2022 Atlanta Regional Commission

REGIONAL SAFETY STRATEGY

The roadway is a shared space; safety is a shared responsibility.

ATLANTA REGIONAL COMMISSION

CREDITS

The Regional Safety Strategy was funded by the Atlanta Regional Commission (ARC) and guided by the Regional Safety Task Force (RSTF), the ARC Transportation Coordinating Committee (TCC), and the ARC Transportation & Air Quality Committee (TAQC).

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EXECUTIVE SUMMARY

The vision for the Atlanta region is ***safe, accessible,*** *and* ***convenient*** *travel for all road users (RSTF, 2022). The safety goal is ZERO deaths and serious injuries on all public roads (ARC, 2020). The Regional Safety Strategy (RSS) provides a comprehensive framework and action plan to support the long-term safety vision and goal. Safety stakeholders throughout the region can use the RSS to address the safety of all road users through data-informed decisions and incremental investments guided by Safe System principles.*

WHAT ARE THE REGIONAL SAFETY ISSUES?

Roughly 600 people die and more than 3,000 are seriously injured in traffic crashes in the ARC region every year. In the nine years from 2013 to 2021, the number of deaths increased from 456 to 933 and the number of serious injuries increased from 1,902 to 4,282 (Figure 1). **This trend is not going in the right direction and it is not going to change course on its own.**

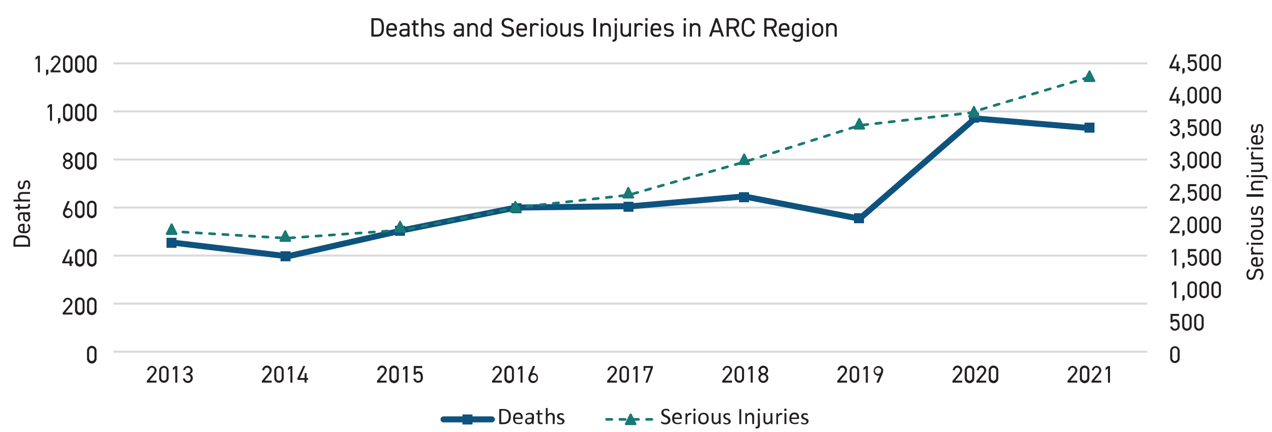
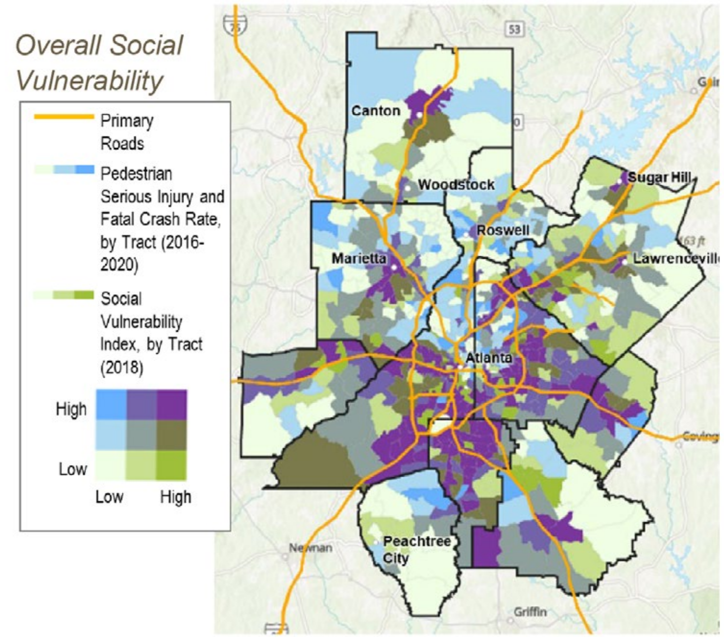


Figure 1. Historical Deaths and Serious Injuries in the Region.

The goal is ***ZERO deaths*** *and* ***serious injuries*** *on public roads in the Atlanta region.*

Deaths and serious injuries in the region have a measurable economic impact. While it is difficult to put a price on the value of a life, national resources suggest that the average cost of just one fatal crash in the region is over $16,000,000 (Harmon et al., 2018). This value includes both the immediate economic costs (tangible costs such as medical bills, lost wages, and property damage) and quality adjusted life years over the remainder of the person's lifetime (intangible consequences such as the physical pain and emotional suffering of people injured in crashes and their families). Just counting the 600 fatal crashes per year, this equates to more than $9.6 billion in annual economic losses in the region.

Deaths and serious injuries are not equitable across the region. Vulnerable members of the community, including low-income residents, minorities, children, disabled persons, and the elderly are disproportionately impacted, as evidenced in Figure 2 (GOHS, 2022). There are several reasons for this including more dependence on walking or transit for low-income households and a lack of investment in communities with a higher proportion of population that represents minority and non-white race and ethnicity. Pedestrian and bicycle facilities (e.g., sidewalks, bike lanes, multiuse paths, marked pedestrian crossings, and lighting) also tend to be afforded to more affluent or more well-connected neighborhoods.



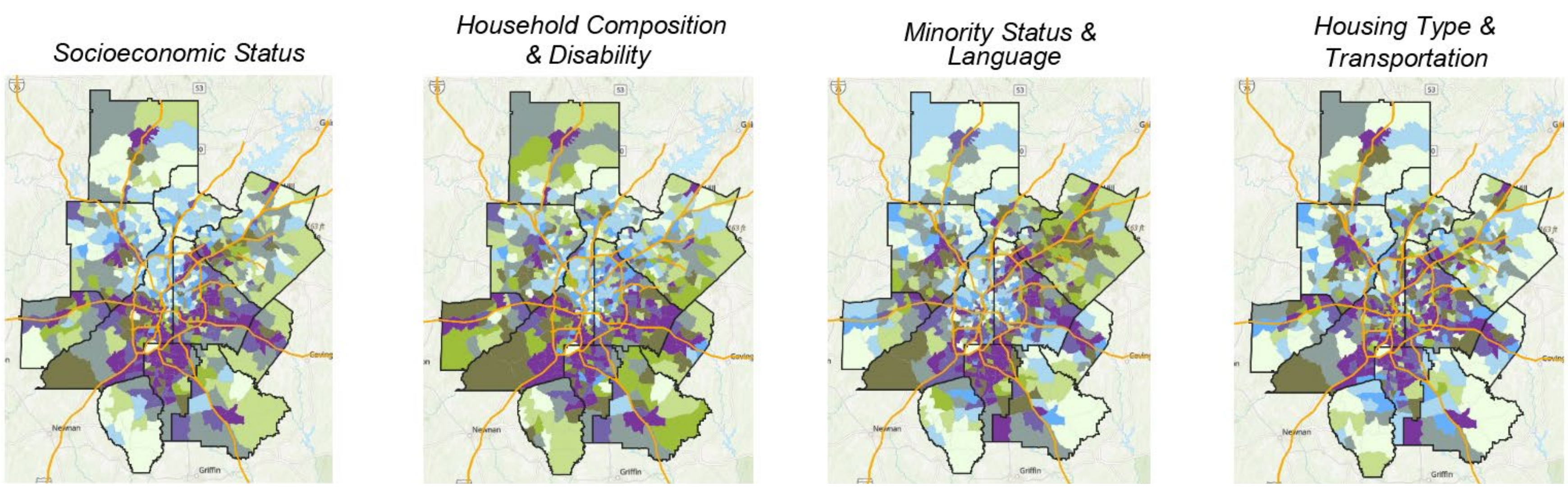
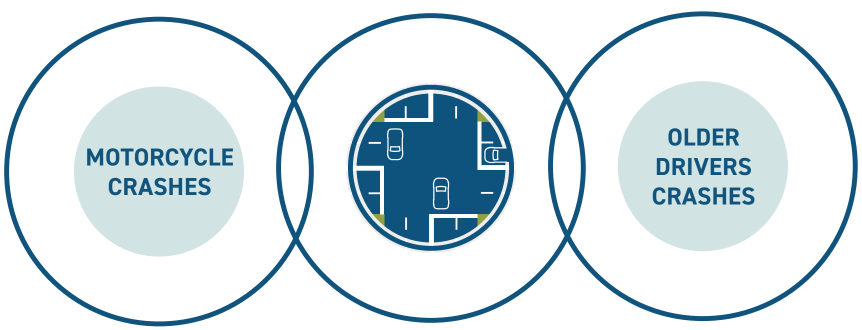


Figure 2. Severe Pedestrian Crash Rates (per 100,000 census tract population) and Social Vulnerability Index in the Atlanta Region (GOHS, 2022).

It is important to break up intractable problems into smaller and more adaptable responses. Establishing emphasis areas is one opportunity to break up larger safety issues into manageable components. Figure 3 shows the average annual deaths and serious injuries in the Atlanta region categorized by the statewide emphasis areas from the Georgia 2022 Strategic Highway Safety Plan (SHSP). The top contributors to deaths are: intersections; roadway departures; and pedestrian and bicycle crashes. ARC selected these crash types as regional emphasis areas because they present the greatest opportunity to reduce deaths and serious injuries and also represent the most logical areas for equitable infrastructure investments through the Transportation Improvement Program (TIP).

While the figure presents emphasis areas individually, these are not siloed issues. There is overlap where a single crash represents multiple emphasis areas (e.g., pedestrian and intersection, older driver and bicycle, young driver and roadway departure). Some emphasis areas such as impaired, distracted, younger, and older drivers may also be better addressed through a combination of strategies, including education and enforcement.

> *These emphasis areas are not siloed issues. 61% of fatal and serious injury motorcycle crashes and 63% of older driver (age 65+) crashes occurred at intersections.*



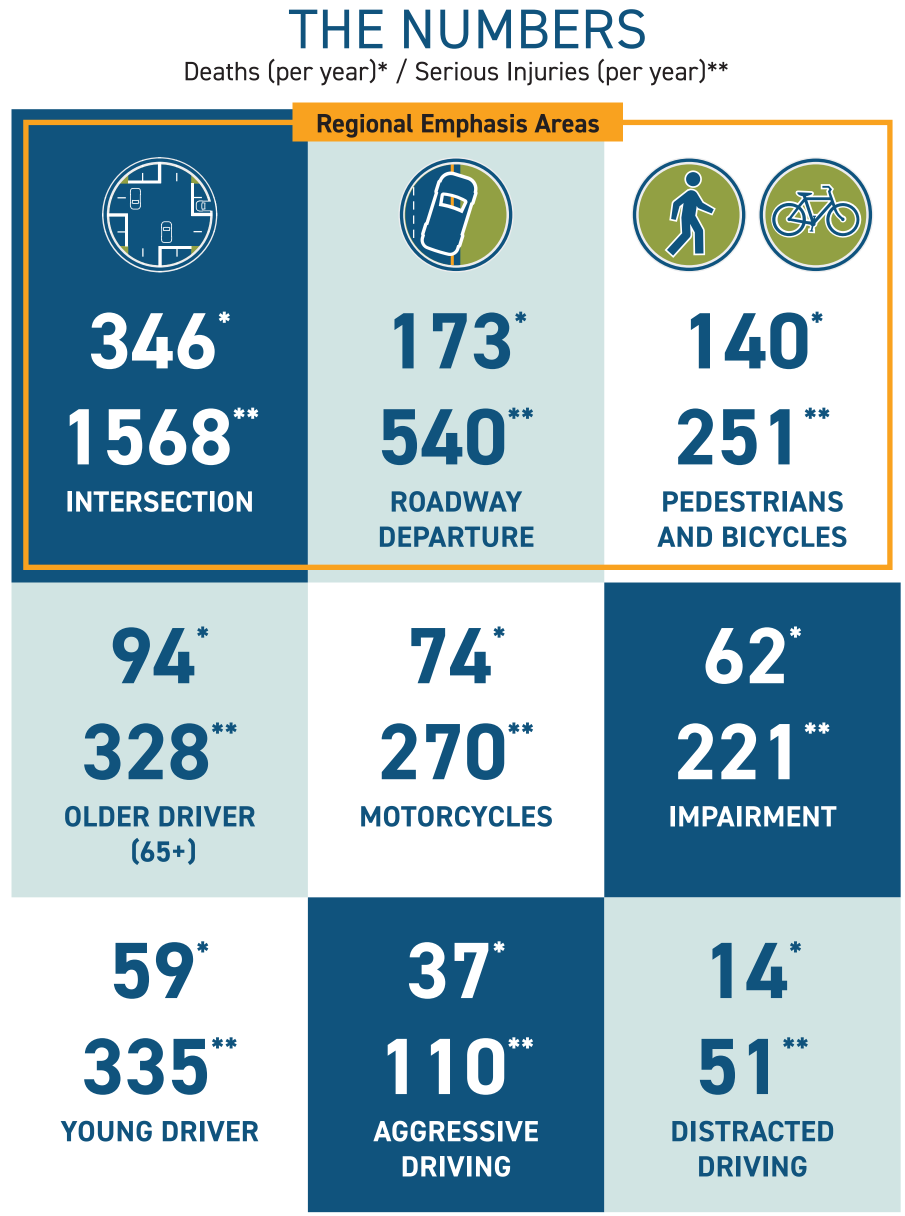


Figure 3. Deaths and Serious Injuries by Georgia SHSP Emphasis Areas.

WHERE ARE THE REGIONAL SAFETY ISSUES?

The regional goal of zero deaths and serious injuries is a daunting task, but **there is an opportunity to focus on the most pressing safety issues through a proactive, data-informed approach.** This involves identifying:

- **Focus crash types:** what crash types are most prevalent in severe crashes?
- **Focus facility types:** where are severe crashes most prevalent?
- **Risk factors:** what characteristics are over-represented in severe crashes?

The most prevalent severe crash types throughout the region are **intersections, roadway departure, and pedestrian and bicycle crashes.** As such, ARC selected these as regional emphasis areas, which represent the focus crash types for the RSS.

Focus facility types, roadway characteristics, and other factors help to identify locations throughout the region with the highest risk for severe crashes. Table 1 – Table 4 present a summary of common factors associated with an increased risk of severe crashes. Agencies can use these risk factors to identify locations for proactive safety improvement as shown in Figure 4.

There is an opportunity to focus on the most pressing safety issues through a proactive, data-informed approach.

Risk factors do not represent causal relationships but help to identify locations with the greatest potential for safety improvement and the greatest need for investment.

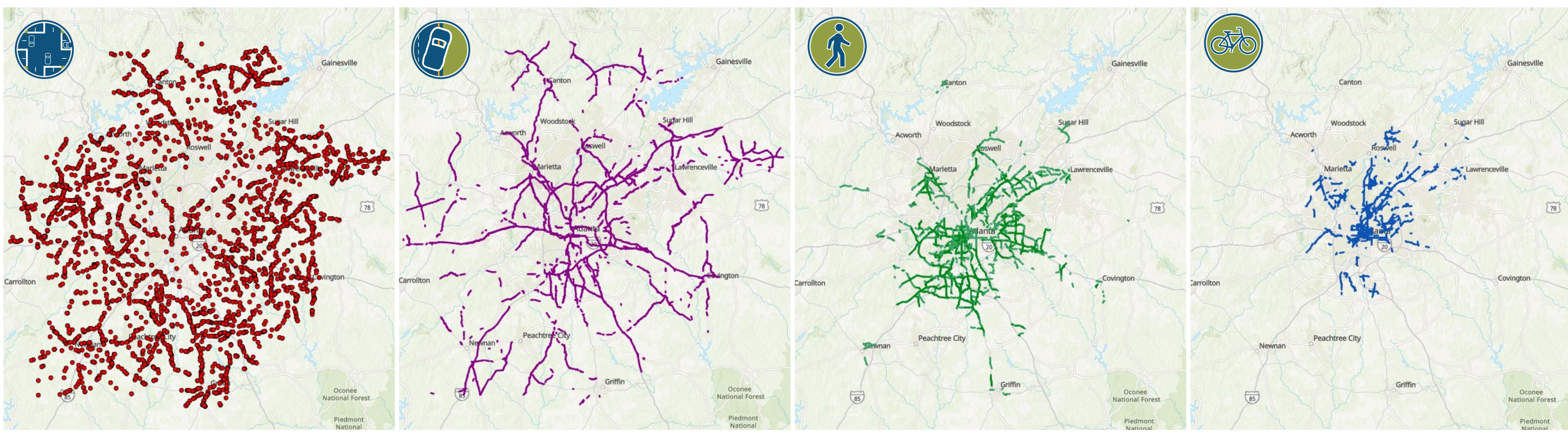


Figure 4. High-Risk Locations.

TABLE 1. INTERSECTION RISK FACTORS

Risk Factors	Values Associated with Increased Risk
Functional class	Urban other principal arterials Urban minor arterials Urban major collectors
Ownership	GDOT
Operating speed	35+ mph on arterial streets 30+ mph on collector and local roads
Observed speed	Larger differences between speed limit and average observed speed
Community context	Lower intensity development
Traffic control	Signalized intersections on principal arterials Uncontrolled or unsignalized intersections on minor arterials and major collectors

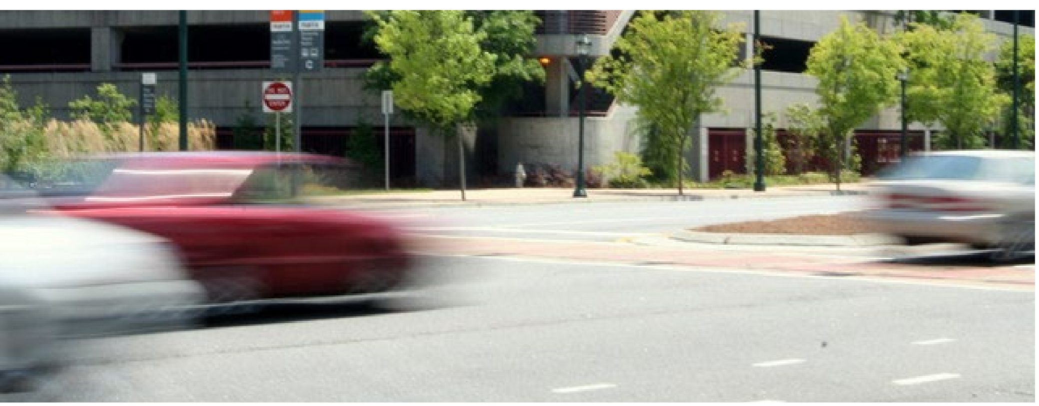


TABLE 2. ROADWAY DEPARTURE RISK FACTORS

Risk Factors	Values Associated with Increased Risk
Functional class	Urban interstates Rural minor arterials Rural major collectors
Ownership	GDOT
Traffic volume	5,000 – 15,000 vehicles per day
Posted Speed	45+ mph on arterial streets 35+ mph on collector roads
Community context	Rural areas and lower intensity development

TABLE 3. PEDESTRIAN RISK FACTORS

Risk Factors	Values Associated with Increased Risk
Functional class	Urban other principal arterials Urban minor arterials
Ownership	GDOT
Traffic volume	9,000+ vehicles per day
Number of lanes	4+ lanes
Posted speed	35+ mph
Community context	Urbanized areas, high population densities, higher intensity development, and high frequency bus service
Socioeconomic status	Lower average income, higher proportion of population that represents minority and non-white race and ethnicity
Environmental justice score	7+

TABLE 4. BICYCLE RISK FACTORS

Risk Factors	Values Associated with Increased Risk
Functional class	Urban minor arterials Urban major collectors
Ownership	City County
Traffic volume	20,000+ vehicles per day for GDOT arterials (does not apply to city and county roads)
Number of lanes	2-lane city and county roads 2- or 4-lane GDOT arterials
Community context	Urbanized areas, high population and employment densities, higher intensity development, and high frequency bus service
Socioeconomic status	Bottom 20% of median household incomes and higher median incomes, particularly in tracts with a high population density
Induced demand	Presence of multiuse paths or marked bike lanes

WHAT ARE THE SOLUTIONS?

The RSS supports the long-term safety goals of the region by addressing the safety of all road users through a collaborative, multidisciplinary, and multimodal approach. This strategy will help state, regional, and local agencies address the senseless loss of life and life-changing injuries through the following key components:

- Adopt a Safe System approach
- Focus on fatal and serious injury crashes
- Employ a proactive, data-informed approach to safety
- Identify locations with the highest risk for severe crashes
- Implement proven safety countermeasures that design for all users
- Foster a culture of collaboration and inclusion

The region can create a safe transportation system by implementing roadway design and operational strategies that anticipate human mistakes and accommodate human vulnerabilities and injury tolerances. The system design should manage the forces and kinetic energy in a crash and provide enough redundancy to minimize the chance of death or serious injury.

The RSS provides a framework for a proactive, data-informed approach to safety management. State, local, and regional agencies can use the risk factors presented in the RSS to focus on locations with the highest risk for severe crashes. Agencies can then implement proven countermeasures to address the risk factors associated with severe intersection, roadway departure, pedestrian, and bicycle crashes.

The RSS presents a wide variety of proven countermeasures to address the safety of all road users while supporting the other regional priorities (accessibility and convenience). The countermeasures are structured around the focus crash types, but a single countermeasure or package of complementary countermeasures can address multiple issues simultaneously. Behavioral and age-based issues such as speeding, distracted driving, impaired driving, and younger/older drivers may be better addressed through a combination of strategies, including education and enforcement. Similar to infrastructure projects, any education and enforcement efforts should be data-informed and equitable.

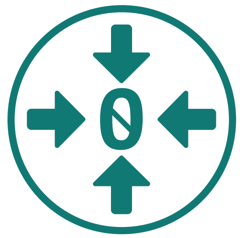
Figure 5. Visualizations of proven countermeasures.

MOVING TOWARD ZERO

Intentional, targeted, and coordinated action is needed to reverse current trends and work toward a vision of zero deaths and serious injuries on all roads in the region. Figure 6 illustrates several projections for reducing road-related deaths in the region. At an average reduction rate of 3% per year, the current number of deaths would be reduced by approximately 60% in the next 30 years. At a rate of 7% per year, deaths would be reduced by almost 90% in 30 years. In either scenario, the region would not achieve zero deaths by 2052, but would make significant progress. As a moderate, achievable goal, **ARC will adopt a 5% reduction target each year for all safety performance measures.** To achieve this goal, there is a need for:

A comprehensive, data-informed approach.

Steady incremental investments guided by Safe System principles.



Targeted and coordinated efforts from all safety stakeholders throughout the region.

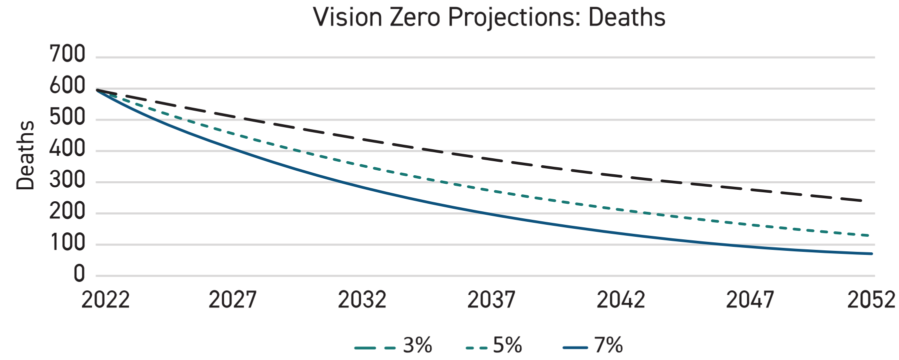
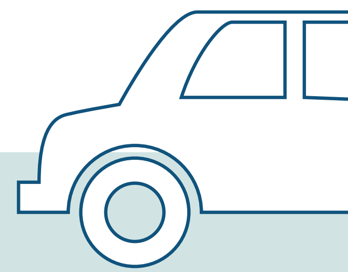


Figure 6. Vision Zero Projections for the Region.

Planners, designers, engineers, and other transportation professionals need to accept and commit to a shared responsibility in creating a safe system. The key to creating a safe system is shared responsibility with a focus on fatal and serious injury crashes. Safety is not traditionally an equally shared responsibility and users have been assigned much of the blame with misleading statistics like "human error is a factor in more than 90 percent of crashes." While road users share some of the responsibility, it is unacceptable to assign users complete responsibility for their safety on a system they do not plan, design, construct, operate, and maintain. It is also unreasonable to assume that any one agency or any one step in the project planning and development process can address all safety issues on the transportation system. There is a need for a cohesive and coordinated effort by all.







*The road is a **shared space**; safety is a **shared responsibility**.*

***Intentional**, **targeted**, and **coordinated action** is needed to move toward zero deaths and serious injuries.*

Shifting to a Safe System approach will require change. Figure 7 provides a summary of the fundamental changes required to move from a traditional engineering approach to a Safe System approach.

Overall, the RSS serves as a roadmap for safety in the Atlanta region and will inform future updates to the RTP, TIP, and other ARC-led plans and programs. The RSS provides a framework for both regional and local agencies to manage safety throughout the region.

The **regional components of the RSS** will serve as a coordinated approach for ARC and other state and regional partners to:

- Shift to a more proactive approach to safety
- Develop regional goals and plans
- Establish and monitor federal safety performance targets
- Evaluate and prioritize projects
- Allocate funds

The **local components of the RSS** will serve as non-regulatory guidance for local agencies to:

- Improve safety in their own communities
- Integrate safety in project planning and development
- Identify safety issues and project locations using a proactive, risk-based approach
- Target risk factors with proven safety countermeasures
- Prioritize projects and strategies for funding and implementation

ARC is committed to eliminating deaths and serious injuries in the Atlanta region through a regional safety approach that is proactive, data-informed, and community-based. Implementing the RSS will help achieve the vision of **safe, accessible,** and **convenient** travel in the Atlanta region for all road users, especially the most vulnerable road users. Specifically, it will help ARC and its partners to identify actionable strategies and resources, improve project development, implement incremental improvements, track progress toward meeting regional safety targets, and promote a culture of safety in the Atlanta region.

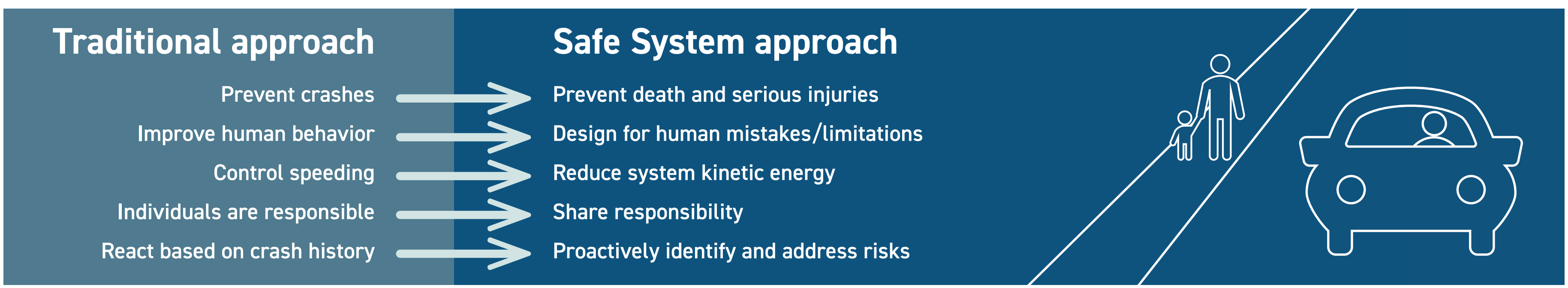


Figure 7. Paradigm Shifts to Implement a Safe System Approach (FHWA, 2020).

INTRODUCTION

WHAT IS THE REGIONAL SAFETY STRATEGY?

The Regional Safety Strategy (RSS) is a regional safety action plan to help the Atlanta Regional Commission (ARC) and its partners proactively achieve safety goals and build a safe transportation system for all users in the Atlanta region. Based on a data-informed analysis, the RSS identifies safety issues and specific actions for local agencies to proactively improve safety. The RSS includes recommendations for both motorized and active modes as well as other elements—land use, regional transit, multiuse trails, or other community factors—to create a comprehensive course of action. The RSS addresses federal and state regulations, including safety performance management goals, measures, and targets. It also expands ARC's safety planning toolbox by providing both a regional and local framework to encourage all agencies to work cohesively toward common safety goals and equitable outcomes.

The RSS advances safety in ARC's plans and processes, building upon strategies in ARC publications like *The Atlanta Region's Plan – Regional Transportation Plan* (ARC 2020) and *Safe Streets for Walking and Bicycling* (ARC 2019). These plans introduce important safety concepts, such as the Safe System approach, the goal of zero traffic deaths and serious injuries across the region, and employing a proactive, data-informed approach to safety that are all furthered in the RSS. The RSS provides the transportation safety action plan for the Atlanta region and will inform future updates to the Regional Transportation Plan (RTP), Transportation Improvement Program (TIP), and other ARC-led plans and programs.

> *A holistic safety plan considers all modes and addresses the specific needs of non-motorized travelers. – Safe Streets*

WHY IS THE REGIONAL SAFETY STRATEGY IMPORTANT?

The RSS advances safety in the Atlanta region in a unified way. Prior to the development of the RSS there was no comprehensive regional safety strategy to address all road users. As a diverse region, applications of safety in the metro Atlanta region are not "one size fits all". The RSS provides a framework to guide ARC member jurisdictions in working cohesively to achieve regional safety targets related to deaths and serious injuries, while recognizing regional differences. The RSS identifies evidence-based countermeasures and provides guidance for project selection and prioritization, allowing each community to address their unique safety needs, while working toward regional targets.

The RSS shifts toward a more proactive approach to safety, rather than one that only reacts to past safety trends. Previous strategies and safety analyses have relied solely on historical crash data. While this provides valuable insights on where crashes are occurring, it is reactionary and does not provide the findings to employ a forward-looking safety strategy. The RSS supplements historic crash analysis with a predictive systemic approach. Systemic analysis identifies risk factors associated with key crash types, in this case intersections, roadway departures, pedestrians, and bicycle riders. Local agencies can identify high-risk locations based on the presence of risk factors and then develop and implement safety projects before crashes occur. National studies have demonstrated the effectiveness of the systemic approach, which can generate high returns on investment, address safety issues proactively, and improve safety at locations that would otherwise not be addressed through the use of historical crash data only (Preston et al. 2013; Gross et al. 2016).

The RSS is needed now more than ever to address rising severe crash trends and to maximize the impact increases in transportation funding. With the passage of the Infrastructure Investment and Jobs Act in 2021, there is a sense of urgency to prioritize federal funds at the regional and local level. The RSS will help the region take full advantage of these federal funds, while keeping safety at the forefront of the decision-making process.

HOW IS THE REGIONAL SAFETY STRATEGY STRUCTURED?

The RSS is structured around the following five sections:

1. What are the regional safety issues?

2. Where are the regional safety issues?

3. What are the solutions?

4. Moving toward zero

5. Advancing the strategy

The RSS includes complementary regional and local components to provide guidance for action at both levels.

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HOW WAS THE REGIONAL SAFETY STRATEGY DEVELOPED?

ARC employed a multistep process to develop the RSS as shown in Figure 8.

REGIONAL SAFETY STRATEGY PROCESS

Literature and Data Review

- Understand and reflect on existing policies and practices
- Summarize noteworthy national practices
- Identify socioeconomic and demographic variables related to safety

Stakeholder and Public Engagement

- Presentations to ARC committees
- Regional surveys
- Transportation safety workshop
- Stakeholder interviews
- Citizen focus groups

Data Analysis

- Identify focus crash types with higher proportion of deaths and serious injuries
- Identify focus facility types and risk factors associated with focus crash types
- Identify priority risk areas and inform development of proactive solutions

Safe Street Visualizations

- Illustrate common high-risk scenarios
- Illustrate options to reduce risk of death and serious injury for all road users

Figure 8. Regional Safety Strategy Development Process.

The RSS planning process began with a literature review of existing policies and practices as well as a data review to understand safety issues and trends. This influenced the RSS by reflecting on current regional and statewide policies and practices, summarizing noteworthy national practices, identifying socioeconomic and demographic variables related to safety, and drawing on commonalities from health and equity literature.

Stakeholder and public engagement were key components in developing the RSS. Engagement activities occurred throughout the RSS development process to understand the safety issues, needs, and challenges of the region. Stakeholder input also helped to establish priorities, brainstorm solutions, and identify resources to enhance safety. ARC used a variety of techniques to connect and engage with the broad base of safety stakeholders, including public and private practitioners, elected officials, advocacy groups, community improvement districts (CIDs), citizens, and others. The following is a summary of the various efforts and how the input helped to shape the RSS. Appendix A provides further details.

» **Presentations to ARC Committees** such as the Regional Safety Task Force (RSTF), Transportation Equity Advisory Group (TEAG), Transportation Coordinating Committee (TCC), and Transportation & Air Quality Committee (TAQC). Feedback shaped the content, tone, and direction of the RSS, including the regional safety goals.
» **Regional Surveys** included a staff survey (of public-serving organizations) and an elected officials survey (of counties and cities). Feedback provided a more complete picture of how safety is viewed and addressed throughout the region, what data are available to support safety decisions, and what topics deserve further conversation in the RSS.
» **Transportation Safety Workshop** included a discussion with over 75 regional stakeholders on safety planning and implementation, common risk factors and safety countermeasures, and general safety concerns in the region. Feedback included local preferences with respect to safety countermeasures.
» **Stakeholder Interviews** included 16 virtual discussions with public and private professionals involved in transportation planning and project development. Feedback identified challenges in planning and implementing safety projects as well as opportunities for the RSS to help overcome these challenges.
» **Citizen Focus Groups** included five roundtable discussions with 30 people. Feedback helped to understand common safety issues, shape depictions of high-risk and low-risk scenarios, and uncover common questions to answer in accompanying concept narratives.

A comprehensive safety data analysis provided insights into the trends, patterns, and factors contributing to crashes in the region. This identified four focus crash types: intersections, roadway departures, pedestrians, and bicycles. A predictive model was developed for each emphasis area to identify risk factors related to roadway, traffic, demographic, and socioeconomic characteristics.

The risk factors were used to identify seven common high-risk scenarios throughout the region, one of which is shown in Figure 9. Each scenario was reviewed to diagnose crash contributing factors and develop targeted countermeasures, representing a low-risk scenario. Appendix B presents the seven high-risk, low-risk scenario pairs. The final recommendations in the RSS were informed by data analysis and guided by stakeholder input.

Figure 9. Visualization of high-risk scenario.

WHO IS THE INTENDED AUDIENCE?

The audience of the RSS includes those responsible for advancing safety practices and achieving safety goals in the Atlanta region. This includes state and regional entities, local agencies, transportation stakeholders, and the general public. Regional partners, like the ARC and Georgia Department of Transportation (GDOT), can use the RSS to support regional coordination, project prioritization, and funding allocation. Local agencies can use the RSS as a toolkit to improve safety through data-informed countermeasures, funding opportunities, and guidance on project selection, prioritization, and development. The public, including safety and transportation advocacy groups and decision-makers, can use the RSS as an educational tool to learn about safety in the region, including the regional priorities and the project development process.

WHAT ARE THE ROLES AND RESPONSIBILITIES OF REGIONAL SAFETY STAKEHOLDERS?

Regional safety stakeholders include ARC, GDOT, counties, cities, and others such as elected officials, CIDs, and advocacy groups. Safety stakeholders can use this section to better understand the various roles of each group and to identify opportunities for collaboration.

> *Regional safety stakeholders can provide safe and equitable mobility using context-sensitive and Safe System design principles, data-informed decision-making, and innovative technology solutions.*

ATLANTA REGIONAL COMMISSION (ARC)

As the region's designated Metropolitan Planning Organization (MPO), ARC plans for the maintenance, operations, and expansion of the 20+ county multimodal transportation system in support of achieving the regional vision of world-class infrastructure, healthy livable communities, and a competitive economy. ARC works with state, regional, and local partners to develop and manage the long-range RTP and short-range TIP utilizing a performance-driven, outcome-based approach and input from the community.

ARC collects and analyzes data to understand and benchmark community trends and needs, including the safety performance of the region's transportation system. ARC coordinates with GDOT and other partners to analyze, interpret, and share the data. ARC also encourages best practices in transportation safety and facility planning and design by serving as a collaborator and technical resource, establishing regional priorities and policy, and programming federal transportation funding. ARC cultivates relationships with leaders, engages stakeholders, and develops materials, messages, and campaigns to address transportation safety issues facing the Atlanta region.

ARC is responsible for leading safety policies and plan-related tasks, including:

1. **Establishing safety goals, priorities, and performance measures.**
2. **Measuring and reporting on federally-required safety performance targets and outcomes.**
3. **Programming and awarding federal transportation funding through an established project selection process guided by regional safety priorities and other policies.**
4. **Reviewing and funding local comprehensive and transportation plans and studies to serve as input into the regional planning process.**
5. **Providing technical expertise to inform safety legislation.**

ARC convenes the **Regional Safety Task Force (RSTF)** which envisions travel in the Atlanta region by any mode will be safe, accessible, and convenient, especially for vulnerable road users. The RSTF makes safety-focused recommendations to ARC's TCC and TAQC which are the technical and policy committees for the MPO. The RSTF also served as the technical advisory committee for the development of the RSS.

GEORGIA DEPARTMENT OF TRANSPORTATION (GDOT)

With a mission of delivering a transportation system focused on innovation, safety, sustainability, and mobility, GDOT plans, designs, constructs, maintains and works to improve roadways and transportation systems throughout the state, including in the Atlanta region. GDOT partners with ARC and other MPOs, local agencies, and other stakeholders to improve transportation systems and communities through planning and policy development, design, implementation, and maintenance.

GDOT evaluates safety and mobility needs and incorporates safety and mobility enhancements into projects to improve the overall transportation network. GDOT employs both a site-based and systemic approach to analyze crash data, identify trends and patterns, and program projects to address safety issues. Additionally, GDOT supports other government agencies and municipalities by providing technical assistance and training on standards, best practices, and emerging trends.

Along with developing long-range planning documents such as the Statewide Transportation Plan, GDOT advances the development of short-range plans and programs including the Statewide Strategic Transportation Plan (SSTP) and Statewide Transportation Improvement Program (STIP). As an extension of planning and outreach responsibilities, GDOT produces content and materials to support educational campaigns. These include safety information, reference guides, and videos for communicating with the public. GDOT also acts as a statewide and district coordinator, providing guidance and support for all safety initiatives statewide and locally.

LOCAL AGENCIES

Local agencies plan, construct, and maintain locally-owned roadways and bridges. Responsibilities include planning municipal and cross-jurisdictional transportation networks and working with local advocacy groups and community leaders to identify critical gaps and connections to destinations, employers, educational institutions, and health services. Municipal transportation agencies also partner with advocates and community leaders to provide educational opportunities and encourage safe travel behaviors.

OTHER REGIONAL AGENCIES

ARC interacts and coordinates with several regional agencies, including the Atlanta-Region Transit Link Authority (ATL), Metropolitan Atlanta Rapid Transit Authority (MARTA), and Georgia Regional Transportation Authority (GRTA).

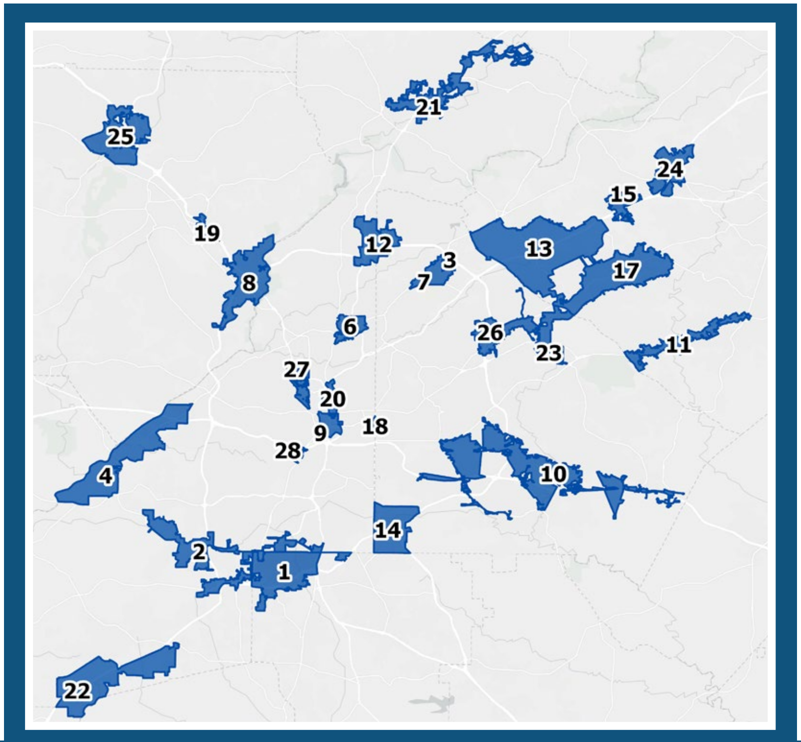
ATL is the region's transit planning and funding agency for the thirteen counties within the MPO boundaries. The agency produces the ATL Regional Transit Plan (ARTP) to outline regional transit investment priorities. This can include transit-supported improvements such as safety. Future updates of the ARTP can incorporate components of the RSS framework such as project identification, evaluation, and funding processes. ATL also operates the regional Xpress transit service, providing an affordable transportation option for commuters and reducing congestion.

MARTA is the region's largest transit operator serving Fulton, DeKalb, and Clayton counties with heavy rail, streetcar, local bus, and paratransit. MARTA is an important partner in planning, designing, constructing, and operating projects that address safety risks within the shared road space. MARTA is responsible for transit-oriented developments in their three county jurisdiction that build housing and retail options near rail stations and is increasing transit options through expansions and operations improvements including the region's first bus rapid transit line.

GRTA is the state-level authority that addresses mobility and air quality in metro Atlanta. GRTA and State Road and Tollway Authority (SRTA) are administratively attached, and The ATL is administratively attached to SRTA. As such, the three authorities provide all functions as a unified staff with executive leadership. GRTA's jurisdiction encompasses 13 counties: Cherokee, Clayton, Coweta, Cobb, DeKalb, Douglas, Fayette, Forsyth, Fulton, Gwinnett, Henry, Paulding, and Rockdale. GRTA is responsible for reviewing and approving ARC's TIP and for evaluating Developments of Regional Impact (DRIs) within its 13-county metro Atlanta jurisdiction for impacts on the surrounding transportation infrastructure.

COMMUNITY IMPROVEMENT DISTRICTS (CIDs)

There are 28 CIDs in the Metro Atlanta region as shown in Figure 10. These districts derive funding from a self-imposed tax on commercial businesses within the boundaries. CIDs have significant influence on the respective areas and can be powerful partners in shaping safety improvements within the community. CIDs can provide private funds for public projects such as construction and maintenance of public roads, public transportation, and active transportation elements, all of which can support safety.



1. Airport South CID
2. Airport West CID
3. Assembly CID
4. Boulevard CID
5. Braselton CID
6. Buckhead CID
7. Chamblee Doraville CID
8. Cumberland CID
9. Atlanta Downtown Improvement District (ADID)
10. East Metro DeKalb CID
11. Evermore CID
12. Perimeter CID
13. Gateway 85 Gwinnett CID
14. Metro South CID
15. Gwinnett Place CID
16. Highway 278 CID
17. Lilburn CID
18. Little 5 Point CID
19. Marietta Gateway CID
20. Midtown CID
21. North Fulton CID
22. South Fulton CID
23. Stone Mountain CID
24. Sugarloaf CID
25. Town Center Area CID
26. Tucker-Northlake CID
27. Upper Westside CID
28. West End CID

Figure 10. Community Improvement Districts (CIDs) in the Atlanta Regional Commission.

ADVOCATES AND NON-PROFITS

Community transportation and safety advocates and non-profit organizations influence regional and local safety policy and decision-making, planning and design, and enforcement. These groups represent diverse sectors across Atlanta. Engaging community advocates through the RSS can help inform, educate, and promote policies and plans to reduce fatal and serious injury crashes.

The Georgia Governor's Office of Highway Safety created task teams to support the Strategic Highway Safety Plan (SHSP). These teams include practitioners, safety advocates, executive leaders, non-profit agencies, and state and local agencies to implement statewide safety countermeasures. Task teams are organized across a range of road users and issues (e.g., pedestrians, motorcycles, older drivers, impaired driving, distracted driving, young drivers, bicycles, intersection safety, and roadway departure). These teams can promote and use the RSS to guide discussions for projects within the region.

HOW DOES THE REGIONAL SAFETY STRATEGY ALIGN WITH OTHER REGIONAL PLANS AND INITIATIVES?

> *The RSS should be reflected in future plans, including the RTP and CTPs.*

The RSS **establishes regional safety priorities** and **provides a roadmap** for accomplishing them. This framework should be incorporated into the regional and local planning processes, and reflected in future plans, including the RTP, TIP, and standalone regional subarea and mode-specific plans. This strategy presents an opportunity to further incorporate effective safety planning into transportation plans, programs, and project development. The RSS provides a framework to inform state plans such as Georgia's SHSP, Statewide Transportation Plan, and Statewide Strategic Transportation Plan. It also provides local safety guidance for county and city Comprehensive Transportation Plans (CTPs), Livable Centers Initiative (LCI) plans, and other plans and studies led by local agencies and CIDs.

While the RSS advances safety in the Atlanta region, there may be challenges in the project planning, development, and implementation process. Specifically, it can be difficult to change current momentum and timelines for projects in the pipeline. Unless planned projects are reevaluated and prioritized based on the RSS, it will take several years to realize the benefits set forth in this document. To overcome these challenges, there is a need to embrace and implement near-term opportunities described in the RSS as part of existing practices and project reviews. In the long-term, there is a need to institutionalize Safe System principles and a proactive approach to safety through future CTPs, RTPs, and the TIP.

Figure 11 illustrates how the RSS aligns with other regional priorities and plans for improving safety, followed by a summary of the most relevant complementary efforts. Many local and regional plans provide relevant information on local and regional policy objectives, project identification, and potential funding sources. Additionally, existing plans may provide data and analysis results to determine key challenges and opportunities for safety improvements.

Figure 11. Alignment of RSS with Other ARC Plans and Initiatives.

- **Livable Centers Initiative (LCI):** The LCI Program provides funding for transportation studies and projects in activity centers and town centers to promote increased density, mixed-use development, and multi-modal transportation options. LCIs can also provide policy guidance and objectives for communities to develop and re-envision transportation networks. Transportation projects identified in LCI plans may be eligible for funding through ARC's TIP. With a multimodal focus, LCIs are a valuable resource for local socioeconomic data and can provide funding for local agencies to plan and identify equitable safety projects.
- **Community Development Assistance Program (CDAP):** CDAP provides planning assistance to local agencies, particularly those with fewer demonstrated resources, to undertake local planning activities. CDAP can provide the resources necessary for local agencies to develop plans that ensure transportation safety projects are considered for future funding. More information on applying for CDAP assistance can be found in ARC's CDAP Application Guidebook.
- **Comprehensive Transportation Plans (CTPs):** CTPs present community needs, local policy guidance and actions, solutions, priorities, and program opportunities. ARC's RTP is largely based upon local CTPs, which can be resources for policy action, project identification, data collection, and potential funding sources. Local agencies should clearly list priorities in CTPs for future TIP funding. CTPs are considered an adopted plan, making projects eligible for federal discretionary grant programs.
- **Freight Cluster Plans:** Freight Cluster Plans complement CTPs and address transportation planning and traffic operations needs with a focus on efficient movement of freight in localized areas. These plans recommend projects and policy changes to address freight and industry needs. Therefore, Freight Cluster Plans can aid in project identification and form the basis for future funding requests from local agencies. Improving access to Freight Clusters is also considered under the Mobility & Access criteria of ARC's TIP solicitation process. Current Freight Cluster Plans exist for the Aerotropolis Atlanta, Gateway 85, and Tucker Summit CIDs.
- **Freight Mobility Plan:** ARC's Freight Mobility Plan identifies and programs transportation improvements to accommodate the increasing freight and goods movements in the Atlanta region. The plan serves as a guiding policy document to support the region's freight movement strategies and identify future freight needs in the region. In parallel with the RSS, the Freight Mobility Plan identifies safety as a critical need and key performance measure in evaluating projects. Similar to CTPs, the Freight Mobility Plan informs ARC's RTP. Local agencies can utilize the Freight Mobility Plan for potential project identification.
- **Regional Transportation Demand Management (TDM) Plan:** ARC's TDM Plan is a long-range plan and strategic framework for developing and integrating TDM strategies in the Atlanta region. The TDM Plan identifies multiple strategies and policies for improving roadway safety and encouraging alternative commute times and routes. One strategy is to develop a toolkit for local agencies that promotes ARC's Last Mile Connectivity and Transportation Alternatives Program. Another is to establish a regional dashboard to share TDM program data, including safety, operations, and congestion.
- **Regional Human Services Transportation/On-Demand Transportation Plan:** ARC's HST Plan establishes a decision-making framework for evaluating mobility options and develops a range of local and regional tactics to improve mobility. The HST Plan includes targeted improvements for HST populations and potential funding sources for projects.

WHAT ARE THE REGIONAL SAFETY ISSUES?

To effectively address safety, it is necessary to understand the issues, establish goals, identify actionable steps, and measure progress. This section establishes the safety goal for the region, describes the current safety performance, and identifies emphasis areas and related risk factors to focus future safety efforts. Efforts to improve safety should align with the regional emphasis areas and target the factors related to severe crashes.

REGIONAL SAFETY PERFORMANCE

Historically, roughly 600 people die and more than 3,000 are seriously injured in traffic crashes in the ARC region every year. In the nine years from 2013 to 2021, the number of deaths increased from 456 to 933 and the number of serious injuries increased from 1,902 to 4,282 as shown in Figure 12. This trend is not going in the right direction and it is not going to change course on its own. **There is a need for intentional, targeted, and coordinated action to reverse these trends and work toward a vision of zero deaths and serious injuries on roads in the region.**

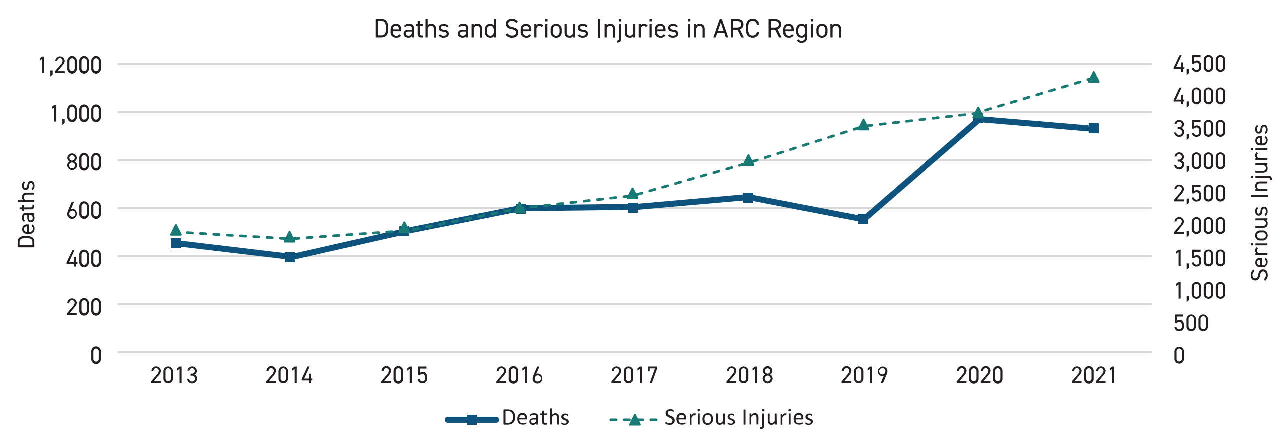


Figure 12. Historical Deaths and Serious Injuries in the Region.

*The regional safety goal is **ZERO deaths** and **serious injuries** on public roads (ARC, 2020).*

Deaths and serious injuries in the region have a measurable economic impact. While it is difficult to put a price on the value of a life, national resources suggest that the average cost of just one fatal crash in the region is over $16,000,000 (Harmon et al., 2018). This value includes both the immediate economic costs (tangible costs such as medical bills, lost wages, and property damage) and quality adjusted life years over the remainder of the person's lifetime (intangible consequences such as the physical pain and emotional suffering of people injured in crashes and their families). With approximately 600 fatal crashes per year, this equates to more than $9.6 billion in annual economic losses in the region. Factoring in the cost of approximately 3,000 serious injury crashes each year, at an average cost of nearly $1,000,000 per crash, the economic costs are much greater. The current RTP includes $172.6 billion of investments through 2050 to maintain and improve metro Atlanta roads, highways, transit and bicycling/walking facilities. This budget is spread among several regional priorities, including safety, mobility, and accessibility. There is a need to consider safety in all projects and target funding to the projects that have the greatest potential to reduce death and serious injury.

Deaths and serious injuries are not equitable across the region. There are several reasons for this including more dependence on walking or transit for low-income households and a lack of investment in communities with a higher proportion of population that represents minority and non-white race and ethnicity. Pedestrian and bicycle facilities (e.g., sidewalks, bike lanes, multiuse paths, marked pedestrian crossings, and lighting) also tend to be afforded to more affluent or well-connected neighborhoods. This is documented in several research reports (Chetty et. al. 2014; Gibbs et al. 2012; Blackburn and Ostrodka 2021). This is also evidenced in Figure 13, which illustrates the correlation between Social Vulnerability Index (SVI) and severe pedestrian crash rate (GOHS, 2022).

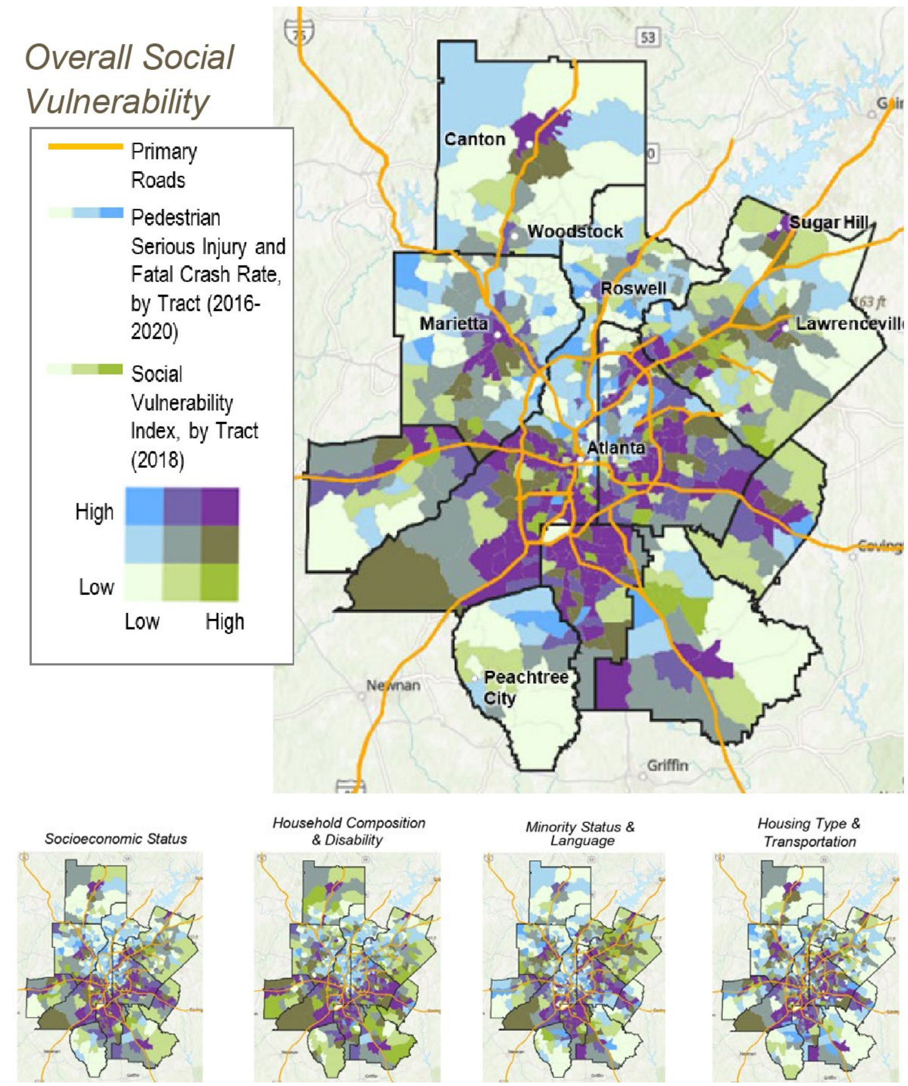


Figure 13. Severe Pedestrian Crash Rates (per 100,000 census tract population) and Social Vulnerability Index in the Atlanta Region (GOHS, 2022).

REGIONAL EMPHASIS AREAS

Establishing emphasis areas breaks up larger safety trends into manageable components. The Federal Highway Administration (FHWA) guidance on systemic safety defines priorities through focus crash types, focus facility types, and risk factors (Preston et al. 2013). This approach supports the prioritization of emphasis areas, identification of risk factors, and development of projects to improve safety throughout the region.

The 2022 update of Georgia's SHSP describes 10 emphasis areas for improving safety on the state's roads. These 10 emphasis areas represent the "top contributing factors of crashes, serious injuries, and fatalities in Georgia" (p. 15). The RSS builds upon this statewide strategy by defining key emphasis areas for the Atlanta region through a systemic safety approach. This approach focuses on potential risk, rather than historic crashes which fluctuate over time.

ARC identified key emphasis areas for the region based on deaths and serious injuries between 2013 and 2021. Figure 14 presents a summary of average annual deaths and serious injuries by emphasis area, sorted in descending order by number of deaths. These crash statistics are from the GDOT Crash Data Portal, which provides historic crash data with SHSP emphasis areas pre-flagged. It is worth noting that crash data relies on police reports, which may be incomplete (e.g., missing information to determine factors involved in the crash), inaccurate (e.g., incorrectly identify the level of injury), and inconsistent (e.g., underreporting of crashes involving people of color). To overcome these potential limitations, the RSS relies on a risk-based approach rather than focusing on sites with a high crash history.

ARC selected intersections, roadway departure, pedestrians, and bicycles as the highest regional priorities. These present the greatest opportunity to reduce death and serious injury and also represent the most logical areas for equitable infrastructure investments through the TIP and to guide local priorities.

GEORGIA 2022 SHSP EMPHASIS AREAS:		
REGIONAL EMPHASIS AREAS	**1. Intersections**	6. Motorcycles
	2. Roadway Departure	7. Impairment
	3. Pedestrians	8. Young Driver
	4. Bicycles	9. Aggressive Driving
	5. Older Driver (65+)	10. Distracted Driving

THE NUMBERS

Deaths (per year)* / Serious Injuries (per year)**

Regional Emphasis Areas

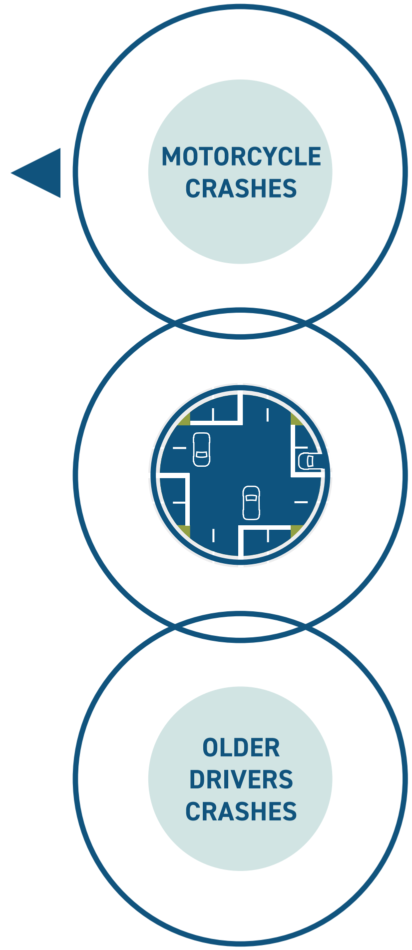
Emphasis Area	Deaths (per year)*	Serious Injuries (per year)**
INTERSECTION	346*	1568**
ROADWAY DEPARTURE	173*	540**
PEDESTRIANS AND BICYCLES	140*	251**
OLDER DRIVER (65+)	94*	328**
MOTORCYCLES	74*	270**
IMPAIRMENT	62*	221**
YOUNG DRIVER	59*	335**
AGGRESSIVE DRIVING	37*	110**
DISTRACTED DRIVING	14*	51**

Figure 14. Deaths and Serious Injuries by Georgia's SHSP Emphasis Areas.

Emphasis areas are not siloed issues. There is overlap where a single crash could represent multiple emphasis areas (e.g., pedestrian and intersection, older driver and bicycle, young driver and roadway departure). This presents an opportunity for ARC and its member communities to address many issues by focusing on the primary emphasis areas. **For instance, 61% of fatal and serious injury motorcycle crashes and 63% of older driver (age 65+) crashes occurred at intersections. This demonstrates how all road users would benefit from intersection designs that reduce speeds and conflict points associated with severe crashes.**

ARC also summarized crashes by KABCO[1] severity and emphasis area to confirm priority areas for the Atlanta region. Table 5 compares the proportion of fatal and serious injury (KA) crashes to the proportion of less severe (BCO)[2] crashes in the region for 2013 to 2021, sorted in descending order by number of fatal and serious injury crashes. Intersection crashes remain a high priority in terms of the magnitude of severe (KA) crashes and are marginally over-represented in severe crashes (60.2% of KA crashes compared to 56.9% of BCO crashes in the region). Roadway departure, pedestrian, and bicycle crashes are highly overrepresented in severe crashes (i.e., 23.3% of KA crashes are associated with roadway departures compared to just 9.5% of BCO crashes; 13.6% of KA crashes are associated with pedestrians and bicycles compared to just 0.8% of BCO crashes).

The final columns of the table show the number and proportion of statewide KA crashes associated with each emphasis area. The proportion of KA crashes in the region is consistent with the proportion of statewide KA crashes by emphasis area. While roadway departure crashes represent a slightly lower proportion of KA crashes in the region (23.3%) compared to statewide averages (31.2%), intersections and pedestrian and bicycle crashes represent a higher proportion of KA crashes in the region (60.2% and 13.6%) compared to the statewide average (58.7% and 10.9%).



Emphasis areas do not represent siloed issues; there is overlap in the crashes and risk factors associated with each emphasis area.

1 KABCO is a crash severity scale where K=fatal, A=suspected serious injury, B=suspected minor injury, C=possible injury, and O=property damage only.
2 Lower severity crashes are considered suspected minor injury (B), possible injury (C), and property damage only (O).

Table 5 shows the other emphasis areas for completeness, confirming lower regional priority for most. The exceptions are motorcycle and impaired crashes. Comparing the proportion of KA crashes to BCO crashes in the region, motorcycle and impaired crashes are highly overrepresented in severe crashes (i.e., 12.0% of KA crashes are associated with motorcycles compared to just 0.7% of BCO crashes; 8.6% of KA crashes are associated with impaired crashes compared to just 1.7% of BCO crashes). While motorcycle and impaired crashes could represent additional emphasis areas, there is overlap with the primary emphasis areas. **Motorcycle crashes represent 38.7% of severe (KA) roadway departure crashes and 63.4% of severe (KA) intersection crashes. Impaired crashes represent 42.3% of severe (KA) roadway departure, intersection, pedestrian, and bicycle crashes combined. Given the extensive overlap, the region can address these and other emphasis areas through countermeasures that target risk factors associated with the primary emphasis areas.** Safer infrastructure achieved through planning, design, and operations can mitigate these severe crashes. Finally, there may be opportunities to address behavior- and experience-related emphasis areas such as impaired, distracted, and younger drivers through a combination of complementary strategies, including education and enforcement.

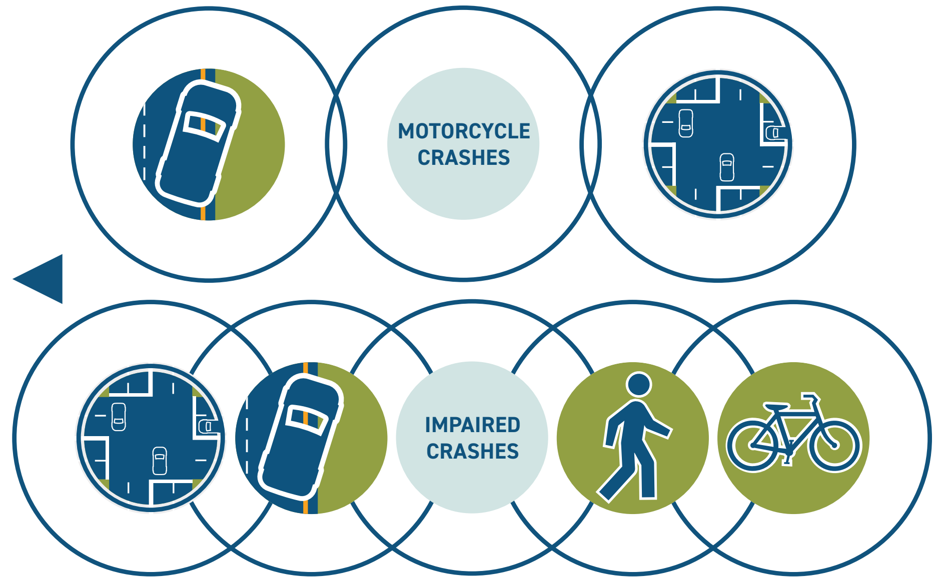


Table 5. Regional Comparison of Crashes by SHSP Emphasis Area (2013 to 2021).

EMPHASIS AREA	ARC		ARC		GEORGIA	
	KA CRASHES	%	BCO CRASHES	%	KA CRASHES	%
Intersection	14,787	60.2%	1,106,042	56.9%	33,067	58.7%
Roadway Departure	5,712	23.3%	183,780	9.5%	17,547	31.2%
Pedestrians and Bicycles	3,339	13.6%	16,127	0.8%	6,113	10.9%
Older Driver Related (65+)	3,212	13.1%	238,590	12.3%	8,478	15.1%
Motorcycles	2,939	12.0%	14,400	0.7%	6,408	11.4%
Young Driver Related	2,848	11.6%	232,840	12.0%	6,747	12.0%
Impairment Related	2,121	8.6%	32,200	1.7%	5,503	9.8%
Aggressive Driving Related	1,099	4.5%	45,001	2.3%	3,037	5.4%
Distracted Driving Related	520	2.1%	47,983	2.5%	1,023	1.8%

WHERE ARE THE REGIONAL SAFETY ISSUES?

The next step in the systemic approach is to determine where focus crashes occur and what characteristics increase the risk of those crashes. ARC analyzed the focus crash types to identify common community and contextual characteristics that contribute to higher risk of severe crashes in the region. The systemic analysis consisted of basic summary statistics to identify focus facility types as well as advanced statistical modeling and spatial data analysis to assess and confirm risk factors.

Exposure is a key consideration for identifying focus facility types and assessing risk. Certain crash or roadway characteristics may only represent a portion of total crashes in the region, but compared to exposure, such as the number of vehicle miles traveled (VMT), lane miles, or amount of pedestrian activity, they may represent a disproportionate share of severe crashes. For instance, urban, four-lane, principal arterials owned by GDOT represent 12.5% of severe (KA) intersection crashes in the region but only represent 2.7% of the lane-miles. This indicates overrepresentation and an opportunity to focus on these facility types to address intersection crashes. Table 6 presents a summary of focus facility types by focus crash type. Refer to Appendix C for a comparison of severe crashes and exposure by facility type for each of the four focus crash types.

Focus facility types target locations where focus crashes are most prevalent and allow agencies to proactively mitigate characteristics that increase the risk of those crashes.

Exposure is a key consideration for identifying focus facility types and assessing risk.

Table 6. Summary of Focus Facility Types by Focus Crash Type.

FOCUS FACILITY TYPE	INTERSECTION	ROADWAY DEPARTURE	PEDESTRIAN	BICYCLE
Urban, GDOT-owned Interstates with 6+ lanes		✓		
Urban, GDOT-owned other principal arterials with 6+ lanes			✓	
Urban, GDOT-owned other principal arterials with 4 lanes	✓		✓	✓
Urban, GDOT-owned minor arterials with 4 lanes	✓		✓	✓
Urban, GDOT-owned minor arterials with 2 lanes	✓	✓		✓
Urban, County-owned minor arterials with 4 lanes			✓	
Urban, County-owned minor arterials with 2 lanes		✓		
Urban, County-owned major collectors with 2 lanes	✓	✓		
Urban, City-owned major collectors with 2 lanes				✓

ARC analyzed the geographic distribution of crashes associated with each emphasis area, comparing the proportion of more severe (KA) crashes to the proportion of less severe (BCO) crashes. The results show counties that are overrepresented in severe focus crashes. Agencies can use this information along with the focus facility types to identify communities and types of roads that represent the greatest potential for safety improvement. For instance, Figure 15 shows that severe roadway departure crashes are a greater safety concern in the more rural and suburban counties because severe roadway departure crashes are overrepresented in the outer counties. Figure 16 shows a summary of counties where the focus crash types are overrepresented compared to the region as a whole. Cobb and Fulton county are not over-represented in a specific focus crash type but together represent more than a third of KA crashes in the region. As shown in Figure 17, Fulton county represents the highest percentage of KA crashes (~25%) and Cobb county represents the third highest percentage of KA crashes (~12%) in the region.

The focus facility types and geographic distribution are general indicators of high-risk locations, but there are more detailed risk factors associated with the focus crash types. ARC performed rigorous statistical analysis to identify roadway, community, and land use characteristics that increase the risk of severe crashes. The following sections provide a summary of focus facility types and risk factors by focus crash type. Agencies can use the focus facility types and risk factors to identify specific locations that represent the greatest potential for safety improvement.

Risk factors do not represent a causal relationship; they are simply correlations. However, these factors can indicate underlying relationships between safety and the transportation system. For instance, household income, local employment opportunities, and proximity to transit do not necessarily lead to pedestrian crashes. Lower income households may be more dependent on transit or walking and mixed-use communities may have more desirable destinations, thereby leading to a greater number of pedestrians, more observed risk to those pedestrians, and a greater need for appropriate pedestrian and crossing facilities in those communities.

> *Risk factors do not represent a causal relationship.*

ARC is committed to improving safety by investing in infrastructure in these communities. Local agencies can use the risk factors to identify and prioritize where infrastructure improvements are most needed. It is generally not appropriate to target specific communities with educational and enforcement strategies based on elevated risk alone. It is more appropriate to identify behaviors (e.g., speeding and impairment) that increase crash risk and then identify corridors where these crashes are more prevalent for targeted education and enforcement to complement infrastructure improvements.

> *Identify behaviors that increase crash risk and then identify corridors where these crashes are more prevalent to target engineering, education, and enforcement strategies.*

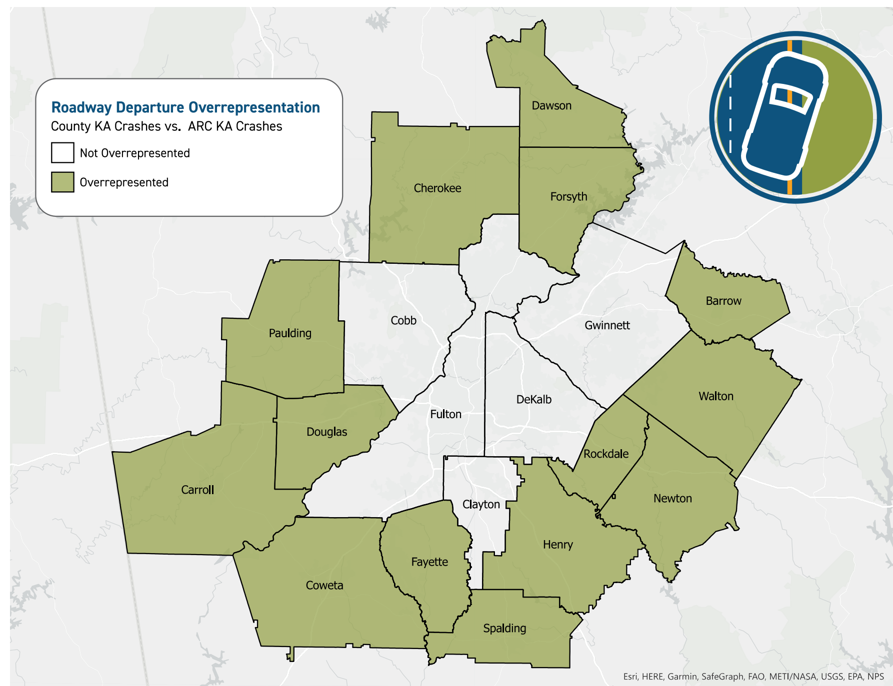


Figure 15. Counties Where Roadway Departure Crashes are Overrepresented.

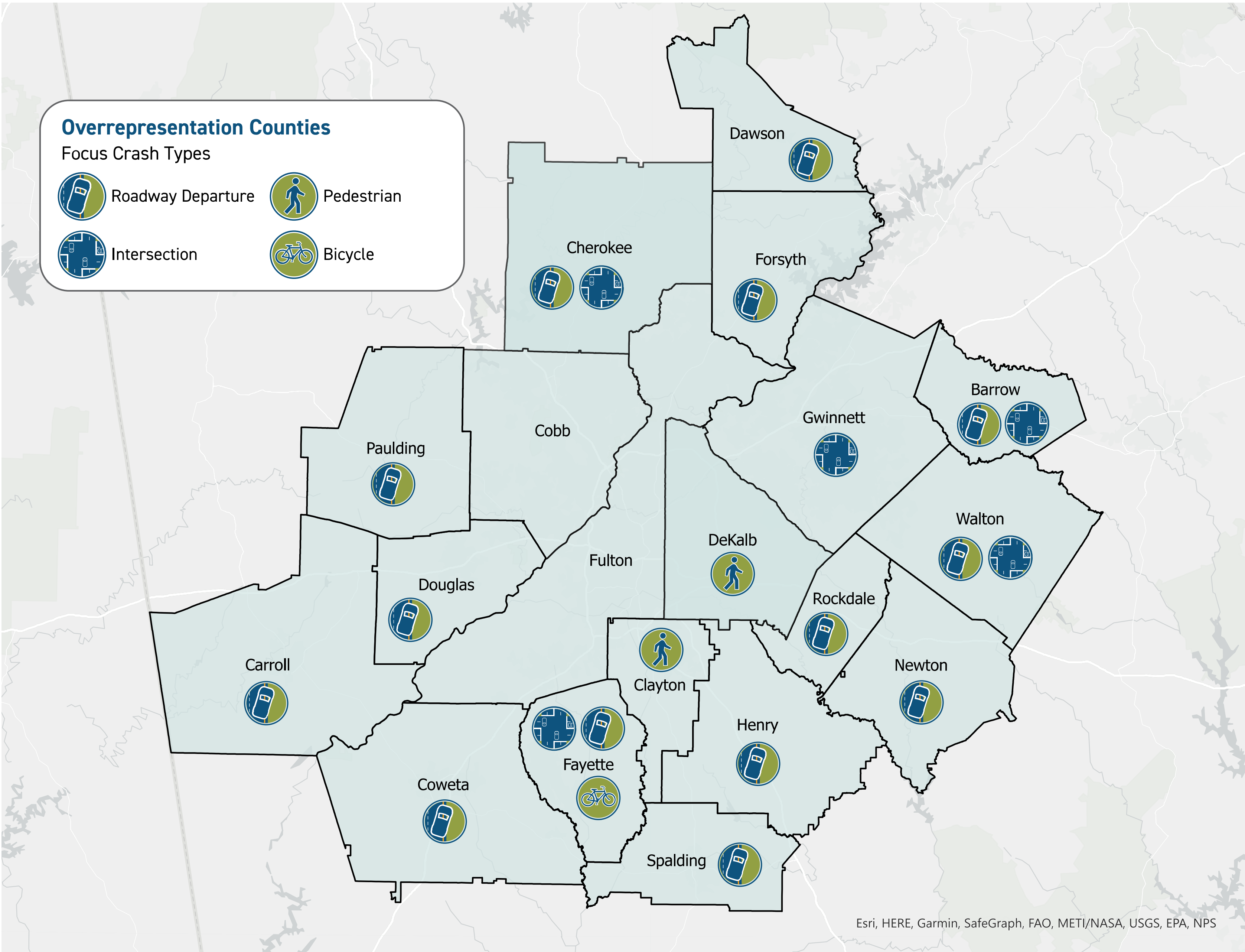


Figure 16. Counties Where Focus Crash Types are Overrepresented.

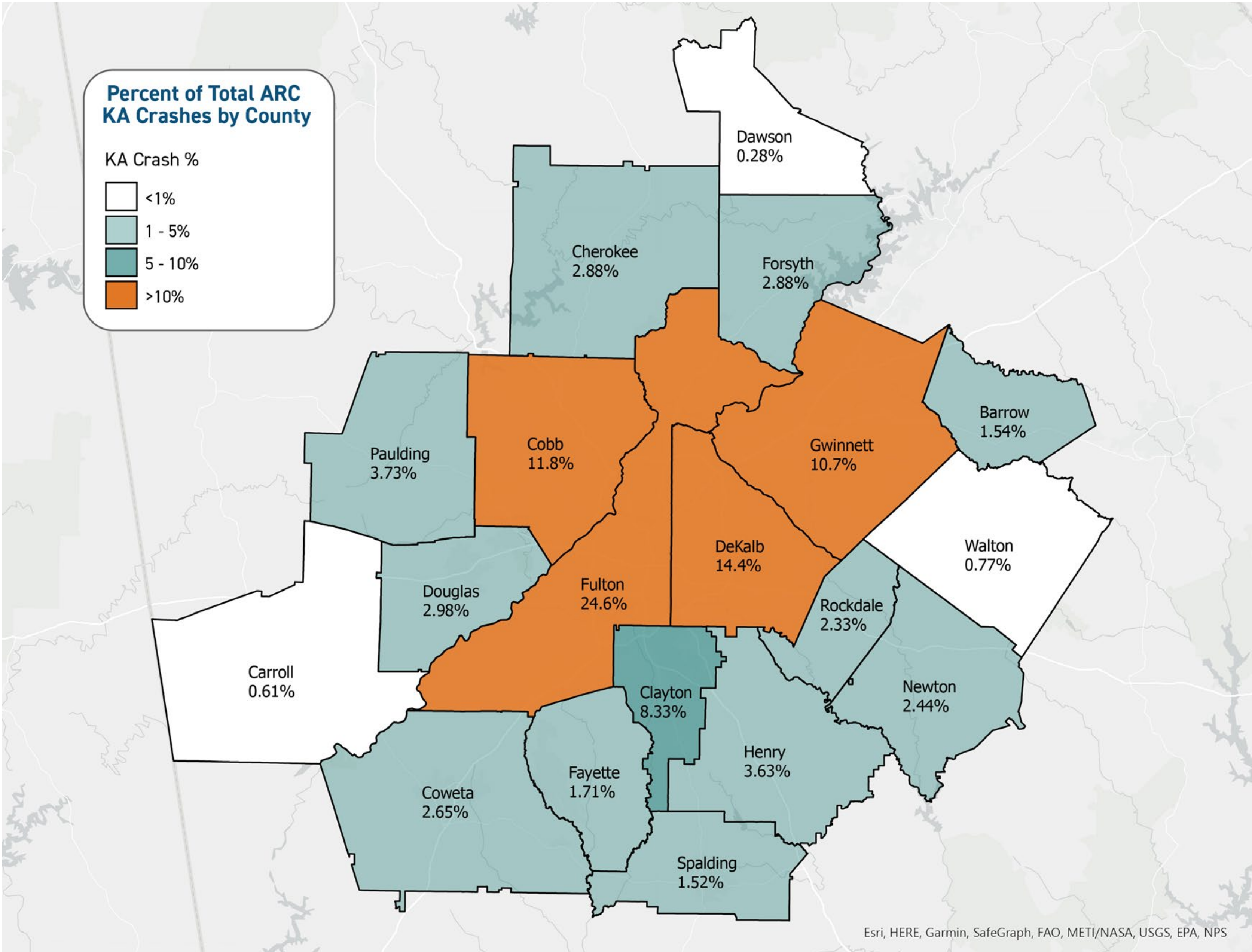


Figure 17. Percentage of Regional KA Crashes by County.

INTERSECTIONS

The following are priority facility types to target severe intersection crashes:

- Urban, GDOT-owned other principal arterials with 4 lanes
- Urban, GDOT-owned minor arterials with 4 lanes
- Urban, GDOT-owned minor arterials with 2 lanes
- Urban, County-owned major collectors with 2 lanes

Georgia does not have a digital inventory of intersections for all public roads, but the crash data provides an indicator for "intersection-related" crashes. ARC used this indicator along with roadway data to identify approach-level characteristics and other factors that indicate an increased risk of severe intersection crashes. Based on statistical analysis, the following characteristics are indicative of severe intersection crashes in the region:

- **Higher approach speeds** – Operating speed factors tend to be the strongest and most consistent indicators of severe intersection-related crashes (Figure 18 - Figure 20). Operating speeds of 35+ mph appear to increase the risk of severe intersection crashes on arterials, and operating speeds of 30+ mph appear to increase risk on collector and local roads.
- **Development patterns** – Low intensity developments tend to have longer block lengths, which encourages higher speeds. High-intensity development is indicative of urbanized environments. These locations may have shorter block lengths and may be more congested than less urban streets. These factors may moderate operating speeds and the kinetic energy involved in a potential crash (see Safe System discussion in the next section).
- **Signalized intersections on higher functional class roads** – Signalized intersections on principal arterials tend to be a risk factor. This may reflect larger, more complex intersections with numerous conflict points. Further, these conflict points may have approach angles that contribute to more severe crash types (e.g., right angle) and outcomes.
- **Uncontrolled (or unsignalized) intersections on lower functional class roads** – Uncontrolled intersections (or intersection-related crashes where no traffic control device is indicated) tend to be present on lower functional class roads. This could relate to driveway access on suburban streets where operating speeds may be higher than other intersection types. Further, vehicles entering traffic from uncontrolled driveways may produce collision angles that contribute to more severe crashes.

These findings support the guidance and recommendations documented in FHWA's *Safe System-based Framework and Analytical Methodology for Assessing Intersections.*[3] The methodology screens locations with potential for high kinetic energy crashes based on vehicular speed, traffic volume, conflict points, and collision angles. The section titled, *Safe System Guiding Principles*, describes the Safe System approach and opportunities to mitigate factors that contribute to severe crashes.

Agencies can use ARC's interactive, web-based systemic screening tool to identify sites with a higher risk of severe intersection crashes. As shown in Figure 21, analysts can select one or more risk factors to screen the network for sites with the highest risk for severe crashes. Additional layers can be turned on to look for correlations with transit stops, the RTP, bikeways, regional truck routes, and the LCI areas.

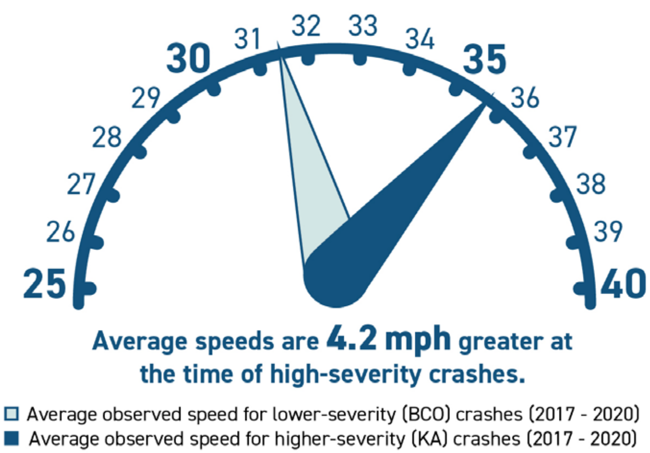


Figure 18. Average Operating Speed at Time of Intersection Crashes for Other Principal Arterials.

3 https://safety.fhwa.dot.gov/intersection/ssi/fhwasa21008.pdf

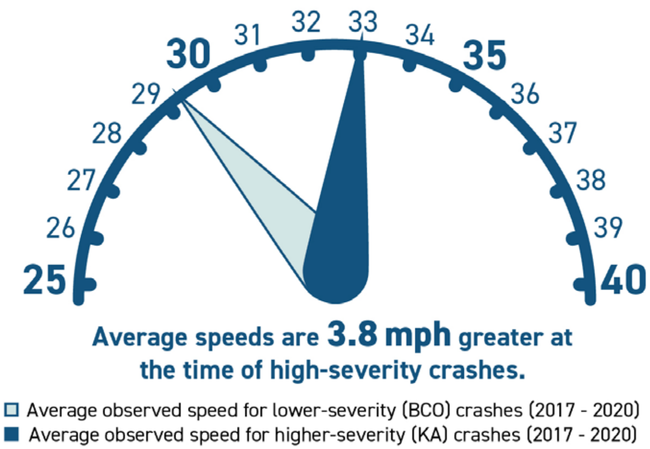


Figure 19. Average Operating Speed at Time of Intersection Crashes for Minor Arterials.

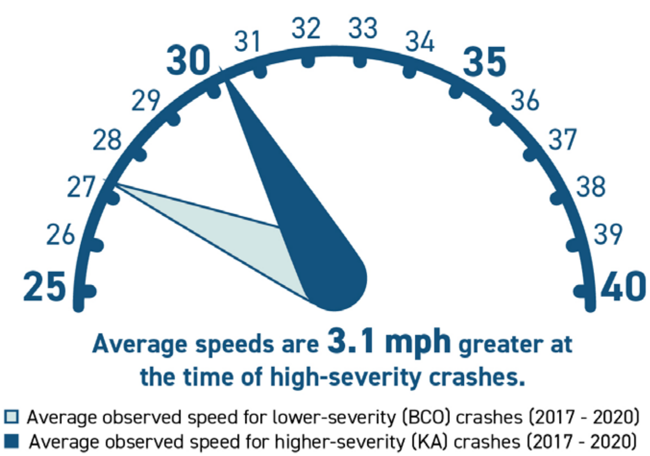


Figure 20. Average Operating Speed at Time of Intersection Crashes for Major Collectors.

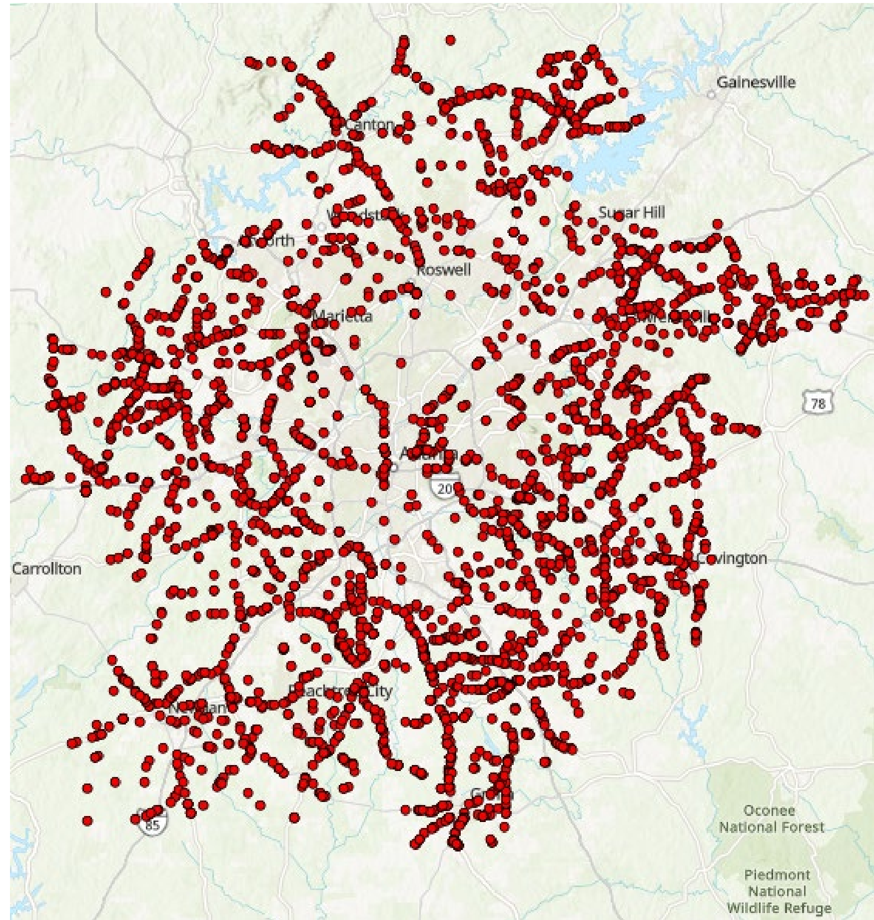


Figure 21. Locations with 3+ Intersection Risk Factors.

ROADWAY DEPARTURE

The following are priority facility types to target severe roadway departure crashes:

- Urban, GDOT-owned Interstates with 6+ lanes
- Urban, GDOT-owned minor arterials with 2 lanes
- Urban, County-owned minor arterials with 2 lanes
- Urban, County-owned major collectors with 2 lanes

The analysis also indicates that non-interstate roadway departure crash risk tends to skew toward rural, two-lane roads. Based on statistical analysis, the following characteristics tend to be indicative of severe roadway departure crashes in the region:

- **More local, rural roads** – Severe roadway departure crashes tend to occur on lower functional classifications, particularly in more rural areas with lower intensity development. This may relate to narrower paved widths and lack of shoulders or a recoverable area for vehicles that depart the travel lane. In urban areas, severe roadway departure crashes tend to be overrepresented on interstates.
- **Relatively moderate traffic volumes** – Severe roadway departure crashes tend to occur on roads with relatively moderate traffic volumes (5,000 to 15,000 vehicles per day).
- **Higher speeds** – Higher operating speeds are correlated with an increased likelihood of a severe roadway departure crash (Figure 22 and Figure 23). The threshold for what constitutes higher operating speed decreases on lower functional classification roads. Higher posted speed limits (45+ mph for arterials and 35+ mph for collectors) and greater differences between posted and operating speeds are also correlated with an increased likelihood of a severe roadway departure crash.

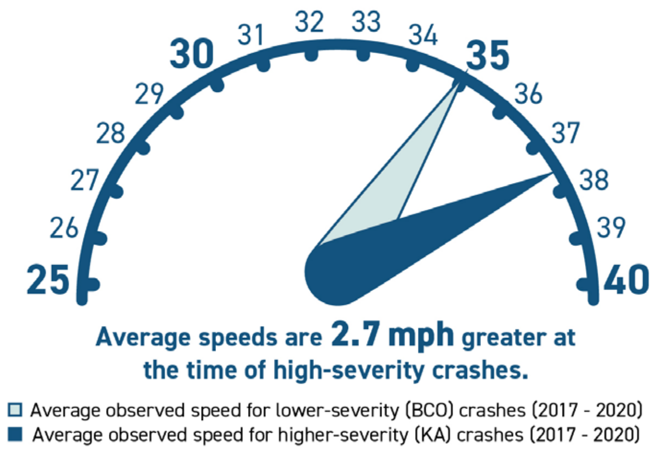


Figure 22. Average Operating Speed at Time of Roadway Departure Crashes for Minor Arterials.

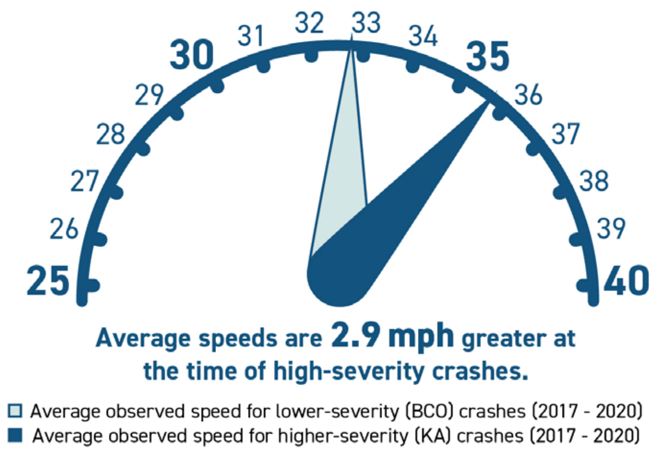


Figure 23. Average Operating Speed at Time of Roadway Departure Crashes for Major Collectors.

Agencies can use ARC's interactive, web-based systemic screening tool to identify sites with a higher risk of severe roadway departure crashes. As shown in Figure 24, analysts can select one or more risk factors to screen the network for sites with the highest risk for severe crashes. Additional layers can be turned on to look for correlations with transit stops, the RTP, bikeways, regional truck routes, and the LCI areas.

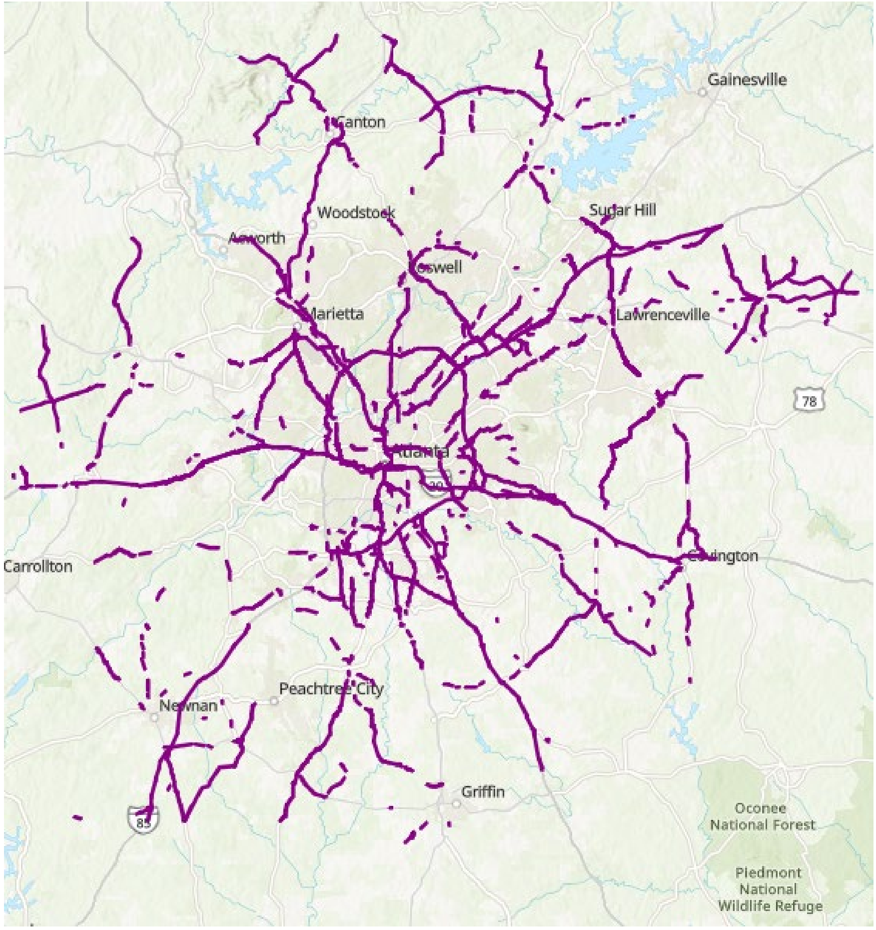
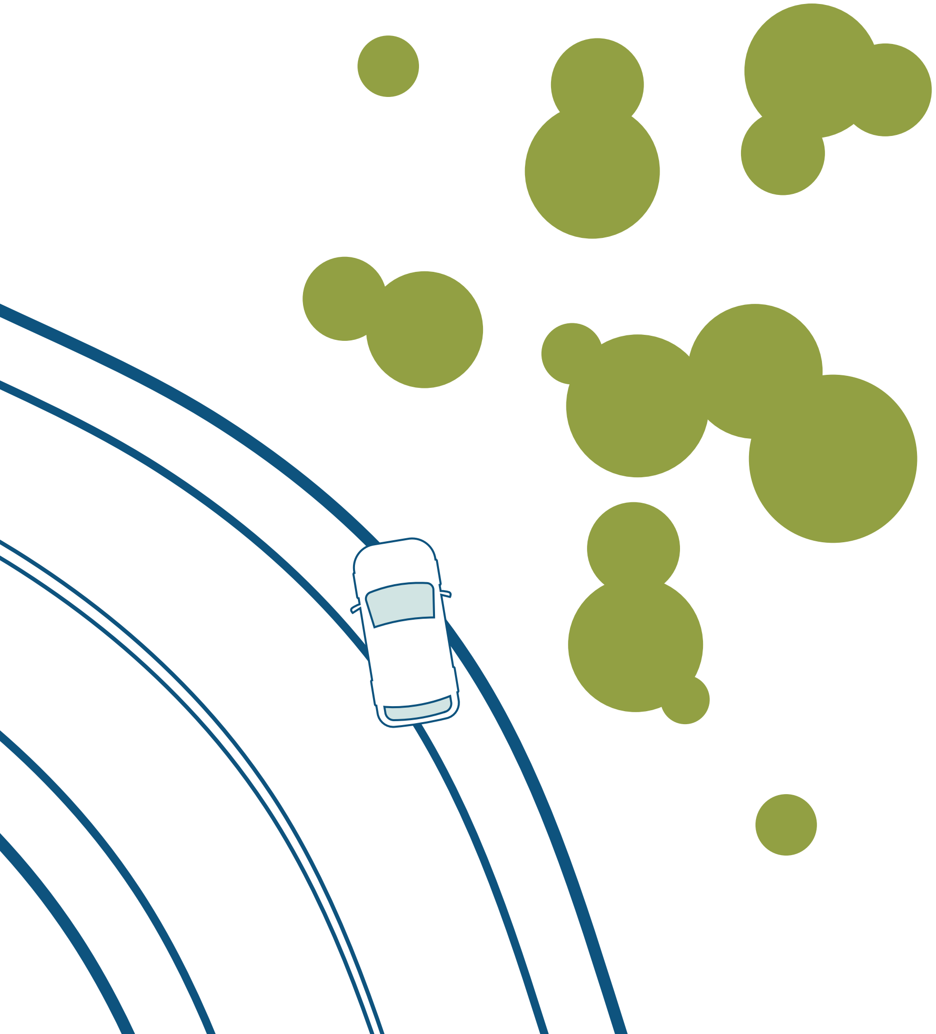


Figure 24. Locations with 6+ Roadway Departure Risk Factors.



PEDESTRIANS

The following are priority facility types to target severe pedestrian crashes:

- Urban, GDOT-owned other principal arterials with 6+ lanes
- Urban, GDOT-owned other principal arterials with 4 lanes
- Urban, GDOT-owned minor arterials with 4 lanes
- Urban, County-owned minor arterials with 4 lanes

Safety literature and research has demonstrated the connection between several contextual factors and pedestrian crash outcomes. These include speed, traffic volume, land use, employment, socioeconomic characteristics, and Environmental Justice score. Based on statistical analysis, the following characteristics tend to be indicative of severe pedestrian crashes in the region:

- **Higher speeds** – Posted speed limits (35+ mph) are a possible surrogate for pedestrian risk, but observed speeds show a definitive trend; more severe crashes are associated with higher operating speeds (Figure 25 and Figure 26). This is intuitive as higher speeds increase the probability of severe injury or death.
- **High volume roads with wider cross sections** – Higher volumes (9,000+ vehicles per day) and wider cross-sections (4+ lanes) tend to produce severe pedestrian crashes. This is intuitive as higher traffic volumes and wider cross-sections increase exposure for pedestrians. GDOT ownership correlates with this result as state-maintained roads tend to be wider with higher volumes and speeds.
- **Urban contexts** – Urbanized areas, high population densities, and higher intensity development tend to correlate with severe pedestrian crashes. Transit access, particularly high frequency bus service, is also correlated with severe pedestrian crashes. These factors are all indicative of urban environments with a mixture of close proximity origins and destinations. This is intuitive, as transit and destinations accessible by foot tend to indicate higher pedestrian traffic. While urban contexts typically include more exposure (i.e., more interactions between pedestrians and vehicles), these areas are critical to achieving other regional goals—economic competitiveness, climate change, and transportation efficiency. These risks need to be mitigated, not avoided.

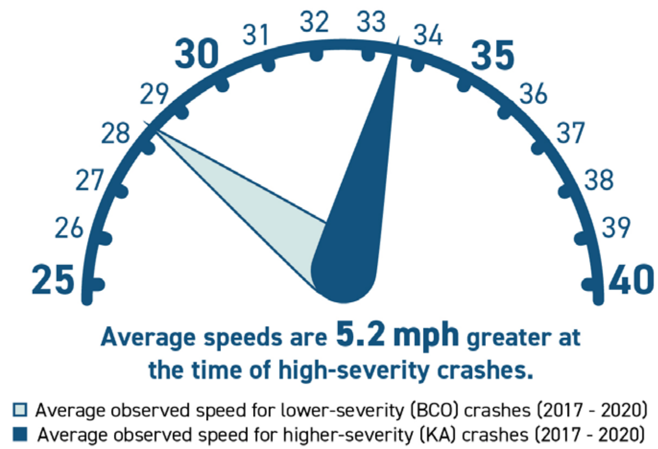


Figure 25. Average Operating Speed at Time of Pedestrian Crashes for Other Principal Arterials.

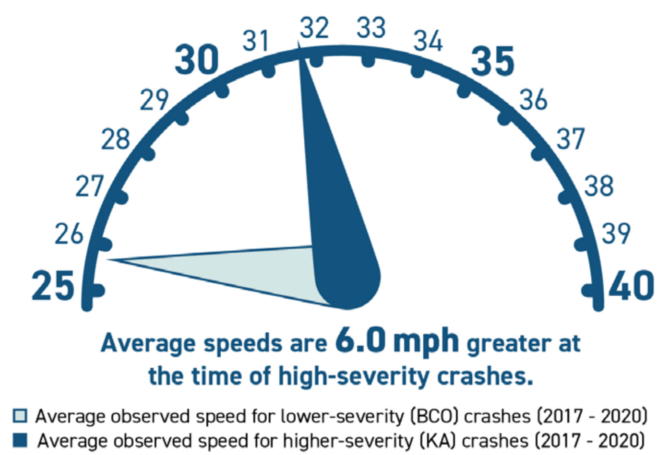


Figure 26. Average Operating Speed at Time of Pedestrian Crashes for Minor Arterials.

» **Socioeconomic status and Environmental Justice** – Communities with lower average incomes and higher proportions of the population that represent minority and non-white race and ethnicity tend to have higher correlations with severe pedestrian crashes. This could represent a combination of factors, including walking or transit dependence for low-income households. This could also indicate underserved communities that lack the types of pedestrian and bicycle amenities (e.g., sidewalks, bike lanes, multiuse paths, marked pedestrian crossings, and lighting) afforded to more affluent or more well-connected neighborhoods.

Agencies can use ARC's interactive, web-based systemic screening tool to identify sites with a higher risk of severe pedestrian crashes. As shown in Figure 27, analysts can select one or more risk factors to screen the network for sites with the highest risk for severe crashes. Additional layers can be turned on to look for correlations with transit stops, the RTP, bikeways, regional truck routes, and the LCI areas.

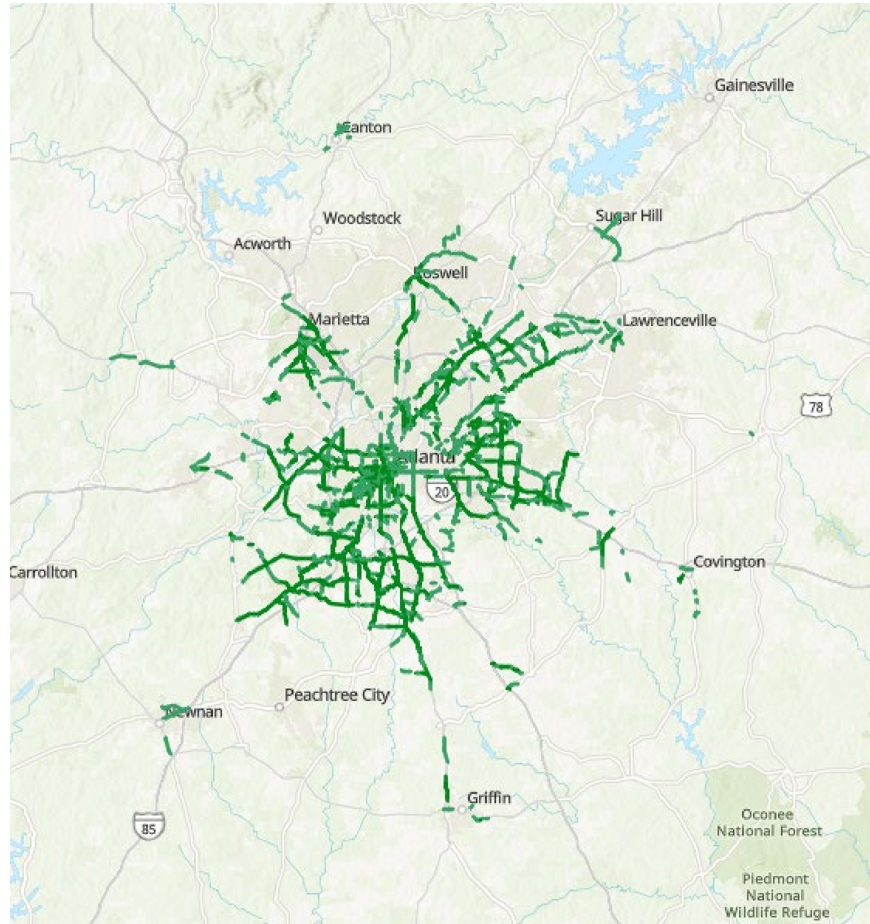


Figure 27. Locations with 7+ Pedestrian Risk Factors.

BICYCLES

The following are priority facility types to target severe bicycle crashes:

- Urban, GDOT-owned other principal arterials with 4 lanes
- Urban, GDOT-owned minor arterials with 2 or 4 lanes
- Urban, City-owned major collectors with 2 lanes

Like pedestrian safety, previous literature and research has demonstrated the connection between several contextual factors and bicycle crash outcomes. Based on statistical analysis, the following characteristics tend to be indicative of bicycle crashes in the region:

- **More local roads** – While GDOT arterials still appear as focus facility types, bicycle crashes tend to occur on lower functional classifications than pedestrian crashes. Severe bicycle crashes tend to be more common on city and county facilities and there is a relatively weak statistical relationship with GDOT ownership.
- **High volume roads** – For GDOT arterials, higher volumes (20,000+ vehicles per day) tend to be associated with severe bicycle crashes. This is intuitive as higher traffic volumes increase exposure for bicycle riders. For city and county roads, traffic volume did not appear as a significant risk factor.
- **Urban and mixed-use contexts** – Urbanized areas, high population and employment densities, and higher intensity development tend to correlate with bicycle crashes. Transit access, particularly high frequency bus service, is also correlated with bicycle crashes. These factors, including the proportion of employment in the retail sector, are all indicative of urban environments with a mixture of close proximity origins and destinations. While urban contexts typically include more exposure (i.e., more interactions between pedestrians and vehicles), these areas are critical to achieving other regional goals—economic competitiveness, climate change, and transportation efficiency. These risks need to be mitigated, not avoided.
- **High or low median household income** – Bicycle crashes are overrepresented (relative to resident population) in tracts at the bottom 20 percent of median household incomes in the region. However, the relationship is not linear and consistent across all income levels; higher median incomes, particularly in tracts with a high population density, are also correlated with bicycle crashes.
- **Induced demand** – Bicycle crashes are correlated with the presence of multiuse paths and marked bike lanes. This is not necessarily a reflection on relative safety, as these facilities are more likely to attract bicycle riders compared to roads without bicycle facilities. It is uncertain whether these facilities generate demand that would not otherwise be present (i.e., induced demand) or these facilities are present due to the high number of bicycle riders already present. It is clear, however, that these locations likely have bicycle riders present and may require additional accommodations or other measures to reduce risk (e.g., speed-related countermeasures).

Agencies can use ARC's interactive, web-based systemic screening tool to identify sites with a higher risk of severe bicycle crashes. As shown in Figure 28, analysts can select one or more risk factors to screen the network for sites with the highest risk for severe crashes. Additional layers can be turned on to look for correlations with transit stops, the RTP, bikeways, regional truck routes, and the LCI areas.

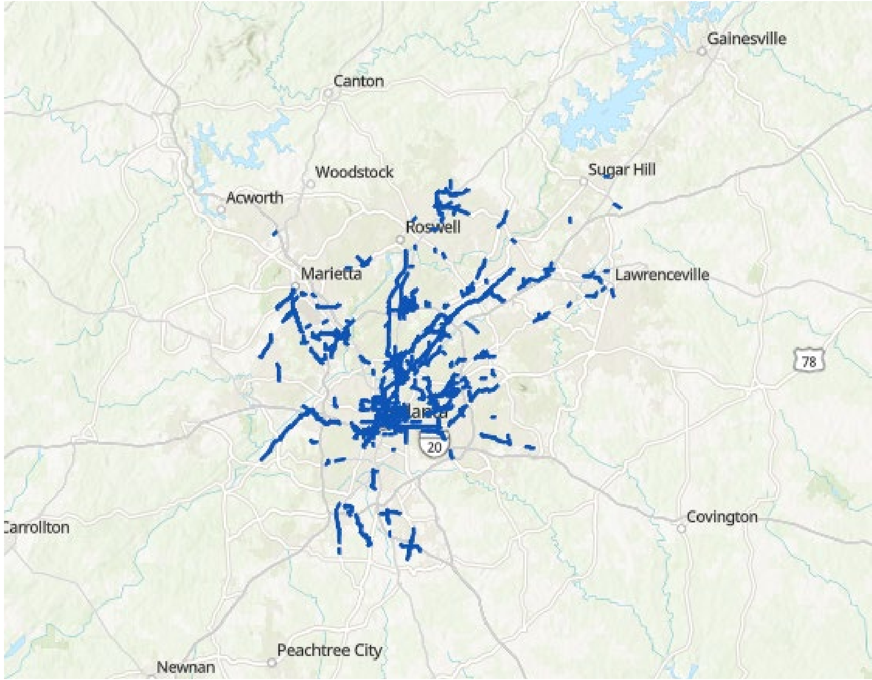


Figure 28. Locations with 7+ Bicycle Risk Factors.

WHAT ARE THE SOLUTIONS?

The solution to traffic-related deaths and injuries is multifaceted: implement proven safety countermeasures through a comprehensive safety management process guided by Safe System principles. The Safe System approach is proven to be an effective policy framework because it does not trade mobility for safety. Instead, it embraces the ideal that mobility follows from achieving the desired level of safety. Safe System principles provide an overarching policy framework to support decisions through the safety management process and, more generally, the project planning and development process. The safety management process is a repeatable, data-informed approach to identifying and diagnosing safety issues, developing and prioritizing projects, and evaluating completed projects. Proven safety countermeasures represent the preferred options to prevent and mitigate severe crashes. This section establishes the Safe System principles, provides an overview of the comprehensive safety management process, and concludes with a series of proven safety countermeasures. This combination of concepts and countermeasures will help local agencies address regional emphasis areas and work toward zero deaths and serious injuries.

SAFE SYSTEM GUIDING PRINCIPLES

> *The Safe System principles should guide all project decisions throughout the region, recognizing that safety is not the only factor in the decision process.*

Figure 29 illustrates the Safe System approach, including the five Safe System elements and the six Safe System principles.

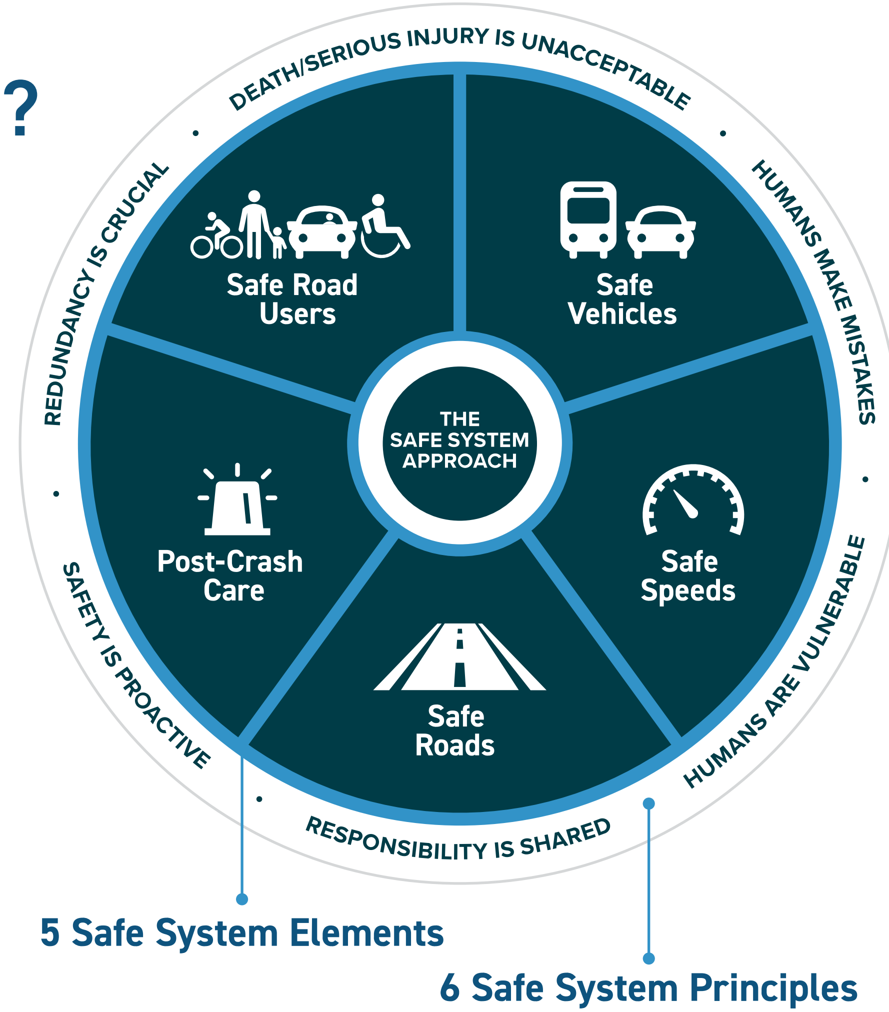
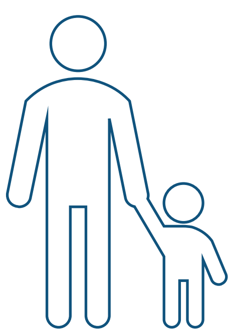
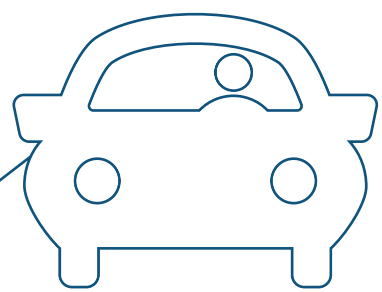


Figure 29. Overview of Safe System approach (FHWA , 2020).





The outer ring of Figure 29 represents the following six Safe System principles:

1. **Death/serious injury is unacceptable:** It can never be ethically acceptable that people are killed or seriously injured when moving within the road transportation system. A key paradigm shift in implementing a safe system is the idea that mobility and safety cannot be "traded off" against each other (Tingvall and Haworth, 1999). Instead, the level of mobility follows from achieving the desired level of safety.
2. **Humans make mistakes:** It is not the intent to design a system that is completely void of all crashes. It should be expected that humans using the transportation system will make mistakes and that those mistakes will lead to crashes. The intent is to design and operate the transportation system to accommodate human mistakes.
3. **Humans are vulnerable:** People have limited tolerance to forces from crash impacts. A safe system is one where forces in collisions do not exceed the limits of human tolerance. Information is available regarding these tolerances (i.e., what levels of kinetic energy will kill or seriously injure a person). Information is also available on the factors that influence the amount and transfer of kinetic energy in a crash, including vehicle size and design, vehicle speed, and impact angle. The intent is to design and operate the transportation system to manage the kinetic energy transferred in a crash. As shown in the previous section, speed is a risk factor in three of the four emphasis areas.
4. **Responsibility is shared:** While litigation tends to focus on the system designers (e.g., roadway owners and operators, vehicle and technology manufacturers), the media and law enforcement tend to focus on the road users when assigning blame for crashes. In a safe system, responsibility falls on both the system designers and the road users. This shared responsibility is clearly laid out in three points from Sweden's Vision Zero (Tingvall and Haworth, 1999):
   a. The designers of the system are ultimately responsible for the design, operation, and use of the road transportation system and therefore responsible for the level of safety within the entire system.
   b. Road users are responsible for following the rules set by the system designers for using the road system.
   c. If road users fail to obey these rules due to lack of knowledge, acceptance, or ability, or if injuries occur, the system managers still have the responsibility for taking necessary steps to address people being killed or seriously injured.
5. **Safety is proactive:** It is not necessary to wait for fatal and serious injury crashes to occur to address them. A Safe System approach proactively identifies risk factors and takes action to reduce the chance of death and serious injury. At the same time, a Safe System approach can reactively address historical safety issues.
6. **Redundancy is crucial:** The five Safe System elements shown on the inner loop of Figure 29 and illustrated in the Swiss Cheese model in Figure 30, represent the transportation system as a whole. Each element represents an opportunity to add redundancy and improve safety within the system. One option to improve the safety performance of the system is to improve all components. Another option is to add redundant components. This is the idea behind the Swiss Cheese model in Figure 30. If one component fails, another component can prevent or mitigate the severity of a crash. A safe system is one that provides enough redundancy to accommodate crash contributing factors without resulting in death or serious injury.

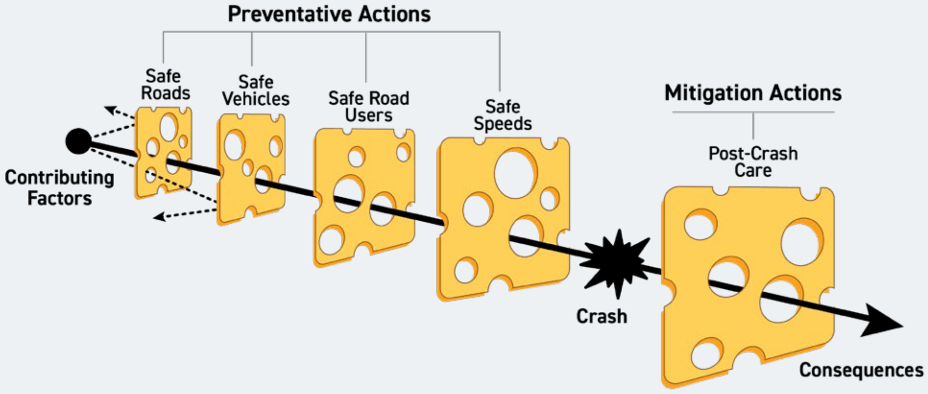


Figure 30. Swiss Cheese Model for Redundancy.

A COMPREHENSIVE APPROACH TO IMPROVING SAFETY

The roadway safety management process comprises three components: planning, implementation, and evaluation as shown in Figure 31 (Herbel et al., 2010). The region will use this process, guided by the Safe System principles, to implement proven safety countermeasures through the TIP and other safety-focused programs. The intent is to employ a combination of site-specific and systemic projects that reflect Safe System principles and address the diverse safety needs throughout the region. This section provides an overview of the site-specific and systemic approaches, which together represent a balanced and comprehensive approach to safety management. The section titled, *Moving Toward Zero*, provides further detail on how ARC and local agencies can use this process to identify sites, inform project development, and prioritize investments.

PLANNING

Identify problems: collect, manage, and analyze data to identify opportunities to improve safety.

Develop countermeasures: develop targeted strategies to address crash contributing factors.

Prioritize projects: develop a balanced portfolio of projects that maximizes return on investment.

IMPLEMENTATION

Implement safety projects: design projects, identify funding sources, allocate resources, program projects, and develop a plan to evaluate investments.

EVALUATION

Estimate effectiveness of projects and programs: perform project-, countermeasure-, and program-level evaluations to understand the safety performance and cost-effectiveness of investments and to inform future decisions.

Figure 31. General Roadway Safety Management Process.

The site-specific and systemic approaches both focus on sites with the highest potential for safety improvement. The difference is how each approach defines "potential for improvement."

The **site-specific approach** defines "potential for improvement" based on site-specific crashes (i.e., historical crashes, predicted future crashes, or a combination of the two). Local agencies can use the site-specific approach to identify and treat high-crash locations such as individual intersections or road segments. If there are many adjacent or proximate sites that represent a high potential for safety improvement, agencies can combine these into a corridor project

The site-specific approach is reactive in that it addresses sites based on historical safety performance.

The **systemic approach** defines "potential for improvement" based on site-specific risk factors (i.e., geometric and operational attributes known to increase crash risk). Local agencies can use the systemic approach to address safety issues from a systemwide risk-based perspective (as opposed to a purely crash-based perspective). The systemic approach focuses on crash types and contributing factors common to many sites across the network and typically involves multiple sites per project. The systemic approach is proactive because it focuses on the presence of risk factors; the sites are not required to have a history of crashes

The systemic approach is proactive in that it addresses sites based on risk rather than crash history.

Site-specific and systemic safety are complementary and support a comprehensive approach to safety program management.

Figure 32 shows the same three components from Figure 31 but disaggregated into specific steps within the site-specific and systemic approaches. Both approaches start by establishing the focus of the analysis, including the selection of focus crash types and facility types. Using the Safe System principles as a guide, the focus crash types include those that result most often in death and serious injury (rather than focusing on all crashes). Similarly, the focus facility types include those where fatal and serious injury crashes are most prevalent (rather than focusing on the entire network). As a reminder, the regional focus crash types are intersection, roadway departure, pedestrian, and bicycle. Refer to the prior section titled, *Where are the Regional Safety Issues*, for details on the focus facility types.

The primary difference between the site-specific and systemic approach is the order in which screening and diagnosis occur in the planning stage. The site-specific approach starts with network screening to identify sites with potential for safety improvement, followed by diagnosis to identify crash contributing factors at each location of interest. The systemic approach starts with diagnosis at the network level to identify risk factors associated with the focus crash type and focus facility type, followed by screening to identify and prioritize locations with the risk factors.

The remaining steps are nearly identical for the site-specific and systemic approach. Countermeasure selection focuses on the use of proven safety countermeasures to target underlying crash contributing factors. Economic appraisal helps to determine the most cost-effective countermeasure(s) for each location of interest. Agencies then prioritize among multiple potential projects, comparing both site-specific and systemic projects, to develop and implement an annual program of safety projects. The final step is to evaluate the performance of implemented projects and programs to determine what is working well (and what is not). Refer to the later section titled, *Moving Toward Zero*, for further details on how ARC and local agencies are involved in these various steps.

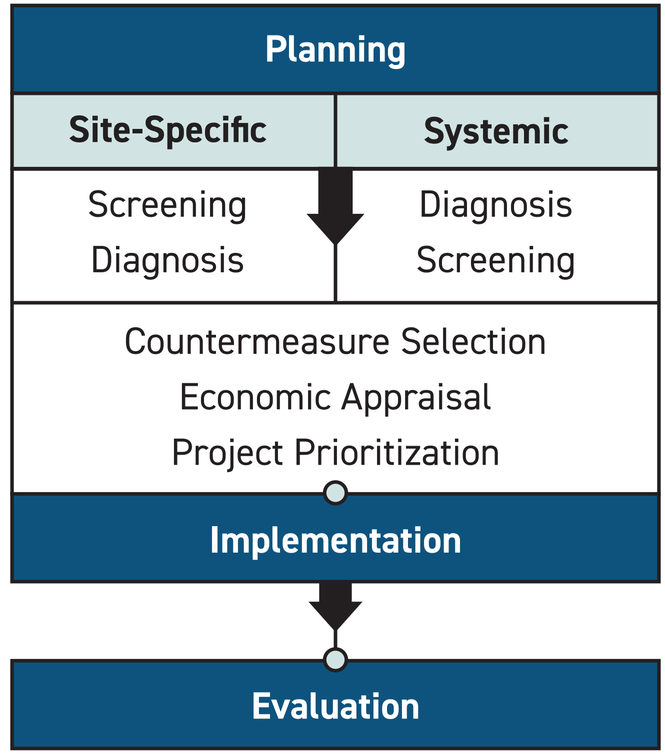


Figure 32. Detailed Roadway Safety Management Process.

PROVEN SAFETY COUNTERMEASURES

ARC promotes the use of FHWA's Proven Safety Countermeasures **to enhance safety for all road users.** Local agencies can:

- **Implement proven safety countermeasures reactively** to address high-crash locations and site-specific safety issues.
- **Implement proven safety countermeasures proactively** to address high-risk locations and systemic safety issues.

Table 9 through Table 11 present proven safety countermeasures to address intersection, roadway departure, and pedestrian and bicycle crashes respectively. Countermeasures are presented individually; however, agencies can implement countermeasures in combination to address multiple issues simultaneously. Appendix B presents common high-risk scenarios in the ARC region with accompanying countermeasure options. Local agencies can use Appendix B to identify similar opportunities to incorporate proven safety countermeasures in projects in their jurisdiction.

Not all countermeasures will be appropriate. The key to countermeasure selection is to:

- **Target the underlying risk factors:** Each table indicates applicable risk factors.
- **Consider the practicality, safety benefits, and cost-effectiveness:** Appendix D provides a list of associated crash modification factors (CMFs) to estimate the safety benefits. Appendix E provides details on how to estimate cost-effectiveness.
- **Recognize the diverse issues and unique community needs:** Agencies can incorporate equity measures and engage the community to develop the most appropriate project.

The key to countermeasure selection is to ***target the underlying risk factors.***

TABLE 7. INTERSECTION COUNTERMEASURES

COUNTERMEASURE	HIGH SPEEDS	HIGH TRAFFIC VOLUMES	PERMISSIVE LEFT-TURN PHASING	LIMITED SIGHT DISTANCE	SKEWED INTERSECTION	INTERSECTION ON CURVE
Advance signs	✓			✓		✓
Application of multiple low-cost countermeasures	✓			✓		✓
Backplates with retroreflective borders	✓	✓				
Convert intersection to roundabout	✓				✓	✓
Corridor access management	✓	✓				
Flashing yellow arrow	✓	✓	✓			
Improve intersection angle	✓	✓		✓	✓	
Improve intersection sight distance	✓	✓	✓	✓	✓	✓
Left- and right-turn lanes	✓	✓				
Protected left-turn phase	✓	✓	✓	✓		
Yellow change intervals	✓	✓	✓			

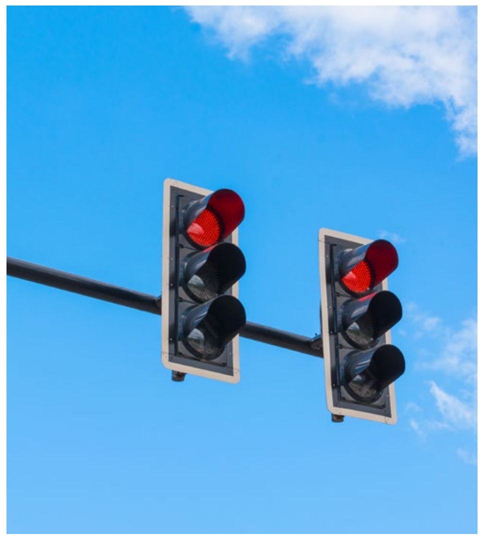
Proven Safety Countermeasures

Focus Crash Type: Intersections

There are a range of flexible and cost-effective countermeasures that have been proven effective in reducing intersection crashes in a variety of settings and contexts. They can be used individually or in combination depending on budget and setting, among other things. Applying countermeasures incrementally can allow for more focused prioritization of a community's needs in a cost effective manner.

For details and more information, visit: https://safety.fhwa.dot.gov/provencountermeasures/

Source: FHWA

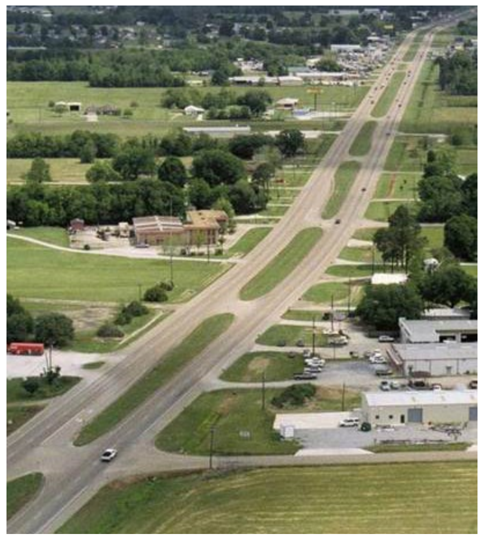


Backplates with Retroreflective Borders

Backplates added to a traffic signal head improve the visibility of the illuminated face of the signal by introducing a controlled-contrast background. Signal heads that have backplates equipped with retroreflective borders are more visible and conspicuous in both daytime and nighttime conditions.

Backplates with reflective borders can reduce total crashes up to

15%



Corridor Access Management

Access management refers to the design, application, and control of entry and exit points along a roadway. This includes intersections with other roads and driveways that serve adjacent properties. Corridor access management can simultaneously enhance safety for all modes, facilitate walking and biking, and reduce trip delay and congestion.

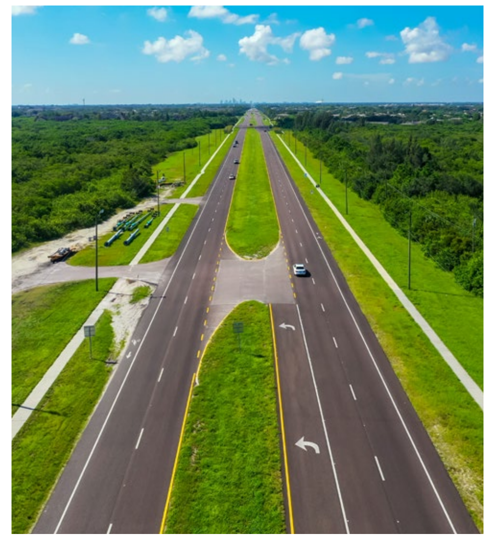
Reducing driveway density can reduce total crashes up to

5-23%

on rural roads and up to

25-31%

on urban/suburban arterials

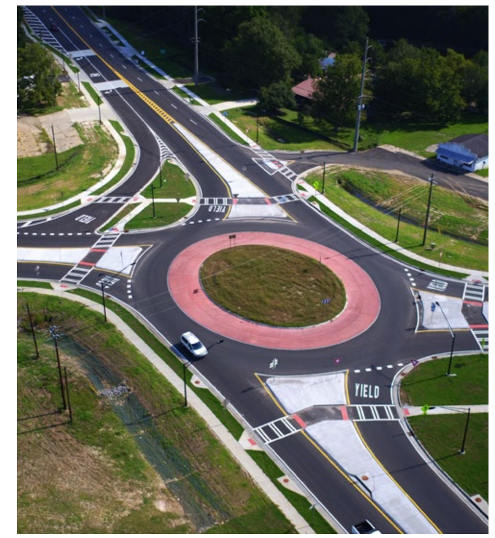


Reduced Left-Turn Conflict Intersections

Reduced left-turn conflict intersections are geometric designs that divert left-turn movements. These intersections simplify decision-making for drivers and minimize the potential for higher severity crash types, such as head-on and angle. Two highly effective designs that rely on U-turns to complete certain left-turn movements are known as the Restricted Crossing U-turn (RCUT) and the Median U-turn (MUT).

Converting unsignalized intersections to unsignalized RCUTs can reduce fatal and injury crashes up to

63%



Roundabouts

The modern roundabout is an intersection with a circular configuration that safely and efficiently moves traffic. Roundabouts feature channelized, curved approaches that reduce vehicle speed, entry yield control that gives right-of-way to circulating traffic, and counterclockwise flow around a central island that minimizes conflict points.

Transforming a two-way stop-controlled intersection to a roundabout can reduce fatal and injury crashes up to

82%

Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections

This systemic approach to intersection safety involves deploying a package of multiple low-cost countermeasures, including enhanced signing and pavement markings, at a large number of stop-controlled intersections within a jurisdiction.

Applying low-cost countermeasures can reduce fatal and injury crashes up to

27%

at rural intersections and up to

19%

at 2-lane by 2-lane intersections

Yellow Change Intervals

At a signalized intersection, the yellow change interval is the length of time that the yellow signal indication is displayed following a green signal indication. The yellow signal confirms to motorists that the green has ended and that a red will soon follow. Since red-light running is a leading cause of severe crashes at signalized intersections, it is imperative that the yellow change interval be appropriately timed.

Applying appropriate yellow change intervals to signalized intersections can reduce red-light running up to

36-50%

TABLE 8. ROADWAY DEPARTURE COUNTERMEASURES

COUNTERMEASURE	NARROW ROAD	NARROW SHOULDER	UNPAVED SHOULDER	HIGH SPEEDS	MULTIPLE LANES	SHARP CURVES	STEEP SLOPES
Advance markings for curves	✓	✓	✓	✓		✓	
Advance signs	✓	✓		✓		✓	
Enhanced delineation for horizontal curves	✓			✓		✓	
Enhanced friction for horizontal curves	✓			✓		✓	
Median barriers				✓	✓		
Median buffer				✓	✓		
Raised pavement markers	✓	✓		✓	✓	✓	
Roadside design improvements				✓		✓	✓
Rumble strips/stripes	✓	✓	✓	✓		✓	✓
SafetyEdge[SM]	✓	✓	✓	✓	✓	✓	✓
Wider pavement markings	✓	✓		✓	✓	✓	
Wider shoulder	✓	✓	✓	✓		✓	✓

Proven Safety Countermeasures

Focus Crash Type: Roadway Departure

There are a range of flexible and cost-effective countermeasures that have been proven effective in reducing roadway departure crashes in a variety of settings and contexts. They can be used individually or in combination depending on budget and setting, among other things. The Federal Highway Administration (FHWA) has identified three primary objectives to reducing roadway departures: 1) Keep vehicles in their lanes; 2) Reduce the potential for crashes; and 3) Minimize crash severity. Each of the proven countermeasures below works toward one or more of these objectives.

For details and more information, visit: https://safety.fhwa.dot.gov/provencountermeasures/

Source: FHWA

Wider Edge Lines

Wider edge lines increase define the edge of the travel lane and can provide a safety benefit to all facility types (e.g., freeways, multilane divided and undivided highways, two-lane highways) in both urban and rural areas. "Wider" edge lines are when the marking width is increased from the normal 4 inches to 6 inches. They are most effective in reducing two-lane single vehicle crashes on rural highways.

Wider edge lines can reduce crashes up to

37%

for non-intersection, fatal and injury crashes on rural, two-lane roads

Enhanced Delineation for Horizontal Curves

Enhanced delineation alerts drivers to upcoming curves, the direction and sharpness of the curve, and appropriate operating speed. Potential strategies include advance pavement markings, in-lane curve warning pavement markings, retroreflective strips on sign posts, curve delineators, chevron signs, larger fluorescent or retroreflective signs, dynamic curve warning signs or speed radar feedback signs.

Chevron signs can reduce nighttime crashes up to

25%

and have been show to reduce non-intersection fatal and injury crashes up to

16%

Longitudinal Rumble Strips and Stripes on Two-Lane Roads

Longitudinal rumble strips are milled or raised elements on the pavement intended to alert drivers through vibration and sound that their vehicle has left the travel lane. They can be installed on the shoulder, edge line, or at or near the center line of an undivided roadway.

Shoulder Rumble Strips can reduce run-off-road crashes up to

13-51%

for single vehicle, fatal and injury crashes on two-lane rural roads

SafetyEdge℠

The SafetyEdge℠ shapes the edge of the pavement at approximately 30 degrees from the pavement cross slope during the paving process. Over time, the edge may become exposed due to settling, erosion and tire wear. The SafetyEdge℠ is preferable to the traditional vertical edge because it gives drivers the opportunity to maintain control and return their vehicle to the travel lane.

SafetyEdge℠ can reduce run-off-road crashes up to

21%

and can reduce fatal and injury crashes up to

11%

Roadside Design Improvements at Curves

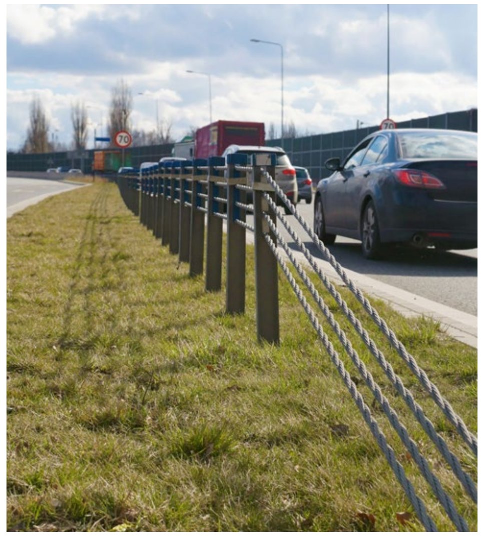
Proper roadside design can reduce the severity of a crash when a vehicle leaves the road. Wider shoulders, flattener sideslopes, and wider clear zone provide drivers with an opportunity to regain control or come to a safe stop before rolling over or encountering a fixed object. Not all roadside hazards can be removed, but countermeasures such as cable barriers, metal-beam guardrails, and concrete barriers can help reduce crash severity.

Flattening sideslopes can reduce single-vehicle crashes up to

8-12%

and increasing the distance to roadside features can reduce all crashes up to

22-44%



Median Barriers

Median barriers are longitudinal barriers (can be cable, metal, or concrete) that separate opposing traffic on a divided highway and are designed to redirect vehicles striking either side of the barrier. Median barriers significantly reduce the number of cross-median crashes, which are attributed to the relatively high speeds that are typical on divided highways. AASHTO's *Roadside Design Guide* provides recommendations for use of median barriers depending on the width of the median and average daily traffic volumes.

Median barriers can reduce cross-median crashes up to

97%

on rural four-lane freeways

TABLE 9. PEDESTRIAN AND BICYCLE COUNTERMEASURES

COUNTERMEASURE	HIGH SPEEDS	HIGH TRAFFIC VOLUMES	HIGH PEDESTRIAN VOLUMES	HIGH BICYCLE VOLUMES	MULTIPLE LANES	NO MEDIAN	LACK OF FACILITIES	LIMITED SIGHT DISTANCE	POOR VISIBILITY
Advance warning signs and markings	✓	✓	✓	✓	✓		✓	✓	✓
Curb extensions			✓		✓	✓	✓	✓	✓
Dedicated bicycle lanes	✓	✓		✓	✓		✓		
Grade separated crossing	✓	✓	✓	✓	✓	✓		✓	
High visibility crosswalk			✓				✓		✓
Leading pedestrian interval	✓	✓	✓		✓				

COUNTERMEASURE	HIGH SPEEDS	HIGH TRAFFIC VOLUMES	HIGH PEDESTRIAN VOLUMES	HIGH BICYCLE VOLUMES	MULTIPLE LANES	NO MEDIAN	LACK OF FACILITIES	LIMITED SIGHT DISTANCE	POOR VISIBILITY
Lighting			✓	✓			✓		✓
Parking restriction near crossing		✓			✓	✓		✓	✓
Pedestrian hybrid signal	✓	✓	✓		✓	✓		✓	✓
Pedestrian refuge island	✓	✓	✓		✓	✓	✓	✓	✓
Prohibit right-turn on red		✓	✓					✓	✓
Protected left-turn phasing	✓	✓	✓					✓	✓
Raised crosswalk			✓				✓		
Rapid rectangular flashing beacon	✓	✓	✓		✓	✓			✓
Road diet	✓			✓	✓	✓	✓		
Separated multiuse path	✓	✓	✓	✓			✓		
Sidewalks	✓	✓	✓		✓		✓		✓

Proven Safety Countermeasures

Focus Crash Type: Pedestrian/Bicycle

There are a range of flexible and cost-effective countermeasures that have been proven effective in reducing pedestrian and bicycle crashes in a variety of settings and contexts. They can be used individually or in combination depending on budget and setting, among other things. Applying countermeasures incrementally can allow for more focused prioritization of a community's needs in a cost effective manner.

For details and more information, visit: https://safety.fhwa.dot.gov/provencountermeasures/

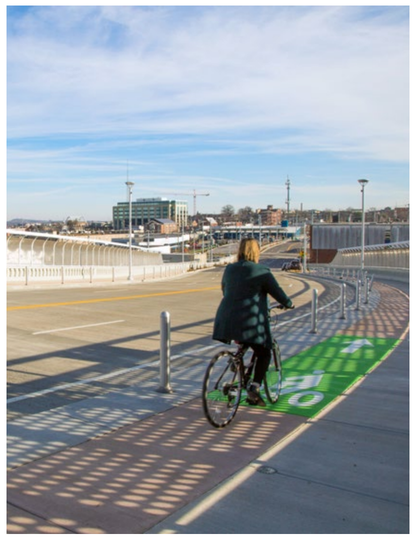
Source: FHWA

Crosswalk Visibility Enhancements

Marked crosswalks inform pedestrians of preferred crossing locations and alert drivers to the potential presence of pedestrians. Three crosswalk visibility enhancements include high-visibility crosswalks, lighting, and signing and pavement markings. These enhancements can also assist pedestrians in deciding where to cross.

High-visibility crosswalks can reduce pedestrian injury crashes up to

40%



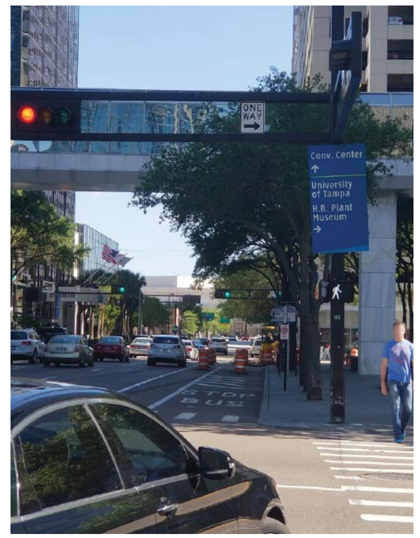
Bicycle Lanes

Bicycle lanes improve safety and comfort for most bicycle riders. Dedicated bicycle facilities can take several forms, including striped bike lanes, buffered bike lanes, and protected bike lanes. Providing bicycle facilities can mitigate or prevent interactions, conflicts, and crashes between bicycle riders and motor vehicles, and create a safer network for cycling.

Adding bicycle lanes can reduce crashes up to

49%

for total crashes on urban 4-lane undivided collectors and local roads



Leading Pedestrian Interval

A leading pedestrian interval (LPI) gives pedestrians the opportunity to enter the crosswalk at a signalized intersection 3-7 seconds before vehicles are given a green indication. Pedestrians can better establish their presence in the crosswalk before vehicles begin to turn right or left.

Installing LPIs can reduce pedestrian-vehicle crashes up to

13%

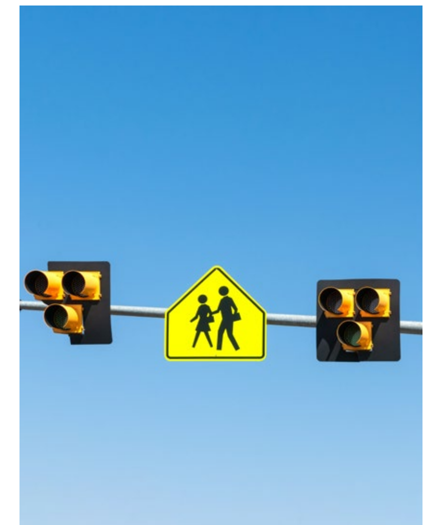
at signalized intersections

Medians and Pedestrian Refuge Islands

A median is the area between opposing lanes of traffic, excluding turn lanes. Medians in urban and suburban areas can be defined by pavement markings, raised medians, or islands to separate motorized and non-motorized road users. A pedestrian refuge island (or crossing area) is a median with a refuge area that is intended to help protect pedestrians who are crossing a road.

Pedestrian refuge islands can reduce pedestrian crashes up to

56%



Pedestrian Hybrid Beacons

The pedestrian hybrid beacon (PHB) is a traffic control device designed to help pedestrians safely cross higher-speed roadways at midblock crossings and uncontrolled intersections.

Installing PHBs can reduce pedestrian crashes up to

55%

and reduce total crashes up to

29%

Road Diets (Roadway Reconfiguration)

A Road Diet, or roadway reconfiguration, can improve safety, calm traffic, provide better mobility and access for all road users, and enhance overall quality of life.

A Road Diet typically involves converting an existing four-lane undivided roadway to a three-lane roadway consisting of two through lanes and a center two-way left-turn lane (TWLTL).

Converting a road from a 4-lane to 3-lane section can reduce total crashes up to

19-47%

Walkways

A walkway is any type of defined space or pathway for use by a person traveling by foot or using a wheelchair. These may be pedestrian walkways, shared use paths, sidewalks, or roadway shoulders.

Sidewalks can reduce crashes up to

65-89%

for pedestrians walking along roadways

TIPS FOR SCREENING AND SELECTING COUNTERMEASURES

How does an analyst determine if a countermeasure aligns with Safe System principles?

Countermeasures that align with Safe System principles are those that reduce the kinetic energy transferred to people during crash events. These can include countermeasures that minimize the potential for crashes (e.g., reduce conflict points) and minimize the severity of crashes that do occur (e.g., reduce vehicle speeds and create less severe impact angles).

Is it appropriate to simply select the countermeasure that has the lowest CMF (i.e., greatest expected safety benefit)?

While safety effectiveness is an important consideration in countermeasure selection, agencies should select countermeasures that target the underlying crash types and risk factors. Ideally, agencies would select a countermeasure that is highly effective at reducing the focus crash type. Agencies should also consider construction and maintenance costs because more effective countermeasures (e.g., roundabouts, roadway realignment) are often associated with higher costs.

Is it better to implement high-cost countermeasures that are highly-effective or lower-cost countermeasures that are less effective?

The answer to this question is best answered using benefit-cost analysis or countermeasure scores. Ideally, the countermeasure(s) selected for implementation would be the most cost-effective (i.e., provide the greatest return per dollar spent). If the goal is to reduce fatal and serious injury crashes, the benefit-cost analysis should only include the benefits associated with fatal and serious injury crashes (as opposed to total crashes).

Are construction costs or maintenance costs more important?

The best way to compare construction costs and maintenance costs is to convert to a common frame of reference. Construction costs are often shown as present value costs while maintenance costs are often reported as annual values. Converting both to the same frame of reference (either present or annual values) will help with this question. Agencies should also consider maintenance responsibilities and determine if those responsible for maintaining the countermeasure have the time and resources to do so. If not, maintenance may be a more significant factor in countermeasure selection.

How does service life affect countermeasure selection?

The Highway Safety Manual defines countermeasure service life as "the number of years in which the countermeasure is expected to have a noticeable and quantifiable effect on the crash occurrence at the site" (AASHTO 2010). Service life is used in benefit-cost analysis to convert annual costs and benefits to present values or vice versa. Understanding the service life for each countermeasure allows the analyst to account for the time value of costs and benefits, particularly when the analysis period is different from the service life or when the service life differs among alternatives.

How do other planned projects and implementation schedule affect countermeasure selection?

Countermeasures that can be implemented sooner and easier may be higher priority, especially if those countermeasures can be implemented as part of a project that is already planned and programmed. Countermeasures implemented as part of other planned projects reduce construction-related costs and impacts and generally provide a cost savings for the overall program. The planning and scoping phase is the best time to identify and add safety components to a project, not the design phase. Local agencies can use tools like ARC's web-based systemic screening tool to determine if future project locations align with high-risk locations. If so, there is an opportunity to perform more detailed safety diagnosis and add a safety component to the planned project.

Are there other quantitative factors besides safety benefits and project costs that can affect countermeasure selection?

Yes, countermeasures with positive environmental benefits may receive higher priority than similar countermeasures with no or negative environmental impacts. Those needing right-of-way (ROW) acquisition may receive lower priority because this presents a potential risk to the schedule and budget.

Are there other qualitative factors besides safety benefits and project costs that can affect countermeasure selection?

Yes, countermeasures that address multiple emphasis areas or promote equity tend to receive higher priority during selection.

Is it appropriate to consider countermeasures that are not part of typical agency policies or practices?

Yes, assuming there is sufficient evidence to support the cost-effectiveness and overall benefits of the countermeasure with respect to the targeted risk factors. In these cases, it is useful to identify peer agencies that have demonstrated successful implementation of the countermeasure and include that as part of the project application.

Is it appropriate to consider education and enforcement countermeasures?

Yes, education and enforcement strategies can complement engineering strategies. However, local agencies will need to work with safety stakeholders, other than ARC, to implement such strategies. These strategies do not fit neatly into ARC's purview because ARC is responsible for developing and managing the long-range RTP and short-range TIP, which focus on infrastructure (i.e., engineering strategies). Agencies should also recognize that education and enforcement strategies can be associated with community and professional concerns. In general, safety strategies should be targeted. This holds true for education and enforcement, but the strategies should target the underlying risk factors and NOT specific communities or populations. For instance, speed is a risk factor in severe pedestrian crashes. As such, local agencies could work with communities to identify corridors where speeding is a concern and target educational and enforcement campaigns to address speeding. Launching educational campaigns before enforcement campaigns can increase effectiveness and acceptance (NHTSA , 2021).

Is it appropriate to consider public and political pressure in selecting an appropriate countermeasure?

Yes, agencies should engage with the community to determine their wants and needs. Agencies can use public feedback to guide countermeasure selection, while justifying the final selection with a data-informed approach that demonstrates the link between the countermeasure and underlying risk factors as well as the cost-effectiveness. Agencies may prioritize countermeasures based on favorable public feedback, support by local elected officials, or high-priority needs (e.g., school safety). Deeper engagement may be necessary for controversial improvements.

BEYOND COUNTERMEASURES (OTHER COMMUNITY FACTORS)

High-intensity land use, employment density, transit stops, and presence of bike facilities are associated with an increased crash risk. These factors are surrogates for increased exposure and support other regional goals such as a competitive economy. While it is not reasonable to reduce risk by eliminating these factors, there is a need to mitigate risk through better design and operational strategies. The proven countermeasures presented in the previous section are one set of tools to improve the safe design and operations of roads. **Other community-level factors can also have a positive and long-lasting influence on safety at the regional level, including speed management, mode shift, and land use and development patterns.**

SPEED MANAGEMENT

Strategies that manage speeds reduce deaths and serious injuries. Speed management can also reduce air and noise pollution, save fuel, and improve the overall experience and level of comfort for all roadway users. A comprehensive speed management program goes beyond building or modifying roads with proven countermeasures that slow speeds and reduce risks, but also includes:

- **Establishing appropriate speed limits.** Speed limits have traditionally been established for roads using an 85th percentile methodology (i.e., the speed at or below which 85% of drivers travel on a road segment). This method may not result in speed targets that are appropriate for the function of the road and community context. Newer approaches such as USLIMITS2 consider several factors, including operating speed, daily traffic, roadway characteristics, adjacent land use, crash rates, and extent of pedestrian and cyclist activity, in setting speed targets.
    - NACTO's City Limits: Setting Safe Speeds for Urban Streets publication provides context sensitive methods to set safe speed limits by evaluating conflict density, activity level, and other factors.
    - The City of Atlanta's Vision Zero Ordinance, adopted in 2020, took a systematic approach and designated a new default speed limit of 25 mph for most city streets to improve public health and safety.
- **Enforcing speed limits.** Ensuring drivers comply with the legal posted speed limits can be greatly influenced by the actions of authorities who enforce speed limits and adjudicate speed infractions. It is important to have sustained, well-resourced law enforcement to help shape road user behaviors and encourage compliance with the law. This can include traditional methods such as police enforcement at spot locations as well as embracing technology with automated speed enforcement. The State of Georgia and local laws impact how, when, and where speeds can be enforced.
- **Raising awareness.** Informing drivers and road users about the rules of the road and the importance of good choices in how they use the road can also help to reduce crash risks and safety outcomes.
    - NHTSA provides marketing tools targeted at speed prevention to educate about the dangers of speeding and why faster doesn't mean safer.
    - ARC's Walk. Bike. Thrive! plan outlines a variety of active transport programs and marketing ideas for local governments that can help improve mobility, safety, and comfort for all road users.
- **Supporting through policy.** Establishing safe speed limits, enforcing speeds, and utilizing proven countermeasures can be negatively impacted and discouraged by outdated or inconsistent laws and policy. A strong speed management program should examine the codes, ordinances, and laws that govern roadway operations and design to determine if they need to be updated or modified to promote safer speeds and roadways.
    - The cities of Brookhaven and Dunwoody adopted Vulnerable Road User (VRU) ordinances in 2020 that impose regulations on how drivers, bicycle riders, and pedestrians are supposed to interact on the roads. The goals of these ordinances are to clarify vague state laws relating to bicycle rider, car, and pedestrian interactions and to dissuade drivers from acting aggressively when passing bicycle riders or pedestrians.
    - The City of Atlanta updated their code in 2021 to enable deployment of the latest best practices in managing speeds through traffic calming. The legislation expanded the types of streets where traffic calming measures can be installed and the methods for public engagement required to install those measures.

MODE SHIFT

Mode shift is changing from one form of transportation to another, such as shifting from driving to walking, biking, or using transit. Automobiles are one of the deadliest modes of transportation. American Public Transportation Association (APTA) research of NHTSA and Federal Transit Administration (FTA) data shows that metro areas with higher public transportation use have lower traffic fatality rates. **Transit is ten times safer per mile than traveling by car** because it has less than a tenth the per-mile injury or fatality rate as automobile travel. Shifting Atlanta region travelers from driving alone to other safer modes is another way to improve safety outcomes.

» **Transportation Demand Management** (TDM) policies and programs, such as Georgia Commute Options, can be employed to encourage a shift to safer modes of travel by working with employers and the general public to educate on the benefits of alternatives to driving alone, incentivize the use of safer modes, and connect travelers with information on how to access those alternative modes.

» Employing a **Complete Streets** approach to the planning, design, and operation of roadways can also encourage mode shift by providing safe access and supporting mobility for all users. Complete Streets approaches vary based on community context and can address a wide range of elements including sidewalks, bicycle facilitates, transit lanes and stops, crossing opportunities, traffic control, and placemaking.

» Improving **access to transit** stops and the **quality and quantity of transit service** also supports mode shift. Eliminating barriers to using transit through sidewalks and bicycle infrastructure, safe crossings, wayfinding and informational signage, and passenger amenities such as seating and shelter improve the environment for potential transit riders. Offering more frequent and higher quality transit service that is convenient and reliable can also encourage shifting modes.

10X

***Transit** is **ten times safer** per mile than traveling by car.*

LAND USE & DEVELOPMENT PATTERNS

Mixed land use was the dominant development style in cities and towns in the early 20th century before the automobile became the predominant mode of transportation. This continued to be the primary pattern until the development of suburbs after World War II. The growth of suburbs had a major influence on roadway patterns, moving away from a grid pattern of streets with more blocks, intersections, and access points to a hub and spoke pattern focused on moving cars greater distances and at faster speeds.

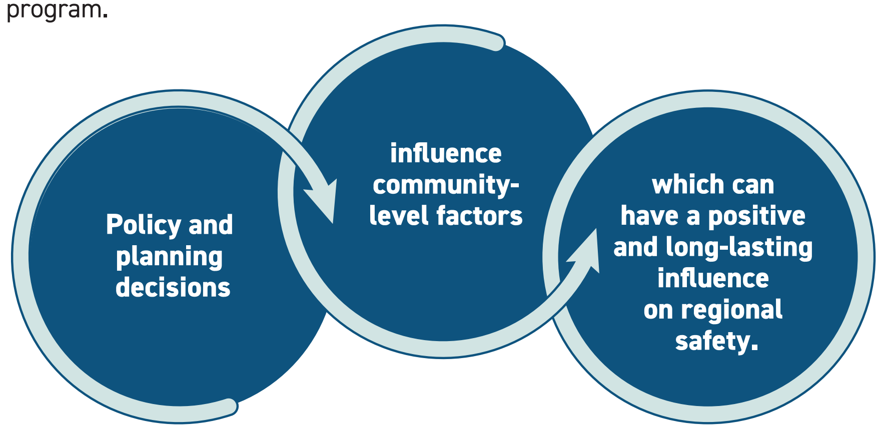
In a mixed land use pattern:

» More choice in travel routes and modes can increase mode shift to safer options.

» Shorter blocks and more access points can slow speeds.

» Mixed uses can allow people to live closer to where they work and play, reducing exposure to crash risks from longer commutes.

Updating zoning regulations, encouraging Transit Oriented Development, and designing public spaces that put people first can support improved safety outcomes. Programs that change local developments and long-term regional growth patterns, such as ARC's Livable Centers Initiative (LCI) program and Developments of Regional Impact (DRI) review can be considered a safety program.



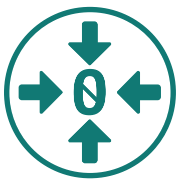
MOVING TOWARD ZERO

> *ARC will adopt a 5% reduction goal each year for all safety targets.*

Moving toward a long-term vision of zero deaths and serious injuries will require annual targets and steady, incremental investments in safety. Figure 33 illustrates several possible projections for reducing deaths in the region. At an average reduction rate of 3% per year, the current number of deaths would be reduced by approximately 60% in the next 30 years. At a rate of 7% per year, the current number of deaths would be reduced by almost 90% in the next 30 years. In either scenario, the region would not achieve zero deaths by 2052, but would make significant progress. As a moderate, achievable goal, ARC will adopt a 5% reduction target each year for all safety performance measures. To achieve this goal, there is a need for:

A comprehensive, data-informed approach.

Steady incremental investments guided by Safe System principles.



Targeted and coordinated efforts from all safety stakeholders throughout the region.

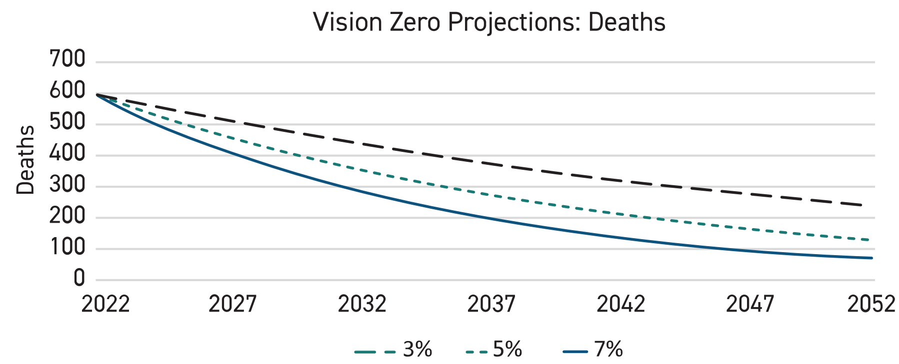


Figure 33. Projected Death and Serious Injury Trends in the Region.

The RSS serves as a roadmap for safety in the Atlanta region and will support future updates to the RTP, TIP, and other ARC-led plans and programs. While local agencies can apply for federal funds through ARC, the RSS also identifies opportunities for local agencies to create change through local initiatives and funding programs.

This section focuses on immediate and long-term opportunities to integrate safety in the local project development process, including:

Project Planning and Development: Provides guidance for agencies to identify priority safety locations, diagnose risk factors, select potential countermeasures, and compare the relative costs and benefits of projects.

Project Prioritization: Describes the ARC project prioritization process so agencies can develop applications that not only meet the minimum criteria but score high with respect to the various prioritization factors.

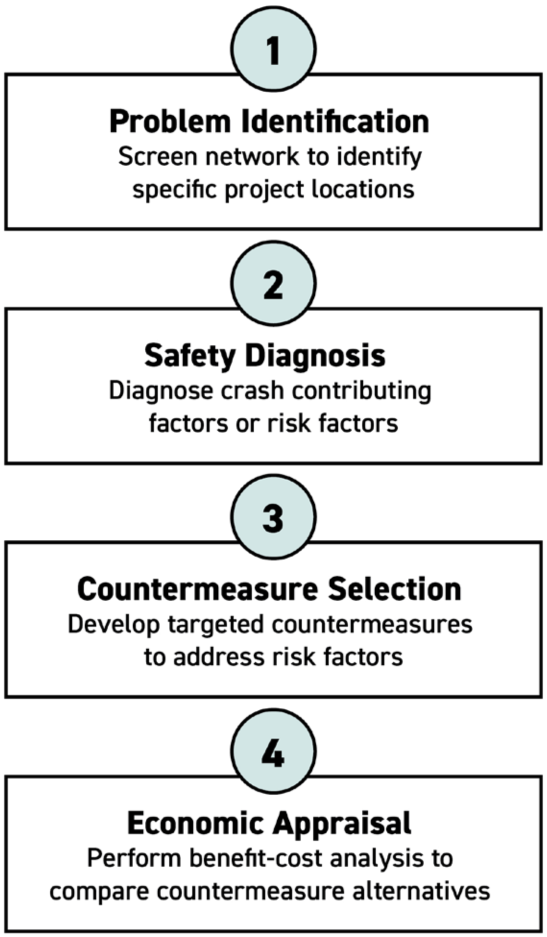
Project Implementation: Provides options for agencies to fund and implement projects with a focus on the TIP.

Project Evaluation: Describes the project evaluation process and how the results help to guide future decisions.

While this section provides non-regulatory guidance for local agencies, the RSS does not satisfy FHWA requirements for the SS4A discretionary program; therefore, local agencies should also develop a local safety action plan to be eligible for SS4A funds. Refer to Appendix F for further details on how to develop a safety action plan.

PROJECT PLANNING AND DEVELOPMENT

Project planning and development includes the following four steps:



PROBLEM IDENTIFICATION

The first step of project planning and development is to identify locations with a high risk for future crashes. This can be based on site-specific crash history, a predictive method, or systemic risk factors. Regardless of the method, agencies should justify the reason for selecting one location over others. Aligning with Safe System principles, this should be based on the potential to address fatal and serious injury crashes. GDOT performs statewide screening for the state system, while local agencies can work with ARC and GDOT District offices to identify sites on county or local roads.

> *Agencies should justify site selection based on the risk for fatal and serious injury crashes.*

The following are basic, intermediate, and advanced approaches to identify sites with high risk for severe crashes as described in the Highway Safety Manual (AASHTO 2010), FHWA Systemic Project Selection Tool (Preston et al. 2013), and other resources (Srinivasan et al. 2016). The methods differ in terms of data needs and reliability where the intermediate and advanced approaches are more reliable but also require more complete data (i.e., crash, roadway, and traffic volume data). This holds for both site-specific and systemic screening. Limited data (e.g., crash or roadway data alone) should not deter an agency from identifying sites with potential for safety improvement. When data are limited, agencies should do the best they can with the data in hand.

Basic Approach: ARC or partner agencies can use site-specific crash history to identify sites with potential for safety improvement. Ranking is based on average crashes per mile per year (for segments and ramps) or average crashes per intersection per year (for intersections). Another option is to use crash rate, incorporating some measure of exposure such as traffic volume or VMT to rank based on crashes per VMT (or per million-entering-vehicles (MEV) for intersections).

The focus crash type for site-specific screening should be fatal and serious injury crashes and should also include specific emphasis areas such as roadway departure, intersection, pedestrian, or bicycle crashes. The focus facility type should be all public roads or a high injury network. Agencies can use the results to identify sites for further investigation and plan safety improvement projects.

Intermediate Approach: Moving away from historical crashes, local agencies can employ a more proactive approach to problem identification. In this approach, agencies can use risk factors from a local road safety plan (LRSP) or CTP. Another option is to use the regional risk factors summarized in the earlier section titled, *Where are the Regional Safety Issues*. ARC provides this information through an interactive, web-based systemic screening tool. As shown in Figure 34, agencies can use this tool to select risk factors for one or more emphasis areas and screen the network for locations with the highest risk for severe crashes. Additional layers can be turned on to look for correlations with transit stops, the RTP, bikeways, regional truck routes, and the LCI areas.

While these candidate sites represent opportunities for systemic improvements, agencies should select appropriate countermeasures and confirm each location is suitable for treatment. All requests to ARC for systemic safety projects are required to include a detailed diagnosis of risk factors or utilize the results of a related systemic analysis to justify the proposed locations.

Advanced Approach: The more reliable site-specific performance measures include Expected Crashes and Excess Expected Crashes (AASHTO 2010). These methods use the Empirical Bayes method, incorporating crash predictions from safety performance functions (SPFs) and site-specific crash history. When detailed roadway and traffic volume data are not available to employ the Empirical Bayes-based measures, research has shown that average crash frequency may serve as a suitable performance measure for site-specific network screening (Srinivasan et al. 2016).

A more advanced systemic approach is to replicate the regional systemic analysis with county- or city-specific data. Local agencies would identify focus crash and facility types within the jurisdiction and then assess risk factors that are over-represented in fatal and serious injury crashes. Finally, the agency would use the list of risk factors to identify locations on the focus facilities as candidates for treatment. Refer to Appendix G for further details on the regional systemic analysis process.

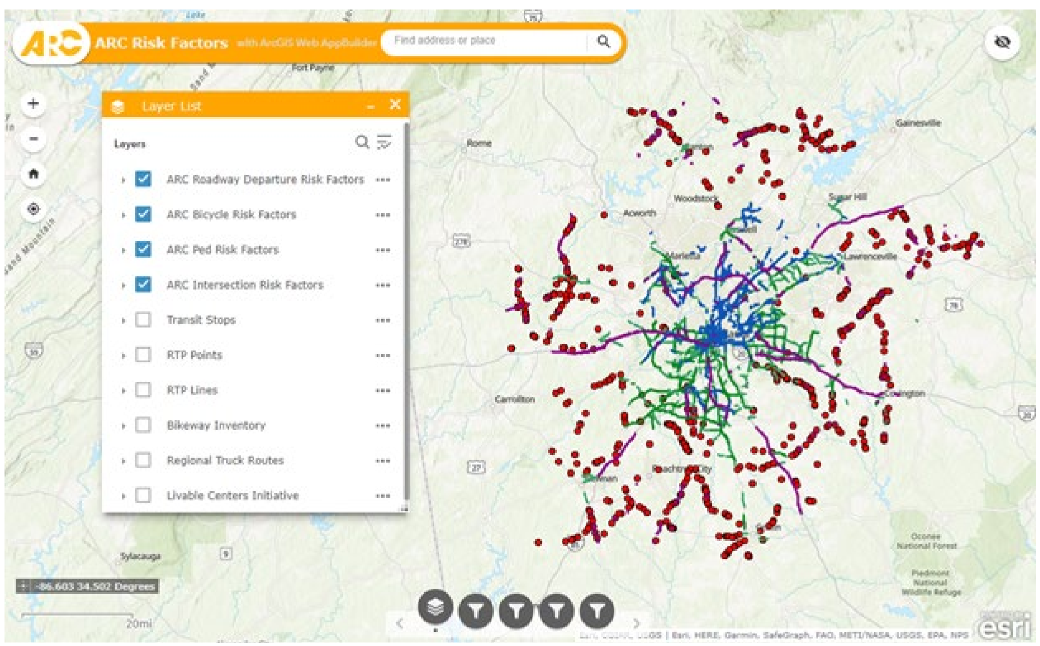


Figure 34. Screenshot of Systemic Screening Tool.

TIPS FOR RANKING

Once potential locations are identified, local agencies should review the list of potential sites to determine if there are any adjustments needed to the ranking. The following is a list of factors to consider, and potential reasons to adjust the ranking or exclude sites, when reviewing results:

Is the identified safety concern from the screening valid (e.g., are the data correct, is there an apparent safety issue, etc.)? If not, is there another safety concern worth addressing?	**Do any of the sites have projects already planned or in progress?** If so, is the project expected to address the underlying issue or is there an opportunity for additional safety improvements through a jointly-funded project?	**Have any of the locations had previous planning or corridor studies noting safety concerns or potential future preferred safety improvements?** If so, consider using these results as a starting point for the current diagnosis.
Are there sites on the list that are in close proximity? If so, consider combining nearby sites for investigation as a corridor or area. Visualizing and mapping results can help identify corridors or areas with nearby sites with promise.	**Is it likely that preferred improvements will be out of scope (e.g., full interchange reconstruction)?** Consider how the project could be funded and whether short-term improvements may be a good starting point while planning a more substantial capital improvement.	**Were any of the sites recently improved?** If so, consider omitting those sites and continue to monitor those locations to see if safety performance improves.

SAFETY DIAGNOSIS

> *Agencies should diagnose crash patterns and underlying safety issues before selecting countermeasures.*

Agencies should diagnose crash contributing factors before selecting countermeasures. By understanding the crashes and risk factors, agencies can target corrective measures and improve the cost-effectiveness of investments. All requests to ARC for safety funding are required to include a detailed diagnosis of crash contributing factors; a field review or road safety audit (RSA) is encouraged as part of the diagnosis.

Systemic diagnosis involves network-level analysis to identify focus crash types, focus facility types, and risk factors. The focus crash type for systemic analysis should be fatal and serious injury crashes and should include specific emphasis areas. ARC performed regional systemic analyses of fatal and serious injury roadway departure, intersection, pedestrian, and bicycle crashes. Local agencies can refer to the risk factors in the RSS and simply note the presence of risk factors at a site to justify the need for a project. Local agencies can also perform systemic analysis to identify focus facility types and risk factors that are specific to the jurisdiction of interest or to identify focus facility types and risk factors for other focus crash types. Once an agency selects locations based on the presence of risk factors, the next step is to investigate the specific site conditions and determine what might be done to reduce the risk.

Site-specific diagnosis involves a review of site-specific crash history, traffic operations, and general site conditions. This may include more traditional engineering studies (e.g., site reviews, policy checks, and speed studies) and/or multidisciplinary RSA. Diagnosis may include a desktop data analysis and/or field visit to review site conditions and identify crash contributing factors. By understanding the crash patterns and contributing factors, agencies can better target corrective measures. All requests to ARC for funding are required to include a safety justification, which could include a simple list or discussion of risk factors. This could also include a more detailed diagnosis of crash patterns with a field review or RSA.

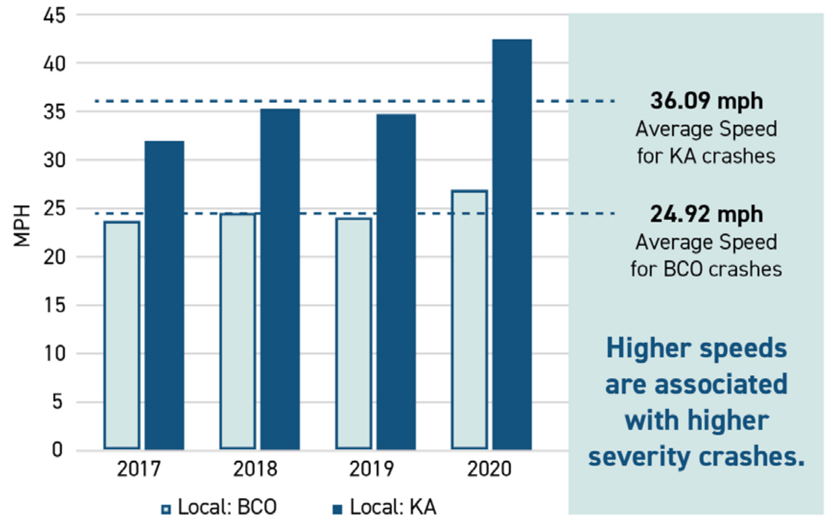


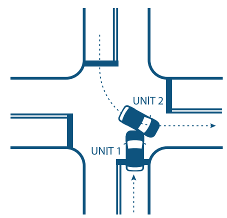
Figure 35. Average Observed Speeds versus Crash Severity.

> *Average observed speeds increased from 2017 to 2020 and the speed at the time of fatal and serious injury crashes is much higher than the speed for lower severity crashes.*

TIPS FOR CONDUCTING SITE-SPECIFIC AND SYSTEMIC DIAGNOSIS.

- **Review crash data (if applicable):** Review and confirm the crashes during the study period to ensure subsequent analysis is based on accurate information. Analysts confirm each crash by reviewing its attributes and location. While site-specific crash data is not the primary driver of systemic projects, it may be useful to help understand site-specific issues.

- **Develop crash summaries (if applicable):** Develop crash summaries to identify crash patterns and contributing factors. Common summaries include the number and percent of crashes by collision type, crash severity, time of day, day of week, weather condition, and light condition. Tools such as collision diagrams can help to identify crash patterns.



- **Assess supporting documentation:** Review documented information such as construction plans and design criteria, maintenance logs, weather patterns, and recent traffic studies. Interview local stakeholders (e.g., transportation professionals, community groups, local board members) to obtain additional perspectives on crash history and site conditions.

- **Develop condition diagram:** Condition diagrams are similar to collision diagrams but indicate surrounding land use, existing signs and pavement markings, and any roadside characteristics of significance. Use an aerial image to call out nearby land uses and annotate safety issues and risk factors. This can be incorporated with the collision diagram.
- **Document results:** Documentation should include the reason for site selection and key findings from diagnosis, including a list of crash patterns and contributing factors. It is also useful to include a sketch or photographs of the site with notes.
- **Assess field conditions:** Observe road user behaviors and site conditions. Field observations supplement the data analysis and help to understand the behavior and interactions among road users. Field reviews should observe traffic operations (e.g., turning movements, conflicts, and operating speeds) and consider accommodations for pedestrians, bicycle riders, and special road users such as children near schools. The recommended procedure for assessing field conditions is as follows:
    - **Drive the location** from different directions to understand the driver's perspective. Consider the common crash patterns and contributing factors identified by the collision diagram and crash summary.
    - **Experience the location** by walking, biking, or rolling the site by wheelchair. This can help to understand the perspectives and challenges of active road users.
    - **Observe road user behaviors** and interactions among the various road users, including drivers and active road users. Note any unexpected or unusual behaviors as well as the possible cause of the behavior.
    - **Observe roadway and roadside design** to determine whether the design and location of roadway and roadside features are consistent with road user expectations and if roadside recovery zones are clear and traversable.
    - **Conduct field reviews under multiple conditions** (e.g., day and night, peak and off-peak travel times, dry and wet) to investigate issues that arise under different conditions and to confirm crash contributing factors identified from the crash history.

Refer to Appendix H for a prompt list of questions and factors to consider in the field review. For further discussion of RSAs and the diagnosis process, including detailed prompts for different emphasis areas, refer to FHWA's Road Safety Audit Guidelines.

COUNTERMEASURE SELECTION

Once the crash patterns, crash contributing factors, and risk factors are understood, local agencies can identify, assess, and select appropriate countermeasures to improve safety at identified locations. The countermeasures should target crash contributing factors and reflect Safe System principles. Agencies may consider engineering, education, enforcement, and other related measures, recognizing that funding requests through ARC should focus on infrastructure.

> *Agencies should identify countermeasures that target underlying risk factors and reflect the Safe System principles.*

Refer to the earlier section titled, *Proven Safety Countermeasures*, to match countermeasures to the underlying issue(s). Other resources such as FHWA's Proven Safety Countermeasures, NCHRP Report 500 series, and NHTSA's Countermeasures that Work also identify countermeasures to address or mitigate crash and risk factors. Local agencies can use these resources to develop a list of potential countermeasures for further analysis. The result of this step is a list of options, not the final recommendation. Agencies compare alternatives and recommend the course of action (if any) in the subsequent step, economic appraisal.

To inform countermeasure selection, agencies should consider:

- Safe System principles (e.g., opportunities to build-in redundancy)
- Multiple potential alternatives
- Equity (among all road users and communities)
- Community wants and needs
- Cost-effectiveness
- Surrounding land use
- Function of the roadway

Agencies should use a consistent countermeasure selection approach, considering quantitative costs and benefits as well as equity and insights from stakeholders including maintenance staff and the public. Professional judgment is necessary for countermeasure selection, but a purely judgment-based method is the least reliable for assessing countermeasures because it is limited by personal experience and susceptible to personal bias and experience that may be relatively limited. The following are opportunities to enhance professional judgment with quantitative information in the countermeasure selection process:

- **Road safety audits:** A multidisciplinary RSA team helps to identify crash contributing factors and identify potential countermeasures. Such a team brings a wealth of combined experience, which limits the influence of personal bias and leads to a holistic consideration of countermeasures.
- **Crash modification factors:** Analysts can use CMFs to quickly compare the expected safety effectiveness of alternatives such as different roadway cross-sections, design elements, and traffic control devices. In the next step, economic appraisal, CMFs support a more detailed benefit-cost analysis. Refer to Appendix D for a shortlist of CMFs for the most common and preferred strategies. Refer to the FHWA CMF Clearinghouse for additional CMFs and guidance on how to select and apply CMFs.
- **Average project costs:** Equally important to the estimated safety benefit of a potential countermeasure is the estimated project cost, including construction and maintenance costs. Agencies can consider planning-level costs at this point to pare down the list of feasible alternatives. Cost estimates are refined during economic appraisal to support a more detailed benefit-cost analysis.

This represents a data-informed approach to countermeasure selection and can enhance traditional judgment-based methods. These factors also support economic analysis and project prioritization, so agencies should document the above information as part of the project application.

ECONOMIC APPRAISAL

Economic appraisal ensures efficient deployment of resources by demonstrating that benefits exceed the costs. At the project level, economic appraisal informs and justifies the selection of a preferred alternative for a given location. At the program level, economic appraisal informs project prioritization to select the most economically-efficient investments. **When seeking funds from ARC, roadway projects require a benefit-cost analysis for use in project prioritization.** While a detailed benefit-cost analysis is not required for each alternative considered, a high-level benefit-cost analysis can help to identify the most cost-effective strategy and justify the preferred alternative. Local agencies are encouraged to perform the economic appraisal and reach out to ARC for technical assistance as needed.

> *Economic appraisal ensures the efficient deployment of resources.*

A common question in project planning and development is whether it is more appropriate to select a more expensive treatment that is more likely to reduce a greater number of crashes per site, or to select a less expensive treatment that may reduce a lower number of crashes per site. It is typically more appropriate to implement higher cost treatments at sites with higher crash frequency (or higher risk), and lower cost treatments at sites with lower crash frequency (or lower risk). Beyond these general guidelines, there is a quantitative approach to identify the most economically-efficient option.

Agencies should perform a benefit-cost analysis to compare countermeasure alternatives. Agencies can select a single countermeasure or combination of countermeasures. When assessing the benefits of multiple (combined) countermeasures, it is important to consider the potential for overlapping effects. For instance, each individual countermeasure is associated with an estimated benefit (or disbenefit), but multiple countermeasures could address the same crash types and underlying risk factors, so the combined effect may not be as simple as adding the individual benefits. The preferred method for estimating the combined effect of multiple countermeasures is to use a CMF that represents the combined effect. The multiplicative method (i.e., multiplying two CMF values) is appropriate when one CMF is greater than 1.0 (expected increase in crashes) and the other CMF is less than 1.0 (expected decrease in crashes). When neither condition is applicable, refer to FHWA's training videos on how to select and how to apply a method for estimating the combined effect of multiple countermeasures.

The following are general steps to estimating the benefit-cost ratio. Refer to Appendix E for more details on each step of the process.

1. Estimate safety benefits
2. Monetize safety benefits
3. Estimate project costs
4. Normalize benefits and costs
5. Compute benefit-cost ratio

PROJECT PRIORITIZATION

Project prioritization is the process of ranking and selecting proposed projects within a given program budget. **Local agencies should prioritize capital improvement projects within their jurisdiction before submitting to ARC for funding consideration.** ARC prioritizes projects for the region using a key decision point (KDP) framework, as outlined in the ARC's TIP Project Evaluation Framework. The project prioritization process was most recently revised in 2021 and will undergo periodic updates as new methods and metrics are developed.

Using a data-informed approach, ARC staff reviews project applications for eligibility and selects those projects that maximize the effectiveness of the program within the available budget. Allocation of safety points in KDP2 (Project Evaluation) will be guided by:

- The number of risk factors in the project boundaries as suggested by the roadway and area characteristics.
- The number of risk factors actively addressed by the proposed project design.
- Review by professional staff on how the project design affects safety outcomes.

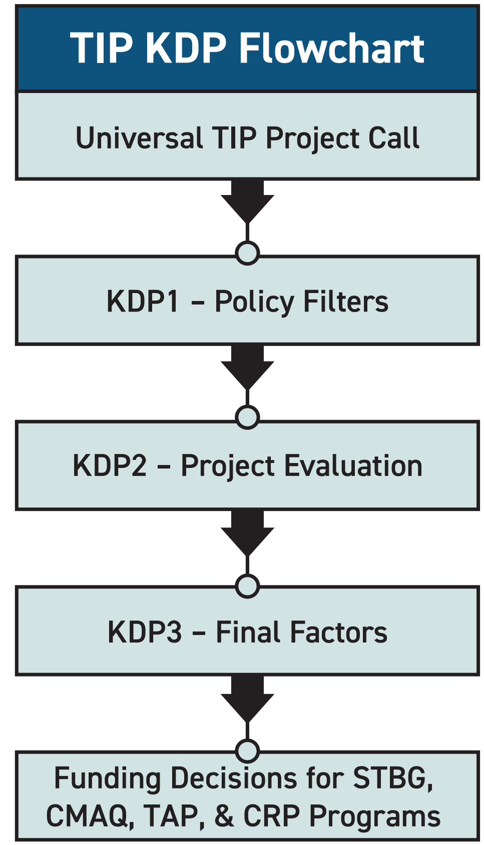
Roadway expansion and TSM&O projects will additionally undergo an economic appraisal, including a safety benefit-cost analysis, that will be considered in the KDP3 stage. These projects are most likely to include major changes to roadway designs that can provide beneficial or detrimental safety outcomes and tend to have larger budget needs compared to other project types that encourages additional scrutiny.

Local agencies should consider these performance measures when developing projects to ensure project competitiveness. Additional details regarding ARC's TIP solicitation process and scoring methodology can be found in the TIP Project Evaluation Framework. Refer to Appendix E for details on how to estimate safety benefits and the related benefit-cost ratio for a proposed project. The estimated lives saved and injuries prevented is a byproduct of the benefit-cost analysis process and details are included in Appendix E.

> *Local agencies should prioritize projects before submitting to ARC for funding consideration.*

While agencies should strive to develop benefit-cost ratios and quantitative measures for all projects, there are times when this may not be possible or feasible. In addition to quantitative safety measures, ARC considers the following qualitative factors in the KDP3 stage (Final Factors) of the TIP project prioritization process:

- Sponsor priority
- Regional equity
- Available funding
- Other programmed projects
- Time/effort to implement the project (deliverability)
- Public and political support and type/amount of public outreach (needed and conducted)
- Environmental and right-of-way impacts and constraints (constructability)
- Overall project design and safe connections to the surrounding network



ARC places a priority on project deliverability to ensure projects are completed in a timely manner and available resources are utilized effectively. Deliverability criteria are noted as an additional section within ARC's TIP Project Evaluation Framework.

ARC leadership works with transportation governing committees to submit projects for approval and inclusion in the TIP. This process includes vetting by the TCC, TAQC, and ARC Board to confirm that the project recommendations meet all technical requirements. Once projects are funded, local agencies develop and implement safety projects with support from ARC.

PROJECT IMPLEMENTATION

Project implementation follows from data-informed project planning and project prioritization. Agencies should complete the following steps before proceeding to project implementation:

1. Perform data analysis
2. Engage the community and consider equity
3. Adopt a plan with prioritized safety projects

Figure 36 provides an overview of when to plan and when to implement. Completing the actions under 'When to Implement' will increase eligibility and competitiveness for both the ARC TIP and discretionary grant programs. Appendix I provides a more detailed questionnaire, adopted from the Safe Streets and Roads for All (SS4A) federal discretionary grant program, that local agencies can use to determine if planning or implementation is appropriate. While the SS4A program has specific eligibility requirements for implementation funding, local agencies should consider these factors to develop more competitive projects.

> *Agencies should complete all project planning steps before proceeding to project implementation.*

Several resources are available to inform and fund planning activities and the plan development process. If an agency does not have an adopted plan that identifies priority safety needs and projects, refer to Appendix F for further details on how to develop a safety action plan. Funding sources such as local general funds, LCIs, and CDAP are available to support local agencies with planning activities.

The next section includes a series of questions and answers to help local agencies identify the appropriate option(s) for implementing projects followed by an overview of funding opportunities and strategies.

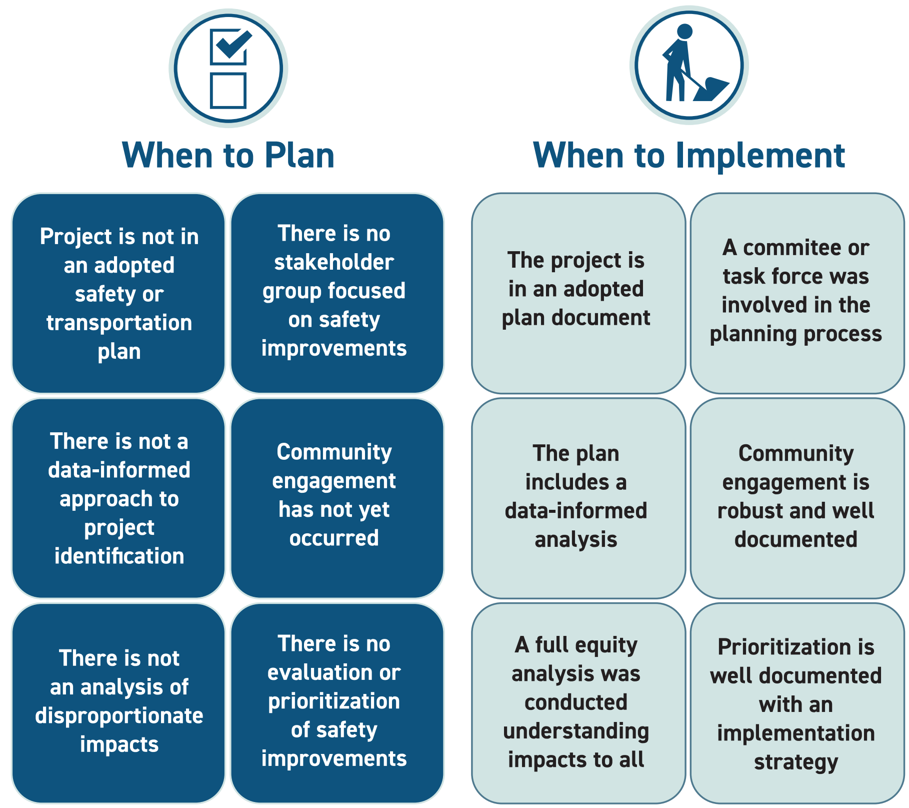


Figure 36. When to Plan vs. When to Implement.

TIPS FOR IMPLEMENTATION

What type of funding is appropriate for the project?

Over the past decade, transportation funding has become more readily available. However, this results in a more complicated process for determining which funding sources are best suited for a particular project. The first decision that should be made is whether the local agency can and should fund the project with local funding. This is typically a decision based on how quickly the project can be implemented and if the local agency can reasonably budget the project into its capital program.

General funds are the traditional funding source to implement local transportation projects. More jurisdictions are passing Special Local Option Sales Tax (SPLOST) which is a supplemental fund for capital expenditures. This can be an excellent source for smaller safety projects that have a relatively low cost and can be implemented within a short timeframe (e.g., within five years). This type of funding can also be useful to better implement systemic safety improvements through a designated safety funding pot within the SPLOST.

Local agencies should also consider if there are other local, private, or philanthropic partners available to combine funding. Having conversations among impacted jurisdictions, CIDs, non-profits, foundations, and private organizations (e.g., property owners) may result in acquiring the necessary funds which will help expedite implementation.

Larger projects that exceed local budgets, or require state coordination (e.g., those on state-owned facilities), may require state and/or federal funding.

> *One major factor to consider with this decision is federal funding requirements. Federal funding requires federal environmental documentation and a federal process which can add significant time to an implementation process.*

Who should local agencies be talking to?

Local agencies should be talking to other impacted jurisdictions, CIDs, and private organizations as applicable. This can help to identify other local funding options and generate local support for the project to include in funding applications. In addition, showing wide-spread support of a project helps increase competitiveness.

It is worthwhile to take the time to discuss the project with as many stakeholders as possible to demonstrate unity and ensure inclusivity during the planning and implementation process. Addressing resident and business concerns, particularly on impacts during construction will help build consensus for the project and help increase competitiveness for federal funding.

The safety of local roads (both urban and rural) is a challenge and may have several contributing factors including land use, zoning, and development. Therefore, increased coordination with other local departments is recommended.

The National Cooperative Highway Research Program (NCHRP) report *17-18(15) Guidance for Safety Improvements on Local Roads* provides guidance to smaller, local agencies on local road safety. The report provides a seven-step framework to a successful safety process for local agencies. These steps are as follows:

1. Decide to make safety a priority
2. Define safety issues
3. Illustrate the results
4. Establish crash reduction goals
5. Find solution to safety concerns
6. Put safety strategies into action
7. Monitor outcomes

For concerns related to road user behavior, there is an opportunity to coordinate with police departments and public information professionals to discuss education and enforcement strategies.

> *Behavior-oriented safety programs and campaigns are not typically eligible for TIP funding, which is intended for infrastructure improvement. Some of these initiatives can be low cost and completed with local funding such as social media campaigns. Larger educational programs can difficult to fund through grants and formula funding, but there are several resources with safety campaign materials that are available for use by local agencies such as FHWA's Pedestrian Safety Campaign Toolkit and GDOT's Drive Alert Arrive Alive campaign. Local agencies should work with partners, specifically non-profits to develop a strategy for campaign deployment.*

It may also be useful to coordinate with other departments such as zoning and development to ensure that development types are appropriately located based on the road network. For example, encouraging residential developments in areas where bicycle and pedestrian infrastructure exists or create a plan to install these facilities. For collector facilities, it would be appropriate to plan developments that minimize driveway cuts and implement inter parcel connectivity.

How do local agencies form partnerships?

Partnerships start with conversations and discussions. If jurisdictions, CIDs, and private organizations can agree upon safety improvements, then the next conversation is among leadership to develop a partnership. This partnership could be to implement the project together, or the partnership may be a financial one where one lead local agency is identified, and other organizations provide financial support. These partnerships may be especially important when there is a requirement for a local match (e.g., some federal funding). Providing the recommendation to leadership about the type of partnership will be helpful for their discussions and the more information you can provide to leadership prior to meetings, the better.

Once parties agree to terms of the partnership, the lead local agency should draft an agreement. These can be in the form of a Memorandum of Understanding (MOU), a contract, or other legally binding document. It is best to defer to local council to assist in drafting partnership documents.

The lead local agency will then send the document out for review and finalize the document. Many times, the partnership, especially one including a financial obligation, will require a vote by the governing authority.

> *The partners should work together to ensure the motion is on upcoming agendas and that all elected representatives are briefed on the agenda item prior to the meeting. This will help reduce the risk of the agenda item being deferred to a future date or resulting in several questions and being voted down.*

After deciding to pursue federal funding, what is the next step for local agencies?

There are several ways to go about pursuing federal funding for transportation projects. There is the traditional method of applying for TIP funding through ARC. More details are provided on the TIP application and evaluation process in Section 2.3.2.

The other federal funding option is through federal discretionary grants. In many cases, federal grants are awarded to projects that are close to construction. This is because USDOT has funding obligations where the capital (i.e., construction) funding must be spent within a certain timeframe. This means USDOT must ensure project timelines are met; hence, why project readiness is an evaluation criterion. Because of this, local agencies should consider funding earlier phases such as scoping and preliminary engineering (PE) through local funding sources or through the TIP and then request grant funding for later phases such as ROW, utility relocation (UTL), and construction (CST). It also helps to demonstrate the local match commitment in a federal grant application if the project is already programmed in the TIP. These funding timelines emphasize the need to conduct thorough safety and project planning to ensure steady implementation.

> *If the entire project and all its phases (PE, ROW, UTL, CST) need federal funding assistance, local agencies should first apply for TIP funding to help fund the upfront cost and get the project into the PE or design phase, then begin thinking about the correct time to apply for grants.*

How do local agencies position a project for federal grants?

The first thing to determine is what funding programs are most applicable and aligned with the identified project. Section 2.3.4 provides a summary of the current programs; however, these programs are updated periodically with new transportation funding acts. USDOT also provides a Funding Matrix based on the applicant type that is a useful resource. There are several other resources available including ARC and GDOT that provide updates on available funding programs including webinars and podcasts. It is recommended that local agencies identify staff to stay current on transportation funding status or at least have these resources available for staff.

Once funding programs are matched to the project, the next step is to understand related funding cycles and timelines. Federal grant applications typically give anywhere from four to eight weeks to complete and submit. USDOT provides notices before funding is made available, but it is suggested that local agencies build a relationship with USDOT. There are staff available to help grant applicants with questions and to provide guidance as to when funding may become available for the various programs. Local agencies can subscribe to the USDOT newsletter for updated information.

Agencies can use the time between funding cycles to compile project documents and information. The more information local agencies can gather and document for the proposed project, the better prepared they will be for the next funding opportunity. Agencies should review previous USDOT funding requirements for reoccurring themes of merit criteria and required information. The following are potential resources:

- Navigating Grant Program Application
- An Introduction to Evaluation Criteria
- USDOT Applicant Consideration

Agencies should complete (or begin) the environmental or National Environmental Policy Act (NEPA) process. USDOT typically includes project readiness as an evaluation criterion and completing NEPA is a big hurdle to solidifying the project feasibility and schedule. If a project requires ROW, it is best to be in the process of obtaining ROW as this phase of the project holds significant risk for schedule delay.

Additional analyses may be required or highly beneficial to support funding applications. All federal grant applications require a benefit-cost analysis to compare the economic value of expected benefits to the capital and ongoing operating and maintenance (O&M) costs.[4] Local agencies should perform and document a robust, defensible, and easy to follow benefit-cost analysis for the project. Refer to Appendix E for details on how to perform benefit-cost analysis and related resources. Local agencies can coordinate with ARC staff to apply the appropriate methodology.

Confirm elected leader and stakeholder support for the project. Notify partners, elected leaders, and stakeholders that a Letter of Support (Letter of Commitment for financial partners) will be sent to them to complete and return for the grant application. Communication for support should be done early and often.

Local agencies must be registered through grants.gov and have a Unique Entity Identifier and System for Award Management (SAM) certification that is current to submit federal grant applications. This process can take several weeks for approval.

If a local agency is using external resources to prepare the grant application, consider completing the procurement process well in advance of the funding opportunity to avoid delays in developing the grant application and provide more time for application review.

4 Maximizing Award Success: USDOT Applicant Considerations | US Department of Transportation

FUNDING OPPORTUNITIES

This section describes local, private/non-profit, state, and federal funding options for various types of projects and strategies, including discretionary and formula funding opportunities. Local agencies can use this guidance to match strategies with funding sources and to identify who to talk to regarding partnerships and funding programs. In general, larger projects that involve multiple safety countermeasures are appropriate for federal funding and smaller low-cost applications are appropriate for local and state funding. While some safety strategies may not be eligible as a standalone project, many programs allow for integration of multiple safety strategies as a broader project and safety solution. For example, installation of a sidewalk and pedestrian hybrid beacon may be integrated as a portion of a larger road diet project that seeks federal funds.

> *Larger high-cost projects are typically appropriate for federal funding and smaller low-cost project are appropriate for local and state funding.*

Local funding sources include various taxes like sales taxes and property taxes. Local agencies can use a Special Option Local Sales Tax (SPLOST), or transportation SPLOST (TSPLOST) to fund transportation projects. Other local funding sources include permit fees, tax allocation districts, and private sector partnerships. ARC also provides local funding support through the LCI and the CDAP. Project eligibility is widespread, but eligible projects can include safety, pedestrian, bike, streetscape, and landscape projects.

State funding options include grant programs and formula funds. Eligible project types include planning studies, maintenance, low-cost safety countermeasures, small traffic operational projects, pedestrian and bicycle rider facilities, and pedestrian streetscaping projects. Examples include GDOT's Off System Safety Program, which applies to locally-owned roads, and GDOT's Quick Response Program, which applies to state-owned roads.

Federal funding opportunities are typically provided through formula funding or discretionary grant opportunities. Formula funding programs, including the SS4A program, are typically awarded on an ongoing basis and, while not often competitive at the federal level, may be awarded competitively within a state or region. Discretionary grants are awarded on a nationally competitive basis and often require detailed grant applications and analysis for justification.

Table 10 provides a list of safety strategies and recommended funding type, which is separated into local, private/non-profit, state, and federal (both formula and discretionary grant). The 'local' funding category includes CIDs, which have been instrumental in funding several bike lane projects throughout the region. While CIDs are private, non-government organizations, they function as de facto local governments, especially in unincorporated areas. Refer to the earlier section titled, *Community Improvement Districts (CID)*, for further details on their roles and responsibilities. Following the table is further discussion of relevant funding options such as the TIP, formula funding, and discretionary grant funding. This section concludes with an overview of alternative funding and delivery methods.

Table 10. Matching Strategies to Funding Sources.

SAFETY STRATEGY	LOCAL	PRIVATE / NON-PROFIT	STATE	FEDERAL (FORMULA)	FEDERAL (DISCRETIONARY GRANT)
INTERSECTIONS					
Backplates with Reflective Borders	✓		✓		
Corridor Access Management	✓	✓	✓	✓	✓
Left- and Right-Turn Lanes at Two-Way Stop-Controlled Intersections	✓		✓	✓	✓
Reduced Left-Turn Conflict Intersections	✓		✓	✓	✓
Roundabouts	✓	✓	✓	✓	✓
Systemic Application of Multiple Low-Cost Countermeasures at Stop-Controlled Intersections	✓		✓	✓	✓
Yellow Change Intervals	✓		✓		
ROADWAY DEPARTURE					
Wider Edge Lines	✓		✓	✓	✓
Enhanced Delineation for Horizontal Curves	✓		✓	✓	✓
Longitudinal Rumble Strips and Stripes	✓		✓		
SafetyEdge[SM]	✓				
Roadside Design Improvements of Curves	✓		✓	✓	✓
Median Barriers	✓		✓	✓	✓
PEDESTRIAN & BICYCLE SAFETY					
Medians and Pedestrian Crossing Island	✓	✓	✓		
Pedestrian Hybrid Beacon	✓	✓	✓		
Road Diet	✓		✓	✓	✓
Sidewalks	✓	✓	✓		
Changing Speed Limits	✓				

SAFETY STRATEGY	LOCAL	PRIVATE / NON-PROFIT	STATE	FEDERAL (FORMULA)	FEDERAL (DISCRETIONARY GRANT)
Leading Pedestrian Interval	✓		✓		
Rectangular Rapid Flashing Beacons	✓	✓	✓		
Crosswalk Visibility Enhancements	✓	✓			
Street Lighting	✓	✓			
Separated Bike Lanes	✓	✓	✓	✓	✓
Neighborhood Greenway/Bike Boulevard	✓	✓	✓	✓	✓
Traffic Calming	✓	✓	✓	✓	
Speed Management	✓	✓	✓	✓	✓
Speed Safety Cameras	✓	✓			
Variable Speed Limits	✓				
CROSSCUTTING					
Pavement Friction Management	✓		✓		
Local Road Safety Plans	✓	✓	✓	✓	✓
Road Safety Audits	✓	✓	✓	✓	✓

Source: ARC's Walk. Bike. Thrive! (https://cdn.atlantaregional.org/wp-content/uploads/arc-safe-streets-webview-revmar19-1.pdf);
FHWA's Proven Countermeasures (https://safety.fhwa.dot.gov/provencountermeasures/)

TRANSPORTATION IMPROVEMENT PROGRAM (TIP)

The TIP is one of the primary funding sources for implementing large-scale transportation infrastructure projects. ARC is responsible for developing and updating the TIP along with the RTP to meet federal planning requirements and address local needs. The TIP allocates federal funds to construct the highest-priority projects in the RTP, which represents the long-term vision for the Atlanta region. The TIP covers the first six years of the RTP, and is how federal, state, and local funds are approved for all significant surface transportation projects and programs. All projects in the TIP must be fully funded.

> *The TIP is a primary funding source for implementing large-scale transportation infrastructure projects.*

TIP funds can serve as a significant resource for transportation safety improvements for local agencies. However, current limitations on the use of certain federal funding sources for locally-classified roadways may preclude local projects from federal funding eligibility. **For projects on locally-classified roadways, local funding sources should be utilized, particularly for smaller-scale safety interventions and improvements.** GDOT's State Functional Classification Map can help local agencies identify roadway functional classifications when determining project funding eligibility.

Other federal programs, such as the Highway Safety Improvement Program (HSIP), provide dedicated safety funding to achieve significant reductions in traffic fatalities and serious injuries on all public roads, regardless of functional classification. Future opportunities may exist for ARC to designate and set aside funds from federal programs, such as the HSIP, to allow local agencies to compete for project funding on locally-classified roadways. Similar practices are currently in place for LCI funding, in which ARC creates a set aside for local agencies to compete for LCI study and project funding. Coordination with GDOT staff to prioritize HSIP funding for local projects may provide another opportunity for increased availability of eligible federal funds for locally-classified roadway projects. Local agencies should coordinate with their ARC representative to discuss any future policy changes to the TIP solicitation process.

FORMULA FUNDING PROGRAMS

Federal formula funding programs are more predictable and less competitive than discretionary programs; however, these programs require participation in grant cycles and may be awarded on a competitive basis across the state or MPO region. Formula funding may have specific limitations for certain local projects. Local agencies should determine if formula funding programs are applicable based upon project type and available funding, timeline, and administrative capacities for grant applications. Table 11 provides an overview of formula programs for local agencies to explore as part of an overall strategy to implement local projects.

The three major formula funding programs related to transportation safety include the Surface Transportation Block Grant (STBG), HSIP, and Railway-Highway Crossings programs. Each program offers funding opportunities based on project and improvement type as well as primary transportation mode. Some projects may be eligible for multiple funding opportunities. Local agencies should coordinate with ARC staff to determine the most appropriate option.

The **purpose of the Surface Transportation Block Grant Program** is to preserve and improve the conditions and performance on Federal-aid highway, bridge, and tunnel projects on public roads, including pedestrian and bicycle infrastructure. This is the most flexible Federal-aid highway program. Eligible projects include highways, bridges and tunnels, transit capital, recreational trails, and vulnerable road user safety assessments.

The **purpose of the HSIP** is to provide for the safety of all road users by reducing traffic fatalities and serious injuries on all public roads. The HSIP funding for the State of Georgia is $507 million for the five-year fiscal period from 2022-2026. Eligible projects include highways, bicycle and pedestrian paths and separation projects, railway-highway crossings, traffic control devices and non-infrastructure activities related to education, research, enforcement, emergency services, and Safe Routes to School.

The **purpose of the Railway-Highway Crossings Program** is to coordinate departmental efforts to prevent or reduce trespasser deaths along railroad right-of-way and at or near railway-highway crossings. The Railway-Highway Crossings Program funding for the State of Georgia is $44 million for the five-year fiscal period from 2022-2026. Eligible projects include railway-highway crossings, grade separations, protective devices, replacement of warning devices, and pedestrian safety improvements at crossings.

Table 11. Formula Funding Programs.

FORMULA PROGRAM	LEAD	PURPOSE	PROS	CONS
Surface Transportation Block Grant Program *	GDOT	Promote flexibility in state and local transportation decisions and provide flexible funding to address local needs	State may transfer up to 50% of funds toward other apportionments including CMAQ, HSIP, LCI	Not eligible for improvements on local functional classification roadways[5]
Highway Safety Improvement Program *	GDOT	Achieve significant reduction in fatalities and serious injuries on all public roads	Can be used on all roadways, regardless of functional classification	Projects must align with state Strategic Highway Safety Plan
Railway-Highway Crossings Program	GDOT	Reduce fatalities and eliminate hazards at railway-highway crossings	Eligible for projects at all public crossings including roadways, bike trails, and pedestrian paths	Projects must be identified in state Railway-Highway Crossing Plan
Metro Planning (PL) Program *	ARC	Provide funding to MPOs	ARC has full authority over funds and can prioritize safety projects	Not eligible for improvements on local functional classification roadways[5]
Off System Safety Program	GDOT	Reduce fatalities for local roads, limited applications include low-cost countermeasures such as striping, sign replacement, rumble strips, raised pavement markers	Improve local roads based on safety needs and data-driven approach	Not eligible for ROW, turn lane installation, pavement, or utilities. State-driven process for approaching local agencies with funding availability. Not grant-based nor based on formula.
Quick Response Program	GDOT	Quickly identify, approve, and construct small traffic operational projects	Quickly implement safety projects covering variety of improvements within 3- to 4-month timeframe	Only eligible for state-owned facilities (not eligible for local functional classification roadways)[5]
Transportation Alternatives Program	GDOT	Provide local government funding for non-traditional transportation projects	Eligible projects include bicycle/ pedestrian facilities, streetscaping, complete streets	Metro Atlanta counties and cities must request funding through MPO
Local Maintenance and Improvement Grants (LMIG)	GDOT	Provide funding to counties and cities for road construction and maintenance.	Quick program implementation with full local authority over use of funds	Limited funding amount typically applied for general maintenance, not additional improvements
Freight Operations Lump Sum Program	GDOT	Provide funding for small-scale improvements in freight facilities and support state Freight and Logistics Plan to improve safety, efficiency, and reliability of truck movements	Funds projects that are too small for state-level funding or too large for smaller funding programs like Quick Response. Prioritizes projects in areas with high crash rate.	Must be nominated by District and should be within 1 mile of state-designated freight corridor. Competitive and preference is given to proximity to GRAD sites.

* Planning Funding

5 Highway Functional Classification Concepts, Criteria and Procedures

DISCRETIONARY PROGRAMS

Federal discretionary grant programs offer local agencies a variety of funding opportunities for transportation projects. These programs are competitive and often require preliminary research and grant writing for the application process. Additionally, discretionary programs often involve significant documentation, consistent reporting to USDOT, and satisfaction of potential NEPA requirements. Local agencies should consider project characteristics, timelines, and funding availability to determine the appropriate funding source. Table 12 provides a summary of select federal discretionary programs.

More information on federal funding opportunities can be found on ARC's IIJA homepage.

While discretionary grant programs can provide targeted funds for specific projects, particularly for local projects, these programs are often established and funded through time-constrained legislation and are subject to change. Current discretionary programs are established under the Bipartisan Infrastructure Law (BIL), which extends through 2026. Future transportation funding acts and legislation may modify current programs and funding levels.

Table 12. Federal Discretionary Funding Programs.

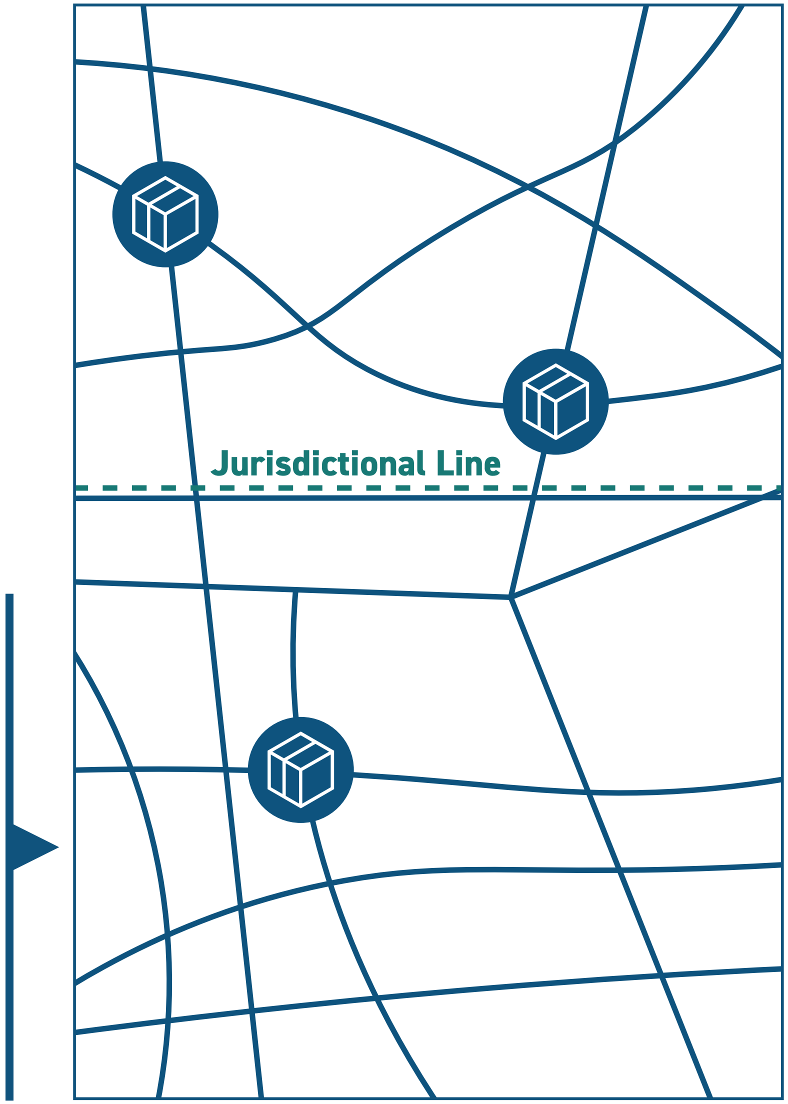
FORMULA PROGRAM	LEAD	PURPOSE	PROS	CONS
Safe Streets and Roads for All (SS4A) *	MPOs, states, counties, cities, transit agencies	Fund safety projects that support Safety Action and Vision Zero plans	Safety-specific program with approximately $1 billion available annually, minimum award is $200,000	Local agencies must have an adopted Safety Action Plan to apply for implementation funds. Funding amount for any one jurisdiction cannot exceed $1 million
Rebuilding American Infrastructure Sustainably and Equitably (RAISE) *	MPOs, states, counties, cities, transit agencies	Fund projects with significant local or regional impact	Provides over $1 billion annually and applicants can apply for up to 3 projects, set aside for planning activities	Minimum project cost is $6.25 million for urban areas. Competitive projects must consider sustainability, climate change, and equity in planning and design
Infrastructure for Rebuilding America (INFRA)	MPOs, states, counties, cities, transit agencies	Fund projects of national or regional significance, typically large projects with regional impacts	Provides over $1 billion annually and applicants can apply for up to 3 projects	Minimum project cost is $6.25 million. Funding is prioritized for regional freight projects on the National Highway System
Other New BIL Programs *	MPOs, states, counties, cities, transit agencies	Fund active transportation, railroad crossing, terrorism prevention, and wildlife crossing projects	Provides significant increase in funding availability to meet specific needs	Each program individually does not have significant funding and is highly competitive nationally

* Planning Funding

ALTERNATIVE FUNDING AND DELIVERY METHODS

Alternative funding and delivery methods present an opportunity to reduce project costs and shorten project timelines. Public-Private Partnerships (P3), project bundling, quick-response projects, and indefinite delivery, indefinite quantity (IDIQ) contracting all represent alternative methods to fund and deliver projects.

- **P3 projects** are partnerships formed between public entities and private companies to better allocate limited resources while leveraging private sector innovation and capital. GDOT is pursuing multiple P3 agreements to shorten delivery times, reduce overall project costs, and utilize private capital in lieu of constrained public resources. The Major Mobility Investment Program (MMIP) contains many P3 projects including the State Road 400 Express Lanes and I-75 Commercial Vehicle Lanes. P3 agreements can support smaller scale projects as well. GDOT provides guidance for P3 programs, including the P3 Manual and P3 Guidelines.
- **IDIQ contracting** is another alternative for project delivery in lieu of traditional methods. IDIQ contracts provide for an indefinite quantity of services for a fixed time, allowing agencies to group smaller, lower-cost projects together via a competitively-bid contract. For example, an agency could group and bid all traffic signal and ITS projects as one IDIQ contract, thus lowering individual contract administration and processing costs.
- **Project bundling** and **quick-response projects** provide an opportunity to reduce costs and timelines, particularly if projects occur concurrently or adjacent to each other. For example, bundling multiple bridge replacement projects for one bid may reduce bidding processes and allow cheaper material purchases at higher quantities. Many transportation projects are eligible for bundling under the new guidance from the Infrastructure Investment and Jobs Act including projects utilizing funding from the National Highway Performance Program, Bridge Investment Program, and the Active Transportation Infrastructure Investment Program.
- **Cross-jurisdictional collaboration** reduces project costs and creates a seamless transportation network. Safety issues do not stop at municipal or county boundaries. As such, project coordination across boundaries and projects is vital to maintaining an efficient regional network. Municipal and state partnerships offer opportunities for cost-sharing and reducing overall project costs, particularly if adjacent projects can be bundled or timed concurrently.
- **Non-traditional funding sources** such as non-profit and philanthropic funding can support safety projects. Refer to ARC's *Walk. Bike. Thrive!* recommendations for further discussion of non-traditional funding sources.



PROJECT EVALUATION

The objective of project evaluation is to determine how a particular project (or group of projects) has affected safety performance. This informs future funding and policy decisions as agencies can use evaluation results to allocate funds and change policies. If certain programs or countermeasures are consistently effective, then agencies may choose to continue those programs and implement similar countermeasures at additional locations. If an agency identifies a project that is not meeting safety performance expectations, then there is an opportunity to address the situation (e.g., remove the countermeasure or install supplemental countermeasures).

Evaluation is a shared responsibility among ARC and the partner agencies.

RESPONSIBILITIES

Local Agencies	» Tracking start and completion dates of construction » Verifying actual improvements
Shared	» Performing project evaluations (i.e., comparing crashes 3 years before and 3 years after construction) » Reporting project evaluation results
ARC	» Tracking and aggregating project evaluation results across the region » Evaluating countermeasure and program effectiveness » Measuring and reporting on federally-required safety performance targets and outcomes

Project-level evaluations become the foundation for countermeasure- and program-level analysis. Countermeasure evaluations provide updated CMF values. Program evaluations can include the entire portfolio of safety projects or specific subprograms that focus on specific emphasis areas (e.g., intersection, roadway departure, pedestrian, and bicycle).

The following subsections describe local agency responsibilities in tracking projects and providing basic information to support countermeasure- and program-level evaluations. While this section focuses on TIP projects, it applies to the evaluation of other discretionary programs as well.

Refer to FHWA's Highway Safety Improvement Program Evaluation Guide for further details on countermeasure and program evaluations and the related templates to support evaluations.

PROJECT TRACKING

As each project is completed, local agencies should document the specific countermeasure(s) implemented, specific locations treated, implementation period (begin and end dates), and final project costs. The specific location(s) is particularly important for systemic projects where similar treatments may be implemented at multiple locations as part of the same project or contract. Documented project costs should include preliminary engineering, right-of-way, and construction based on the final cost to complete the project (not the initial estimate used in the funding application).

Tracking individual projects supports project-level evaluations, and subsequently countermeasure- and program-level evaluations. As such, there is a need to link each project with specific countermeasures, programs, and subprograms. As part of project tracking and reporting, the local agency should select the applicable program that funded the project (e.g., TIP, SPLOST, TSPLOST, etc.) as well as any emphasis areas targeted by the project (e.g., intersection, roadway departure, pedestrian, bicycle). If there were any changes to the proposed project, then this should be noted as part of the documentation.

Refer to Appendix J for a project tracking template.

PROJECT EVALUATION

Project-level evaluation focuses on individual projects and measures safety effectiveness based on changes in the frequency and severity of crashes before and after implementation. The following are guidelines related to project evaluation.

1. **Performance measures:** Crash-based measures are preferred for project evaluations and include the change in crash frequency and severity. It is useful to evaluate target crashes, particularly if a project targets specific crash types or crash contributing factors. For instance, median separation targets cross-centerline crashes, so it would be useful to evaluate the change in cross-centerline crashes in addition to other common measures (e.g., total and fatal plus injury crashes). There is the potential to use non-crash-based performance measures such as changes in operating speed, driver compliance, or driver response to assess the intermediate effectiveness of projects.
2. **Study period:** Agencies should use a minimum of three full years of before data and three full years of after data to evaluate projects. Agencies should use data for 12-month increments to avoid seasonal impacts. If the duration of the before and after period are different, agencies should normalize the analysis by comparing crashes per year. There may be a need for more years of data to better understand the long-term averages for projects that target rare or seemingly random crash types (e.g., pedestrian or bicycle crashes). Agencies should balance the study period with the potential for other changes over time.
3. **Methodology:** The simple before-after analysis is appropriate for evaluating projects. While more rigorous methods can produce more reliable results, this is generally not necessary at the project level. Instead, agencies should focus on whether the project appears to have addressed the crashes and/or risk factors that were the impetus of the project.

   Collision diagrams are useful to assess the change in target crashes. Agencies can develop and compare collision diagrams for the before and after periods to determine if a project achieved the initial objective (i.e., to address a specific crash type or crash contributing factor). If a project does not address the target crashes, or if other crash types increased unexpectedly, then alternative or supplemental countermeasures may be necessary. Figure 37 illustrates the use of collision diagrams to compare crash patterns and target crash types before and after converting a two-way stop-controlled intersection to all-way stop-controlled (Gross 2017). In this example, the target crashes were right-angle crashes, which are shown to decrease dramatically after the conversion.
4. **Interpretation of Results:** Project evaluation results may not represent the general countermeasure effect. For instance, not all projects improve safety performance, but this does not mean the countermeasure is generally not effective. There may be site-specific characteristics or other factors that contribute to an ineffective project. Project evaluations help to understand the change in safety performance at a specific site or group of project locations and serve as the basis for more aggregate evaluations.

Refer to Appendix J for a project evaluation template and an example project evaluation using the simple before-after method.

BEFORE

AFTER

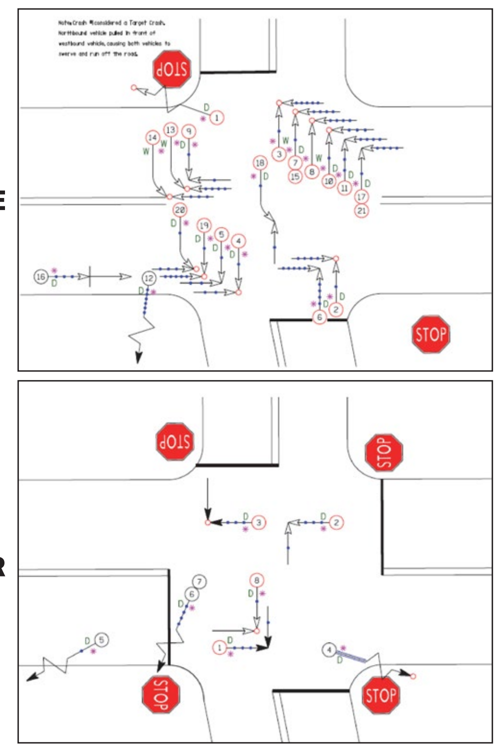


Figure 37. Example of Collision Diagrams to Compare Crash Patterns.

ADVANCING THE STRATEGY

The RSS provides a foundation for planning, prioritizing, implementing, and evaluating transportation projects that integrate Safe System principles to save lives and prevent serious injuries throughout the region. Moving forward, it is important to recognize that the state-of-the-practice for safety management continues to evolve. ARC and safety partners should stay informed of the latest practices and identify opportunities to integrate those practices in the project planning and development process.

The following are recommended next steps to advance the RSS, which are further expanded below:

» Use RSS to inform future plans and funding programs

» Improve funding flexibility

» Enhance safety data capabilities

» Enhance safety analysis capabilities

» Solicit stakeholder feedback

» Update RSS

USE RSS TO INFORM FUTURE PLANS AND FUNDING PROGRAMS

The rollout of the RSS presents an ideal opportunity to integrate safety management practices into the regional planning process through the RTP and TIP updates. As the Atlanta region's comprehensive long-range plan for transportation projects, adding an element that specifically targets safety goals will strengthen the established vision of the RTP that focuses on the social, economic, and environmental needs of the region. The current RTP policy framework is built on three main goals: providing world-class infrastructure, building a competitive economy, and ensuring healthy and livable communities. Weaving the regional focus of the RSS throughout these three pillars of the RTP will ensure that ARC is maintaining a unified vision for safety by setting regional goals, ensuring coordination across jurisdictions, understanding safety risks and needs at the system level, and evaluating and prioritizing projects with established safety performance measures. The specific, actionable policies put forth in the RTP Policy Framework should be modified or expanded to include the safety approaches and recommendations from the RSS.

Bringing the RSS into the TIP Project Solicitation process is another way to inform and support the funding of projects across the Atlanta region in a way that brings safety to the forefront. Prioritization could favor projects that address the following safety-related factors:

» **Demonstrated safety need** based on the potential for safety improvement: site-specific projects demonstrate a need based on crash history and expected future crashes. Systemic projects demonstrate a need based on presence of risk factors and potential risk of future crashes.

» **Alignment with regional priorities** based on number of emphasis areas addressed (or targeted) by the proposed project.

» **Economic-efficiency** based on the estimated safety benefit-cost ratio.

» **Potential to move the needle toward zero** based on the estimated lives saved and serious injuries prevented.

ARC should update the TIP Project Evaluation Framework by revisiting the filters, evaluation measures, and factors that are part of the framework. In doing so, ARC should integrate RSS safety considerations more explicitly, accounting for historical crash data, assessed risk, and proposed countermeasures for all project types regardless of the funding source.

Transportation projects in the TIP and RTP most commonly originate through the CTP Program. The CTP Program does require agencies to consider safety in the development process but has focused more on historical crash data. ARC manages the CTP Program and can establish consistency of regional safety goals through this program. Local agencies can use the RSS as a framework to incorporate risk assessment and proven countermeasures to proactively reduce fatal and serious injury crashes. Integrating the RSS into the CTP Program will allow each agency to develop project selection and prioritization methods that address unique community needs, while working to achieve regional safety targets. Specifically, there is an opportunity to review current CTPs and flag high-risk locations for further safety analysis using ARC's systemic screening tool. Ideally, any changes to incorporate safety elements in the project scope would be done during the project planning and scoping phase. While it can be challenging to add safety elements during the design phase, there may be opportunities to incorporate low-cost safety improvements to address existing risk factors.

ARC manages several other planning efforts into which the RSS can be integrated. As these plans and programs are updated, ARC should incorporate the strategies and recommendations from the RSS into the assessment and analysis sections of the studies. These programs include:

- Unified Planning Work Program (UPWP)
- Livable Centers Initiative (LCI) Program
- Regional Transportation Planning Study Program
- Freight Cluster Plan Program
- Regional Strategic Transportation Systems Management & Operations (TSMO) Plan
- Atlanta Regional Freight Mobility Plan
- Strategic Truck Route Master Plan (ASTRoMaP)
- Regional Bike-Pedestrian Plan (Walk, Bike, Thrive!)
- Regional Transportation Demand Management (TDM) Plan

IMPROVE FUNDING FLEXIBILITY

There are opportunities for ARC and GDOT to improve funding flexibility. One option is for ARC to perform a data scan and help GDOT prioritize HSIP projects similar to the CMAQ and statewide TAP. Another option is to designate set-aside funds from federal programs, such as the HSIP, allowing local agencies to compete for project funding on locally-classified roadways. Similar practices are currently in place for LCI funding where ARC creates a set-aside for local governments to compete for LCI study and project funding. Coordination with GDOT staff to prioritize HSIP funding for local projects may provide an opportunity for increased availability of eligible federal funds for locally-classified roadway projects.

ENHANCE SAFETY DATA CAPABILITIES

In the future, agencies should **collect or estimate traffic volumes for a larger portion of local roads**. This will allow for the use of VMT in identifying overrepresented facility types and in predicting crashes. ARC should also identify high-priority risk factors from national research and collect related data. This will allow for more rigorous systemic analysis and support future updates to the RSS. One specific example is for intersections. Intersections represent nearly 60 percent of fatal and serious injury crashes in the region. An intersection inventory that includes traffic control, number of approaches, major and minor road traffic volume, and number of lanes would help to better identify risk factors and target investments at those intersections with the highest risk for severe crashes.

There is limited information on pedestrian and bicycle exposure and crashes, particularly those crashes that do not involve a vehicle (e.g., pedestrian-bicycle, pedestrian-scooter, or single bicycle collision). In the future, ARC and regional partners should collect data on active transportation crashes and exposure. This includes incidents that occur on regional multi-use paths, such as the Atlanta BeltLine. This will help to identify and address emerging safety issues appropriately.

There are emerging challenges in local communities that could create safety issues. One example is the increasing freight movement in the Port of Savannah. This has resulted in more trucks on two-lane roads such as Highway 16 between I-75 and I-85, changing the dynamics of the county and local communities such as Griffin. It is recommended to monitor crash data and perform ad hoc analysis to investigate such concerns. If confirmed, there is an opportunity to incorporate these issues and applicable actions in future updates of the RSS. GDOT's Freight Operations program can fund projects to address such issues.

ENHANCE SAFETY ANALYSIS CAPABILITIES

In the future, ARC should **develop and deploy a safety management application or system** for local agencies to implement the site-specific and systemic approaches. The system could help local agencies identify sites with potential for safety improvement, diagnose safety issues, select countermeasures, perform economic analysis, and track and evaluate projects.

Local agencies could use this system to perform more localized systemic analysis, following the steps used to develop the RSS. This can establish local emphasis areas and better target countermeasures to address localized risk factors.

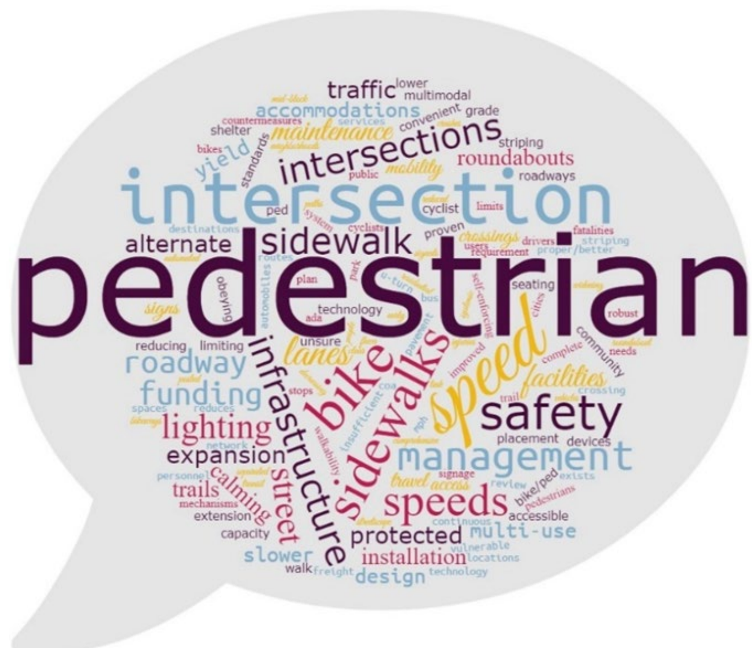
Project tracking is a key component to support project evaluation, but this can be an onerous process to perform manually. A safety management application could support project tracking by carrying forward information from project planning and development and providing a template for local agencies to enter basic project data once construction is complete. The application could also provide notifications when it is time to perform a project evaluation (3 years after construction) and automate much of the process.

SOLICIT STAKEHOLDER FEEDBACK

The RSS is intended to serve the needs of safety partners throughout the region. If the RSS is not aligned with local needs, then there is an opportunity to update the RSS to reflect those needs. ARC should conduct periodic surveys, interviews, and focus groups to solicit feedback on the RSS. Questions could ask if the RSS is meeting local needs and how the RSS could be improved. Opportunities to update the RSS can also be identified through unsolicited feedback. For instance, during the project planning and development process, a safety stakeholder might state something like “it would be nice if someone could create a guide or recommendations for implementing and maintaining low-cost landscaping.” ARC should keep a running list and consider these suggestions during future RSS updates.

UPDATE RSS

Safety management practices continue to evolve and safety issues continue to emerge. Over time, safety priorities can change and new risk factors can appear. ARC should **revisit and update the RSS to reflect the latest safety issues and local community needs**. The Georgia SHSP is updated at least once every five years. The RSS should be updated on a similar or more regular schedule, but it is generally not necessary to update more than once every three years. Each update should not entail a complete rewrite. Instead, ARC should perform similar data analysis to determine if the emphasis areas, focus facility types, and risk factors have changed. If so, these sections can be updated accordingly. It is recommended to review the FHWA Proven Safety Countermeasures to determine if there are new strategies and update the RSS with those that apply to the Atlanta region. Similarly, there is a need to identify and review the latest funding options (federal, state, and local) and update the RSS accordingly. Finally, there is a need to update the RSS to reflect the needs of safety partners based on solicited (or unsolicited) feedback.



ARC is committed to changing the current trajectory and working toward a goal of zero deaths and serious injuries in the Atlanta region.

The RSS provides a proactive, data-informed, and community-based approach to achieve the vision of safe, accessible, and convenient travel for all road users. The RSS will help ARC and its partners:

- Identify locations with high potential for safety improvement based on both crash history and future risk.
- Develop better transportation projects that target underlying risk factors and address the needs of all road users.
- Invest in proven safety countermeasures to make incremental safety improvements and regional changes to shift long-term safety outcomes.
- Promote a culture of safety in the Atlanta region.

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APPENDIX A

SUMMARY OF STAKEHOLDER AND PUBLIC ENGAGEMENT

SUMMARY OF STAKEHOLDER AND PUBLIC ENGAGEMENT

Stakeholder and public involvement were key components in developing the RSS and were instrumental in understanding the safety issues, needs and challenges of the region and identifying meaningful and impactful resources and recommendations. While much of the outreach was conducted during the social-distancing precautions of COVID-19, ARC was able to engage with a broad base of stakeholders interested in transportation safety, including public and private practitioners, elected officials, advocacy groups, CIDs, and citizens. ARC used a variety of techniques to connect and engage remotely with stakeholders throughout the region to obtain a diversity of perspectives. The following is a summary of the various efforts and how the input helped to shape the RSS. The final section of Appendix A provides a summary of overall input themes.

PRESENTATIONS TO ARC COMMITTEES

Throughout development of the RSS, the project team made regular presentations to and sought input from ARC committees such as the RSTF, TEAG, TCC, and TAQC. Membership of each of the committees is broad and representative of the region's counties and cities, both staff and elected officials, as well as planning professionals, pedestrian and bicycle advocacy groups, community organizations, and citizens. Feedback from these committees was helpful in shaping the content, tone, and direction of the RSS.

REGIONAL SURVEYS

Two surveys were developed and administered early in the process geared toward specific audiences: 1) staff of public-serving organizations such as state, regional, county, and city agencies and organizations, and 2) elected officials of counties and cities. The opt-in surveys were intended to collect information on attitudes and practices related to transportation safety. The surveys ran from August 2021 to September 2021 and were advertised to the RSTF, TCC, and TAQC. A total of 42 people responded to the surveys. The surveys were useful in gaining a more complete picture of the region's status of transportation safety, supplementing technical data, and identifying topics for further conversations and the overall development of the RSS.

TRANSPORTATION SAFETY WORKSHOP

On October 20, 2021, the project team conducted a half-day workshop for regional stakeholders in support of the RSS development. The objectives of the workshop were to present an overview of the process and ARC's role in safety planning and implementation; present safety countermeasures; and solicit feedback from attendees regarding the countermeasures and general safety concerns in the region. Over 75 participants attended the workshop with wide representation from counties and cities throughout the Atlanta region; CIDs; community and advocacy groups; consultant firms; Georgia Institute of Technology; GDOT; and FHWA. The workshop was successful in spreading the word about development of the RSS and disseminating safety resource information, as well as collecting input from practitioners on their experiences and feedback on the countermeasures.

STAKEHOLDER INTERVIEWS

From November 2021 to March 2022, sixteen (16) stakeholder interviews were conducted virtually to connect with public and private transportation professionals involved in state, regional, and local transportation planning and project development. The goals of the interviews were to solicit input on the processes, challenges, and successes in identifying, planning, and implementing safety measures and projects; identify any gaps in guidance; and further define how the RSS can be beneficial in overcoming the identified challenges and gaps. The interviews provided a unique opportunity to perform a deep dive on specific issues pertaining to safety planning and implementation, revealing a wealth of information from a variety of perspectives.

CITIZEN FOCUS GROUPS

During the weeks of June 20 and June 27, 2022, a series of five citizen-based focus groups were conducted to gather input from community members on how transportation safety affects their daily lives and travel-based decisions, as well as collect feedback on draft concepts depicting transportation countermeasure scenarios. A total of 30 people engaged in the group discussions. The participants provided diverse perspectives from rural, suburban, and urban communities throughout the region. The participants also represented a variety of backgrounds including community advocacy, business, engineering, and government. Input from the participants played a key role in the refinement of the draft concepts and the development of the accompanying concept narratives.

KEY INPUT THEMES

The following represents a compilation of the key themes heard across the stakeholder and public outreach efforts.

- Majority of participating stakeholders described the state of transportation safety in the Atlanta region today as challenging, chaotic, dangerous, piecemeal, and slow to change.
- On average, local counties and organizations surveyed rated themselves a "D" in effectiveness at generating positive change in transportation safety outcomes.
- State, local agencies, and the public need to be aligned on the issues and the solutions proposed to address the issues. Coordination needs to start early in the project development process and continue through to implementation to ensure the goals of the project and community are met.
- Partnerships are needed between local, state, and regional agencies to share resources such as data, funding, knowledge of community context, and public education.
- Delivery of safety projects can be very lengthy and there is a great need to expedite implementation.
- Education across the board is needed – public, elected officials, practitioners – on safety measures, the planning and implementation process, and how safety and mobility objectives can work together.
- Driver behavior, specifically speeding, is a major threat to safety on the roadways for all users. Infrastructure that slows down traffic and provides protection for active non-motorized mode users is essential.
- The Atlanta region is incredibly large and diverse in density and land use characteristics, environment, topography, and resources; it's important to recognize and account for these differences in the RSS. Scenarios should address these differences and provide solutions for a variety of jurisdictions and budgets.
- The growing potential for conflicts with increasing commercial vehicle traffic on roadways and motorized scooters and bicycles on multi-use paths are emerging safety issues that will need to be addressed.
- Maintenance is very important; adequate signing, delineation, and lighting as well as clearing of vegetation and trash is critical to providing safe facilities for all users.
- The implementation of countermeasures should not decrease the safety of another user. For instance, measures such as rumble strips should be used appropriately and with the bicycle rider in mind.
- The RSS could be helpful in the following ways:
  - Elevating the conversation on safety to include more than crash data and creating the space for those conversations to occur.
  - Performing the analysis, identifying the needs, and giving guidance and direction on where to focus efforts.
  - Defining regional safety goals to work towards together.
  - Defining a comprehensive safety approach.
  - Providing guidance on design elements and strategies that enhance multimodal safety.
  - Providing a directory for practitioners to access information on safety planning, including performance measures, proven countermeasures, funding sources, roles of partners and programs, and contact lists.
  - Providing a directory of educational materials for drivers, bicycle riders, and pedestrians navigating different scenarios and infrastructure with easy-to-understand graphics for diverse populations.
  - Providing a toolkit on how to implement quick-build solutions and how to navigate/work with planning partners and utility companies.
  - Advocating to elected officials to foster a safety mindset from top down.
  - Facilitating coordination between adjoining local agencies to incorporate safety elements on cross-jurisdictional corridors and to promote connectivity.
  - Continuing to be an outspoken voice for regional bicycle and pedestrian planning and implementation of plans for a regional network.

APPENDIX B

SCENARIOS

OVERVIEW

The RSS focuses on four specific crash types:

INTERSECTION

ROADWAY DEPARTURE

PEDESTRIAN

BICYCLE

This section presents seven pairs of higher-risk/lower-risk scenarios that represent common opportunities to address the focus crash types and improve safety in the region. These scenarios are loosely based on real conditions observed within the region.

Higher-risk scenarios ("before" condition):

- Represent locations with multiple risk factors for the focus crash types.
- Indicate general risk factors from systemic analysis.
- Identify safety issues based on further diagnosis of specific site.

Lower-risk scenarios ("after" condition):

- Illustrate design options to incorporate Safe System principles.
- Represent application of proven safety countermeasures individually and in combination.
- Illustrate applicability of proven safety countermeasures in various contexts and settings.

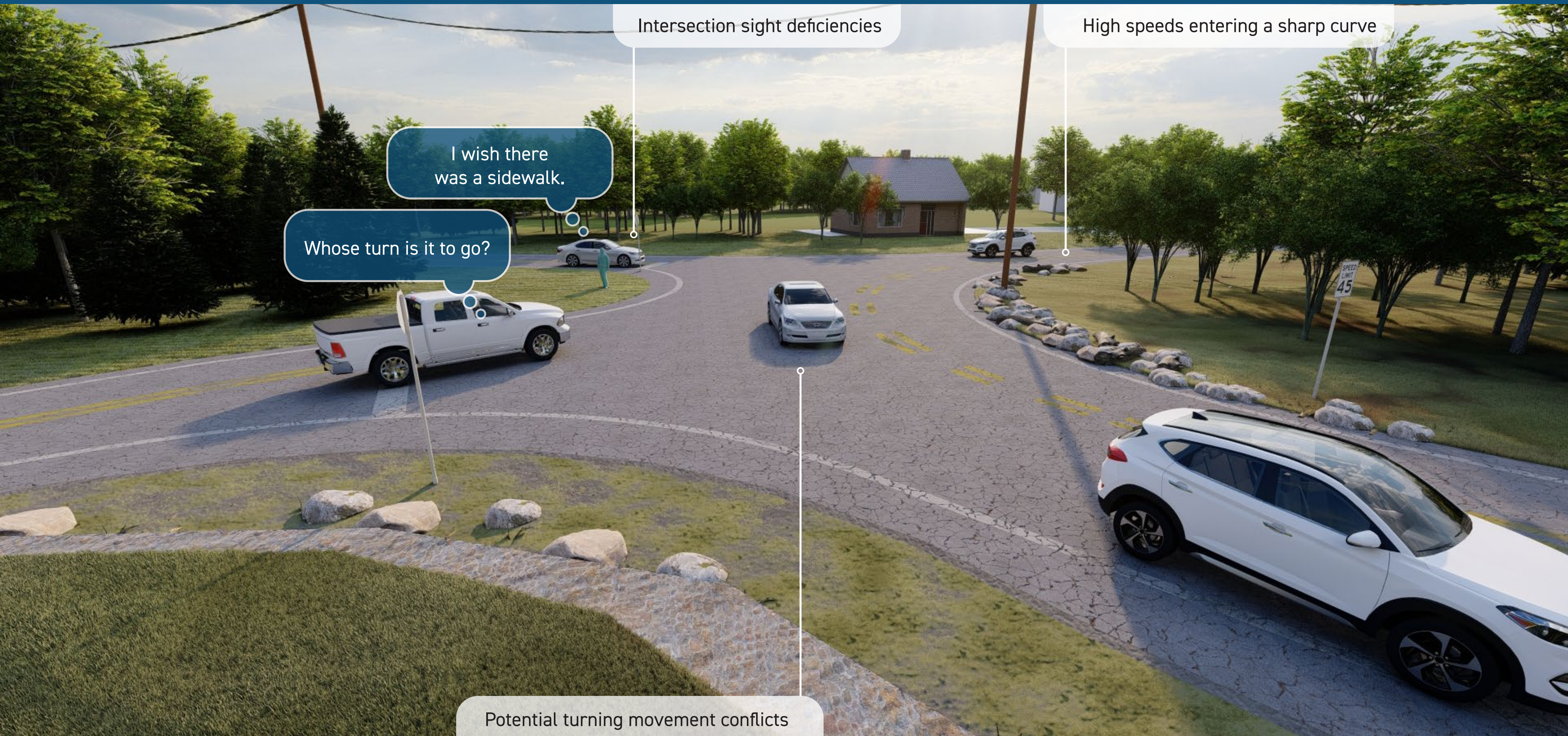
The scenarios are not meant to serve as exhaustive illustrations of all proven safety countermeasures, nor are they meant to suggest these are the only options for addressing known safety issues. The visualizations are intended to:

- Serve as examples for local agencies to consider when designing and implementing safety improvements.
- Facilitate discussion of benefits, considerations, and potential trade-offs with the community.

Accompanying each visualization is a list of considerations to help community members, elected officials, and agency staff in developing and selecting the preferred alternative.

BEFORE

SCENARIO 1 HIGHER RISK



Focus Crash Types

Risk Factors

- ✓ Limited sight distance
- ✓ Intersection within a curve
- ✓ Lack of sidewalk and crosswalks
- ✓ Higher speeds
- ✓ Conflicts between turning vehicles
- ✓ Ambiguous right-of-way for turning drivers (whose turn it is to go when stopped at the stop signs)

SCENARIO 1 LOWER RISK

AFTER

Focus Crash Types

Countermeasures

- ✓ Roundabout
- ✓ Pedestrian walkways and crosswalks
- ✓ Lighting

SCENARIO 1

Focus Crash Types

Focus Facility Types and Risk Factors

- Minor road stop-controlled intersection
- Two-lane road
- Minor arterial or major collector
- GDOT-owned
- Posted speed limit 35-45 mph
- Not adjacent to medium- or high-intensity development (more rural/suburban setting)

Site-Specific Safety Issues

- Limited sight distance
- Higher speeds
- Intersection within a curve
- Conflicts between turning vehicles
- Lack of sidewalk and crosswalks
- Ambiguous right-of-way for turning drivers (whose turn it is to go when stopped at the stop signs)

Resources

FHWA Proven Safety Countermeasures

GDOT Roundabout Design Guide

GDOT Design Policy Manual

Countermeasures

Roundabouts slow traffic, reduce potential for right-angle crashes, and define right-of-way for turning movements.

- Channelized approaches with slight curvature reduce vehicle speed and encourage drivers to yield to traffic already circulating, reducing the potential for conflicts.
- Slower speeds and reduced conflict points greatly reduce the likelihood of death and serious injury.
- Modern roundabouts reduce delay and queuing compared to other types of intersections.

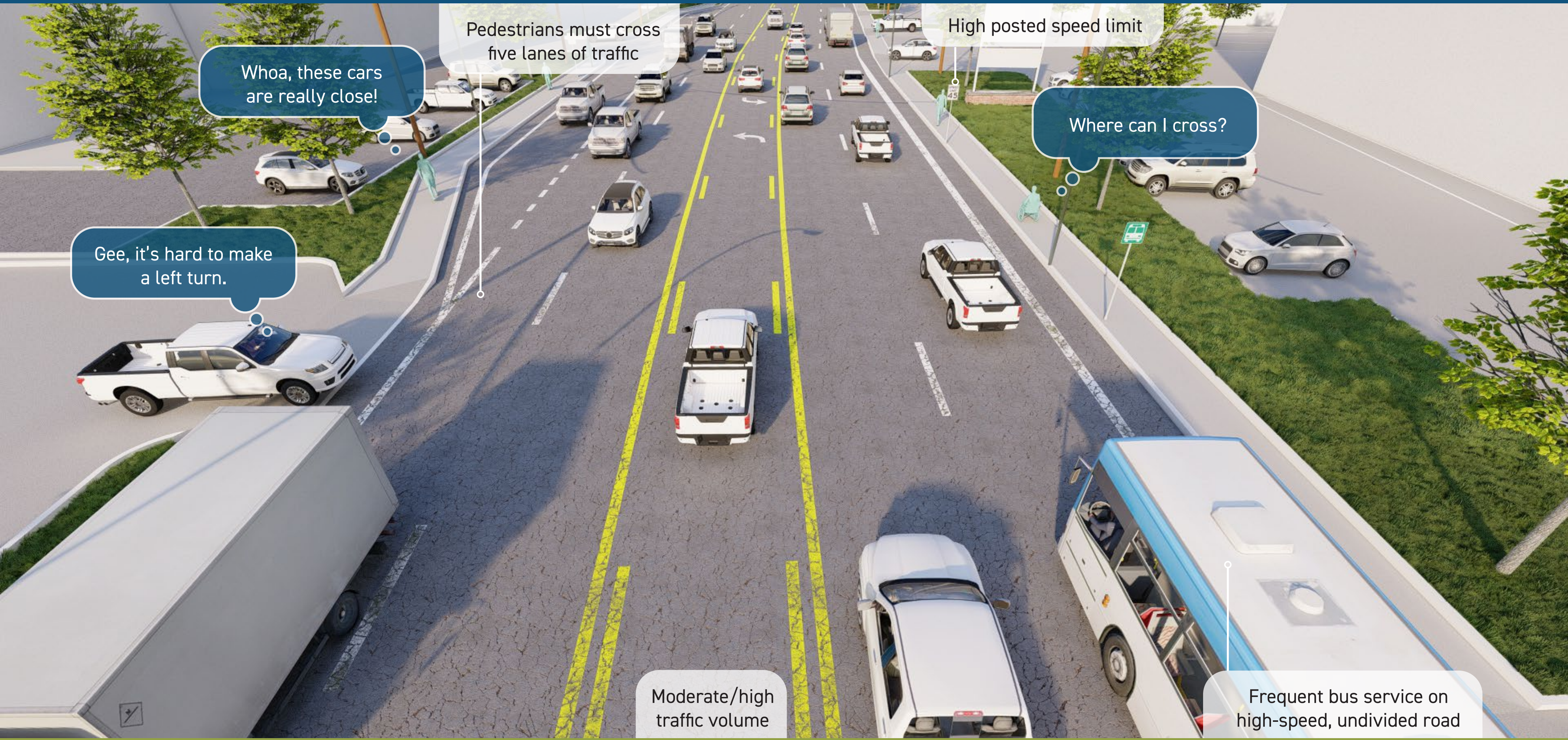
Pedestrian walkways and crosswalks provide dedicated facilities for pedestrians and separate them from traffic. Slower vehicle speeds create a more suitable environment for pedestrians.

Lighting improves visibility of pedestrians and the intersection as a whole.

Considerations

1. **Consider roundabouts for both urban and rural contexts.** Roundabouts can be designed for a range of traffic conditions, including large trucks and are effective at transitioning traffic from higher-speed environments to lower-speed environments.
2. **Consider the amount of right-of-way** needed to fit a roundabout at a given location.
3. **Consider factors such as daily traffic volumes and the general character of the area** in the decision to construct a roundabout.
4. **Consider factors such as posted speed limit and surrounding context** in the design of a roundabout.
5. **Provide appropriate signing for the roundabout and pedestrians.** Provide advance warning and guide signs to guide drivers through the roundabout. Provide pedestrian warning signs at the crossings.
6. **Consider lighting for roundabouts.** GDOT requires lighting for roundabouts on state routes.
7. **Consider opportunities to connect with nearby sidewalks.** This scenario depicts pedestrian improvements within the intersection project limits but there remains a need to provide a connected network.
8. **Consider long-term maintenance** when designing the center island in the roundabout.

SCENARIO 2 HIGHER RISK



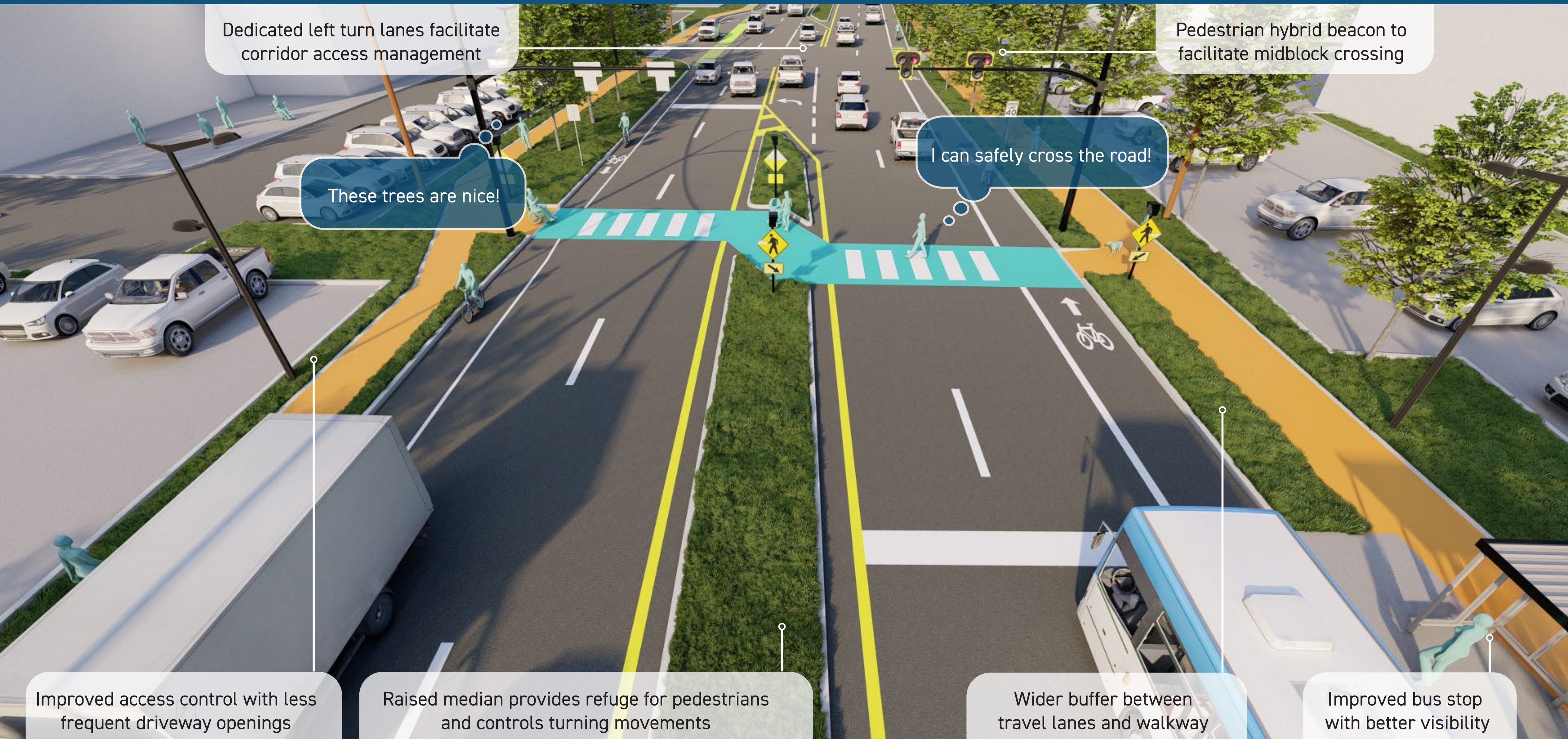
Focus Crash Types

Risk Factors

- ✓ Conflicts between turning vehicles
- ✓ Wide road with multiple lanes
- ✓ Higher speeds
- ✓ Lack of crosswalks

SCENARIO 2 LOWER RISK

AFTER



Focus Crash Types

Countermeasures

- ✓ Pedestrian hybrid beacon
- ✓ Raised median with pedestrian refuge
- ✓ Bicycle lanes
- ✓ Dedicated turn lanes
- ✓ Corridor access management
- ✓ Lighting

SCENARIO 2

Focus Crash Types

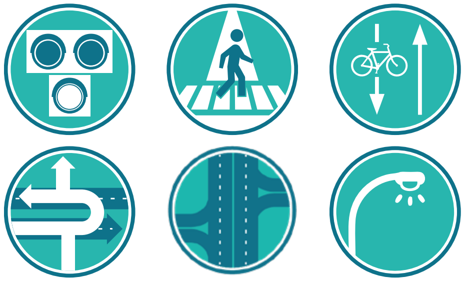
Focus Facility Types and Risk Factors

- Four or more lanes
- Other principal arterial or minor arterial
- GDOT-owned
- Posted speed limit 45 mph or higher
- Traffic volumes greater than 9,000 vehicles per day
- Bus stops present along corridor
- High population density along corridor
- Medium- or high-intensity development along corridor

Site-Specific Safety Issues

- High-speed, multilane road
- Moderately high traffic volumes
- Several driveways create potential conflict points
- Difficult for pedestrians to cross the road
- Limited separation between pedestrians and vehicles
- Lack of designated bicycle facilities
- Difficult for drivers to turn left (in or out of driveways)

Countermeasures



Pedestrian hybrid beacon with accessible crossing provides a dedicated time and place for pedestrians to cross the road.

Raised median and pedestrian refuge island reduces the number of lanes that pedestrians cross and gives pedestrians a place to wait if they cannot make it across the road quickly. The median refuge allows for a two-stage crossing, where pedestrians cross one direction of traffic while the other direction continues moving. This can improve mobility for traffic along the corridor.

Bicycle lanes provide a dedicated place for bicycle riders and separate them from vehicles and pedestrians. Bicycle lanes can mitigate or prevent conflicts between bicycle riders and motor vehicles.

Dedicated turn lanes separate turning vehicles from through traffic while making the turning movements less confusing than a continuous center turn lane.

Corridor access management reduces the number of potential conflict points between turning vehicles and improves the flow of traffic and general mobility along a corridor.

Lighting improves visibility of pedestrians and bicycle riders along the corridor.

SCENARIO 2

Resources

FHWA Proven Safety Countermeasures

Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways

GDOT Design Policy Manual

GDOT Regulations for Driveway & Encroachment Control Manual

NACTO Urban Street Design Guide

NACTO Urban Bikeway Design Guide

FHWA Bikeway Selection Guide

FHWA Improving Safety for Pedestrians and Bicyclists Accessing Transit

Considerations

1. **Consider pedestrian hybrid beacons where it is difficult for pedestrians to cross the road**, such as multilane streets with posted speed limit of 35 mph or more and traffic volumes of 9,000 vehicles per day or higher.
   - Under the right conditions (lower traffic volumes and lower speeds), rectangular rapid flashing beacons (RRFB) may be appropriate in place of a pedestrian hybrid beacon.
   - In rare cases with the right conditions, pedestrian bridges or tunnels may be an appropriate alternative.

2. **Consider medians in curbed sections of urban and suburban multilane roads**, particularly where there is a significant mix of pedestrian and vehicular traffic.
   - Raised medians should be at least 4 feet wide, and preferably 8 feet wide for pedestrian comfort.
   - Consider the placement and length of turn lanes to accommodate left-turns and U-turns.

3. **Design bicycle lanes for the safety of the bicycle riders.**
   - Wider bicycle lanes and those with painted buffers or physical separation from vehicular traffic are preferred to simple painted on-street bicycle lanes.
   - In this scenario, it may be preferable to adjust the curb location and move the bicycle facility to a multiuse path.

4. **Consider the benefits and challenges** of narrowing travel lanes, the amount of public right-of-way available, and the placement of medians, median openings, pedestrian hybrid beacons, and bus stops within the context of a given roadway setting.

5. **Consider roadway and contextual challenges** such as traffic volumes, lane and shoulder width, travel speeds, buffer space between the road and sidewalk, and the location of curb and utilities.
   - In this scenario, a physically-separated bicycle lane does not fit neatly within the existing right-of-way.
   - Enhancements could include reflective, flexible post delineators.

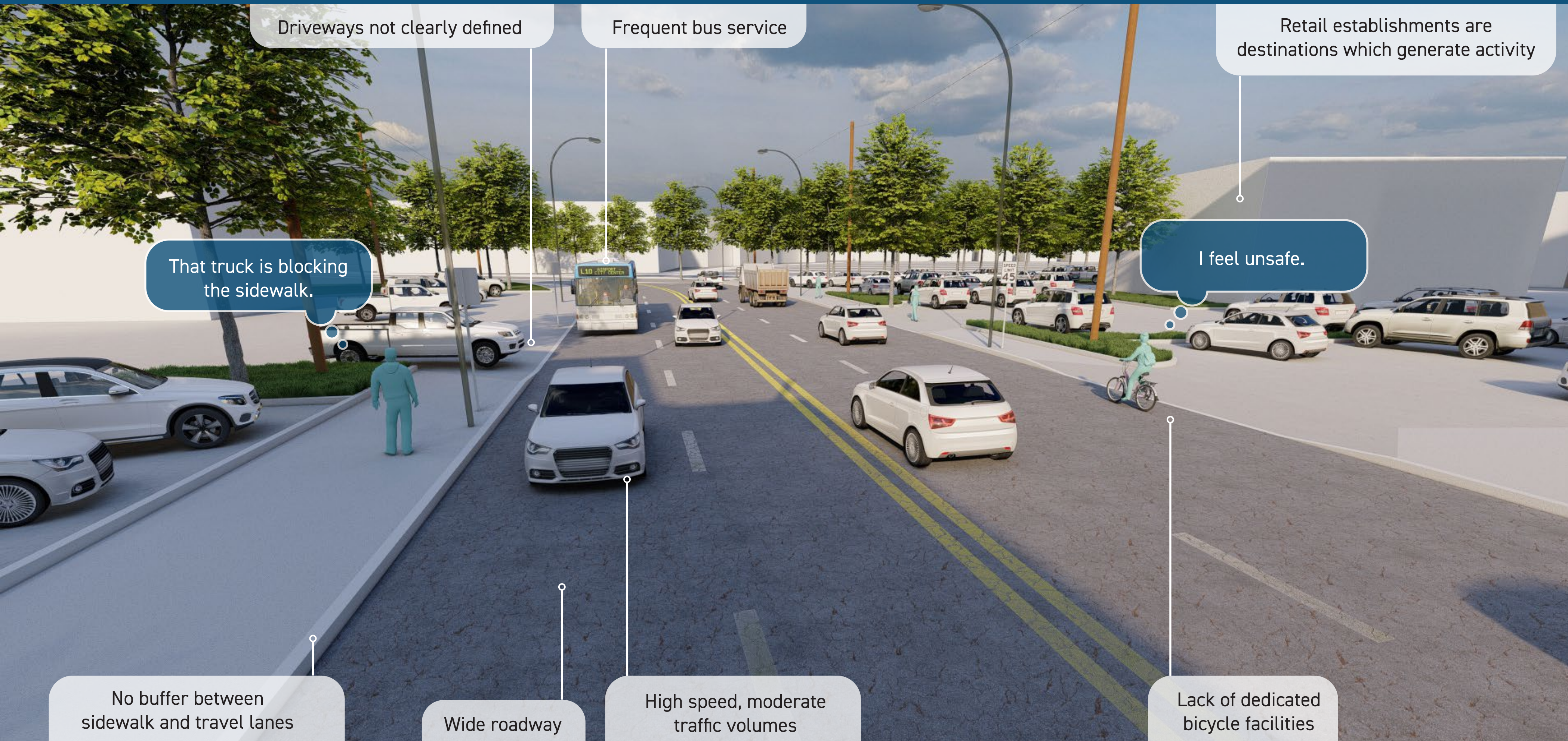
6. **Consider access management on a corridor-wide basis**, including intersection spacing, median openings, and driveways. Meet with businesses to explain the safety and mobility benefits. Refer to GDOT access management guidelines and requirements for state routes.

7. **Coordinate with transit service providers before planning to move or relocate bus stops.** If there are concerns with conflicts between buses and bicycle riders, particularly at bus stops, other options include a floating bus stop or rerouting the bicycle lane behind the bus stop.

8. **Provide safer and more accessible pedestrian, bicycle, and transit accommodations** with the potential to influence mode choice (and mode shift).

BEFORE

SCENARIO 3 HIGHER RISK



Focus Crash Types

Risk Factors

- ✓ Conflicts between turning vehicles
- ✓ Wide road with multiple lanes
- ✓ Lack of bike facilities
- ✓ Higher speeds
- ✓ Lack of buffer between travel lane and walkway
- ✓ Activity generators on both sides of the road
- ✓ No dedicated turn lanes

SCENARIO 3 LOWER RISK

AFTER

Focus Crash Types

Countermeasures

- ✓ Road diet or reduction in number of lanes
- ✓ Driveway crosswalk visibility enhancements
- ✓ Lighting
- ✓ Bicycle lane (protected)

SCENARIO 3

Focus Crash Types

Focus Facility Types and Risk Factors

- Four or more lanes
- Other principal arterial or minor arterial
- GDOT-owned
- Posted speed limit 45 mph or higher
- Traffic volumes between 15,000 and 18,000 vehicles per day
- Bus stops present along corridor
- Bicycle activity near the corridor
- Medium or high population density along corridor
- Medium- or high-intensity development along corridor

Site-Specific Safety Issues

- High-speed, multilane road
- Moderately high traffic volumes
- Lack of separation between opposing directions of travel
- Several driveways create potential conflict points
- Difficult for pedestrians to cross road
- Limited separation between pedestrians and vehicles
- Lack of designated bicycle facilities
- Difficult for drivers to turn left (in or out of driveways)

Countermeasures

Road diet reduces the number of lanes and converts the space to a shared center turn lane and protected bicycle lane.

- Road diets improve safety and mobility by reducing the number of travel lanes for pedestrians to cross, creating more consistent travel speeds, and allowing for safer turning movements.
- Road diets reduce rear-end and angle crashes.
- Converting four-lane to three-lane roads does not significantly reduce capacity or throughput on roads with traffic volumes up to 25,000 vehicles per day because drivers tend not to fully utilize the inside (left) travel lanes, anticipating other drivers making left-turns.

Protected bicycle lane provides a dedicated place for bicycle riders and separates them from vehicles and pedestrians. Bicycle lanes can mitigate or prevent conflicts between bicycle riders and motor vehicles.

Multiuse path provides a dedicated place for pedestrians and bicycle riders and separates them from vehicles. The buffer between the walkway and travel lanes increases comfort and safety for pedestrians and bicycle riders.

Corridor access management in this example does not reduce the number driveways. Instead, it defines the driveways by controlling driveway width. It accommodates turning movements via the center left-turn lane, which improves the flow of traffic and reduces conflicts between turning vehicles.

Crosswalk visibility enhancements improves awareness of pedestrians at driveway crossings.

Lighting improves visibility of pedestrians and bicycle riders along the corridor.

SCENARIO 3

Resources

FHWA Proven Safety Countermeasures

Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways

GDOT Design Policy Manual

GDOT Regulations for Driveway & Encroachment Control Manual

NACTO Urban Street Design Guide

NACTO Urban Bikeway Design Guide

FHWA Bikeway Selection Guide

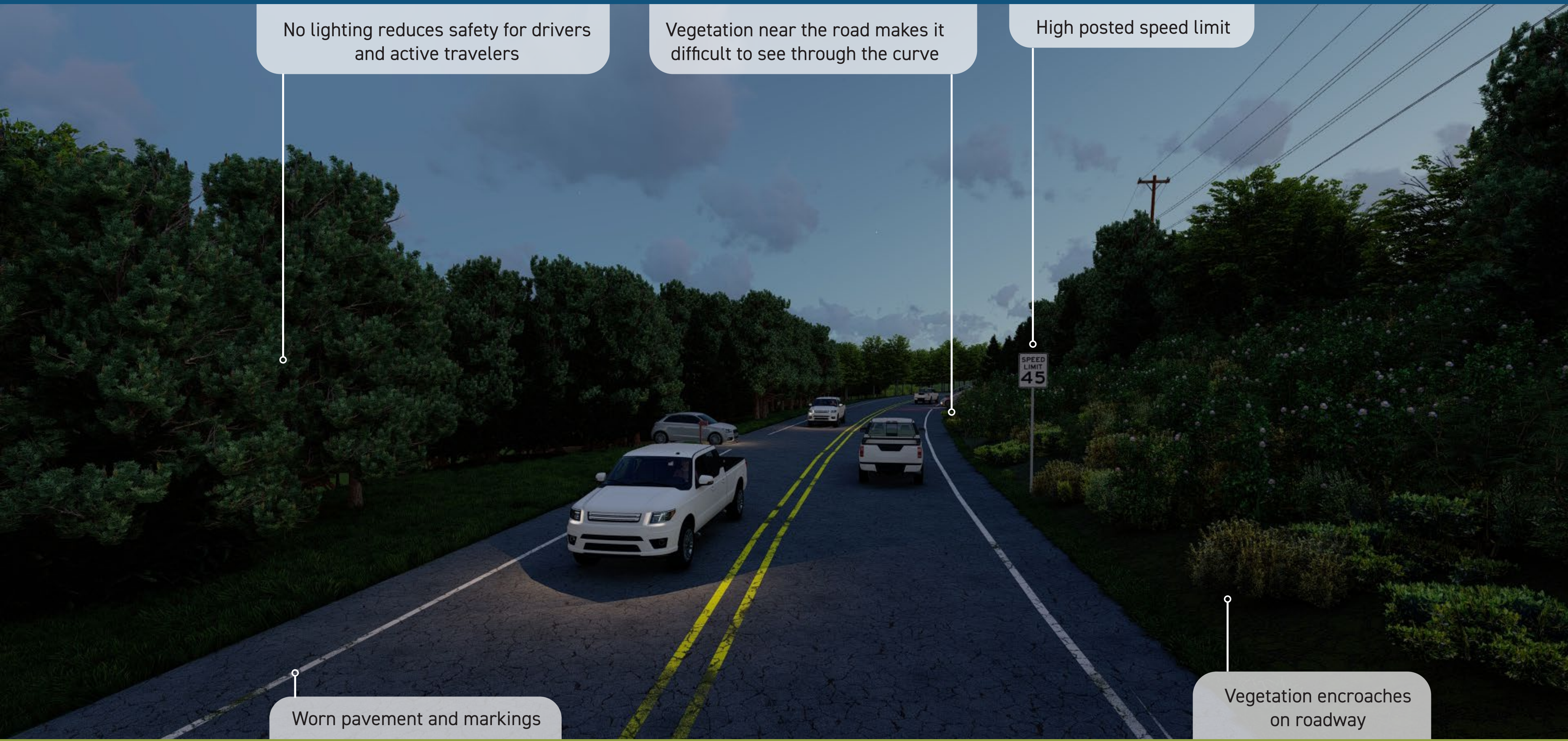
FHWA Improving Safety for Pedestrians and Bicyclists Accessing Transit

Considerations

1. **Consider context when evaluating design options.**
   - This includes factors such as travel speed, posted speed limit, traffic volumes, available right-of-way, and the location of bus stops and driveways.
   - These and other factors affect the selection and design of bicycle facilities as well as the viability of a road diet and overall roadway configuration.
2. **Design bicycle facilities for the safety of bicycle riders.**
   - Wider bicycle lanes and those with painted buffers or physical separation from vehicular traffic are preferred to simple painted on-street bicycle lanes.
   - This scenario shows both a multiuse path and a protected bike lane to illustrate options. In most situations, one or the other would be appropriate.
   - If conditions can accommodate a protected on-street bicycle lane, then sidewalk should also be provided.
   - A multiuse path may be appropriate when it is not feasible to provide separate pedestrian and bicycle facilities.
3. **Consider pedestrian crossing needs.**
   - This scenario does not show a pedestrian crossing within the view, but there is a signalized intersection just out of view.
   - If a midblock crossing is appropriate, consider placement with respect to driveways and the bus stop.
   - Road diets provide space for a pedestrian median refuge at the crossing if desired.
4. **Consider long-term maintenance of vegetation in buffer areas.**
   - Features such as street trees and wider buffers between the road enhance comfort for people using sidewalks or multiuse paths.
   - There is an opportunity to plant low maintenance trees with manageable roots that will not create issues with the sidewalk, road, or utilities.
5. **Consider long-term maintenance of pavement markings.** Delineation of bicycle lanes and crosswalks across driveways and side streets improves driver awareness of pedestrians and bicycle riders in the area.
6. **Consider opportunities to incorporate multimodal safety enhancements with road diets.** These include raised medians or refuge islands, bicycle lanes, on-street parking, and/or transit stops.
7. **Consider public education and outreach when implementing road diets** to improve awareness of the safety and mobility benefits.

BEFORE

SCENARIO 4 HIGHER RISK



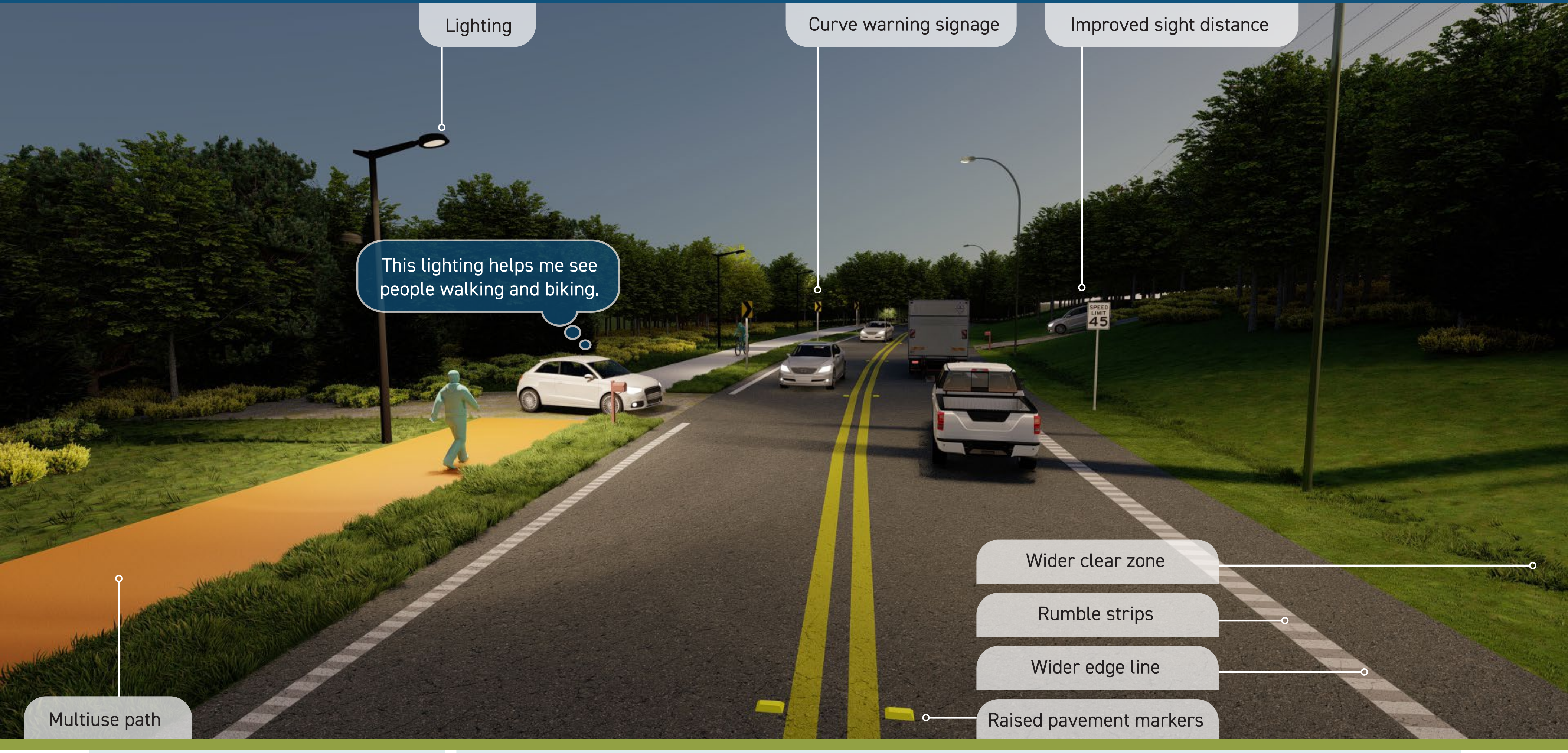
Focus Crash Types

Risk Factors

- ✓ Higher speeds
- ✓ Horizontal curvature
- ✓ Dark conditions
- ✓ Lack of separation between travel lanes

SCENARIO 4 LOWER RISK

AFTER



Focus Crash Types

Countermeasures

- ✓ Wider edge lines
- ✓ Enhanced delineation for horizontal curves (chevron signs)
- ✓ Longitudinal rumble strips and stripes
- ✓ Lighting
- ✓ Wider clear zone
- ✓ Walkways

SCENARIO 4

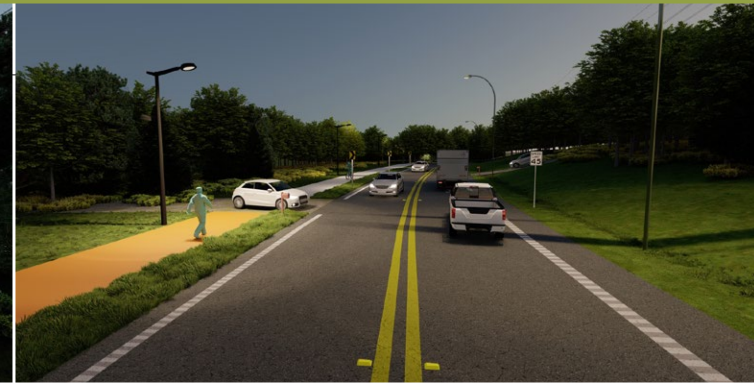
Focus Crash Types

Focus Facility Types and Risk Factors

- Two lanes
- Minor arterial or major collector
- GDOT-owned
- Posted speed limit 45 mph or higher
- Traffic volumes between 5,000 and 15,000 vehicles per day
- Not in a densely populated area
- Not adjacent to medium- or high-intensity development (more rural/suburban setting)

Site-Specific Safety Issues

- High speeds
- Horizontal curve
- Limited sight distance through the curve
- Lack of separation between travel lanes
- Lack of designated pedestrian and bicycle facilities
- Narrow shoulders
- Faded pavement markings



Countermeasures

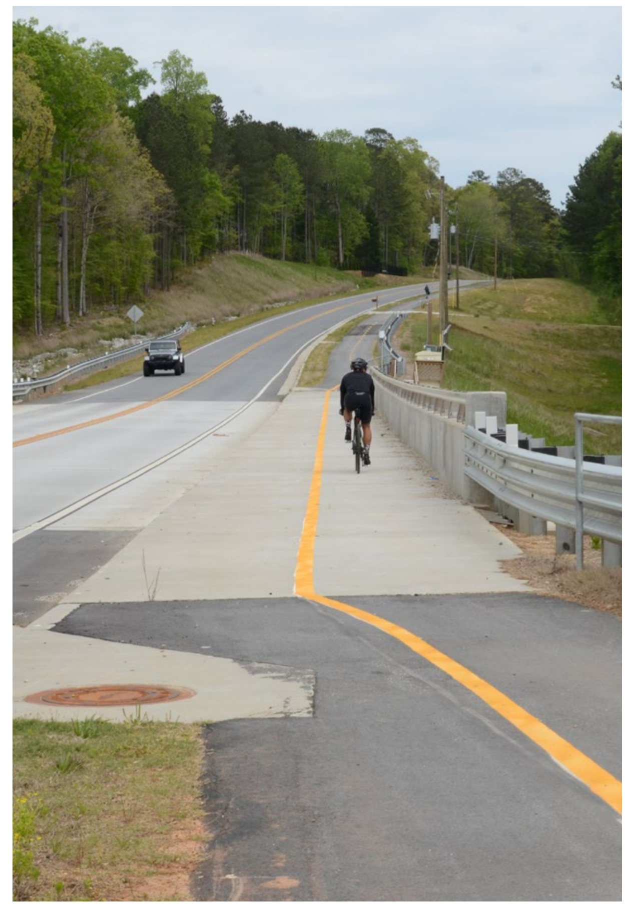
Enhanced delineation including **wider edge lines** and raised reflective pavement markers along the corridor and **chevrons within horizontal curves** improve lane keeping and alert drivers to the presence of the curve. This reduces the likelihood of roadway departure and head-on collisions.

Longitudinal rumble strips or stripes alert drivers that leave the travel lane. This reduces the chance of roadway departure crashes.

Roadside design improvements (wider clear zone) improves sight distance through the curve, reduce the potential for crashes with fixed objects, and provide drivers the opportunity to recover if they run off the road. Roadside design improvements such as wider clear zones reduce crash severity and are particularly effective at targeted locations such as horizontal curves.

Multiuse path provides a dedicated place for pedestrians and bicycle riders and separates them from vehicles. The buffer between the walkway and travel lanes increases comfort and safety for pedestrians and bicycle riders.

Lighting improves visibility for drivers and also improves visibility for pedestrians and bicycle riders along the corridor.



SCENARIO 4

Resources

FHWA Proven Safety Countermeasures

Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways

AASHTO Roadside Design Guide

GDOT Design Policy Manual

GDOT Regulations for Driveway & Encroachment Control Manual

FHWA Bikeway Selection Guide

FHWA Incorporating On-Road Bicycle Networks into Resurfacing Projects

Solutions for Making Rumble Strips Safer for Cyclists

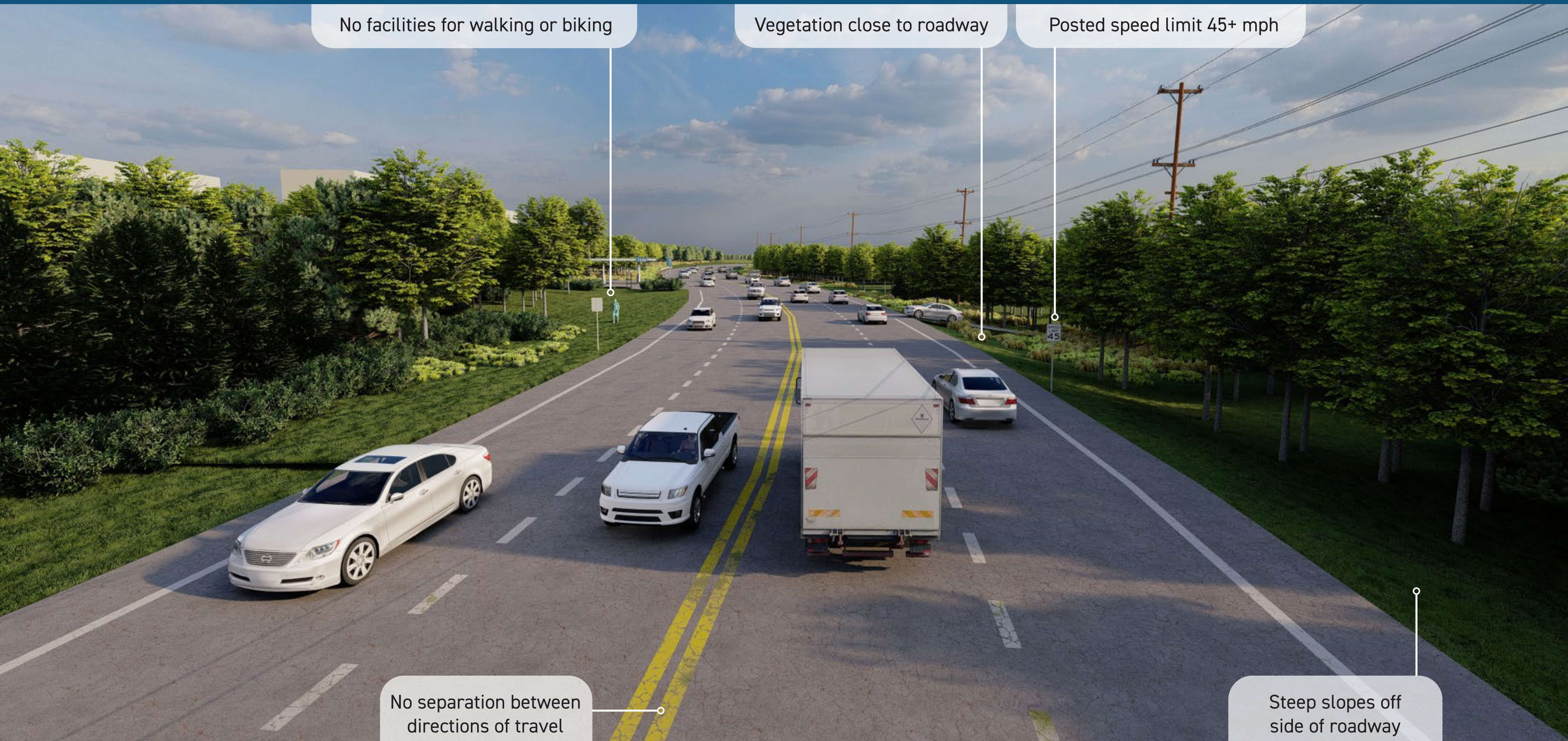
FHWA Small Town and Rural Multimodal Networks

Considerations

1. **Consider an incremental approach to minimize improvement costs.**
   - Lower-cost measures can be applied quickly and may be sufficient to reduce crash risk.
   - Low-cost roadway departure countermeasures include enhanced pavement markings, raised pavement markers, minor vegetation clearing, and enhanced curve signage.
   - If safety issues persist, more complex and long-term measures may be considered, such as widening clear zones, flattening side slopes, adding rumble strips, creating a multiuse path, and installing lighting.
   - A combination of short-term and long-term measures may be most effective.
2. **Coordinate low-cost safety improvements with road maintenance and resurfacing projects** to increase efficiency and reduce overall costs.
3. **Edge lines** are considered "wider" when the width is increased from 4" markings to 6" markings.
4. **Consider narrower bicycle-friendly rumble strips or stripes** where rumble strips are used.
   - There is a need for appropriate breaks in rumbles to accommodate bicycle riders riding on the shoulder.
   - Alternatives to rumble strips include profiled thermoplastic, raised pavement markers, and adding or widening shoulders.
5. **Consider curve delineation enhancements** to alert drivers of the presence, direction, and sharpness of the curve as well as appropriate operating speed.
   - Enhanced curve delineation includes strategies such as in-lane curve warning pavement markings, delineator posts, retroreflective strips on sign posts, chevron signs, larger retroreflective or fluorescent signs, and dynamic speed feedback signs.
6. **Consider clear zone enhancements to reduce the severity of roadway departure crashes.** Clear zone widening and sideslope flattening provide more space for drivers to regain control of their vehicles or allow them to come to a stop before striking a roadside object.
7. **Consider adding signage and pavement markings along multiuse paths.** This can include stop signs at street or driveway crossings and dividing lines and signage to keep right.

BEFORE

SCENARIO 5 HIGHER RISK



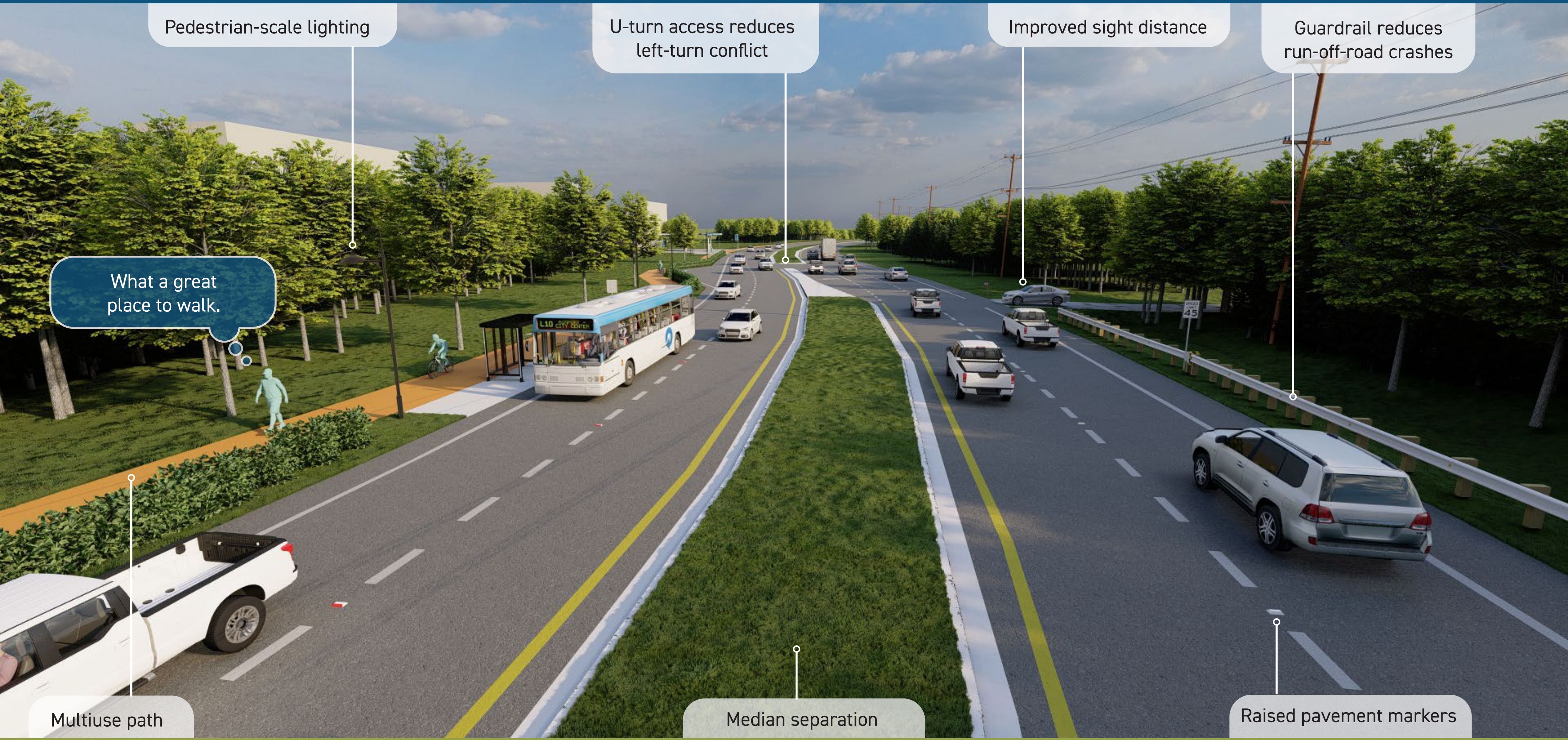
Focus Crash Types

Risk Factors

- ✓ Higher speeds
- ✓ Lack of separation between travel lanes
- ✓ Steep slopes off side of roadway

SCENARIO 5 LOWER RISK

AFTER



Focus Crash Types

Countermeasures

- ✓ Raised median
- ✓ Guardrail
- ✓ Dedicated biking and walking facilities
- ✓ Lighting
- ✓ Corridor access management

SCENARIO 5

Focus Crash Types

Focus Facility Types and Risk Factors

- Four or more lanes
- Minor arterial
- GDOT-owned
- Posted speed limit 45 mph or higher
- Traffic volumes between 5,000 and 15,000 vehicles per day
- Not in a densely populated area
- Not adjacent to medium- or high-intensity development (more rural/suburban setting)

Site-Specific Safety Issues

- High-speed, multilane road
- Moderate traffic volumes
- Lack of separation between opposing directions of travel
- Difficult for pedestrians to cross the road
- Lack of designated pedestrian and bicycle facilities
- Steep roadside slopes and fixed objects close to the road

Countermeasures

Raised median increases separation between opposite directions of traffic, reducing the likelihood for head-on collisions.

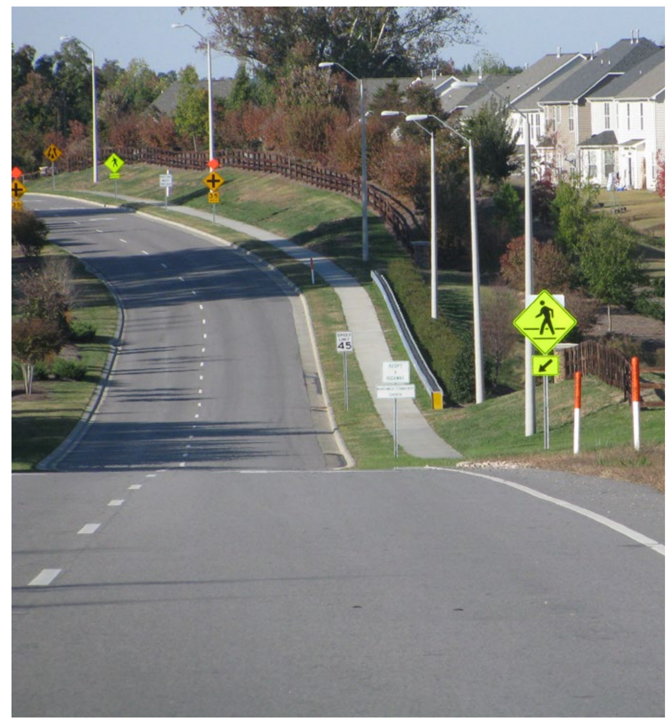
- Raised medians provide a refuge for pedestrians crossing the road.
- The use of a raised median necessitates median openings to allow for U-turns and access to adjacent businesses and side streets.
- A flush painted median is another option depending on the context and setting.
- On state routes, GDOT design guidance prevails.

Guardrail can minimize the severity of roadway departure crashes, especially in locations where flattening slopes and removing fixed objects along the roadside is infeasible.

Multiuse path provides a dedicated place for pedestrians and bicycle riders and separates them from vehicles. The buffer between the walkway and travel lanes increases comfort and safety for pedestrians and bicycle riders.

Lighting improves visibility for drivers and also improves visibility for pedestrians and bicycle riders along the corridor.

Corridor access management reduces the number of potential conflict points between turning vehicles, pedestrians, and bicycle riders. Corridor access management can also improve the flow of traffic and general mobility along a corridor.



SCENARIO 5

Resources

[FHWA Proven Safety Countermeasures]

[Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways]

[GDOT Design Policy Manual]

[GDOT Regulations for Driveway & Encroachment Control Manual]

[NACTO Urban Street Design Guide]

[FHWA Bikeway Selection Guide]

[FHWA Improving Safety for Pedestrians and Bicyclists Accessing Transit]

Considerations

1 Consider an incremental approach to reduce the risk of roadway departure crashes.

- Starting with short-term measures such as signage, pavement markings, and resurfacing.
- This scenario shows widening as part of the project, which has cost and right-of-way implications.
- Ultimately, a combination of short-term and long-term strategies (median, roadside, pedestrian, bicycle, and lighting improvements) may be needed.

2 Consider raised or flush medians as options, depending on the setting.

- Raised medians may require median openings to allow access and U-turns.
- The type and width of median must comply with applicable standards.
- Trees should not be planted in the median near intersections because they can limit sight distance.

3 Shield roadside hazards when it is not possible to remove, relocate, or redesign.

- Guardrail may be more cost-effective than flattening slopes along the roadside.
- There is a need to provide appropriate deflection distance in accordance with applicable standards.

4 Provide designated facilities for pedestrians and bicycle riders.

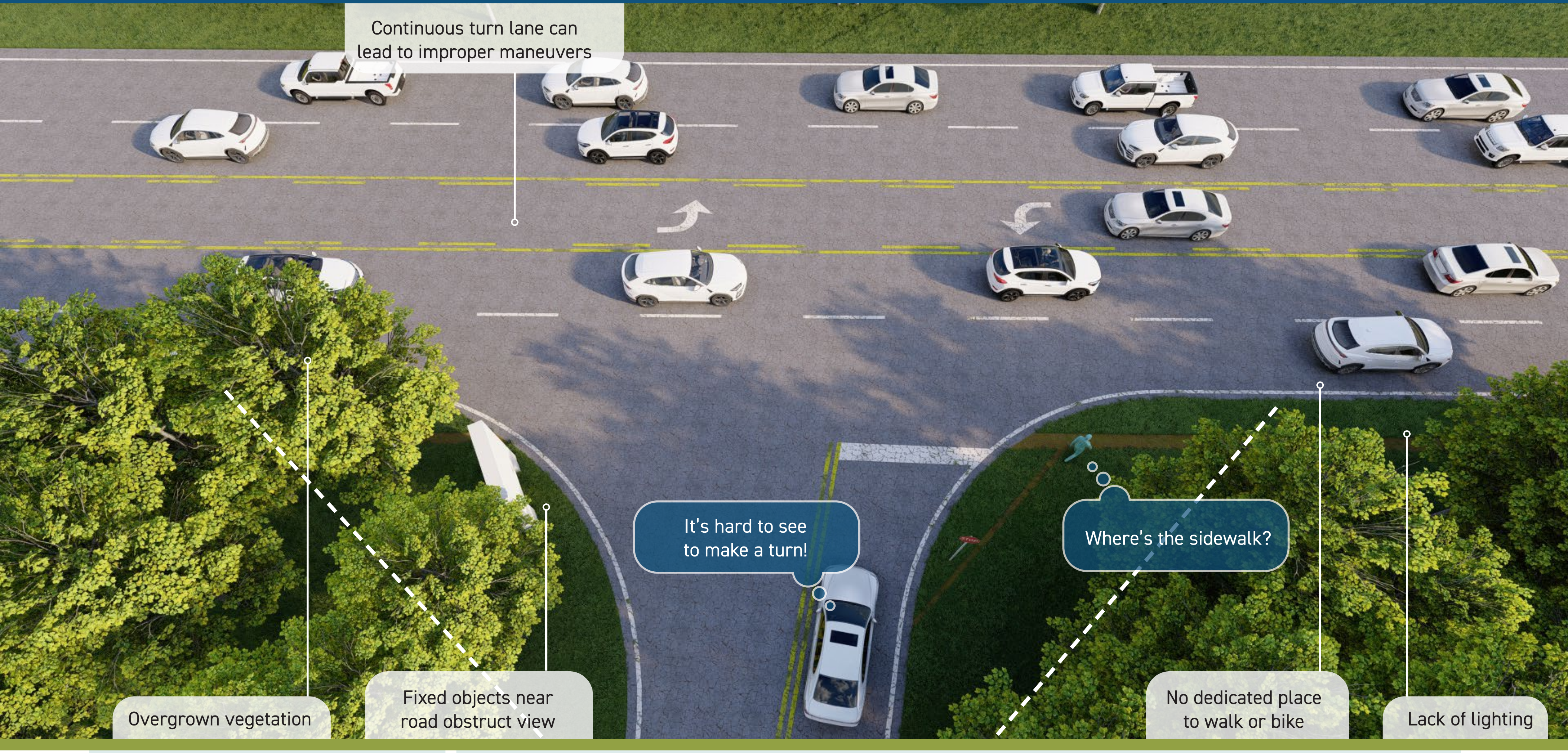
- A combination of sidewalk and protected on-street bike lanes may be more appropriate than a multiuse path where space allows. Consider factors such as right-of-way, nearby destinations, and potential for network connectivity.
- Multiuse paths are located behind the curb, farther from travel lanes, and provide more comfort for people biking and walking in higher speed, higher-volume settings.

5 Provide a bicycle-friendly shoulder where a separate, dedicated bicycle facility is not provided. Factors to consider include the width of the shoulder and the use of bicycle-friendly rumble strips.

6 Integrate landscaping shrubs and trees along multiuse paths and grass in the median.

- Consider the long-term maintenance of the vegetation.
- Vegetation can support other priorities such as resiliency and sustainability.

SCENARIO 6 HIGHER RISK



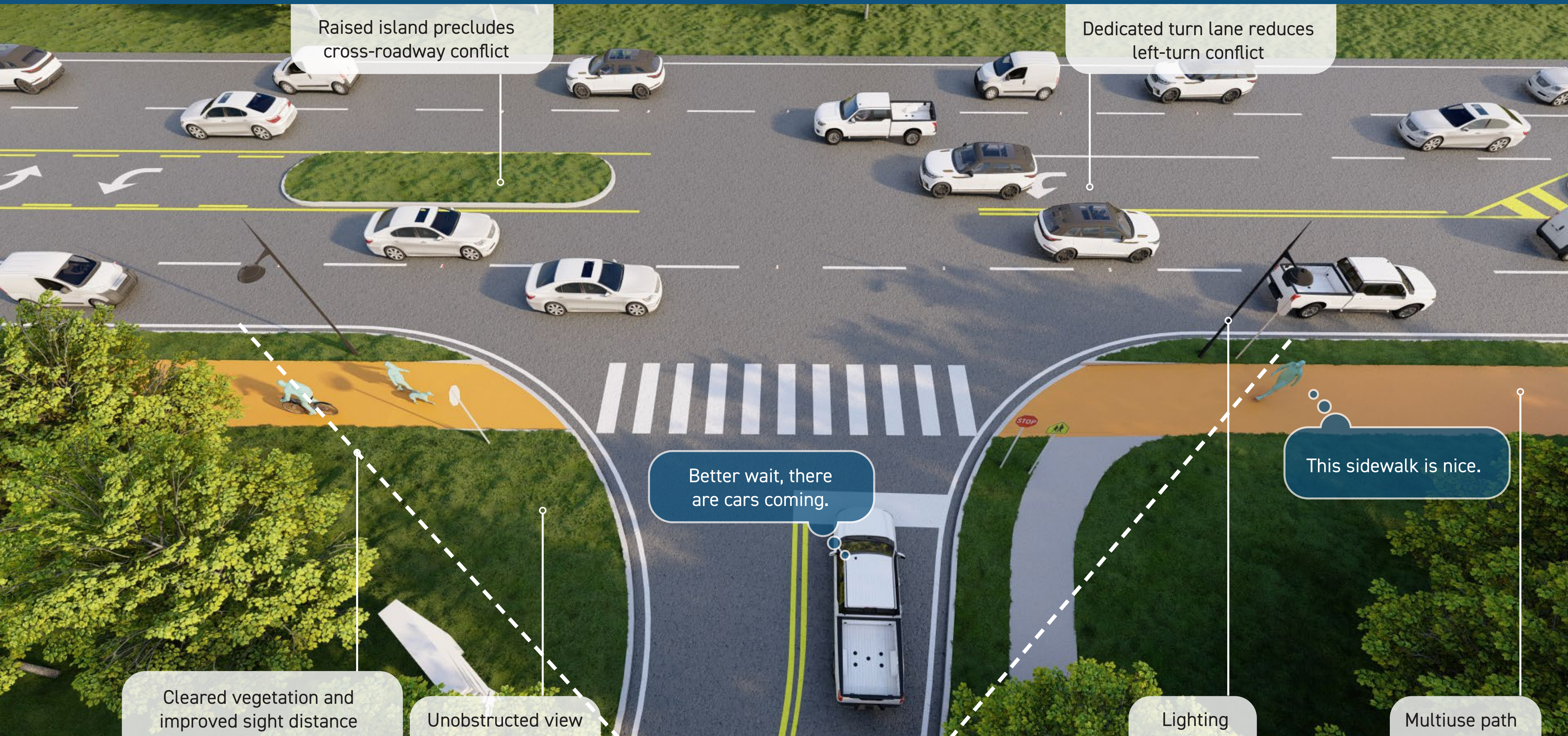
Focus Crash Types

Risk Factors

- ✓ Sight obstructions
- ✓ Lack of sidewalk
- ✓ Skew angle
- ✓ Turning across multiple lanes of traffic

SCENARIO 6 LOWER RISK

AFTER



Focus Crash Types

Countermeasures

- ✓ Raised median
- ✓ Systemic application of multiple low-cost countermeasures (properly placed stop bar, removal sight obstructions)
- ✓ Corridor access management
- ✓ Dedicated biking and walking facilities
- ✓ Lighting

SCENARIO 6

Focus Crash Types

Focus Facility Types and Risk Factors

- Minor road stop-controlled intersection
- Four-lane major road
- Minor arterial or major collector
- GDOT-owned
- Posted speed limit 35 mph (on mainline)
- Not in a densely populated area
- Not adjacent to medium- or high-intensity development (more rural/suburban setting)

Site-Specific Safety Issues

- Limited sight distance (signing, vegetation)
- Intersection skew
- Lack of sidewalk and crosswalks
- Difficult for drivers to turn left (to or from minor road) due to multiple lanes

Countermeasures

Systemic application of multiple low-cost countermeasures at stop-controlled intersections include properly placed stop bar, high-visibility crosswalk, and sight distance improvements (cutting back the vegetation and relocating the neighborhood sign). Low-cost improvements are a good first step to improving safety.

Left-turn lane designates location for left turns from the major road.

- The two-way center left-turn lane serves this purpose, but drivers sometimes use these lanes inappropriately. Short, raised medians prevent drivers from traveling longer distances in the two-way center left-turn lane.
- A flush painted median may be used in lieu of a raised median.

Intersection realignment improves the skew and improves sight distance for drivers turning from the side street.

Multiuse path provides a dedicated place for pedestrians and bicycle riders and separates them from vehicles. The buffer between the walkway and travel lanes increases comfort and safety for pedestrians and bicycle riders.

Lighting improves visibility of pedestrians at the intersection and helps drivers locate the intersection at night.

Corridor access management reduces the number of potential conflict points between turning vehicles, pedestrians, and bicycle riders. Corridor access management can also improve the flow of traffic and general mobility along a corridor.

SCENARIO 6

Resources

FHWA Proven Safety Countermeasures

Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways

GDOT Design Policy Manual

GDOT Regulations for Driveway & Encroachment Control Manual

NACTO Urban Street Design Guide

Considerations

1 Consider an incremental approach to minimize improvement costs.

- Lower-cost measures can be applied quickly and may be sufficient to reduce crash risk.
- Low-cost intersection and pedestrian countermeasures include enhanced pavement markings and sight distance improvements (vegetation trimming and sign relocation).
- If safety issues persist, more complex and long-term measures may be considered, such as intersection realignment, raised medians, or changes in intersection type or traffic control.
- A combination of short-term and long-term measures may be most effective.

2 Provide designated facilities for pedestrians and bicycle riders.

- A combination of sidewalk and protected on-street bike lanes may be more appropriate than a multiuse path where space allows. Consider factors such as right-of-way, nearby destinations, and potential for network connectivity.
- Multiuse paths are located behind the curb, farther from travel lanes, and provide more comfort for people biking and walking in higher speed, higher-volume settings.

3 Consider raised or flush medians as options, depending on the setting.

- Raised medians require median openings to allow access and U-turns.
- The type and width of median must comply with applicable standards.
- Trees should not be planted in the median near intersections because they can limit sight distance.

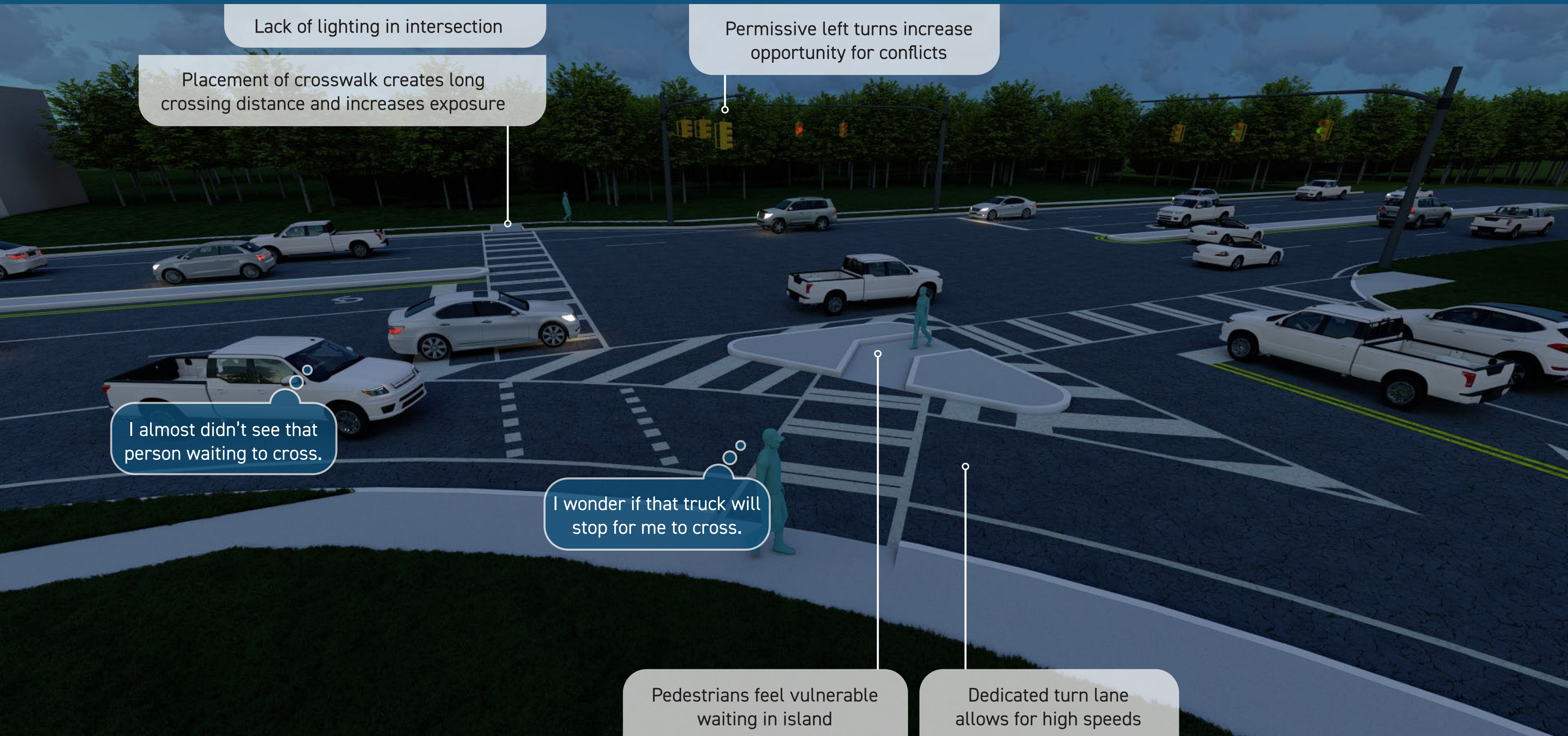
4 Consider alternative intersection designs and configurations to meet local community needs.

- An alternative would be to reroute the crosswalk and multiuse path to a point that allows one vehicle to queue at the stop sign.
- This would move the stop bar closer to the mainline, improving sight distance for minor road drivers.
- The drawback to this design is that it takes pedestrians and bicycle riders out of their desire line.

5 Integrate landscaping shrubs and trees along multiuse paths and grass in the median.

- Consider the long-term maintenance of the vegetation.
- Vegetation can support other priorities such as resiliency and sustainability.

SCENARIO 7 HIGHER RISK



Focus Crash Types

Risk Factors

- ✓ Dark, unlighted conditions
- ✓ Higher speed turning movements
- ✓ Long crossing distances
- ✓ Turning movement conflicts

SCENARIO 7 LOWER RISK

AFTER

Focus Crash Types

Countermeasures

- ✓ Crosswalk visibility enhancements and median for refuge
- ✓ Leading pedestrian interval
- ✓ Yellow change intervals (flashing yellow arrows)
- ✓ Backplates with retroreflective borders
- ✓ Dedicated biking and walking facilities
- ✓ Lighting

SCENARIO 7

Focus Crash Types

Focus Facility Types and Risk Factors

- Signalized intersection
- Four-lane major road
- Other principal arterial or minor arterial
- GDOT-owned
- Posted speed limit 35 mph (on mainline)
- Moderate population density along corridor
- Medium- or high-intensity development along corridor

Site-Specific Safety Issues

- Channelized right-turn lane (more complex and higher speed conflicts with pedestrians)
- Long crosswalks and multiple crossing points
- Difficult for drivers to turn left from major road (permissive left-turns)
- Lack of lighting

Countermeasures

Systemic application of multiple low-cost countermeasures at signalized intersections include: properly placed stop bars, high-visibility crosswalks, leading pedestrian interval, yellow change interval, flashing yellow arrows, and backplates with retroreflective borders.

- Low-cost safety improvements are a good first step to improving safety.
- Leading pedestrian intervals allow pedestrians to enter the crosswalk several seconds before vehicles, increasing visibility of crossing pedestrians and reducing the potential for conflict between pedestrians and vehicles.
- Flashing yellow arrows reinforce the need for left-turning drivers to yield to oncoming traffic, reducing turning movement conflicts and reducing the likelihood of intersection crashes.

Access management strategies, such as removing the channelized right-turn lane controls right-turn speeds and reduces the crossing distance and complexity for pedestrians.

- The width of the major road plus the channelized right-turn lane results in a long distance for pedestrians to cross.
- Pedestrians who end up waiting in the raised median of the channelized turn lane may not feel comfortable.

Median nose extension (extending end of median beyond the crosswalk) provides refuge for pedestrians crossing the major road.

Multiuse path provides a dedicated place for pedestrians and bicycle riders and separates them from vehicles. The buffer between the walkway and travel lanes increases comfort and safety for pedestrians and bicycle riders.

Lighting improves visibility of pedestrians and bicycle riders at the intersection and also helps drivers identify the location of the intersection at night.

SCENARIO 7

Resources

[FHWA Proven Safety Countermeasures]

[Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways]

[GDOT Design Policy Manual]

[GDOT Regulations for Driveway & Encroachment Control Manual]

[NACTO Urban Street Design Guide]

Considerations

1 Consider an incremental approach to minimize improvement costs.

- Lower-cost measures can be applied quickly and may be sufficient to reduce crash risk.
- Low-cost intersection and pedestrian countermeasures include enhanced pavement markings, signal improvements (leading pedestrian interval, yellow change interval, flashing yellow arrows), and backplates with retroreflective borders.
- If safety issues persist, more complex and long-term measures may be considered, such as removing the channelized right-turn lane, extending the median nose, or changing the intersection type or traffic control.
- A combination of short-term and long-term measures may be most effective.

2 Provide sidewalks, marked crosswalks, and pedestrian signals at signalized intersections.

- A combination of sidewalk and protected on-street bike lanes may be more appropriate than a multiuse path where space allows, and considering factors such as right-of-way, nearby destinations, and potential for network connectivity.
- Multiuse paths are located behind the curb, farther from travel lanes, and provide more comfort for people biking and walking in higher speed, higher-volume settings.

3 Consider context when evaluating design options.

- The design and configuration of right-turn lanes should consider factors such as the percentage of turning trucks.
- For pedestrian safety, it is preferable to control vehicles with the traffic signal and stop bar, rather than a yield sign provided in channelized turn lanes.
- It is preferred to prohibit right-turn on red to reduce conflicts with pedestrians.
- Right turn overlap phases can mitigate delays caused by the red signal phase for right-turn movements.

4 Consider the length of the yellow signal phase in accordance with MUTCD recommendations.

5 Consider extending the median nose on the main road.

- Extending the median nose improves pedestrian safety by defining the turning path for left-turns and providing a median refuge for crossing pedestrians.
- Consider maintenance concerns and vehicle turning movements in the design of median extensions.

APPENDIX C

SYSTEMIC ANALYSIS RESULTS

SYSTEMIC ANALYSIS RESULTS

Appendix C contains the detailed analysis results for focus crash types, focus facility types, and risk factors.

FOCUS CRASH TYPES

The focus crash types for the region are intersection, roadway departure, pedestrian, and bicycle. Local agencies may choose to focus on one or more of these emphasis areas such as those that are more prevalent or overrepresented locally; however, it is important to recognize that there is overlap among these and other crash types. Specifically, the factors that increase risk for one crash type tend to increase risk for other crash types as well. As such, projects that address the factors contributing to one crash type will often help to address other crash types. Further, all projects should consider the safety of all road users, regardless of the focus crash type.

Figure 38 to Figure 41 show pairs of maps for each of the four emphasis areas, highlighting the counties where fatal (K) and suspected serious injury (A) crashes are overrepresented. The first map in each pair shows overrepresentation of KA focus crashes in the county with respect to the ARC region as a whole. The second map in each pair shows overrepresentation of KA focus crashes in the county with respect to less severe (BCO) crashes in the county.

> *Factors that increase risk for one crash type tend to increase risk for other crash types; projects that address factors contributing to one crash type often address other crash types.*

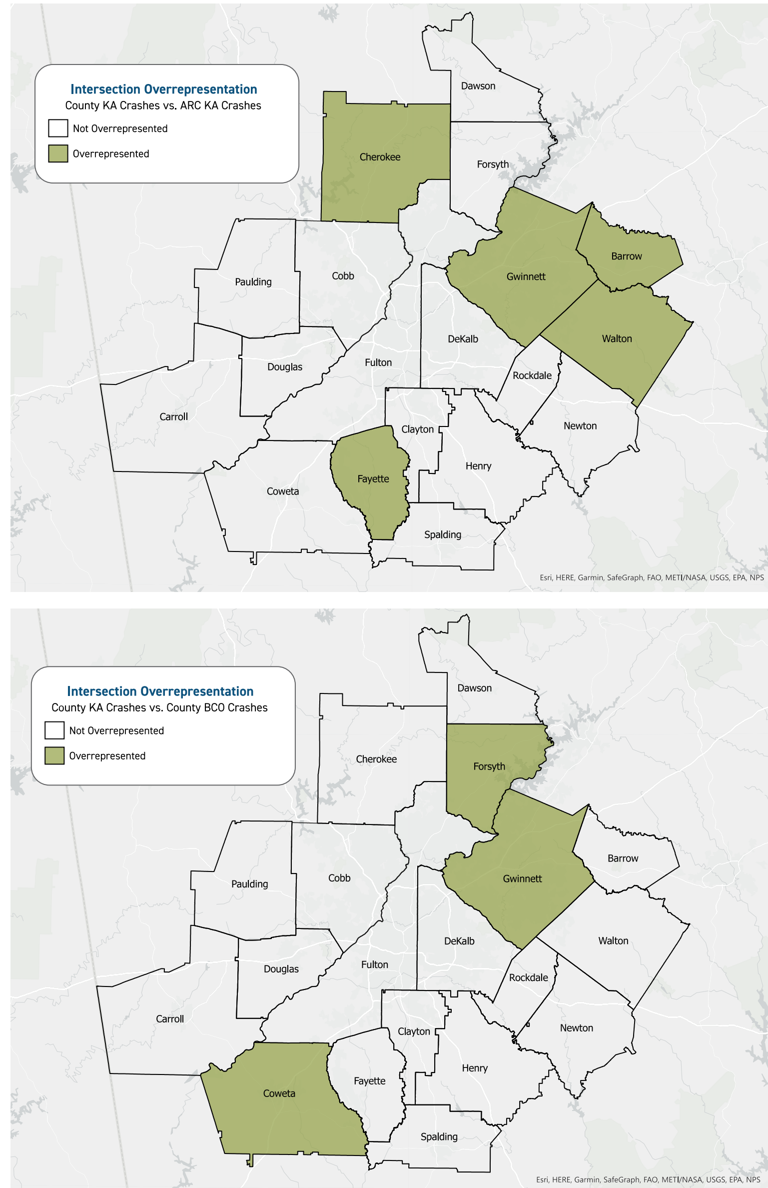


Figure 38. Overrepresented Counties for Intersection KA Crashes.

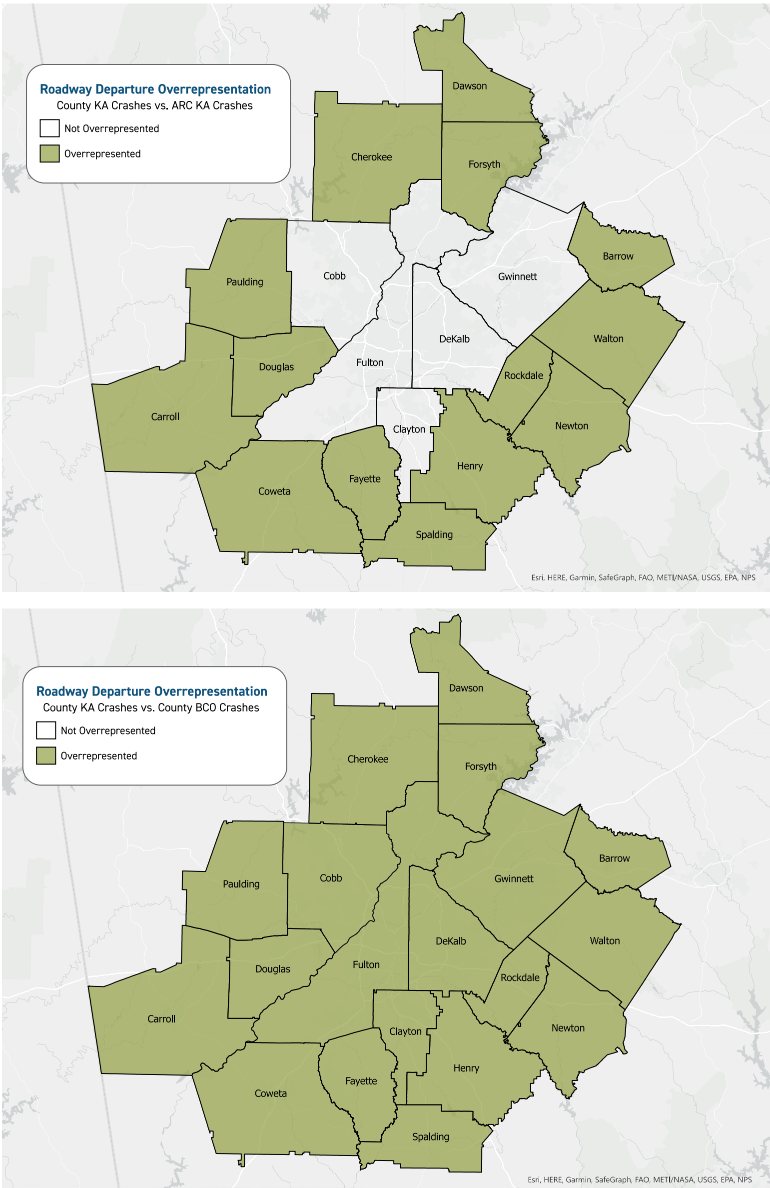


Figure 39. Overrepresented Counties for Roadway Departure KA Crashes.

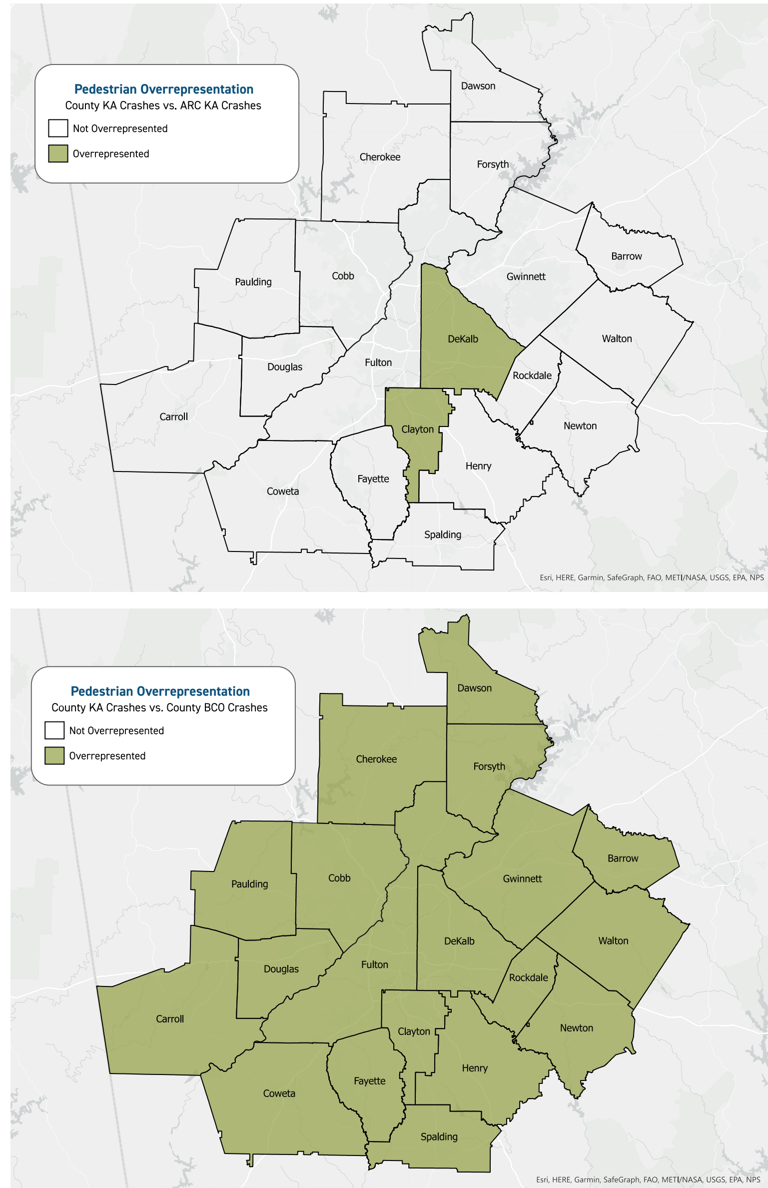


Figure 40. Overrepresented Counties for Pedestrian KA Crashes.

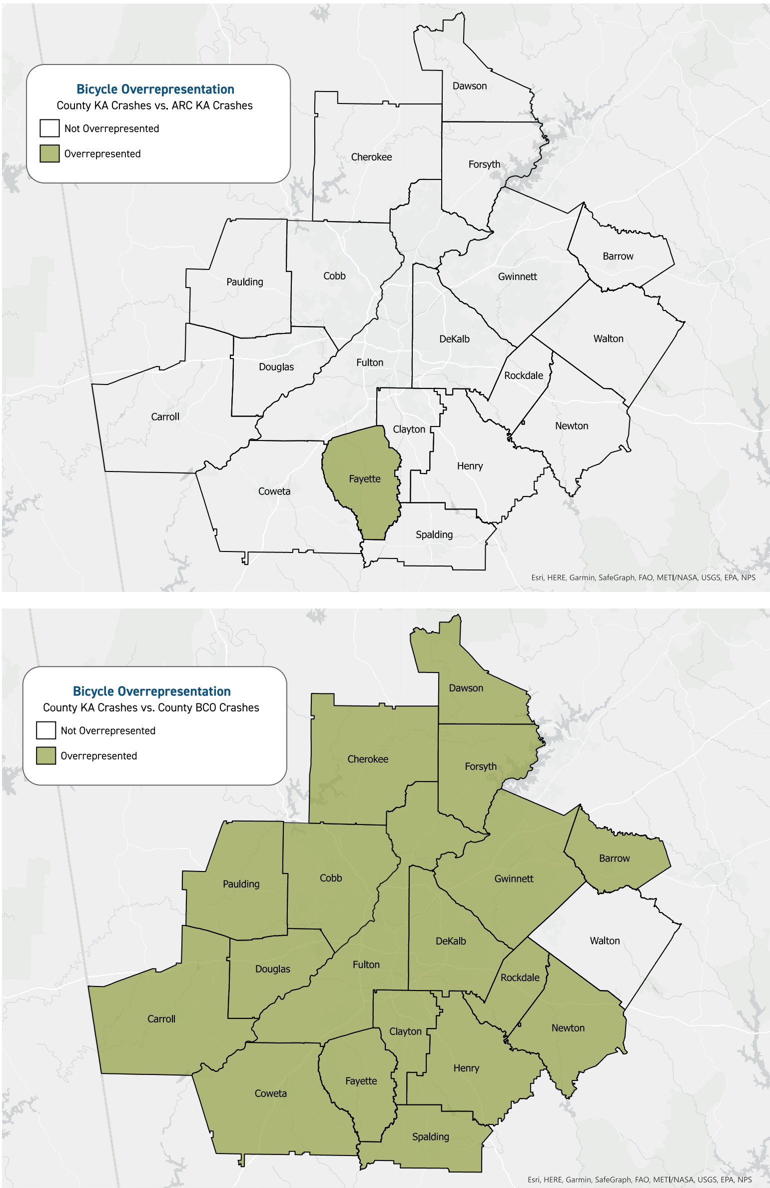


Figure 41. Overrepresented Counties for Bicycle KA Crashes.

FOCUS FACILITY TYPES

The focus facility type analysis builds upon the focus crash types. VHB collated crash data, with a particular focus on fatal (K) and suspected serious injury (A) crashes, with roadway and traffic data obtained from GDOT. Key criteria for focus facility types include:

» Functional classification
» Traffic operation (one-way or two-way)
» Ownership
» Number of through lanes
» Urban or rural classification

The functional class, operation, ownership, urban/rural classification, and traffic data came in one geodatabase as separate layers downloaded from GDOT. Those layers, along with the number of through lanes, were conflated with the road system using a series of geospatial processes. Two measures of exposure, lane miles and vehicle-miles traveled (VMT), were created using GIS geometry length calculations and multiplying those lengths by the average daily traffic volume, respectively.

Similar to the focus crash type analysis, focus facility types are those where focus crash types are overrepresented relative to exposure. For instance, if a specific functional classification experiences 45 percent of severe roadway departure crashes while only accounting for 25 percent of VMT or 10 percent of lane mileage, then that functional class is considered overrepresented and could be used to define a focus facility type. VMT is typically a more robust measure of exposure for identifying over-representation; however, traffic volume data are unavailable for most local roads within ARC. As a result, VMT is undefined for many local roads and this skews the results for VMT-based analysis. Instead, lane mileage is a more comprehensive metric of exposure across the entire region. While lane mileage does not account for the number of vehicles on the road, it does account for the prevalence of a given facility within the region and the 'number of lanes' within this measure is a surrogate for traffic volume (i.e., facilities with higher volumes have more lanes).

The following two approaches were considered for identifying focus facility types:

1. **Overrepresentation of focus crash types by county according to exposure:** The three exposure metrics considered were VMT, lane mileage, and centerline mileage. As described previously, VMT is typically a more robust measure of exposure for identifying over-representation, followed by lane miles and centerline miles. ARC used lane mileage as the measure of overrepresentation for these analyses because it provided the most comprehensive coverage of the road network within the region. For future analyses, VMT could serve as the measure of exposure if traffic volume data are collected or estimated for most local roads within the ARC boundary.
2. **Overrepresentation of focus crash types relative to the results of a crash tree:** Crash trees visually illustrate the distribution according to a suite of criteria. For instance, using the aforementioned key criteria, a crash tree could identify the number and percentage of KA crashes that meet key criteria such as urban setting, county owned, two-way traffic operation, minor arterial, and 4 through lanes.

Table 13 presents a summary of the focus facility types for intersection, roadway departure, pedestrian, and bicycle KA crashes followed by detailed tables that present the results of the overrepresentation analyses.

Table 13. Summary of Focus Facility Types by Emphasis Area.

FOCUS FACILITY TYPE	INTERSECTION	ROADWAY DEPARTURE	PEDESTRIAN	BICYCLE
Urban, GDOT-owned Interstates with 6+ lanes		✓		
Urban, GDOT-owned other principal arterials with 6+ lanes			✓	
Urban, GDOT-owned other principal arterials with 4 lanes	✓		✓	✓
Urban, GDOT-owned minor arterials with 4 lanes	✓		✓	✓
Urban, GDOT-owned minor arterials with 2 lanes	✓	✓		✓
Urban, County-owned minor arterials with 4 lanes			✓	
Urban, County-owned minor arterials with 2 lanes		✓		
Urban, County-owned major collectors with 2 lanes	✓	✓		
Urban, City-owned major collectors with 2 lanes				✓

INTERSECTIONS

RURAL | URBAN

	RURAL		URBAN
	8%	TOTAL LANE MILES 60,288	92%
	3.5%	TOTAL KA CRASHES 8,340	96.5%

Rural

Functional Class	# of Lanes	Lane Miles %	KA Crashes %	Diff
GDOT				
* Minor Arterial	2	0.4%	0.8%	0.4%
Principal Arterial-O	2	0.1%	0.4%	0.3%
Principal Arterial-O	4	0.2%	0.3%	0.1%
Major Collector	2	0.2%	0.3%	0.1%
Interstate	4	0.0%	0.0%	0.0%
Interstate	5	0.0%	0.0%	0.0%
Interstate	6+	0.1%	0.0%	0.0%
Principal Arterial-OFE	4	0.0%	0.0%	0.0%
Principal Arterial-O	1	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
COUNTY				
* Minor Arterial	2	0.1%	0.1%	0.1%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	3	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Major Collector	2	0.5%	0.4%	-0.1%
Minor Collector	2	0.4%	0.2%	-0.2%
Local	2	5.1%	0.6%	-4.5%
CITY				
* Minor Arterial	2	0.0%	0.1%	0.1%
Major Collector	2	0.1%	0.1%	0.0%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Principal Arterial-O	4	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Minor Collector	2	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	3	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Unknown		0.0%	0.0%	0.0%
Local	2	0.8%	0.0%	-0.7%
UNKNOWN				
		0.0%	0.0%	0.0%

*** Observation:**

Rural 2-lane minor arterial

Urban

Functional Class	# of Lanes	Lane Miles %	KA Crashes %	Diff
GDOT				
* Principal Arterial-O	4	2.7%	12.5%	9.7%
Minor Arterial	4	1.6%	7.6%	5.9%
Interstate	6+	3.8%	8.5%	4.7%
Minor Arterial	2	1.6%	5.9%	4.3%
Principal Arterial-O	6+	0.6%	2.6%	1.9%
Principal Arterial-O	2	0.5%	2.3%	1.8%
Minor Arterial	6+	0.2%	0.9%	0.7%
Principal Arterial-OFE	3	0.0%	0.5%	0.5%
Principal Arterial-O	5	0.1%	0.7%	0.5%
Major Collector	2	0.1%	0.5%	0.4%
Principal Arterial-OFE	6+	0.4%	0.7%	0.3%
Minor Arterial	3	0.1%	0.4%	0.3%
Minor Arterial	5	0.1%	0.4%	0.3%
Principal Arterial-O	3	0.1%	0.2%	0.2%
Interstate	2	0.1%	0.2%	0.1%
Interstate	4	0.3%	0.4%	0.1%
Interstate	5	0.1%	0.1%	0.1%
Major Collector	4	0.0%	0.1%	0.1%
Local	2	0.1%	0.1%	0.1%
Interstate	1	0.0%	0.0%	0.0%
Interstate	3	0.0%	0.0%	0.0%
Interstate	Unknown	0.0%	0.0%	0.0%
Principal Arterial-OFE	1	0.0%	0.0%	0.0%
Principal Arterial-OFE	2	0.0%	0.0%	0.0%
Principal Arterial-OFE	5	0.0%	0.1%	0.0%
Principal Arterial-O	1	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Principal Arterial-OFE	4	0.2%	0.0%	-0.2%
COUNTY				
* Minor Arterial	2	1.7%	4.8%	3.1%
Minor Arterial	4	1.3%	4.1%	2.8%
Major Collector	2	2.4%	4.5%	2.2%
Principal Arterial-O	4	0.4%	1.3%	1.0%
Major Collector	4	0.4%	0.8%	0.4%
Principal Arterial-O	2	0.0%	0.2%	0.2%
Principal Arterial-O	6+	0.1%	0.3%	0.2%
Minor Arterial	3	0.0%	0.1%	0.1%
Minor Arterial	5	0.0%	0.1%	0.1%
Major Collector	3	0.0%	0.1%	0.1%
Major Collector	6+	0.0%	0.1%	0.1%
Minor Collector	2	0.6%	0.7%	0.1%
Local	3	0.2%	0.2%	0.0%
Principal Arterial-OFE	4	0.1%	0.1%	0.0%
Minor Arterial	6+	0.1%	0.1%	0.0%
COUNTY CONTINUED				
Principal Arterial-OFE	2	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Major Collector	5	0.0%	0.0%	0.0%
Minor Collector	3	0.0%	0.0%	0.0%
Minor Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	5	0.0%	0.0%	0.0%
Local	6+	0.0%	0.0%	0.0%
Local	Unknown	0.0%	0.0%	0.0%
Local	4	0.5%	0.4%	-0.1%
Local	2	41.3%	11.3%	-30.0%
CITY				
* Minor Arterial	2	1.4%	3.9%	2.5%
Minor Arterial	4	1.0%	3.0%	2.0%
Major Collector	2	1.7%	3.2%	1.4%
Major Collector	4	0.4%	0.9%	0.4%
Principal Arterial-O	4	0.1%	0.3%	0.2%
Minor Arterial	3	0.1%	0.3%	0.2%
Minor Arterial	6+	0.1%	0.2%	0.1%
Major Collector	3	0.1%	0.2%	0.1%
Minor Arterial	5	0.0%	0.1%	0.1%
Minor Collector	2	0.1%	0.1%	0.0%
Local	1	0.1%	0.1%	0.0%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Principal Arterial-O	6+	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Major Collector	5	0.0%	0.0%	0.0%
Major Collector	6+	0.0%	0.0%	0.0%
Minor Collector	3	0.0%	0.0%	0.0%
Minor Collector	4	0.0%	0.0%	0.0%
Minor Collector	5	0.0%	0.0%	0.0%
Local	5	0.0%	0.0%	0.0%
Local	6+	0.0%	0.0%	0.0%
Local	Unknown	0.0%	0.0%	0.0%
Local	4	0.5%	0.5%	-0.1%
Local	3	0.3%	0.1%	-0.2%
Local	2	22.8%	5.7%	-17.1%
UNKNOWN				
		0.8%	3.3%	2.5%

*** Observation:**

Urban 2-lane minor arterial and 4-lane principal arterial-other

ROADWAY DEPARTURE

RURAL | URBAN

8% — TOTAL LANE MILES 60,288 — 92%

7% — TOTAL KA CRASHES 3,174 — 93%

Rural

Functional Class	# of Lanes	Lane Miles %	KA Crashes %	Diff
GDOT				
* Minor Arterial	2	0.4%	1.4%	0.9%
Principal Arterial-O	2	0.1%	0.4%	0.3%
Major Collector	2	0.2%	0.5%	0.3%
Principal Arterial-O	4	0.2%	0.4%	0.2%
Interstate	4	0.0%	0.1%	0.1%
Interstate	6+	0.1%	0.2%	0.1%
Interstate	5	0.0%	0.0%	0.0%
Principal Arterial-OFE	4	0.0%	0.0%	0.0%
Principal Arterial-O	1	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
COUNTY				
* Major Collector	2	0.5%	1.0%	0.6%
Minor Collector	2	0.4%	0.7%	0.3%
Minor Arterial	2	0.1%	0.1%	0.1%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	3	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Local	2	5.1%	1.8%	-3.3%
CITY				
* Minor Arterial	2	0.0%	0.2%	0.1%
Major Collector	2	0.1%	0.1%	0.0%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Principal Arterial-O	4	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Minor Collector	2	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	3	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Local	2	0.8%	0.1%	-0.7%
UNKNOWN				
		0.0%	0.0%	0.0%

* Observation:

Rural 2-lane minor arterials and major collectors

Urban

Functional Class	# of Lanes	Lane Miles %	KA Crashes %	Diff
GDOT				
* Interstate	6+	3.8%	14.4%	10.5%
Minor Arterial	2	1.6%	6.2%	4.6%
Principal Arterial-O	4	2.7%	5.0%	2.3%
Minor Arterial	4	1.6%	3.2%	1.5%
Principal Arterial-O	2	0.5%	2.0%	1.4%
Interstate	4	0.3%	1.0%	0.7%
Principal Arterial-OFE	4	0.2%	0.9%	0.7%
Principal Arterial-OFE	6+	0.4%	1.1%	0.7%
Principal Arterial-O	6+	0.6%	1.1%	0.5%
Major Collector	2	0.1%	0.5%	0.4%
Interstate	2	0.1%	0.3%	0.3%
Interstate	5	0.1%	0.3%	0.3%
Principal Arterial-O	5	0.1%	0.3%	0.2%
Interstate	1	0.0%	0.1%	0.1%
Interstate	3	0.0%	0.1%	0.1%
Interstate	Unknown	0.0%	0.1%	0.1%
Minor Arterial	3	0.1%	0.2%	0.1%
Major Collector	1	0.0%	0.1%	0.1%
Major Collector	3	0.0%	0.1%	0.1%
Minor Arterial	6+	0.2%	0.2%	0.0%
Minor Arterial	5	0.1%	0.1%	0.0%
Local	2	0.1%	0.1%	0.0%
Principal Arterial-OFE	5	0.0%	0.1%	0.0%
Principal Arterial-OFE	1	0.0%	0.0%	0.0%
Principal Arterial-OFE	2	0.0%	0.0%	0.0%
Principal Arterial-OFE	3	0.0%	0.0%	0.0%
Principal Arterial-O	1	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.1%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
COUNTY				
* Minor Arterial	2	1.7%	5.7%	4.0%
Major Collector	2	2.4%	5.2%	2.8%
Minor Arterial	4	1.3%	2.6%	1.2%
Minor Collector	2	0.6%	1.4%	0.8%
Principal Arterial-O	4	0.4%	0.6%	0.3%
Principal Arterial-O	2	0.0%	0.3%	0.2%
Minor Arterial	5	0.0%	0.2%	0.2%
Major Collector	4	0.4%	0.6%	0.2%
Major Collector	3	0.0%	0.2%	0.1%
Major Collector	5	0.0%	0.1%	0.1%
Local	3	0.2%	0.3%	0.1%
Principal Arterial-OFE	4	0.1%	0.1%	0.0%
Principal Arterial-O	6+	0.1%	0.1%	0.0%
Minor Arterial	3	0.0%	0.1%	0.0%
Major Collector	6+	0.0%	0.1%	0.0%
COUNTY CONTINUED				
Principal Arterial-OFE	2	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Minor Collector	3	0.0%	0.0%	0.0%
Minor Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	5	0.0%	0.0%	0.0%
Local	6+	0.0%	0.0%	0.0%
Local	Unknown	0.0%	0.0%	0.0%
Minor Arterial	6+	0.1%	0.0%	-0.1%
Local	4	0.5%	0.3%	-0.2%
Local	2	41.3%	17.2%	-24.2%
CITY				
* Minor Arterial	2	1.4%	3.5%	2.1%
Major Collector	2	1.7%	2.9%	1.2%
Minor Arterial	4	1.0%	1.6%	0.6%
Principal Arterial-O	4	0.1%	0.2%	0.1%
Major Collector	4	0.4%	0.4%	0.0%
Minor Arterial	3	0.1%	0.1%	0.0%
Minor Arterial	5	0.0%	0.1%	0.0%
Minor Arterial	6+	0.1%	0.1%	0.0%
Minor Collector	2	0.1%	0.1%	0.0%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Principal Arterial-O	6+	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Major Collector	3	0.1%	0.0%	0.0%
Major Collector	5	0.0%	0.0%	0.0%
Major Collector	6+	0.0%	0.0%	0.0%
Minor Collector	3	0.0%	0.0%	0.0%
Minor Collector	4	0.0%	0.0%	0.0%
Minor Collector	5	0.0%	0.0%	0.0%
Local	5	0.0%	0.0%	0.0%
Local	6+	0.0%	0.0%	0.0%
Local	Unknown	0.0%	0.0%	0.0%
Local	1	0.1%	0.1%	-0.1%
Local	3	0.3%	0.0%	-0.2%
Local	4	0.5%	0.3%	-0.2%
Local	2	22.8%	6.6%	-16.2%
UNKNOWN				
		0.8%	4.3%	3.5%

* Observation:

Urban 2-lane minor arterials and 6+-lane interstates

PEDESTRIANS

	RURAL	URBAN
TOTAL LANE MILES 60,288	8%	92%
TOTAL KA CRASHES 1,660	2%	98%

RURAL

Functional Class	# of Lanes	Lane Miles %	KA Crashes %	Diff
GDOT				
Major Collector	2	0.2%	0.2%	0.0%
Principal Arterial-O	2	0.1%	0.1%	0.0%
Principal Arterial-O	3	0.0%	0.1%	0.0%
Interstate	4	0.0%	0.0%	0.0%
Interstate	5	0.0%	0.0%	0.0%
Principal Arterial-OFE	4	0.0%	0.0%	0.0%
Principal Arterial-O	1	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Minor Arterial	2	0.4%	0.3%	-0.1%
Principal Arterial-O	4	0.2%	0.1%	-0.1%
Interstate	6+	0.1%	0.0%	-0.1%
COUNTY				
Principal Arterial-O	2	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	3	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Minor Arterial	2	0.1%	0.0%	-0.1%
Minor Collector	2	0.4%	0.1%	-0.3%
Major Collector	2	0.5%	0.1%	-0.4%
Local	2	5.1%	0.5%	-4.6%
CITY				
* Minor Arterial	2	0.0%	0.1%	0.1%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Principal Arterial-O	4	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Minor Collector	2	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	3	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Unknown		0.0%	0.0%	0.0%
Major Collector	2	0.1%	0.1%	-0.1%
Local	2	0.8%	0.2%	-0.6%
UNKNOWN				
		0.0%	0.0%	0.0%

* Observation:

Rural 2-lane minor arterial

URBAN

Functional Class	# of Lanes	Lane Miles %	KA Crashes %	Diff
GDOT				
* Minor Arterial	4	1.6%	13.0%	11.3%
Principal Arterial-O	4	2.7%	13.5%	10.8%
Principal Arterial-O	6+	0.6%	6.6%	6.0%
Interstate	6+	3.8%	7.0%	3.1%
Minor Arterial	2	1.6%	4.2%	2.6%
Minor Arterial	6+	0.2%	1.9%	1.7%
Principal Arterial-O	5	0.1%	1.1%	1.0%
Principal Arterial-O	2	0.5%	1.1%	0.6%
Principal Arterial-OFE	6+	0.4%	1.0%	0.5%
Minor Arterial	5	0.1%	0.6%	0.5%
Major Collector	2	0.1%	0.4%	0.2%
Interstate	1	0.0%	0.1%	0.1%
Principal Arterial-O	3	0.1%	0.1%	0.1%
Minor Arterial	3	0.1%	0.2%	0.1%
Major Collector	4	0.0%	0.1%	0.1%
Interstate	3	0.0%	0.1%	0.0%
Interstate	5	0.1%	0.1%	0.0%
Local	2	0.1%	0.1%	0.0%
Interstate	Unknown	0.0%	0.0%	0.0%
Principal Arterial-OFE	1	0.0%	0.0%	0.0%
Principal Arterial-OFE	2	0.0%	0.0%	0.0%
Principal Arterial-OFE	3	0.0%	0.0%	0.0%
Principal Arterial-OFE	5	0.0%	0.0%	0.0%
Principal Arterial-O	1	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Interstate	2	0.1%	0.0%	-0.1%
Interstate	4	0.3%	0.1%	-0.2%
Principal Arterial-OFE	4	0.2%	0.0%	-0.2%
COUNTY				
* Minor Arterial	4	1.3%	5.4%	4.1%
Minor Arterial	2	1.7%	4.5%	2.7%
Principal Arterial-O	4	0.4%	1.3%	0.9%
Major Collector	2	2.4%	3.3%	0.9%
Principal Arterial-O	6+	0.1%	0.7%	0.5%
Minor Arterial	3	0.0%	0.2%	0.2%
Minor Arterial	5	0.0%	0.2%	0.2%
Minor Arterial	6+	0.1%	0.3%	0.2%
Major Collector	4	0.4%	0.5%	0.2%
Principal Arterial-O	3	0.0%	0.1%	0.1%
Principal Arterial-O	2	0.0%	0.1%	0.0%
Principal Arterial-O	5	0.0%	0.1%	0.0%
Major Collector	3	0.0%	0.1%	0.0%
Principal Arterial-OFE	2	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%

Functional Class	# of Lanes	Lane Miles %	KA Crashes %	Diff
COUNTY CONTINUED				
Major Collector	1	0.0%	0.0%	0.0%
Major Collector	5	0.0%	0.0%	0.0%
Major Collector	6+	0.0%	0.0%	0.0%
Minor Collector	3	0.0%	0.0%	0.0%
Minor Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	5	0.0%	0.0%	0.0%
Local	6+	0.0%	0.0%	0.0%
Local	Unknown	0.0%	0.0%	0.0%
Local	3	0.2%	0.1%	-0.1%
Principal Arterial-OFE	4	0.1%	0.0%	-0.1%
Local	4	0.5%	0.2%	-0.3%
Minor Collector	2	0.6%	0.1%	-0.5%
Local	2	41.3%	8.7%	-32.7%
CITY				
* Minor Arterial	4	1.0%	4.1%	3.1%
Minor Arterial	2	1.4%	3.2%	1.8%
Major Collector	2	1.7%	2.5%	0.8%
Major Collector	4	0.4%	0.9%	0.5%
Minor Arterial	3	0.1%	0.4%	0.3%
Principal Arterial-O	4	0.1%	0.4%	0.2%
Minor Arterial	5	0.0%	0.2%	0.2%
Minor Arterial	6+	0.1%	0.3%	0.2%
Major Collector	3	0.1%	0.3%	0.2%
Major Collector	5	0.0%	0.1%	0.1%
Principal Arterial-O	6+	0.0%	0.1%	0.0%
Major Collector	6+	0.0%	0.1%	0.0%
Minor Collector	2	0.1%	0.1%	0.0%
Minor Collector	4	0.0%	0.1%	0.0%
Local	1	0.1%	0.1%	0.0%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Minor Collector	3	0.0%	0.0%	0.0%
Minor Collector	5	0.0%	0.0%	0.0%
Local	5	0.0%	0.0%	0.0%
Local	6+	0.0%	0.0%	0.0%
Local	Unknown	0.0%	0.0%	0.0%
Local	3	0.3%	0.1%	-0.2%
Local	4	0.5%	0.4%	-0.2%
Local	2	22.8%	6.4%	-16.4%
UNKNOWN				
		0.8%	1.7%	0.9%

* Observation:

Urban 4-lane minor arterial

BICYCLISTS

RURAL | URBAN

RURAL		URBAN
8%	TOTAL LANE MILES 60,288	92%
3.5%	TOTAL KA CRASHES 143	96.5%

RURAL

Functional Class	# of Lanes	Lane Miles %	KA Crashes %	Diff
GDOT				
* Minor Arterial	2	0.4%	1.4%	1.0%
Principal Arterial-O	4	0.2%	0.7%	0.5%
Major Collector	2	0.2%	0.7%	0.5%
Interstate	4	0.0%	0.0%	0.0%
Interstate	5	0.0%	0.0%	0.0%
Principal Arterial-OFE	4	0.0%	0.0%	0.0%
Principal Arterial-O	1	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Interstate	6+	0.1%	0.0%	-0.1%
Principal Arterial-O	2	0.1%	0.0%	-0.1%
COUNTY				
* Major Collector	2	0.5%	0.7%	0.2%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	3	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Minor Arterial	2	0.1%	0.0%	-0.1%
Minor Collector	2	0.4%	0.0%	-0.4%
Local	2	5.1%	0.0%	-5.1%
CITY				
Principal Arterial-O	2	0.0%	0.0%	0.0%
Principal Arterial-O	4	0.0%	0.0%	0.0%
Minor Arterial	2	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	4	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Minor Collector	2	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	3	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Unknown		0.0%	0.0%	0.0%
Major Collector	2	0.1%	0.0%	-0.1%
Local	2	0.8%	0.0%	-0.8%
UNKNOWN				
		0.0%	0.0%	0.0%

*** Observation:**

Rural 2-lane minor arterials and 2-lane major collectors

URBAN

Functional Class	# of Lanes	Lane Miles %	KA Crashes %	Diff
GDOT				
* Minor Arterial	2	1.6%	8.4%	6.8%
Minor Arterial	4	1.6%	7.7%	6.1%
Principal Arterial-O	4	2.7%	7.0%	4.3%
Principal Arterial-O	6+	0.6%	2.8%	2.2%
Minor Arterial	3	0.1%	1.4%	1.3%
Principal Arterial-O	2	0.5%	1.4%	0.9%
Major Collector	2	0.1%	0.7%	0.6%
Minor Arterial	6+	0.2%	0.7%	0.5%
Interstate	1	0.0%	0.0%	0.0%
Interstate	3	0.0%	0.0%	0.0%
Interstate	Unknown	0.0%	0.0%	0.0%
Principal Arterial-OFE	1	0.0%	0.0%	0.0%
Principal Arterial-OFE	2	0.0%	0.0%	0.0%
Principal Arterial-OFE	3	0.0%	0.0%	0.0%
Principal Arterial-OFE	5	0.0%	0.0%	0.0%
Principal Arterial-O	1	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
Major Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	4	0.0%	0.0%	0.0%
Interstate	2	0.1%	0.0%	-0.1%
Interstate	5	0.1%	0.0%	-0.1%
Principal Arterial-O	3	0.1%	0.0%	-0.1%
Principal Arterial-O	5	0.1%	0.0%	-0.1%
Minor Arterial	5	0.1%	0.0%	-0.1%
Local	2	0.1%	0.0%	-0.1%
Principal Arterial-OFE	4	0.2%	0.0%	-0.2%
Interstate	4	0.3%	0.0%	-0.3%
Principal Arterial-OFE	6+	0.4%	0.0%	-0.4%
Interstate	6+	3.8%	0.0%	-3.8%
COUNTY				
* Minor Arterial	4	1.3%	3.5%	2.1%
Minor Arterial	2	1.7%	3.5%	1.8%
Major Collector	2	2.4%	4.2%	1.8%
Local	4	0.5%	1.4%	0.9%
Principal Arterial-O	6+	0.1%	0.7%	0.6%
Major Collector	4	0.4%	0.7%	0.3%
Principal Arterial-OFE	2	0.0%	0.0%	0.0%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Minor Arterial	3	0.0%	0.0%	0.0%
Minor Arterial	5	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Major Collector	3	0.0%	0.0%	0.0%
COUNTY CONTINUED				
Major Collector	5	0.0%	0.0%	0.0%
Major Collector	6+	0.0%	0.0%	0.0%
Minor Collector	3	0.0%	0.0%	0.0%
Minor Collector	4	0.0%	0.0%	0.0%
Local	1	0.0%	0.0%	0.0%
Local	5	0.0%	0.0%	0.0%
Local	6+	0.0%	0.0%	0.0%
Local	Unknown	0.0%	0.0%	0.0%
Minor Arterial	6+	0.1%	0.0%	-0.1%
Principal Arterial-OFE	4	0.1%	0.0%	-0.1%
Local	3	0.2%	0.0%	-0.2%
Principal Arterial-O	4	0.4%	0.0%	-0.4%
Minor Collector	2	0.6%	0.0%	-0.6%
Local	2	41.3%	16.1%	-25.2%
CITY				
* Major Collector	2	1.7%	8.4%	6.7%
Minor Arterial	4	1.0%	4.2%	3.2%
Minor Arterial	2	1.4%	3.5%	2.1%
Major Collector	4	0.4%	1.4%	1.0%
Minor Arterial	3	0.1%	0.7%	0.6%
Local	1	0.1%	0.7%	0.6%
Local	4	0.5%	0.7%	0.2%
Principal Arterial-O	2	0.0%	0.0%	0.0%
Principal Arterial-O	3	0.0%	0.0%	0.0%
Principal Arterial-O	5	0.0%	0.0%	0.0%
Principal Arterial-O	6+	0.0%	0.0%	0.0%
Minor Arterial	1	0.0%	0.0%	0.0%
Minor Arterial	5	0.0%	0.0%	0.0%
Major Collector	1	0.0%	0.0%	0.0%
Major Collector	5	0.0%	0.0%	0.0%
Major Collector	6+	0.0%	0.0%	0.0%
Minor Collector	3	0.0%	0.0%	0.0%
Minor Collector	4	0.0%	0.0%	0.0%
Minor Collector	5	0.0%	0.0%	0.0%
Local	5	0.0%	0.0%	0.0%
Local	6+	0.0%	0.0%	0.0%
Local	Unknown	0.0%	0.0%	0.0%
Minor Collector	2	0.1%	0.0%	-0.1%
Major Collector	3	0.1%	0.0%	-0.1%
Minor Arterial	6+	0.1%	0.0%	-0.1%
Principal Arterial-O	4	0.1%	0.0%	-0.1%
Local	3	0.3%	0.0%	-0.3%
Local	2	22.8%	15.4%	-7.4%
UNKNOWN				
		0.8%	1.4%	0.6%

*** Observation:**

Urban 2 and 4-lane minor arterials and 2-lane major collectors

APPENDIX D

CMF SHORTLIST

CMF SHORTLIST

Table 14 provides a shortlist of preferred CMFs for common countermeasures in the region. Analysts are not restricted to using CMFs from this list but should provide justification for using an alternate value. Refer to the FHWA CMF Clearinghouse for additional CMFs and guidance on how to select and apply CMFs.

Table 14. Summary of Focus Facility Types by Emphasis Area.

COUNTERMEASURE	CMF (TOTAL CRASHES)	CMF (INJURY CRASHES)	CMF (PEDESTRIAN-VEHICLE)	CMF BICYCLE-VEHICLE)	COMMENTS / APPLICABILITY
Convert 4-Lane to 3-Lane Cross-Section (Road Diet)	0.71	0.63	—	—	All crash types, urban arterials
Convert Signal-Controlled Intersection to Roundabout	0.62	0.49	—	—	All crash types
Convert Signalized Intersection to Reduced Left-Turn Conflict Intersection	0.85	0.95	—	—	All crash types
Convert Stop-Controlled Intersection to Roundabout	0.53	0.41	—	—	All crash types
Convert Unsignalized Intersection to Reduced Left-Turn Conflict Intersection	0.80	0.66	—	—	All crash types
Enhance Crosswalk Visibility	—	—	0.60	—	Vehicle-pedestrian crashes, urban, signalized and unsignalized intersections
Implement Traffic Calming Measures	0.96	0.94	—	—	All crash types, urban, 2 lane collectors
Improve Curve Design	0.32	0.26	—	—	All crash types
Install Backplates with Retroreflective Borders	0.85	0.85	—	—	Urban intersections
Install Centerline Rumble Strips	0.89	0.91	—	—	All crash types, rural undivided arterials
Install Leading Pedestrian Interval (LPI)	0.90	0.83	—	—	All crash types, Urban and suburban
Install Left-Turn Lane at Signal-Controlled Intersection	0.80	0.73	—	—	All crash types
Install Left-Turn Lane at Stop-Controlled Intersection	0.65	0.58	—	—	All crash types
Install Median & Pedestrian Crossing Islands	0.74	0.71	—	—	All crash types, urban and suburban, 2 to 8 lane median divided minor arterials

COUNTERMEASURE	CMF (TOTAL CRASHES)	CMF (INJURY CRASHES)	CMF (PEDESTRIAN-VEHICLE)	CMF BICYCLE-VEHICLE)	COMMENTS / APPLICABILITY
Install Median Barrier	1.24	0.70	—	—	All crash types, rural divided arterials
Install Multiuse Path/Bike Boulevard	—	—	—	0.37	Vehicle-bicycle crashes, urban and suburban
Install Pedestrian Hybrid Beacon	0.82	0.75	—	—	All crash types, Urban and suburban
Install Raised Median	0.69	0.73	—	—	All crash types
Install Rectangular Rapid Flashing Beacon (RRFB)	—	—	0.53	—	Vehicle-pedestrian crashes, urban and suburban
Install Right-Turn Lane at Signal-Controlled Intersection	0.94	0.91	—	—	All crash types
Install Right-Turn Lane at Stop-Controlled Intersection	0.80	0.77	—	—	All crash types
Install SafetyEdge℠	0.99	0.89	—	—	All crash types, rural, 2 lane arterials
Install Separated Bike Lanes	0.90	0.87	—	—	All crash types, Urban, undivided 4 lane roadways
Install Shoulder Rumble Strips	0.86	0.78	—	—	All crash types, rural undivided arterials
Install Sidewalks/Walkways	—	—	1.66	—	Vehicle-pedestrian crashes, urban, divided 4 lane roadways
Install Street Lighting	0.92	0.90	—	—	All crash types
Install Systemic, Low-Cost Countermeasures at Signalized Intersections	0.91	0.86	—	—	All crash types
Install Systemic, Low-Cost Countermeasures at Stop-Controlled Intersections	0.91	0.90	—	—	All crash types
Install Two-Way Left-Turn Lane on 2-lane Undivided Road (non-Road Diet)	0.95	0.74	—	—	All crash types
Install Two-Way Left-Turn Lane on 4-lane Undivided Road (non-Road Diet)	0.45	0.45	—	—	All crash types
Modify Yellow Change Interval	0.83	0.80	—	—	All crash types, urban
Reduce Signalized Intersection Density	0.40	0.40	—	—	All crash types
Reduce Speed Limit	0.89	0.85	—	—	All crash types
Reduce Unsignalized Intersection Density	0.90	0.75	—	—	All crash types

APPENDIX E

BENEFIT-COST ANALYSIS

BENEFIT-COST ANALYSIS

Appendix E presents the detailed steps for estimating safety benefits and the related benefit-cost ratio. Refer to the Highway Safety Benefit-Cost Analysis Guide for additional information on quantifying project costs and benefits of project alternatives.

1. Estimate safety benefits: Analysts can use a combination of observed crash history, safety performance functions (SPFs), and CMFs to estimate the number and severity of crashes under two conditions: 1) no action, and 2) proposed alternative. The difference in safety performance between the two scenarios represents the estimated safety benefit. Refer to FHWA's training videos on the Predictive Method and Application of CMFs for more information on estimating safety benefits. Refer to Appendix D for a shortlist of CMFs for the most common strategies.

2. Monetize safety benefits: Analysts can use average crash costs to:

a. Estimate the economic impact of crashes in a previous year,

b. Monetize estimated safety benefits for comparison with proposed project costs, or

c. Monetize the safety benefit of avoided crashes after projects are completed.

Crash costs provide a general valuation of the impacts of crashes in monetary terms. Such valuation may represent the cost per crash, cost per injury, or otherwise (Harmon et al., 2018). When applying crash-based costs or injury-based costs, it is important to apply each appropriately; crash-based costs should be applied to the number of crashes whereas injury-based costs should be applied to the number of injured or involved persons.

Table 15 provides average crash-based costs for use in ARC funding applications to justify the economic efficiency of a proposed project. The Crash Costs for Highway Safety Analysis describes the process for modifying and applying crash costs in support of highway safety benefit-cost analysis. It also provides procedures to update crash costs over time.

Table 15. Average Crash Costs by Severity.

CRASH SEVERITY	CRASH COST
K: fatal	$16,374,467
A: suspected serious injury	$988,918
B: suspected minor injury	$326,938
C: possible injury	$184,435
O: property damage only	$18,816
KA: severe injury	$3,600,900
KABC: all injury combined	$393,287
KABCO: total crashes	$117,559

Annual safety benefits represent the monetary value of the difference between the annual estimated crashes without the countermeasure and the annual estimated crashes with the countermeasure, as shown in the equation below.

$$\text{Annual Safety Benefit (\$)} = \text{Crash Cost}_i * (N_{annual\_expected\_without\_i} - N_{annual\_expected\_with\_i})$$

Where:

- Annual Safety Benefit = monetary value of the estimated change in annual crashes between the condition without the countermeasure and the condition with the countermeasure
- Crash Cost_i = average crash cost associated with severity level i
- $N_{annual\_expected\_without\_i}$ = annual estimated crashes of severity level i without the countermeasure
- $N_{annual\_expected\_with\_i}$ = annual estimated crashes of severity level i with the countermeasure

3. Estimate project costs: Project costs include both the initial implementation cost as well as the annual operations and maintenance costs. These estimates should include all costs required for implementation, including preliminary engineering, right-of-way, and construction. Refer to GDOT's Cost Estimation System (CES) for information on planning-level construction cost estimates. Refer to GDOT's Right-of-Way and Utility Relocation Cost Estimate Tool (RUCEST) for information on planning-level right-of-way and utility relocation cost estimates. For more details on quantifying and normalizing project costs, refer to the Highway Safety Benefit-Cost Analysis Guide.

4. **Normalize benefits and costs:** It is important to compare benefits and costs in the same economic terms (i.e., present value or annual value). Project benefits and maintenance costs are typically expressed in annual values. Initial construction costs are typically expressed in present values. As such, there is a need to normalize these values over the project service life before computing the benefit-cost ratio. For instance, the annual countermeasure cost is based on the annualized value of initial construction costs plus the value of any annual maintenance costs, as shown in the equation below.

Annual Cost ($) = (Initial Construction Cost) / M + Annual Maintenance Cost

Where:

- Annual Cost = annual cost of construction and maintenance costs
- M = factor to convert present value costs to annual costs, as shown in the equation below

$$M = ((1+r)^s - 1) / (r * (1+r)^s)$$

Where:

- r = discount rate (6% is typical value and consistent with GDOT safety benefit-cost analysis)
- s = service life of countermeasure

The Countermeasure Service Life Guide provides typical service lives for a wide range of safety countermeasures and demonstrates the benefits of standardizing countermeasure service life application throughout an agency. It also provides background information on factors that can impact countermeasure service life and analytical considerations when conducting benefit-cost analysis for multiple countermeasures or alternatives with differing service life.

5. **Compute benefit-cost ratio:** The benefit-cost ratio is simply the present monetary value (or annual monetary value) of project benefits divided by the present monetary value (or annual monetary value) of project costs. Again, remember to normalize the project benefits and costs over the service life of the project before computing the benefit-cost ratio.

In addition to the benefit-cost ratio, it is useful to present the safety benefits in terms of estimated lives saved and serious injuries prevented. This is a matter of converting the estimated changes in crashes to person-based statistics. Specifically, Step 1 results in an estimate of the number of crashes by severity under two conditions: 1) no action, and 2) proposed alternative. The estimated change in crashes is the difference between the estimated crashes for the no action and proposed alternative. To estimate the change in deaths and injuries, it is necessary to convert the crash-based estimate to an injury-based estimate.

Table 16 presents the ratios for converting crash-based estimates to deaths and serious injuries. To use the table, first determine if the crash-based estimates from Step 1 above represent specific severity levels (i.e., K and A crashes separately) or all crashes combined. If the crash-based benefits reflect **fatal (K) and serious injury (A) crashes**, apply the ratios in the corresponding rows of Table 16 to estimate the number of deaths and serious injuries. If the crash-based benefits reflect **all crashes**, apply the ratios in the last row of Table 16 to estimate the number of deaths and serious injuries.

Table 16. Converting Crash-based Estimates to Deaths and Serious Injuries.

CRASH SEVERITY	DEATHS (K-LEVEL INJURIES)	SERIOUS INJURIES (A-LEVEL INJURIES)
K: fatal crash	1.0822	0.2177
A: suspected serious injury crash	--	1.1409
All crashes	0.0056	0.0313

Note the results are different for the two examples below. The first example represents the preferred method, which is to estimate crashes by severity level and then convert the results to lives saved and serious injuries prevented. Also note that the results for both examples reflect annual values and, as such, are relatively small numbers. When presenting these results to the community or decision-makers, it is useful to extend the results over the service life of the project. So if the project in the first example below is expected to last 10 years, then the results would indicate 2 lives saved and 17 serious injuries prevented over the life of the project.

EXAMPLE 1

If the results from Step 1 above resulted in an estimated reduction of 0.2 fatal crashes per year and 1.5 serious injury crashes per year, then the following are the computations to estimate the lives saved and injuries prevented.

Lives Saved = (0.2 fatal crashes)/year * (1.0822 deaths) / (fatal crash) = 0.22 deaths per year

Serious Injuries Prevented = [(0.2 fatal crashes) / year * (0.2177 serious injuries) / (fatal crash)] + [(1.5 serious injury crashes) / year * (1.1409 serious injuries) / (serious injury crash)] = 1.76 serious injuries per year

EXAMPLE 2

If the results from Step 1 above resulted in an estimated reduction of 7.5 total crashes per year, then the following are the computations to estimate the lives saved and injuries prevented.

Lives Saved = (27.5 total crashes) / year * (0.0056 deaths) / (total crash) = 0.15 deaths per year

Serious Injuries Prevented = (27.5 total crashes) / year * (0.0313 serious injuries) / (total crash) = 0.86 serious injuries per year

APPENDIX F

HOW TO DEVELOP A SAFETY ACTION PLAN

HOW TO DEVELOP A SAFETY ACTION PLAN

Figure 42 shows a summary of the step-by-step process to prepare an adopted plan prior to submitting project applications for funding. The timeline to develop a plan varies depending on the scope and level of detail the local agency wants to incorporate. Many smaller scale scoping studies, whether at an intersection or along a corridor, can take 6 to 12 months to complete. Larger master plans can take anywhere from 12 to 24 months depending on the size and complexity of the study area.

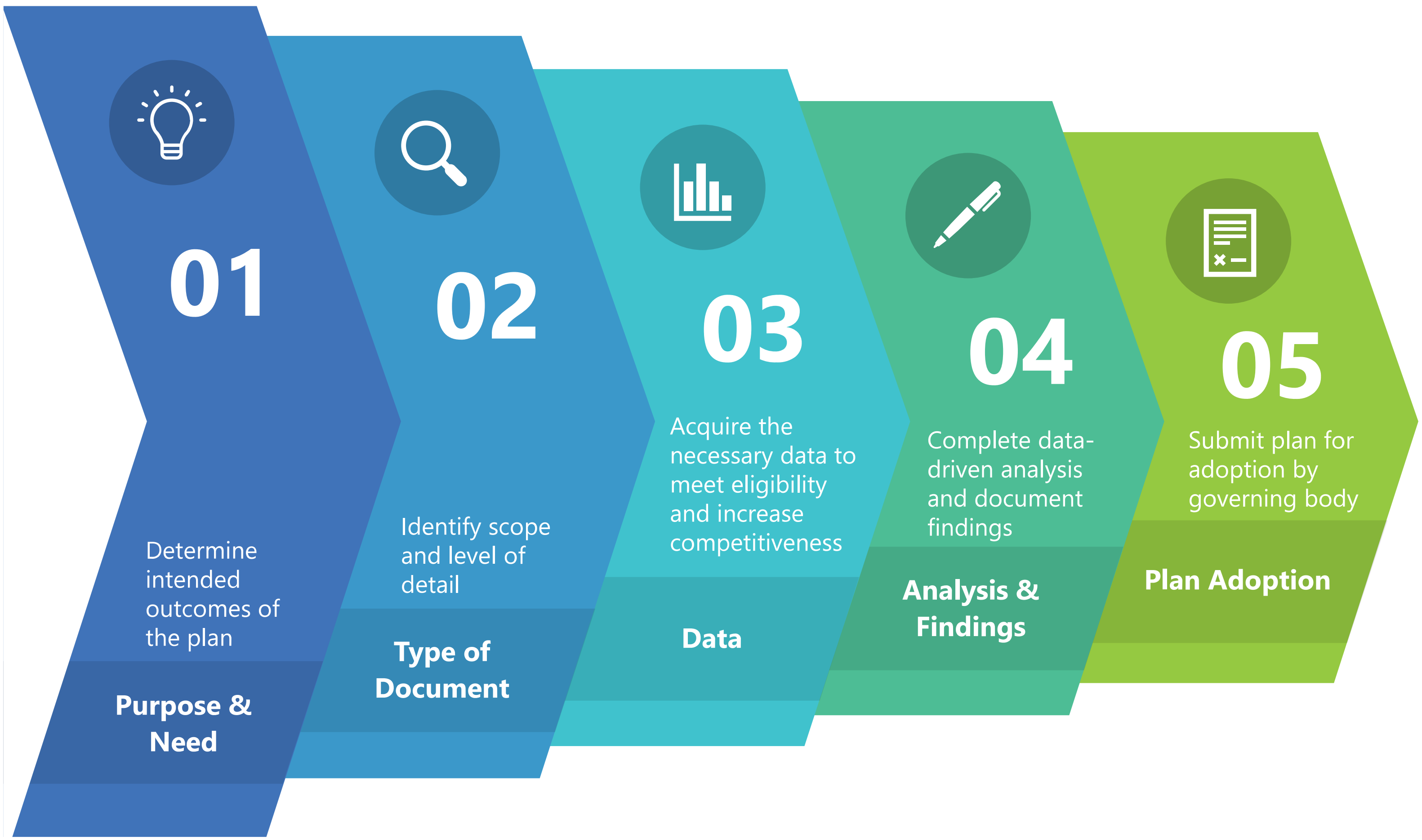


Figure 42. Safety Plan Development Process.

The following are more details on each step from Figure 42.

1 Purpose and Need

Determine the Purpose and Need of the Plan

This step is about knowing the intended outcomes of the plan and can be done by asking a series of questions with the help of stakeholders and residents. Some questions include:

What is the primary objective of the study?

- This could be safety, it could be operations, it could be pedestrian and bicycle safety.

What level of detail do I need on identified projects?

- This could include the identification of high-level locations for projects or could include the development of concept designs for one or more projects.

Who should be involved in the planning process?

- This will result in a list of stakeholders. It is advised to work with ARC to ensure the stakeholder group is inclusive and equitable.

Where is the study area?

- This could include a smaller node, such as one intersection, or a wider area, such as an entire roadway corridor.

What time period should the plan cover?

- This plan could focus on a few improvements over the next few years, or it could be a long-range plan covering several decades.

2 Type of Document

Determine What Type of Document to Prepare

General Plan

- This type of plan would cover a broader area and could focus on safety (e.g., Safety Action Plan or Vision Zero Plan), or could be a more comprehensive transportation plan with a robust safety component (e.g., CTP, Master Transportation Plan).

Scoping Study

- This type of plan is more specific in nature and its purpose is to determine feasibility of a project or set of projects with a solid concept design. In many cases, local agencies develop a draft Concept Report that follows the GDOT Concept Report Template. This report is required for any federally-funded project on GDOT right-of-way. For locally-funded projects in locally-owned right-of-way, this template can be used as a guide.

3 Data

Acquire the necessary data to meet eligibility and increase competitiveness

Crash Data

Crash data for the State of Georgia is housed by GDOT in a database called GEARS. GDOT more recently released the GDOT Crash Data Dashboard, available through Numetric, which provides crash and vehicle data including the ability to filter by county, city, MPO, crash severity, and driver demographics. The data is publicly accessible and available to download as a CSV file with coordinates for geolocation if needed. It is helpful in the local plan to develop crash rates for a specific area or roadway and compare to statewide crash rates for similar roadway facility types. ARC and GDOT can provide guidance and support on how to acquire the statewide average crash rates and how to accurately calculate crash rates. Safety is housed in the Traffic Operations[6] Office at GDOT; alternatively, local agencies can work with their ARC area representative to coordinate with GDOT. Additionally, if more specific information is required or crash reports, a request can be made to GDOT for crash data or technical assistance at Gears.Support@LexisNexisRisk.com, or (866) 495-4206.

Traffic Data

» GDOT houses traffic count and traffic volume data through the Traffic Analysis & Data Application (TADA). This is a publicly accessible database which allows users to export data in report, graph, or data formats. The more detailed data available on TADA includes average directional hourly volume, count history, annual average daily traffic (AADT), and type of vehicle classification volume. Local agencies can use TADA data in determining crash rates relative to total roadway volume.

Traffic Counts

» If the plan is to focus on a smaller area, the local agency can consider collecting traffic count and turning movement data. Traffic count collection is done typically through third party traffic count collection companies who will collect, analyze, and summarize data. Traffic engineers can use this data with software such as Synchro and the Highway Capacity Software (HCS) to understand existing traffic flows and inform what options are available to improve safety and operations.

Equity Data

» Equity is a major emphasis for ARC and USDOT and is a consideration when making transportation funding decisions in the TIP and through federal funding programs. There are several easy-to-use equity analysis tools that agencies can use to shape the plan. The following are a few examples:

- ARC Equity Analysis Protected Classes Model: This model “directly and clearly identifies the nine populations protected under Title VI of the Civil Rights Act and considers within the Executive Order on Environmental Justice”.[7] Additional considerations were added based on several federal requirements, recommendations, and guidelines.
- Social Vulnerability Index (SVI): The Centers for Disease Control/Agency for Toxic Substances and Disease Registry created the SVI as a “database to help planners and public health officials identify and map communities that will most likely need support before, during, and after a hazardous event. It uses 15 social factors such as poverty, lack of vehicle access, and crowded housing and groups them and provides a score on how vulnerable an area is”. [8]

6 CDC/ATSDR SVI Fact Sheet | Place and Health | ATSDR
7 protected-classes-model.pdf (atlantaregional.org)
8 CDC/ATSDR SVI Fact Sheet | Place and Health | ATSDR

- Climate and Economic Justice Screening Tool: This is a tool released by the White House Council on Environmental Quality (CEQ) in 2022 to "help agencies identify disadvantaged communities that are marginalized, underserved, and overburdened by pollution as part of the Justice40 Initiative".[9]
- ArcGIS Social Equity Analysis: ESRI developed and deployed a Social Equity Analysis Tool for ArcGIS that "identifies and analyzes demographics, assets, conditions, and outcomes to optimize plans for community investment".[10] This platform requires a license with ESRI.

There may be additional data collection to support the plan development process including at-grade railroad crossings, bicycle and pedestrian facilities, traffic signals, pedestrian crossing infrastructure, and pavement condition. Many of these data are readily available through ARC's geospatial database, local databases, and from national databases. ARC is available to discuss the relevant data sources and guide local agencies to the locations for download.

For more detailed Scoping Studies, the local agency may consider conducting an RSA. GDOT will conduct these on state-owned facilities to determine safety needs and project recommendations. Local agencies can (and should) conduct RSAs for specific locations that are identified as high-risk or an opportunity for safety improvement. Resources include the GDOT RSA process and FHWA guides on how to conduct an RSA.

4 Analysis and Findings

Complete Analysis and Document Findings

Local agencies should leverage partnerships with ARC, GDOT, and other agencies to assist in completing the analysis and documenting appropriate information to meet any federal requirements. Consultants are one option to support the development of plans, but these plans can also be completed with "in-house" staff. FHWA provides a Do-It-Yourself (DIY) website to support local road safety plan development.

A few considerations when conducting the analysis and documenting the findings:

- Clearly document any methods used for the analyses. This includes crash rate calculations, systemic analysis, benefit-cost analyses, etc.
- Develop a task force, stakeholder group, citizen review committee, or another committee to provide input and feedback throughout the process.
- Be inclusive in public outreach and include several opportunities and methods for the public to provide input. Thoroughly document participation, methodology, and feedback.
- Develop a project prioritization framework and methodology and clearly document the process. In many cases, agencies will first develop a set of goals and then identify evaluation measures for each of the goals to determine which projects more closely align with the goals. Those that are more aligned are higher priority. Prioritization can also be a direct result of safety performance based on measures such as crash modification factors or benefit-cost comparison. More details on these metrics are provided in Section 2.2.
- Format the document in an easy-to-understand manner, ensuring language is understood by all and eliminates technical jargon, acronyms, and complicated information. Try to create graphics to tell the story and help communicate important themes in the report.

5 Plan Adoption

Ensure the document is adopted by the governing body of the local agency. Attach the motion and documentation of the adoption to the plan once acquired. Submit a copy of the adopted plan to ARC for record-keeping.

9 Justice40 Initiative | US Department of Transportation
10 Introduction to Social Equity Analysis—ArcGIS Solutions | Documentation

APPENDIX G

REGIONAL SYSTEMIC ANALYSIS PROCESS

REGIONAL SYSTEMIC ANALYSIS PROCESS

The RSS data analysis consisted of three core components:

1. An analysis of KA crashes in the ARC region to identify focus crash types (i.e., emphasis areas).
2. An analysis of KA crashes and roadway characteristics in the ARC region with respect to exposure to identify focus facility types.
3. A statistical analysis of focus crash types on focus facility types to identify specific factors that increase the risk of severe crashes in the ARC region.

FOCUS CRASH TYPE ANALYSIS METHOD

ARC downloaded crash data for all years between 2016 and 2020 from GDOT's Crash Data Portal hosted by Numetric.[11] These data included crash-level factors, including crash dates, times, conditions, contributing circumstances, and indicators for relevant Strategic Highway Safety Plan (SHSP) emphasis areas. ARC focused on fatal (K) and suspected serious injury (A) crashes for the purposes of this analysis. To assess crash risk factors unique to the ARC and its constituent jurisdictions, ARC used the Federal Highway Administration's (FHWA's) Crash Data Summary Template to assess over-represented crash characteristics.[12] This tool compares crashes in a subject jurisdiction (e.g., a county) to crashes in a reference group (e.g., the ARC as a whole).

The tool flags a crash characteristic if it meets one of two criteria:

1. The percentage of subject area crashes is at least five percent higher than the reference dataset, or
2. The percentage of subject area crashes is double that of the reference dataset.

ARC developed the following analyses:

- KA crashes in the ARC compared to remaining injury and property damage only crashes (BCO) in the ARC jurisdiction.
- KA crashes in each constituent county compared to KA crashes in the ARC as a whole.
- KA crashes in each constituent county compared to BCO crashes in the same county.

FOCUS FACILITY TYPE ANALYSIS METHOD

Similar to focus crash type analysis, focus facility type analysis relied on overrepresentation of focus crash types relative to exposure on those facility types. For instance, if a specific functional classification experiences 45 percent of all roadway departure crashes while only accounting for 25 percent of vehicle miles traveled (VMT) or 10 percent of lane mileage, then that functional class is considered overrepresented and could be used to define a focus facility type. **VMT is typically a more robust measure of exposure for identifying over-representation**; however, AADT data are unavailable for most local roads within the ARC boundary. As a result, VMT for many local roads is missing and this skews the results for VMT-based analysis. Instead, **lane mileage is a more comprehensive metric of exposure across the entire region.** While lane mileage does not account for the number of vehicles on the road, it does account for the prevalence of a given facility within the region and the 'number of lanes' within this measure is a surrogate for traffic volume (i.e., facilities with higher volumes have more lanes).

11 https://gdot.numetric.net/crash-data#/
12 https://safety.fhwa.dot.gov/LRSPDIY/downloads/Crash_Data_Summary_Template.xlsm

ARC considered two approaches for identifying focus facility types:

1. **Overrepresentation of focus crash types by county** according to three exposure metrics.
   a. The three exposure metrics are VMT, lane mileage, and centerline mileage. VMT is a more robust measure of exposure followed by lane miles and centerline miles. ARC used lane mileage as the measure of overrepresentation for these analyses because it provided the most comprehensive coverage of the road network within the region. For future analyses, VMT could serve as the measure of exposure if AADT data are collected or estimated for most local roads within the ARC boundary.
2. **Overrepresentation of focus crash types relative to the results** of a crash tree.
   a. Crash trees illustrate the distribution of focus crashes according to a suite of criteria. For instance, using the aforementioned key criteria, a crash tree would identify the number and percentage of KA crashes that meet criteria such as urban setting, county-owned, two-way traffic operation, minor arterial, and 4 through lanes.

RISK FACTOR ANALYSIS METHOD

ARC compiled data using GDOT's roadway characteristics inventory as the basic unit of analysis. All sites included in the final analysis database represent continuous, homogenous segments; in other words, the characteristics of that segment (i.e., number of lanes, AADT, posted speed limit, etc.) are consistent for the entire length of that segment. ARC applied the following processes to define analysis study segments according to key attributes:

- For all GDOT attribute layers, ARC used the Identity[13] tool in ArcGIS Pro to **overlay spatially contiguous centerlines.** This tool segments the centerline as attributes change, thereby producing homogenous segments where characteristics are consistent. Future iterations of analysis could acquire GDOT data where this process is applied, or ARC could use routes and mileposts as the basis for overlaying multiple roadway inventory attribute layers.
- The next tier in the analysis required ARC to **link census data to individual homogenous segments.** ARC linked demographic and socioeconomic data to the roadway network using census tract geographies. This process also used the Identity tool, thereby segmenting the road network further by breaking the segment as it crossed a census tract boundary. This tool also applied the census tract ID, as well as all associated data with that ID, to the individual homogenous segment within the tract.
- All remaining data not associated with roadway attributes or census tracts such as **transit stops, sidewalks, bicycle lanes, greenways, and land use development were added using the Spatial Join tool in ArcGIS Pro.**[14] The settings of this tool vary, but most often the settings provided a small search distance (typically 100 feet or fewer). While this does not provide a highly-refined road network, it does allow ARC to analyze general characteristics and systemic trends.
- ARC used a **binary outcome for the statistical analysis** (i.e., did a severe crash occur during the study period or not). The benefit of this approach is that it does not require crash counts by segment. ARC filtered crash data for relevant crashes (i.e., K and A crashes for each focus crash type on the focus facility types) prior to joining crashes to individual homogenous segments. If a crash was located (within a token distance of 100 feet) on a segment within the five-year study period, that segment received a value of "1"; otherwise it received a value of "0" (i.e., a crash did not occur on that segment within the five-year period).

ARC used binary logistic regression[15] and the Stata software package to determine if the characteristics associated with focus facility types are correlated with severe focus crash types. Stata is a common statistical package for data science and analysis with a relatively simple interface and low barrier to entry for novice users.[16] Future iterations of the ARC RSS analysis should continue to account for the following statistical issues, which are discussed below:

- Accounting for correlation among independent variables
- Selecting an appropriate functional form
- Controlling for confounders
- Overfitting prediction models
- Endogenous independent variables
- Statistical significance
- Expert judgment

13 https://pro.arcgis.com/en/pro-app/2.8/tool-reference/analysis/identity.htm
14 https://pro.arcgis.com/en/pro-app/2.8/tool-reference/analysis/spatial-join.htm
15 https://stats.oarc.ucla.edu/stata/dae/logistic-regression/
16 https://www.stata.com/

ACCOUNTING FOR CORRELATION AMONG INDEPENDENT VARIABLES

A high degree of correlation among the independent variables makes it difficult to estimate the effect of a particular variable. There are no easy solutions to this problem because removing correlated variables can lead to omitted variable bias. A common diagnostic approach is to examine the correlation matrix and establish a threshold for exclusion. For systemic prediction models, the intent is to identify high-risk locations rather than estimate the safety effects of individual characteristics. As such, this is less of a concern as long as the results are understood to represent associations (and not causal relationships).

The Correlate[17] command in Stata provides a correlation matrix, showing the correlations between independent variables. Figure 43 is a sample correlation matrix of independent variables. ARC should consider variables with correlations between -0.5 and 0.5. ARC should not include variables in the same model if the correlations are between -0.7 and -1.0 or 0.7 to 1.0 unless there is a valid reason for inclusion in the analysis.

	PEDEST~N	AAD~9000	Lanes_~s	GDOT	Speed~40	MEDIAN	POP_DE~K	MED_IN~K	PROP_N~K	BUS_10~T	HFL~2015	ETA_2015	URBAN_~L
PEDESTRIAN	1.0000												
AADT_9000	0.0810	1.0000											
Lanes_4Plus	0.1523	0.2971	1.0000										
GDOT	0.0463	0.1551	0.1721	1.0000									
SpeedUnder40	-0.0490	-0.0532	-0.1048	-0.2181	1.0000								
MEDIAN	0.0281	0.1670	0.4241	0.1716	-0.2277	1.0000							
POP_DENS_R~K	0.1316	0.2576	0.3514	-0.1948	0.2800	-0.0099	1.0000						
MED_INC_RANK	-0.1285	0.0533	-0.1001	-0.0030	-0.0595	0.0518	-0.0734	1.0000					
PROP_NONWH~K	0.1523	0.0392	0.1560	-0.1306	-0.0187	-0.0157	0.2620	-0.6146	1.0000				
BUS_100FT	0.1795	0.1066	0.2021	-0.0512	0.1774	-0.1215	0.4302	-0.1616	0.2160	1.0000			
HFLOCAL~2015	0.0994	0.0360	0.0745	-0.0231	0.0295	-0.0064	0.1514	-0.1724	0.2081	0.2019	1.0000		
ETA_2015	0.1112	-0.0100	0.1287	-0.0187	0.1853	-0.0703	0.2455	-0.5907	0.4122	0.2199	0.1661	1.0000	
URBAN_RURAL	0.0507	0.1966	0.1457	-0.1428	0.0969	0.0387	0.2588	-0.0349	0.2297	0.1042	0.0526	0.0766	1.0000
LENGTH_MI	0.0731	-0.1181	-0.1186	0.0648	-0.2327	-0.0248	-0.2655	0.1287	-0.1113	-0.0756	-0.0633	-0.1714	-0.1405

	LENGTH~I
LENGTH_MI	1.0000

= Notably high correlation (>0.5 or <-0.5)

Figure 43. Example Correlation Matrix with Relatively Highly Correlated Variables Indicated.

17 https://www.stata.com/manuals13/rcorrelate.pdf

SELECTING AN APPROPRIATE FUNCTIONAL FORM

The selection of an appropriate functional form improves the reliability of prediction models. Logistic regression is appropriate for systemic analysis because it relates to risk and the probability associated with a crash occurring. This is especially relevant when exposure (i.e., VMT data) are not available for all applicable segments. Negative binomial models are more appropriate for developing crash prediction models (i.e., models that estimate the number of crashes on a segment as opposed to risk).[18]

The relationship between crash frequency and traffic volume is often non-linear and the current state of the practice is to assume a log-linear relationship between crash frequency and site characteristics. In addition to the functional form for the overall model, it is important to select the appropriate functional form for the individual variables. ARC should document the reason for selecting a particular functional form and why it is appropriate for the data.

CONTROLLING FOR CONFOUNDERS

A confounder is a variable that is a significant predictor for the outcome under study, and is associated with, but not a consequence of, the predictor variable in question. Reasons for confounding include lack of available data and variables that are not practical to measure or cannot be measured. In systemic risk modeling, it is important to recognize that the results do not represent causal relationships; the risk factors are simply associated with sites that have an increased risk of severe crashes.

OVERFITTING PREDICTION MODELS

Overfitting occurs when the model is too complex and includes too many parameters. When this occurs, the model does a poor job of showing the underlying relationship. This results in models that do not predict crashes well and increases the chance of correlation among variables in the model. This can also create false relationships (i.e., those that appear to be statistically significant but are just noise). **Statistical models should be stable**; variables that change direction of effect (i.e., positive or negative coefficient) or magnitude of effect (i.e., the size of the coefficient) should be avoided or explored for correlation with other independent variables. Variables that change little, regardless of the inclusion of other variables, should be higher priority as risk factors.

18 https://stats.oarc.ucla.edu/stata/dae/negative-binomial-regression/

ENDOGENOUS INDEPENDENT VARIABLES

Endogeneity occurs when an independent variable depends on the dependent variable. This can lead to incorrect conclusions from a model. A practical example is the association of angle crashes at intersections with traffic signals and left-turn lanes. Signalized intersections with dedicated left-turn lanes may experience more angle crashes, but that is because a traffic signal and left-turn lane have been installed as a result of frequent left-turn movements on that approach, increasing the potential for angle crashes.

STATISTICAL SIGNIFICANCE

Statistical significance is an important indicator in regression modeling, but it is not an absolute threshold. While 95 percent ($p < 0.05$) and 90 percent ($p < 0.1$) confidence levels are often used as demarcations of "significance," these are not fixed thresholds for considering risk present or not present. When evaluating model performance, it is important to exercise professional judgment and evaluate model results according to intuitiveness or impact on other variables in the model. As noted earlier, excluding variables without substantial reason may lead to omitted variable bias.

PROFESSIONAL JUDGMENT

A final caveat to using statistical modeling is the application of professional judgment. **There is no replacement for professional judgment in statistical modeling.** All results should be assessed according to practical judgment (i.e., do the relationships make sense). If relationships do not make sense from a practitioner perspective, that may indicate:

- Input data are incorrect or aggregated in such a way that the model interpretation is inherently flawed.
- If input data are correct, there may be deeper relationships that the model has not captured. For example, the model may indicate that streets with high pedestrian crossing volumes are lower risk than similar streets in the same neighborhood with lower pedestrian crossing volumes. Could this reflect a possible 'safety in numbers' effect or is there an underlying relationship (confounding factor) at play?

APPENDIX H

DIAGNOSIS PROMPT LIST

DIAGNOSIS PROMPT LIST

This prompt list is intended to guide the field review. It is not an exhaustive list and professional judgment is essential. Further, specific factors on the list may not be applicable at a given specific location.

INTERSECTION

Topic	Subtopic	Prompt
Location	Visibility; sight distance	Is the presence of each intersection obvious to all road users?
	Visibility; sight distance	Is the sight distance appropriate for all movements and all road users?
	Visibility; sight distance	Are all intersections located safely with respect to the horizontal and vertical alignment?
	Controls and delineation	Are pavement markings and intersection control signs satisfactory?
	Controls and delineation	Are all lanes properly marked (including any arrows)?
	Controls and delineation	Where intersections occur at the end of high-speed environments (for example, at approaches to towns), are there traffic control devices to alert drivers?
	Layout	Is the intersection layout obvious to all road users?
	Layout	Can all likely vehicle types be accommodated?
Traffic signals	Operations	Are traffic signals operating correctly?
	Operations	Are the number, location and type of signal displays appropriate for the traffic mix and traffic environment?
	Visibility	Are traffic signals clearly visible to approaching motorists?

ROADWAY DEPARTURE

Topic	Subtopic	Prompt
Road alignment and cross-section	Visibility; sight distance	Is sight distance adequate for the speed of traffic using the route?
	Visibility; sight distance	Is adequate sight distance provided for intersections and crossings? (for example, pedestrian, bicycle rider, cattle, railway)
	Design speed	Is the horizontal and vertical alignment suitable for the (85th percentile) traffic speed?
	Design speed	Are the posted advisory speeds for curves appropriate?
	Speed limit / speed zoning	Is the speed limit compatible with the function, road geometry, land use and sight distance?
	Overtaking	Are safe overtaking opportunities provided?
	Readability by drivers	Is the road free of elements that may cause confusion? For example: is alignment of the roadway clearly defined? has disused pavement (if any) been removed or treated? have old pavement markings been removed properly? do tree lines follow the road alignment? does the line of street lights or the poles follow the road alignment?
	Widths	Are medians and islands of adequate width for the likely users?
	Widths	Are traffic lane widths adequate for the traffic volume and mix?
	Shoulders	Are shoulders wide enough to allow drivers to regain control of errant vehicles?
	Shoulders	Are shoulders wide enough for broken-down or emergency vehicles to stop safely?
	Cross slopes	Is appropriate superelevation provided on curves?
	Drains	Are roadside drains and culvert end walls traversable?
Auxiliary lanes	Tapers	Are starting and finishing tapers located and aligned correctly?
	Shoulders	Are appropriate shoulder widths provided at merges?
	Signs and markings	Have all signs been installed in accordance with the appropriate guidelines?
	Signs and markings	Are all signs conspicuous and clear?
	Signs and markings	Do all markings conform with guidelines?

Topic	Subtopic	Prompt
Signs and lighting	Lighting	Has lighting been adequately provided where required?
	General signs issues	Are all necessary regulatory, warning and direction signs in place? Are they conspicuous and clear?
	Sign legibility	In daylight and darkness, are signs satisfactory regarding visibility and: clarity of message? readability/legibility at the required distance?
	Sign legibility	Is sign retroreflectivity or illumination satisfactory?
	Sign supports	Are sign supports out of the clear zone? If not, are they: frangible or shielded by barriers (for example, guard fence, crash cushions)?
Markings and delineation	General issues	Is the marking and delineation: appropriate for the function of the road? consistent along the route? likely to be effective under all expected conditions? (day, night, wet, dry, fog, rising and setting sun position, oncoming headlights, etc.)
	Centerlines, edge lines, lane lines	Are the markings in good condition?
	Curve warning and delineation	Are curve warning signs and advisory speed signs installed where required? Are the signs correctly located in relation to the curve? (i.e. not too far in advance) Are the signs large enough?
Crash barriers and clear zones	Clear zones	Is the clear zone width traversable? (i.e. drivable)
	Clear zones	Is the clear zone width free of rigid fixtures? (if not, can all of these rigid fixtures be removed or shielded?)
	Crash barriers	Are crash barriers installed where necessary?
	End treatments	Are end treatments constructed correctly?
Bridges and culverts	Crash barriers	Are there suitable traffic barriers on bridges and culverts and their approaches to protect errant vehicles?
Pavement	Pavement defects	Is the pavement free of defects (for example, excessive roughness or rutting, potholes, loose material, etc.) that could result in safety problems (for example, loss of steering control)?
Parking	General issues	Are the provisions for, or restrictions on, parking satisfactory in relation to traffic safety?
Provision for heavy vehicles	Design issues	Does the route generally cater for the size of vehicle likely to use it?
Floodways and causeways	Ponding, flooding	Are all sections of the route free from ponding or flow across the road during wet weather?
Miscellaneous	Landscaping	Is landscaping in accordance with guidelines? (for example, clearances, sight distance)
	Headlight glare	Have any problems that could be caused by headlight glare been addressed? (for example, a two-way service road close to main traffic lanes, the use of glare fencing or screening)

PEDESTRIAN/BICYCLE

Topic	Subtopic	Prompt
Physical Environment/ Infrastructure	Presence / Placement	Do facilities address pedestrian and bicycle rider needs, including those with disabilities?
	Connectivity / Consistency	Are safe, continuous, and convenient pedestrian and bicycle rider routes provided throughout the study area?
	Visibility	What obstructions block the view of pedestrian and bicycle rider facilities (e.g., crosswalks, traffic control devices, signs)?
	Lighting	Are pedestrian and bicycle rider facilities well-lit?
	Transit	How does transit infrastructure interact with pedestrian and bicycle rider facilities?
	Presence / Placement	Are facilities shared, separate, or buffered?
	Presence / Placement	What is the comfort level for users?
	Presence / Placement	Are pedestrian and bicycle rider facilities appropriate for the adjacent land use?
	Presence / Placement	Does parking adversely affect bicycle rider safety?
	Quality / Condition	Are the pedestrian and bicycle rider facilities in good condition and well maintained?
	Quality / Condition	Are there obstacles (e.g. utility poles or signs) in the pedestrian travel path?
	Quality / Condition	Does vegetation or debris infringe on pedestrian or bicycle rider facilities?
	Visibility	Are there obstructions blocking the driver's view of pedestrian and bicycle rider?
	Presence / Placement	What are the distances between the mid-block crossing and other marked crosswalks?
	Lighting	Are pedestrian crossings adequately lit?
	Transit	Are transit users crossing mid-block to get to/from the transit stop?
	Connectivity / Consistency	How far is it to the nearest controlled crossing?
	Presence / Placement	What intersection characteristics increase/decrease pedestrian and bicycle rider safety (e.g., channelized right turns, large curb radii, wide crossing distances, right-turn-on-red)?
	Quality / Condition	How many legs have a crosswalk? In what condition?
	Quality / Condition	Are pedestrian push buttons accessible, with a locator tone, properly located and connected to the walkway, and functioning correctly?
	Quality / Condition	Are curb ramps in good condition and ADA-compliant for each crosswalk or does a single curb ramp serve both crosswalks?
	Quality / Condition	Are the grades and cross slopes accessible to individuals with disabilities?

Topic	Subtopic	Prompt
Traffic Control Devices	Signs and Pavement Markings	Are signs and pavement markings for pedestrian and bicycle rider facilities present and effective?
	Signals	Are pedestrian and bicycle rider accommodated at signals through adequate signal timing and phasing?
	Signals	Are pedestrian push buttons accessible, with a locator tone, properly located and connected to the walkway, and functioning correctly?
	Signs and Pavement Markings	Are there signage enhancements for the crossing, such as RRFBs or flashing beacons?
	Signals	Are there any devices (i.e., PHB or signalization) to control the crossings?
	Signals	Do vehicles have protected or permitted left-turn control?
Operations/ Interactions/ Behaviors	Characteristics	Are design, posted, and operating traffic speeds compatible with pedestrian and bicycle rider safety?
	Road User Interactions	Are drivers and bicycle riders yielding to pedestrians at crossings?
	Characteristics	Are vehicles traveling at appropriate speeds?
	Road User Interactions	Are there conflicts between bicycle riders and pedestrians on sidewalks?
	Road User Interactions	Is it clear between roadway users who has the right-of-way and is there compliance?

APPENDIX I

SS4A SELF-CERTIFICATION ELIGIBILITY WORKSHEET

SS4A SELF-CERTIFICATION ELIGIBILITY WORKSHEET

The following is a detailed questionnaire from the SS4A federal discretionary grant program. This questionnaire can help local agencies determine if planning or implementation is the next step. If planning is the next step, return to the section titled, *Project Planning and Development*, or refer to Appendix F for details on how to develop a safety action plan.

Question
1. Are both of the following true: » Did a high-ranking official and/or governing body in the jurisdiction publicly commit to an eventual goal of zero roadway fatalities and serious injury? » Did the commitment include either setting a target date to reach zero, OR setting one or more targets to achieve significant declines in roadway fatalities and series injuries by a specific date?
2. To develop the Action Plan, was a committee, task force, implementation group, or similar body established and charged with the plan's development, implementation, and monitoring?
3. Does the Action Plan include all of the following? » Analysis of existing conditions and historical trends to baseline the level of crashes involving fatalities and serious injuries across a jurisdiction, locality, Tribe, or region; » Analysis of the location(s) where there are crashes, the severity, as well as contributing factors and crash types; » Analysis of systemic and specific safety needs is also performed, as needed (e.g., high risk road features, specific safety needs of relevant road users; and » A geospatial identification (geographic or locational data using maps) of higher risk locations.
4. Did the Action Plan development include all of the following activities? » Engagement with the public and relevant stakeholders, including the private sector and community groups; » Incorporation of information received from the engagement and collaboration into the plan; and » Coordination that included inter- and intra-governmental cooperation and collaboration, as appropriate.
5. Did the Action Plan development include all of the following? » Consideration of equity using inclusive and representative processes; » The identification of underserved communities through data; and » Equity analysis, in collaboration with appropriate partners, focused on initial equity impact assessments of the proposed projects and strategies, and population characteristics.
6. Are both of the following true? » The plan development included an assessment of current policies, plans, guidelines, and/or standards to identify opportunities to improve how processes prioritize safety; and » The plan discusses implementation through the adoption of revised or new policies, guidelines, and/or standards.
7. Does the plan identify a comprehensive set of projects and strategies to address the safety problems identified in the Action Plan, time ranges when the strategies and projects will be deployed, and explain project prioritization criteria?

APPENDIX J

PROJECT TRACKING AND EVALUATION

PROJECT TRACKING AND EVALUATION

PROJECT TRACKING TEMPLATE

Table 17 provides a template for local agencies to track projects and compile data for project-level evaluations. The fields provide a method for organizing projects by location, countermeasure type, costs, project date, and safety performance.

Table 17. Project Tracking Template.

Data Field	Project Data
Project Location and Characteristics: data provided under this category will identify the location and characteristics of the project. Road 1 is the primary field for segment-related projects and represents the major road for intersection-related projects. Road 2 will generally be blank for segment-related projects and represents the minor road for intersection-related projects. For projects where improvements occur intermittently between the begin and end milepost, consider adding a column to indicate specific treated locations or create separate entries for each improvement location, using the project identification number to link multiple improvement locations from the same project.	
Project ID	Unique project identification number to link various data to a given project
Facility Type	Type of facility for the project (e.g., intersection, ramp, road segment, corridor)
District	GDOT district in which the project occurred
County	County in which the project occurred
Municipality	City/township/municipality in which the project occurred (if applicable)
Road 1 Route Number(s)	Route number(s) for the major road(s) in the project
Road 1 Route Name(s)	Route name(s) for the major road(s) in the project
Road 1 Traffic Volume Before	Annual average daily traffic volume for the major road in the project for the before period
Road 1 Traffic Volume After	Annual average daily traffic volume for the major road in the project for the after period
Road 1 Begin Milepost	Starting milepost for the major road in the project
Road 1 End Milepost	Ending milepost for the major road in the project
Road 1 Federal Functional Class	Federal functional classification of the major road on the project
Road 2 Route Number(s)	Route number(s) for the minor road(s) in the project (leave blank for segment projects)
Road 2 Route Name(s)	Route name(s) for the minor road(s) in the project (leave blank for segment projects)
Road 2 Traffic Volume Before	Annual average daily traffic volume for the minor road in the project for the before period (leave blank for segment projects)
Road 2 Traffic Volume After	Annual average daily traffic volume for the minor road in the project for the after period (leave blank for segment projects)

Data Field	Project Data
Road 2 Begin Milepost	Starting milepost for the minor road in the project (leave blank for segment projects)
Road 2 End Milepost	Ending milepost for the minor road in the project (leave blank for segment projects)
Road 2 Federal Functional Class	Federal functional classification of the minor road on the project (leave blank for segment projects)
Project Dates: data provided under this category will provide relevant dates for the project and help analysts identify the before and after periods for analysis.	
Begin Construction Date	Date on which the contractor begins construction
End Construction Date	Date on which the contractor ends construction
Open to Traffic	Date on which the facility is open to live traffic
Project Cost: data provided under this category will identify the project cost and funding source(s) of the project.	
Estimated Cost	Estimated cost of project in planning or programming stage
Bid Cost	Winning bid cost
Final Cost	Final cost of project
Funding Source(s)	List the funding source(s) of the project (e.g., HSIP, SPLOST, etc.)
Funding Amount	List the funding amount provided by each funding source
Safety Focus: data provided under this category will identify the reason for the project and related safety emphasis areas.	
Emphasis Area(s)	Emphasis area(s) of the RSS and/or Georgia SHSP the project falls under (e.g., roadway departure, intersections, pedestrians, bicyclists)
Project Selection Method	Pre-construction safety analysis method used to select the project (site-specific crash history, systemic risk factors)
Target Crash Type(s)	List the target crash type(s) as applicable
Target Crash Contributing Factor(s)	List the target crash contributing factor(s) as applicable
Countermeasure(s)	List the countermeasure(s) implemented as part of the project

PROJECT EVALUATION TEMPLATE

Table 18 presents sample data for an example project and Table 18 provides a spreadsheet template and completed example for estimating project effectiveness using the simple before-after method. As an example, consider a scenario where an agency installed a raised median and a pedestrian crossing with rapid rectangular flashing beacons along an urban arterial. The analyst would like to estimate the safety effectiveness for this project using the simple before-after method. Using the spreadsheet template in Table 19, the teal cells represent user inputs. The orange cells represent the outputs, computed automatically based on the user inputs. Row 17 provides the estimate of project effectiveness in terms of a CMF value. Row 20 shows this same information but converted to a percent reduction in crashes.

Table 18. Sample Project Data for Simple Before-After Evaluation.

PROJECT DATA	BEFORE	AFTER
Total observed crashes	18	10
Duration (years)	3	2
Traffic volume (vehicles/day) *Assume this is estimated based on 365-days of count data from permanent traffic count station	7,500	8,300

BEFORE

AFTER

Table 19. Spreadsheet Template for Simple Before-After Project Evaluation.

EXCEL ROW	VARIABLE INPUTS (COLUMN A)	EXCEL FORMULA (COLUMN B)	BEFORE
1	Number of Observed Crashes "Before"	User Input	18
2	Traffic Volume Before	User Input	7,500
3	Years Before	User Input	3
4	Number of Observed Crashes "After"	User Input	10
5	Traffic Volume After	User Input	8,300
6	Years After	User Input	2
7	Number of Count Days to Estimate AADT Before	User Input	365
8	Number of Count Days to Estimate AADT After	User Input	365
9	Adjustment for Duration of Before and After Period [Years After/Years Before]	=B6/B3	0.67
10	Adjustment for Change in Traffic Volume	=B5/B2	1.11
11	Estimated Number of Crashes "After" in Treatment Group Without Change	=B1*B9*B10	13.28
12	Variance of Observed Crashes "After" in Treatment Group	=B4	10
13	Coefficient of Variation (v) Before	=1+(7.7/B7)+(1650/(B2)^0.82)	2.12
14	Coefficient of Variation (v) After	=1+(7.7/B8)+(1650/(B5)^0.82)	2.03
15	Variance of Adjustment for Change in Traffic Volume	=B10^2*(((B13/100)^2)+((B14/100)^2))	0.0011
16	Variance of Estimated Number of Crashes "After" in Treatment Group Without Change	=B9^2*(((B10^2)*B1)+((B1^2)*B15))	9.95
17	Estimate of Effectiveness	=(B4/B11)/(1+(B16/(B11^2)))	0.71
18	Variance of Estimate of Effectiveness	=(B17^2)*((B12/(B4^2))+(B16/(B11^2)))/(1+(B16/(B11^2))^2)	0.08
19	Standard Error of Estimate of Effectiveness	=SQRT(B18)	0.28
20	Estimated Percent Reduction in Crashes	=100*(1-B17)	29%

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