

Case Studies in Delivering Safe, Comfortable and Connected Pedestrian and Bicycle Networks (FHWA) https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/network_report/network_report.pdf

Guidebook for Developing Pedestrian and Bicycle Performance Measures (FHWA) https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/performance_measures_guidebook/pm_guidebook.pdf

Measuring Multimodal Network Connectivity (FHWA) https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_connectivity/fhwahep18032.pdf

Metropolitan Pedestrian and Bicycle Planning Handbook https://www.fhwa.dot.gov/planning/processes/pedestrian_bicycle/publications/mpo_handbook/fhwahep17037.pdf

Noteworthy Local Policies That Support Safe and Complete Pedestrian and Bicycle Networks https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa17006-Final.pdf

Pedestrian Safety Program Technical Assessment (NHTSA) https://one.nhtsa.gov/Driving-Safety/Pedestrians/Pedestrian-Safety-Program-Technical-Assessment:-Process-Overview

Resources for Conducting Pedestrian and Bicyclist Counts (PBIC) http://www.pedbikeinfo.org/topics/countingestimating.cfm

Small Town and Rural Multimodal Networks (FHWA) https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/fhwahep17024_lg.pdf

Statewide Pedestrian and Bicycle Planning Handbook https://www.fhwa.dot.gov/planning/processes/pedestrian_bicycle/publications/pedestrian_bicycle_handbook/fhwahep14051.pdf

Resources for Diagnosing Safety Problems

FHWA RSA Case Studies https://safety.fhwa.dot.gov/rsa/case_studies/fhwasa06017/

Road Safety Audit Tools (PBIC)
http://www.pedbikeinfo.org/resources/resources_details.cfm?id=5085

Countermeasure and Design Resources

Bicycle Safety Guide and Countermeasure Selection System (FHWA)
http://www.pedbikesafe.org/bikesafe/

Bikeway Selection Guide (FHWA)
https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18077.pdf

Crash Modification Factors Clearinghouse (FHWA) http://www.cmfclearinghouse.org/

Design Resource Index (PBIC)
http://www.pedbikeinfo.org/resources/resources_details.cfm?id=4975

Designing Sidewalks and Trails for Access (FHWA)

Part I: Review of Existing Guidelines and Practices
https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/sidewalks/

Part II: Best Practices Design Guide
https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/sidewalk2/

Incorporating On-Road Bicycle Networks into Resurfacing Projects (FHWA)
https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/resurfacing/resurfacing_workbook.pdf

Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (FHWA)
https://safety.fhwa.dot.gov/ped_bike/step/docs/STEP_Guide_for_Improving_Ped_Safety_at_Unsig_Loc_3-2018_07_17-508compliant.pdf

Guide for the Development of Pedestrian Facilities (AASHTO)

Guide for the Development Bicycle Facilities 2012 4th Edition (AASHTO)

Guide for Maintaining Pedestrian Facilities for Enhanced Safety (FHWA)
https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa13037/fhwasa13037.pdf

Urban Street Design Guide (NACTO) https://nacto.org/publication/urban-street-design-guide/

Urban Bikeway Design Guide (NACTO) https://nacto.org/publication/urban-bikeway-design-guide/

How to Develop a Pedestrian and Bicycle Safety Action Plan (FHWA)
https://safety.fhwa.dot.gov/ped_bike/ped_focus/docs/fhwasa17050.pdf

Manual on Uniform Traffic Control Devices (FHWA) https://mutcd.fhwa.dot.gov/

Pedestrian Safety Guide for Transit Agencies (FHWA) https://safety.fhwa.dot.gov/ped_bike/ped_transit/ped_transguide/transit_guide.pdf

Crash Modification Factors Clearinghouse (FHWA) http://www.cmfclearinghouse.org/

Pedestrian Safety Guide and Countermeasure Selection Systems (FHWA) http://www.pedbikesafe.org/pedsafe/

Separated Bike Lane Planning and Design Guide (FHWA) https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/separatedbikelane_pdg.pdf

Small Towns and Rural Multimodal Networks (FHWA) https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/fhwahep17024_lg.pdf

Systemic Safety Project Selection Tool (FHWA) https://safety.fhwa.dot.gov/systemic/fhwasa13019/

The Road Diet Informational Guide (FHWA) https://safety.fhwa.dot.gov/road_diets/guidance/info_guide/rdig.pdf

USLIMITS2: A Tool to Aid Practitioners in Determining Appropriate Speed Limit Recommendations (FHWA) https://safety.fhwa.dot.gov/uslimits/

Behavioral Resources

Advancing Pedestrian and Bicyclist Safety: A Primer for Highway Safety Professionals (NHTSA) https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812258-peds_bike_primer.pdf

Bicycle Safer Journey (FHWA) http://www.pedbikeinfo.org/bicyclesaferjourney/

Countermeasures That Work: A Highway Safety Countermeasure Guide for State Highway Safety Offices (NHTSA) https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/812478_countermeasures-that-work-a-highway-safety-countermeasures-guide-.pdf

Data Driven Approaches to Crime and Traffic Safety (DDACTS) https://one.nhtsa.gov/Driving-Safety/Enforcement-&-Justice-Services/Data%E2%80%93Driven-Approaches-to-Crime-and-Traffic-Safety-(DDACTS)

National Pedestrian Safety Campaign (FHWA) https://safety.fhwa.dot.gov/local_rural/pedcampaign/

Pedestrian Safer Journey (FHWA) http://www.pedbikeinfo.org/pedsaferjourney/

Pedestrian Safety Enforcement Operations: A How-To Guide (NHTSA) https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812059-pedestriansafetyenforceoperahowtoguide.pdf

Safe Routes to School Guide (PBIC, NHTSA, FHWA, CDC, ITE)
http://guide.saferoutesinfo.org/

Policy Resources

Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (US Access Board) https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way/proposed-rights-of-way-guidelines

Supplemental Notice of Proposed Rulemaking, Shared Use Paths https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/shared-use-paths/supplemental-notice

Department of Justice (DOJ) ADA Standards https://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/ada-standards/doj-s-2010-ada-standards

National Complete Streets Coalition and Smart Growth America (Smart Growth America) https://smartgrowthamerica.org/program/national-complete-streets-coalition/

Noteworthy Local Policies that Support Safe and Complete Pedestrian and Bicycle Networks (FHWA) https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa17006-Final.pdf

Road to Zero Coalition (National Safety Council) https://www.nsc.org/road-safety/get-involved/road-to-zero

Vision Zero Network (Vision Zero Network) https://visionzeronetwork.org/

References

1. Pedestrian and Bicycle Information Center. (n.d.). Safety. FHWA. http://pedbikeinfo.org/factsfigures/facts_safety.cfm. Last accessed March 31, 2020.
2. FHWA. (2020). Office of Safety Proven Safety Countermeasures. FHWA. https://safety.fhwa.dot.gov/provencountermeasures/. Last accessed March 31, 2020.
3. Nabors, D., Gross, F., Moriarty, K., Sawyer, M., & Lyon, C. (2012). "Road Safety Audits: An Evaluation of RSA Programs and Projects." FHWA, Report No. FHWA-SA-12-037. https://safety.fhwa.dot.gov/rsa/case_studies/fhwasa12037/fhwasa12037.pdf. Last accessed March 31, 2020.
4. NHTSA. Fatality Analysis Reporting System. https://www.nhtsa.gov/research-data/fatality-analysis-reporting-system-fars.
5. NHTSA. (2019). Pedestrian Traffic Safety Facts 2017. NHTSA. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812681. Last accessed March 31, 2020.
6. NHTSA. (2019). Traffic Safety Facts: 2017 Data, Bicyclists and Other Cyclists. NHTSA, Report DOT HS 812 765, June 2019, Accessed September, 13, 2018 [online], Available: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812681
7. NHTSA. (2019). Traffic Safety Facts: 2017 Data, Pedestrians, NHTSA, Report DOT HS 812 681, March 2019, Accessed September 13, 2018 [online], Available: https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812681
8. Thomas, L., Vann, M., & Levitt, D. "North Carolina Pedestrian Crash Trends and Facts 2011-2015." University of North Carolina Highway Safety Research Center. http://www.pedbikeinfo.org/pbcat_nc/pdf/summary_ped_facts11-15.pdf. Last accessed March 31, 2020.
9. Thomas, L., Nordback, K., & Sanders, R. (2019). Bicyclist Crash Types on National, State, and Local Levels: A New Look. *Transportation Research Record 2673*(6), 664-676. https://journals.sagepub.com/doi/10.1177/0361198119849056. Last accessed March 31, 2020.
10. Virginia Department of Transportation. (2020). Virginia Pedestrian Crash Assessment.
11. Harkey, D.L., J. Mekemson, M.C. Chen, and K.A. Krull, PBCAT: Pedestrian and Bicycle Crash Analysis Tool, Version 1.0, Software and Users Manual (Publication No. FHWARD-99-192), Federal Highway Administration, Washington, DC, December 1999.
12. New York State Department of Transportation. (2016). New York State Pedestrian Safety Action Plan. https://www.ny.gov/sites/ny.gov/files/atoms/files/pedestriansafetyactionplan.pdf. Last Accessed April 30, 2020.
13. Vann, M., Thomas, L. & Levitt, D. (2018). North Carolina Pedestrian Crash Types 2012-2016. The University of North Carolina Highway Safety Research Center. http://www.pedbikeinfo.org/pbcat_nc/pdf/summary_ped_types12-16.pdf. Last accessed March 31, 2020.
14. Schultheiss, B., D. Goodman, L. Blackburn, A. Wood, D. Reed, and M. Elbech. (2019). Bikeway Selection Guide. FHWA. https://safety.fhwa.dot.gov/ped_bike/tools_solve/docs/fhwasa18077.pdf. Last accessed March 31, 2020.

15. Pedestrian and Bicycle Information Center. (2018). Webinar on Using Crash Types to Understand Pedestrian and Bicyclist Safety. Pedestrian and Bicycle Information Center. http://www.pedbikeinfo.org/webinars/webinar_details.cfm?id=18. Last accessed March 31, 2020.
16. Preusser, D., Wells, J., Williams, A., & Weinstein, H. (2002). Pedestrian crashes in Washington, DC and Baltimore. *Accident Analysis and Prevention*, *34*(5), 703-710. https://www.sciencedirect.com/science/article/abs/pii/S0001457501000707?via%3Dihub. Last accessed March 31, 2020.
17. Kwan, I., & Mapstone, J. (2009). Visibility aids for pedestrians and cyclists: a systematic review of randomised controlled trials. *Accident Analysis and Prevention*, *36*(3), 305–312. https://doi.org/10.1016/S0001-4575(03)00008-3. Last accessed March 31, 2020.
18. Hoffman, M. R., Lambert, W. E., Peck, E. G., & Mayberry, J. C. (2010). Bicycle commuter injury prevention: it is time to focus on the environment. *The Journal of Trauma*, *69*(5), 1112–7; discussion 1117. https://doi.org/10.1097/TA.0b013e3181f990a1. Last accessed March 31, 2020.
19. Tin, S. T., Woodward, A., & Ameratunga, S. (2013). Incidence, risk, and protective factors of bicycle crashes: Findings from a prospective cohort study in New Zealand. *Preventive Medicine: An International Journal Devoted to Practice and Theory*, *57*(3), 152–161.
20. Bullough, J. D., Skinner, N. P., & Plummer, T. T. (2016). Assessment of an adaptive driving beam headlighting system: Visibility and glare. *Transportation Research Record: Journal of the Transportation Research Board*, *2555*, 81–85. https://doi.org/10.3141/2555-11. Last accessed March 31, 2020.
21. Thomas, L., Lan, B., Sanders, R., Frackelton, A., Gardner, S., & Hintze, M. (2017). Changing the Future? Development and Application of Pedestrian Safety Performance Functions to Prioritize Locations in Seattle, WA. Transportation Research Board 96th Annual Meeting Compendium Papers. https://journals.sagepub.com/doi/10.3141/2659-23. Last accessed March 31, 2020.
22. Thomas, L., Kumfer, W., Lang, K., Zegeer, C., Sandt, L., Lan, B., Nordback, K., Bergh, C., Butsick, A., Horowitz, Z., Toole, J., & Schneider, R. (2018). NCHRP Research Report 893 Systemic Pedestrian Safety Analysis.
23. Porter, C., Danila, M., Fink, C., Toole, J., Mongelli, E., & Schultheiss, W. (2016). Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts. FHWA, FHWA Report No. FHWA-HEP-16-055. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/multimodal_networks/fhwahep16055.pdf. Last Accessed March 31, 2020.
24. 2010 ADA Standards for Accessible Design. (2010). Department of Justice.
25. Thomas L., Sandt L., Zegeer, C., Kumfer, W., Lang, K., Lan, B., Horowitz, Z., Butsick, A., Toole, J., & Schneider, R. (2018). NCHRP 893 Systemic Pedestrian Safety Analysis.
26. FHWA Division Offices webpage. https://www.fhwa.dot.gov/about/field.cfm.
27. FHWA Resource Center webpage. https://www.fhwa.dot.gov/resourcecenter/.
28. FHWA RSA webpage. https://safety.fhwa.dot.gov/rsa/resources/.
29. Sandt, L., Thomas, L., Langford, K., & Nabors, D. (2015). "A Resident's Guide for Creating Safer Communities for Walking and Biking." FHWA, FHWA Report No. FHWA-SA-14-099.

https://safety.fhwa.dot.gov/ped_bike/ped_cmnity/ped_walkguide/residents_guide2014_final.pdf. Last accessed March 31, 2020.
30. AASHTO. (2012). Guide for the Development of Bicycle Facilities.
31. Nabors, D., Goughnour, E., Thomas, L., DeSantis, W., & Sawyer, M. (2012). Bicycle Road Safety Audit Guidelines and Prompt Lists. FHWA, FHWA Report No. FHWA-SA-12-018.
32. Watkins, K., Clark, C., Mokhtarian, P., Circella, G., Handy, S., & Kendall, A. (2020). NCHRP 941 Bicyclist Facility Preferences and Effects on Increasing Bicycle Trips.
33. Pedestrian and Bicycle Information Center. (2020). Pedestrian and Bicyclist Crash Analysis Tool (PBCAT). http://www.pedbikeinfo.org/pbcat_us/index.cfm. Last accessed May 1, 2020.
34. FHWA Systemic Approach to Safety webpage. https://safety.fhwa.dot.gov/systemic/.
35. FHWA Systemic Safety Project Selection Tool. https://safety.fhwa.dot.gov/systemic/fhwasa13019/.

U.S. Department of Transportation

Federal Highway Administration

FHWA-SA-20-042