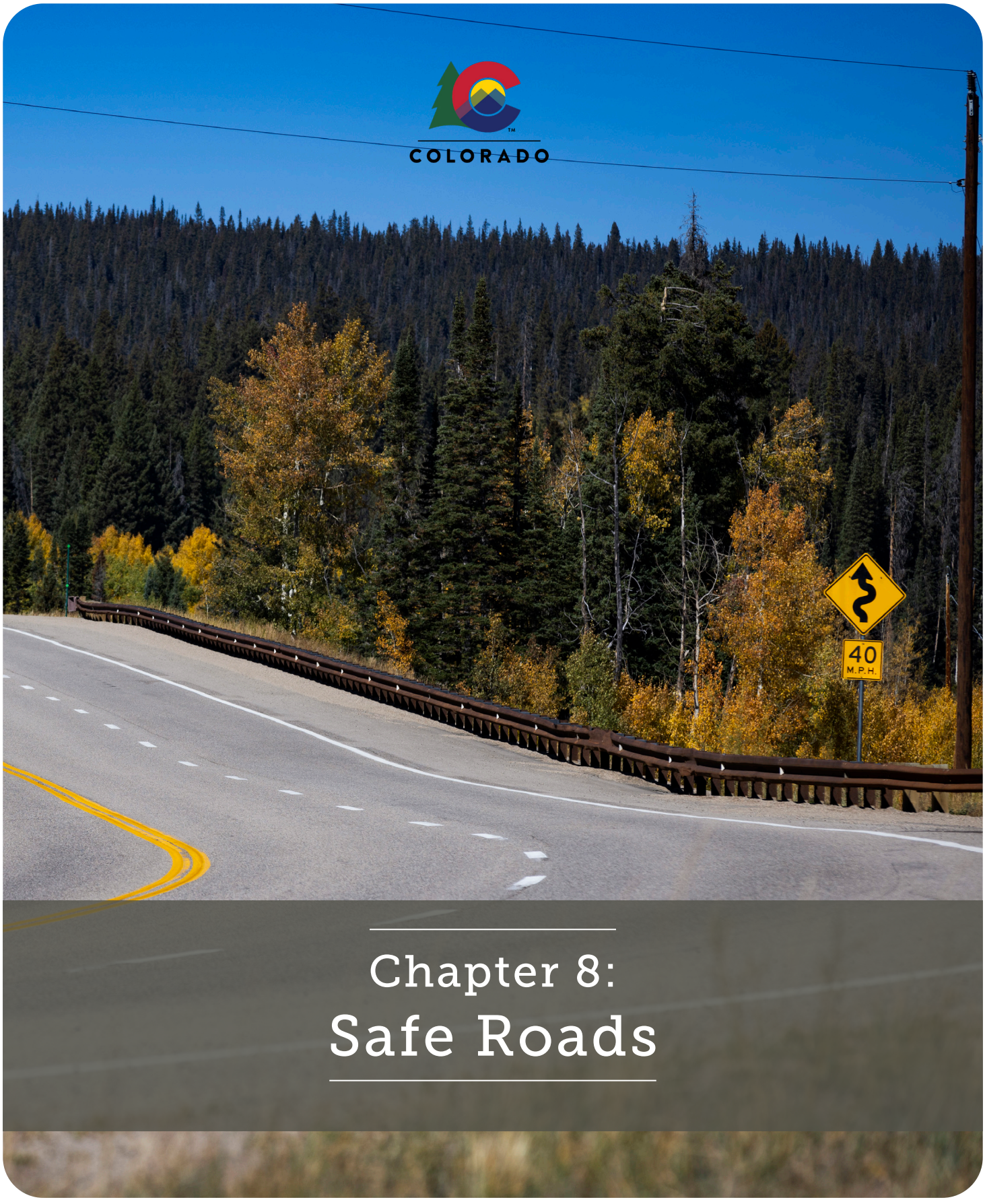


Chapter 8:
Safe Roads

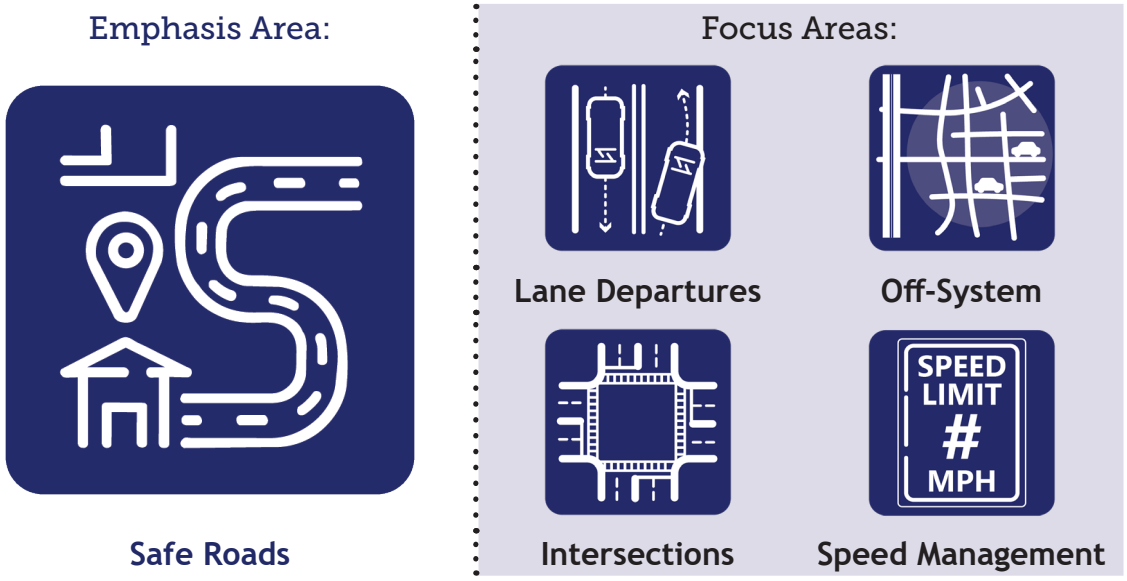
Introduction

The Safe Roads Emphasis Area acknowledges that safety is proactive and that humans make mistakes. It focuses on designing and improving infrastructure to anticipate and reduce the impact of human errors, preventing fatalities and serious injuries.

The primary objective of the Safe Roads Emphasis Area is to identify and implement targeted roadway infrastructure improvements to reduce the occurrence of fatal and serious injury crashes on Colorado's roadways. Fundamental to this objective is the understanding that responsibility is shared, and local agency contributions are essential.

Focus Areas

The Safe Roads Emphasis Area identifies four Focus Areas:



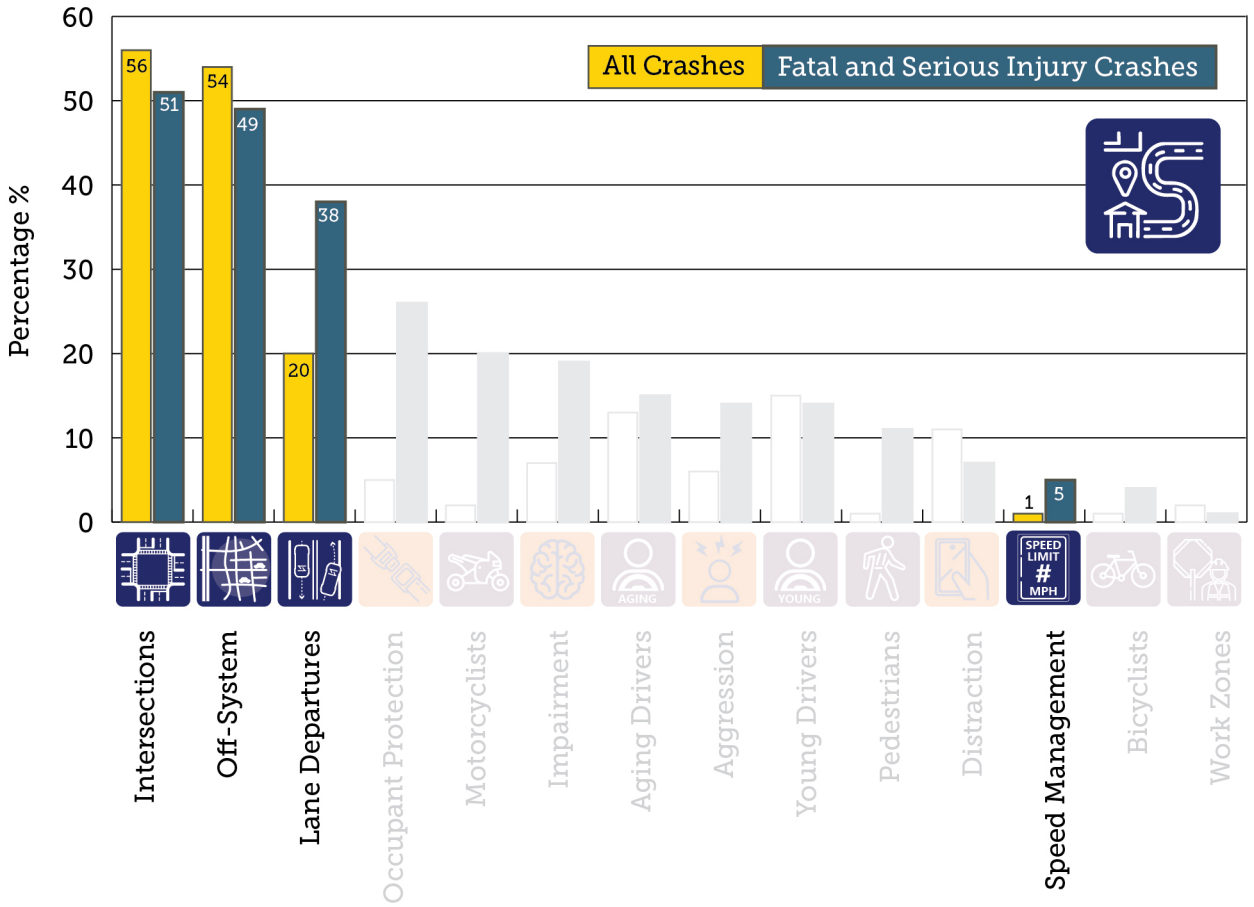


Figure 8-1: Percentage of Total & Fatal/Serious Injury Crashes Involving Focus Areas

The Safe Roads Emphasis Area focuses on different roadway environments where severe crashes occur. The Focus Areas within this Emphasis Area have high potential for reducing or eliminating future severe crashes and include intersections, lane departures, off-system roads, and speed management.

Additionally, the strategies identified in the Safe Roads Emphasis Area could all apply to High Risk Rural Roads (HRRR) depending on the safety needs of the given location.

Lane Departures

Focus Area Definition: Crashes that occur due to a driver leaving their lane including run-off-road, fixed object, head-on, rollover, and sideswipe crash types.

Focus Area Goal: Reduce the number of fatalities and serious injuries caused by lane departure crashes by five percent from the previous year through 2029.

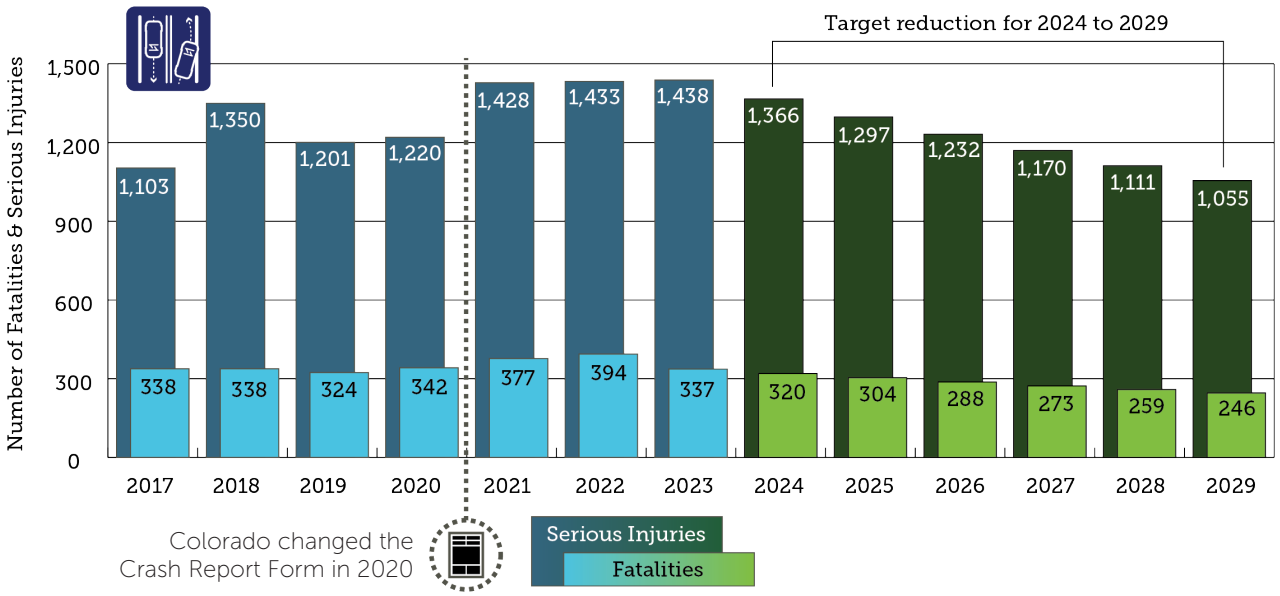
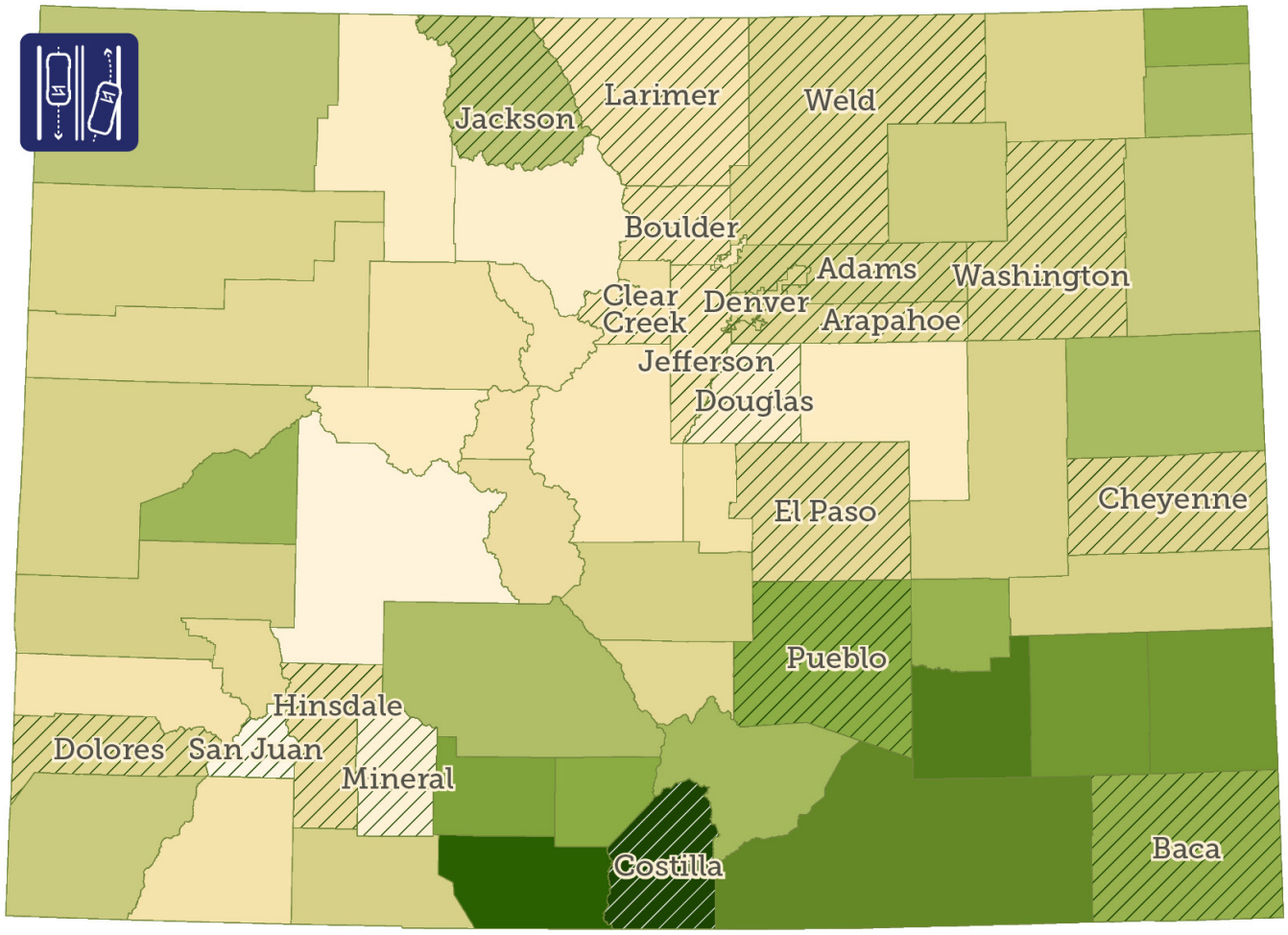


Figure 8-2: Lane Departure-Involved Fatalities and Serious Injuries by Year (2017 to 2023)

Figure 8-2 illustrates a relatively stable trend in lane departure fatalities and serious injuries. In 2023, there were 1,775 lane departure fatalities and serious injuries. Lane departure crashes occur more often in rural areas than in urban areas due to higher speeds and reduced lighting infrastructure, making lane markings more difficult to discern. Rural areas account for 62% of lane departure fatal and serious injury crashes, while only accounting for 38% of all crash types in the state. This disparity shows the need for addressing lane departures in rural areas.

Figure 8-3 shows a map identifying the counties with the highest transportation disadvantage, as well as the counties with the highest lane departure-involved fatalities and serious injuries and the highest rates per capita. Counties with the highest number of lane departure-involved fatalities and serious injuries are the counties along the Front Range. Top counties per capita tend to be rural counties along the Eastern Plains and Southwestern Colorado.

Figure 8-3: Top Counties of Lane Departure-Involved Fatalities and Serious Injuries



Rank	Top Counties Overall	Top Counties per Capita
1	El Paso	Mineral
2	Denver	San Juan
3	Adams	Jackson
4	Jefferson	Cheyenne
5	Weld	Baca
6	Larimer	Hinsdale
7	Arapahoe	Costilla
8	Douglas	Washington
9	Boulder	Clear Creek
10	Pueblo	Dolores

Map Legend

Weighted TDI Score

Low — High

Diagonal Striping = Top 10 overall and/or per capita counties

This map shows the Transportation Disadvantage Index (TDI) and labels the top 10 counties for total fatalities and serious injuries, along with the top 10 counties with the highest per-capita impact among relevant demographics. The table provides rankings for both categories.

The three most common lane departure crash types are fixed objects, overturning, and roadside barriers, as depicted in Figure 8-4. While same direction lane departure crashes are problematic, data indicates that the most severe lane departure crashes involve vehicles veering off the roadway or into oncoming traffic.

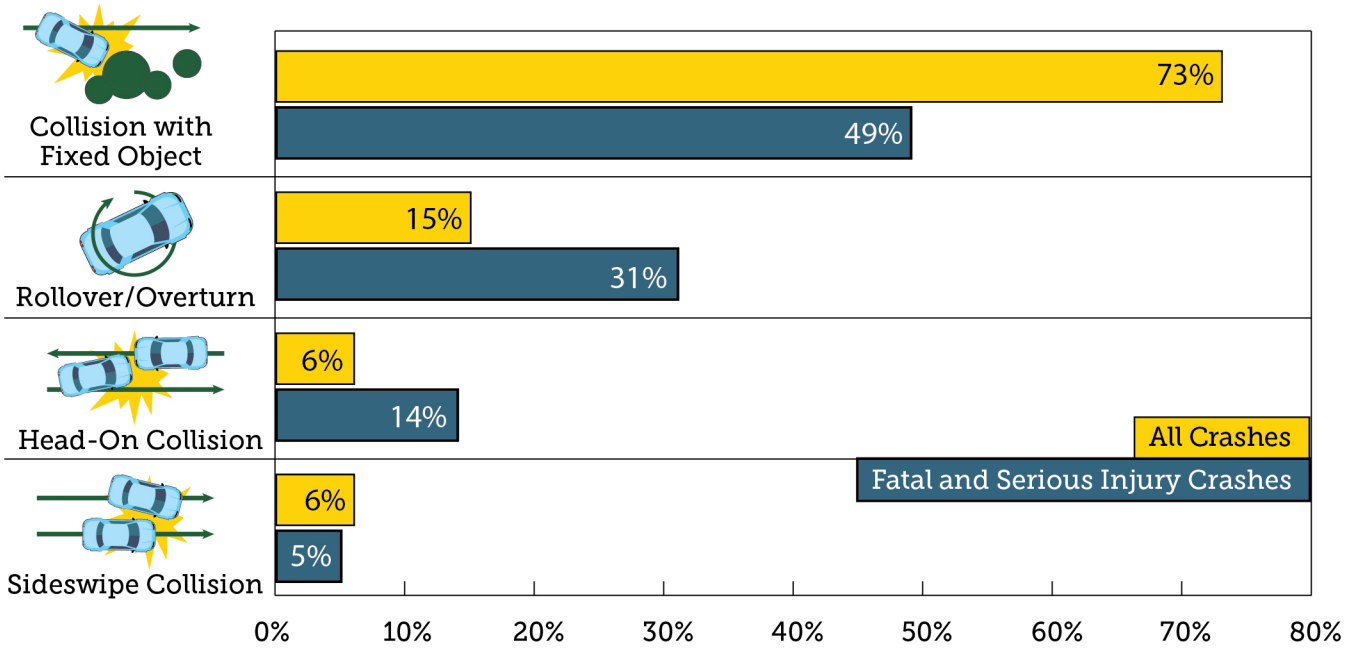


Figure 8-4: Lane Departure Severe Crashes by Crash Type (2019-2023)

Lane Departure Strategies

SR1: Install traffic controls and safety barriers

Reduce fatal and serious injury crashes caused by lane departures by installing improved traffic control devices and safety barriers on high-risk road segments.

The primary crash types associated with lane departures include fixed object collisions, overturning, and head-on crashes. Installing roadside barriers to keep errant vehicles on the road and enhancing traffic control to improve awareness of changing road conditions can reduce the frequency and severity of lane departure crashes.

SR2: Improve roadway geometry

Implement roadway geometric improvements to encourage or accommodate appropriate driving speeds, while providing a forgiving roadside condition that minimizes severe crashes along high-risk road segments.

This strategy focuses on roadway design that accommodates the inevitability of human error, specifically when lane departures occur. In addition to forgiving roadside designs, aligning roadway design with realistic driving speeds can further mitigate the occurrence of severe lane departure crashes.

Off-System

Focus Area Definition: Crashes that occur on public roadways that are not maintained by the State of Colorado.

Focus Area Goal: Reduce the number of fatalities and serious injuries that occur on off-system roadways by five percent from the previous year through 2029.

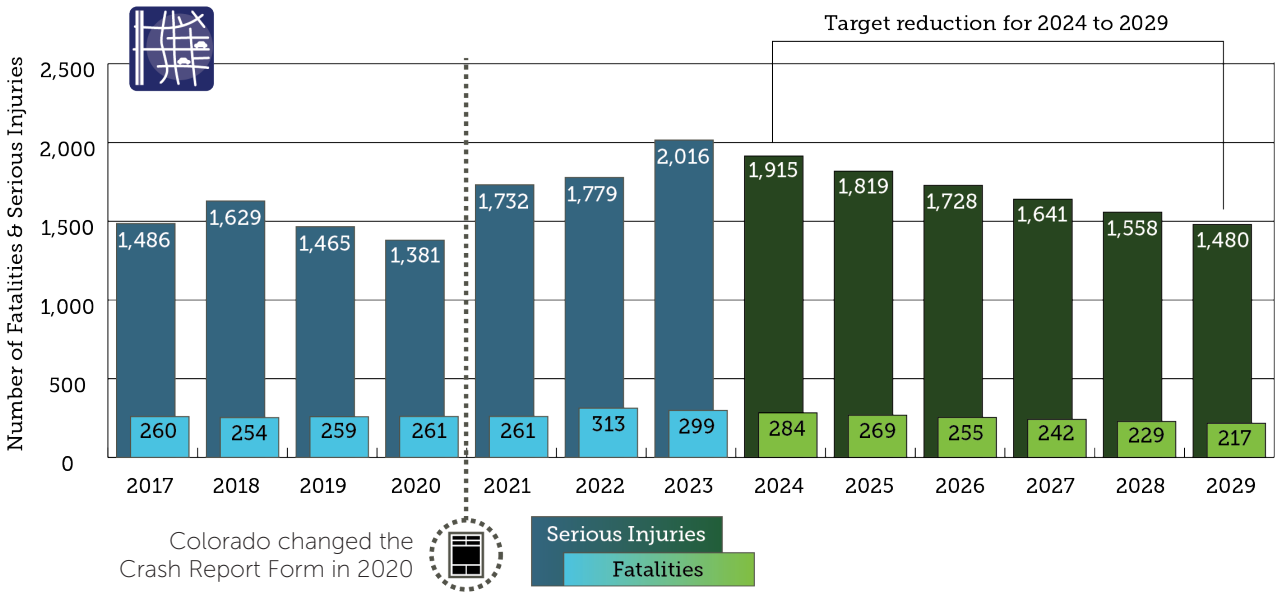


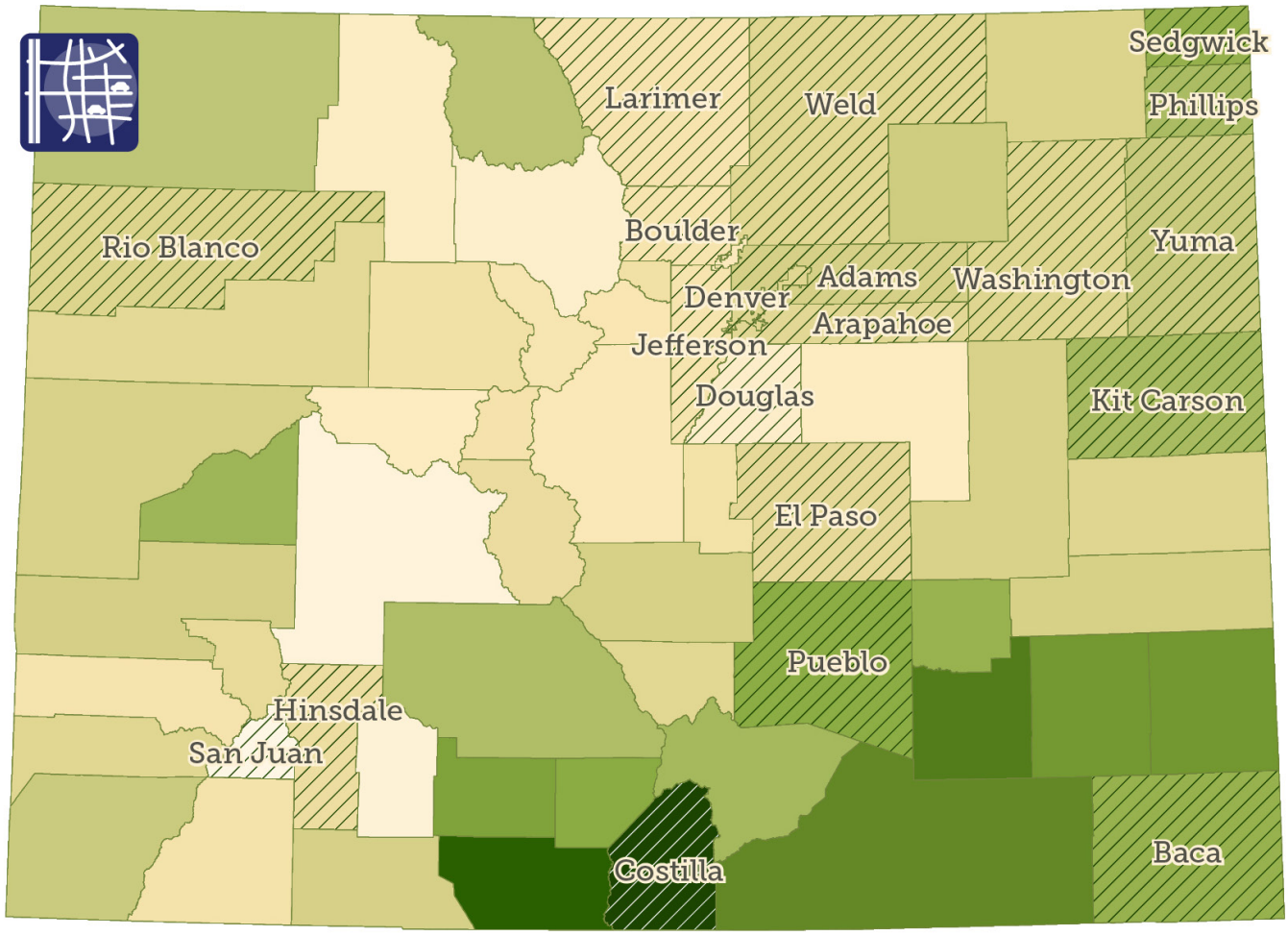
Figure 8-5: Off-System-Involved Fatalities and Serious Injuries by Year (2017 to 2023)

Off-system roadways refer to public roadways that are not maintained by the State of Colorado. This means that local jurisdictions (e.g., city, town, county) are responsible for the maintenance and operations of these roadways, including identifying and mitigating safety concerns. While the State is not directly responsible for these networks, safety improvements should be implemented in cooperation with state and local agencies to maximize crash reduction throughout Colorado.

Off-system roadways comprise approximately 90% of the total centerline miles and account for about half of the annual vehicle miles traveled (VMT). While 52% of fatal and serious injury crashes occur on state highways, 48% happen on off-system roadways. This emphasizes the importance of continuing to improve off-system roadways and emphasizing the Safe System principle that responsibility is shared across state and local agencies.

Figure 8-5 shows a steady upward trend in off-system fatalities and serious injuries. In 2023, there were 2,315 off-system fatalities and serious injuries, representing over half of the fatalities and serious injuries in the state. Prioritizing safety on these roadways is critical to reduce the number of fatalities and serious injuries.

Figure 8-6: Top Counties of Off-System-Involved Fatalities and Serious Injuries



Rank	Top Counties Overall	Top Counties per Capita
1	Denver	San Juan
2	El Paso	Baca
3	Arapahoe	Hinsdale
4	Adams	Washington
5	Jefferson	Costilla
6	Larimer	Sedgwick
7	Boulder	Kit Carson
8	Weld	Yuma
9	Douglas	Phillips
10	Pueblo	Rio Blanco

Map Legend

Weighted TDI Score

Low — High

Diagonal Striping = Top 10 overall and/or per capita counties

This map shows the Transportation Disadvantage Index (TDI) and labels the top 10 counties for total fatalities and serious injuries, along with the top 10 counties with the highest per-capita impact among relevant demographics. The table provides rankings for both categories.

Figure 8-6 shows the counties that have the highest number off-system-involved fatalities and serious injuries. This graphic may seem surprising initially, as Denver County has the highest number of off-system-involved fatalities and serious injuries. This is due to most city streets in large cities and towns being off-system roadways, not all off-system roadways are rural roadways. The rural roadway representation can be seen in the top counties of off-system involved fatalities and serious injuries per capita with San Juan, Baca, and Hinsdale counties being the top counties per capita.

High Risk Rural Roads (HRRR) are important to note within the Off-System focus areas as they align in many cases. The Off-System strategy of providing assistance to local agencies can help local agencies identify HRRRs on their local systems and identify safety improvement projects to improve safety on these HRRRs.

Off-System Strategies

Due to the shared responsibility of safety on off-system roadways, this Focus Area identifies strategies to support local jurisdictions in making safety improvements on local roadways.

SR3: Provide local agency assistance

Provide detailed guidance to local agencies on how to apply for state and federal safety funding and improve outreach to enhance awareness and participation in the Safety Circuit Rider Program, the LTAP, and other relevant assistance programs.

This strategy aims to strengthen support for existing programs, like the Safety Circuit Rider, that provide technical assistance, training, and safety-program support to local agencies to enhance roadway safety across the state. Several different types of funding sources are available including the Highway Safety Improvement Program (HSIP), which is a core federal-aid program to states for the purpose of achieving a significant reduction in fatalities and serious injuries on all public roads.

SR4: Encourage community-specific plans

Encourage local agencies to create community-specific safety plans and actively participate in their development, ensuring alignment with the Strategic Highway Safety Plan (SHSP) goals.

This strategy increases outreach efforts and provides targeted support to help local agencies develop community-specific plans aligned with the goals of the Strategic Highway Safety Plan (SHSP). This alignment results in local safety plans that meet state and federal grant criteria, making it easier to secure funding for projects. Some examples of these community specific plans are Safe Streets for All (SS4A) and building Complete Streets toolkits to guide local governments in planning, designing and implementing roadway designs to accommodate all road users.

Intersections

Focus Area Definition: Crashes occurring at intersections or are intersection-related.

Focus Area Goal: Reduce the number of fatalities and serious injuries that occur at intersections by five percent from the previous year through 2029.

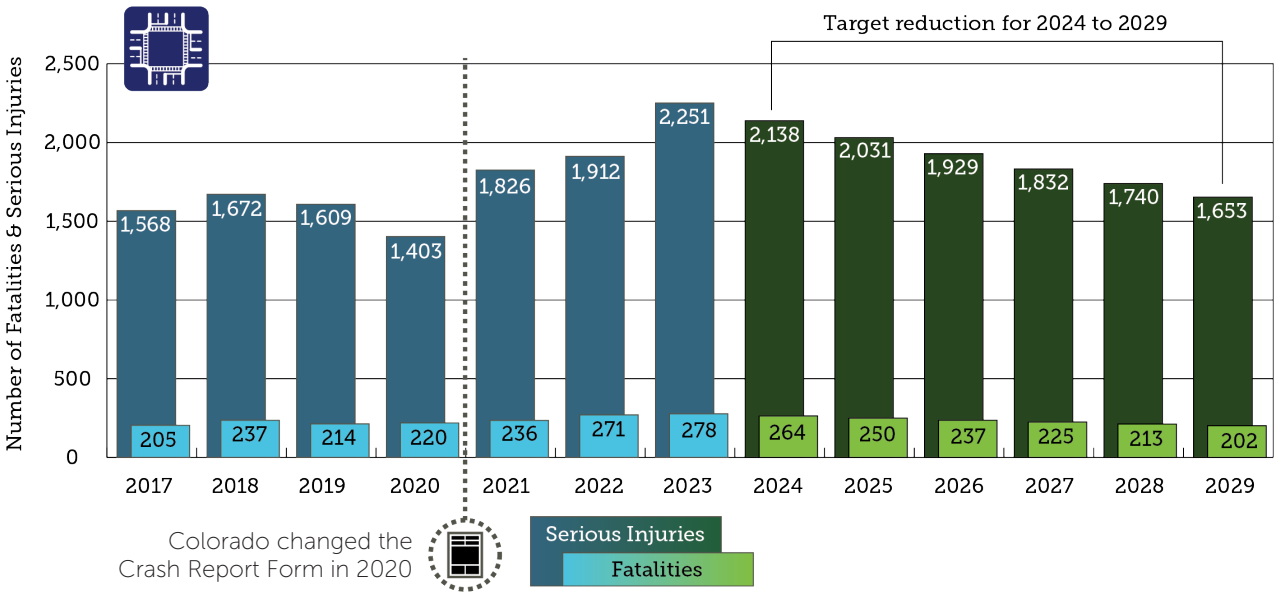
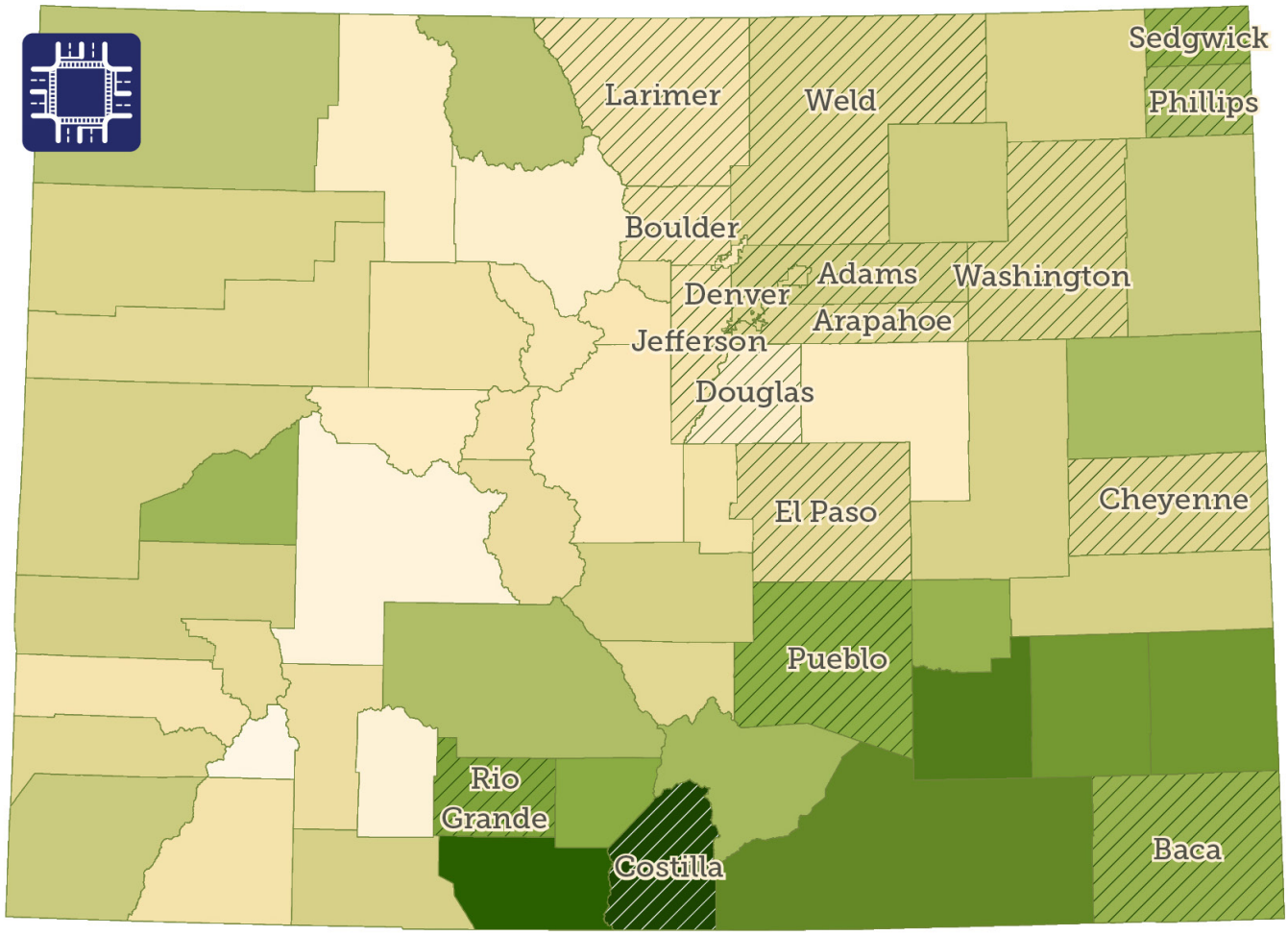


Figure 8-7: Intersection-Involved Fatalities and Serious Injuries by Year (2017 to 2023)

Intersections are points where two or more roads cross or meet, bringing together different road users and increasing the chance of collisions. Figure 8-7 defines intersection related crashes as crashes that occur at intersections, but does not include driveway access related crashes. The severity of a crash depends on factors like the angle of impact, speed, and the size of the vehicles involved. Intersections account for 56% of all reported crashes and 51% of all fatal and serious injury crashes in Colorado (Figure 8-1). From 2017-2023, there has been a consistent upward trend in the number of fatalities and serious injuries occurring at intersections (Figure 8-7). In 2023, intersection crashes resulted in 278 fatalities and 2,251 serious injuries. Addressing intersection-related crashes is critical to reducing the overall number of severe crashes statewide.

Figure 8-8: Top Counties of Intersection-Involved Fatalities and Serious Injuries



Rank	Top Counties Overall	Top Counties per Capita
1	Denver*	Phillips
2	El Paso	Denver*
3	Arapahoe	Sedgwick
4	Adams*	Baca
5	Jefferson	Washington
6	Boulder*	Boulder*
7	Weld	Costilla
8	Larimer	Rio Grande
9	Douglas	Adams*
10	Pueblo	Cheyenne

* represented in both top and per capita categories

Map Legend

Weighted TDI Score

Low — High

Diagonal Striping = Top 10 overall and/or per capita counties

This map shows the Transportation Disadvantage Index (TDI) and labels the top 10 counties for total fatalities and serious injuries, along with the top 10 counties with the highest per-capita impact among relevant demographics. The table provides rankings for both categories.

Figure 8-8 shows the counties that have the highest number of intersection-involved fatalities and serious injuries. Top counties overall tend to be the more highly populated urban areas, which also have a higher density of intersections along the transportation network. On a per capita basis, Denver, Boulder, and Adams county are represented as well as rural counties to the east and south.

The three most prevalent crash types at intersections are broadside, approach-turn, and VRUs. Targeted efforts to raise awareness and reduce these crash types are key to mitigating intersection-related crashes.

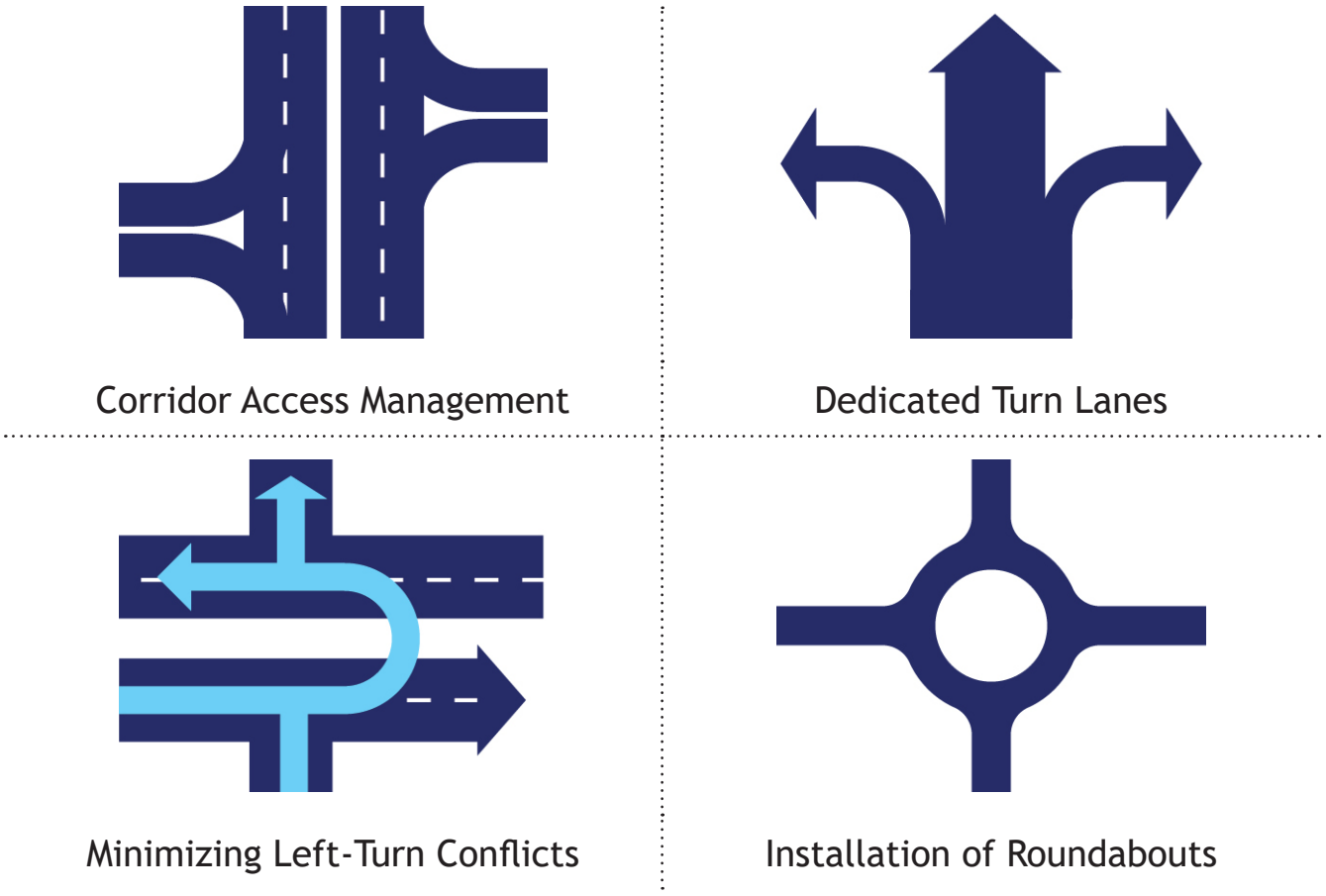


Figure 8-9: Key Safety Countermeasures to Reduce Intersection-Related Crashes

According to the U.S. Department of Transportation (USDOT), corridor access management, dedicated turn lanes, minimizing left-turn conflicts, and roundabouts are safety countermeasures proven to reduce intersection-related crashes. These proven countermeasures reduce crash severity by managing impact forces on drivers, occupants, and all other road users. Not all intersection types are familiar to road users; education and training can help individuals properly navigate intersections safely.

Intersection Strategies

SR5: Reduce intersection conflicts

Implement design and operational improvements that reduce the number of conflicts at intersections, especially those experiencing a high number of severe broadside and approach-turn crashes (Aging Pedestrian Strategy).

This strategy aims to reduce intersection conflicts that often result in broadside or approach turn crashes, accounting for 54% of all fatal and serious injury crashes. Good access management principles reduce or eliminate these conflicts at intersections by combining accesses, reducing the allowable movements at intersections, or implementing alternative routes such as service roads on high-traffic roadways. Alternative or innovative intersection types can have fewer conflicts by design.

SR6: Perform Intersection Control Evaluations (ICE)

Perform ICE prior to upgrading or constructing intersection improvements.

This strategy emphasizes the importance of preemptively addressing crashes through the application of a data-driven, performance-based framework to screen intersection alternatives and select an optimal solution.

SR7: Incorporate VRU designs

Incorporate project design elements to improve safety for Vulnerable Road Users (VRUs) where there is a high number of fatal/serious injury VRU crashes (Aging Pedestrian Strategy).

Intersections create additional risk for pedestrians and bicyclists. Traditionally, intersection design has prioritized motorists over VRUs. This strategy shifts focus to designing intersection improvements that enhance safety for VRUs, particularly pedestrians, utilizing proven safety countermeasures.

SR8: Prioritize high-risk intersection locations

Improve safety at high-risk intersections by addressing design deficiencies such as inadequate lighting, insufficient sight distance, and substandard turning radii.

Data analysis identifies over 3,000 severe crashes at intersections with poor lighting or insufficient visibility, with pedestrian crashes disproportionately common. This strategy addresses intersection deficiencies to enhance driver and pedestrian safety. FHWA identifies having greater sight distances at an intersection as a proven countermeasure that can greatly improve safety at an intersection.

SR9: Implement improved traffic controls

Implement improved traffic controls at intersections with a high frequency of broadside, approach turn, and rear-end fatal and serious injury crashes (Aging Drivers & Pedestrians Strategy).

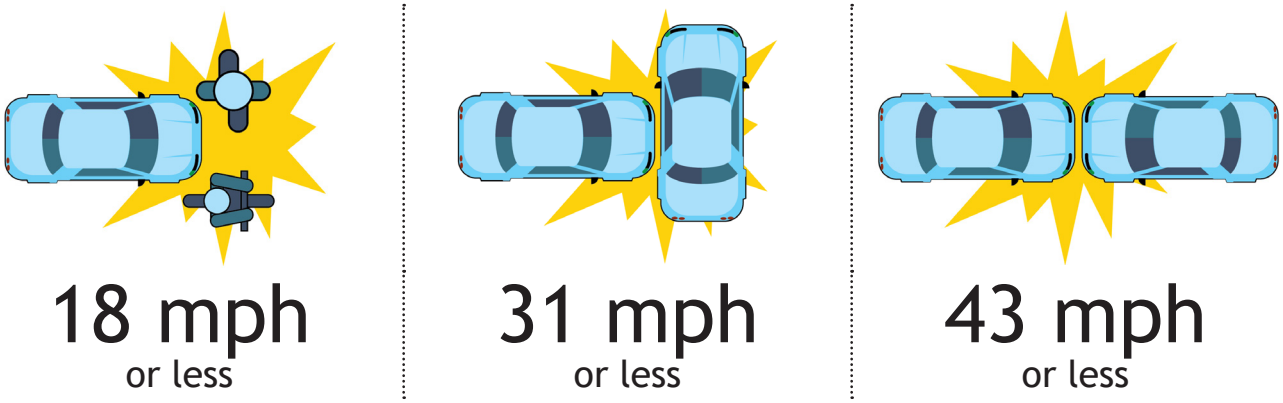
In situations where physical improvements are infeasible, this strategy focuses on cost-effective traffic control measures to reduce the frequency of severe crashes. Targeted improvements include enhanced striping and signage, signal systems, and other traffic control measures to mitigate crash risk.

Speed Management

Focus Area Definition: Roadway safety issues that are related to speed fostered by the roadway environment.

Focus Area Goal: Reduce the number of fatalities and serious injuries occurring at high speed by five percent from the previous year through 2029.

Vehicles traveling at higher speeds increase both the probability and severity of crashes. Higher speeds reduce the available time for a driver to perceive and react to an unexpected event. Further, higher speeds result in larger kinetic energy transfer to the human body during a crash, leading to more severe crash outcomes.



According to the World Road Association (PIARC) Road Safety Manual, the distinction of what makes a safe speed varies by crash type.[10] Vulnerable road users (VRUs) such as pedestrians and bicyclists have the best chance of surviving a crash at impact speeds of 18 mph or less. Passenger car occupants involved in angle crashes or head-on crashes have the best chance of surviving at impact speeds of 31 mph and 43 mph or less, respectively.

Figure 8-10: Maximum Survival Speed by Crash Type

Driver speed is a psychological factor and driver, vehicle, roadway, and environmental characteristics are all factors that influence driving speeds. This Focus Area promotes roadway infrastructure design elements that encourage lower speeds, thus reducing crash risk and severity. Because Colorado's crash report does not provide detailed roadway characteristics, a crash summary is not available for the Speed Management Focus Area.

Most drivers will select a speed they consider appropriate for the conditions. This decision is dependent on several factors, including the driver's perception of risk, traffic flow (i.e., the speed of other vehicles around them), and road design. Specific roadway design characteristics that influence driver speed choice include cross-sectional elements (e.g., number of lanes, lane width, shoulder width, and median type), access point density and intersection spacing, horizontal curvature, vertical grades, roadside conditions, and sight distance.

10 The Safe System Approach," The Safe System Approach | Road Safety Manual - World Road Association (PIARC), accessed December 13, 2024, https://roadsafety.piarc.org/en/road-safety-management/safe-system-approach.

Roadways have two primary transportation functions: mobility and access. Roadway classification describes where different categories of roadways fall within these functions. Very high mobility roadways (e.g., freeways and expressways) permit less access to adjacent land while minor roads (e.g., residential local streets) have much lower mobility but a high level of access. Arterials and collectors fall between these two extremes with arterials providing a higher level of mobility and collectors providing a higher level of access.

Principal Arterial and Minor Arterial roadways account for nearly 60% of all fatal crashes (Figure 8-11), while only accounting for 40% of the total vehicle miles traveled (VMT). Crashes on these roadway types are disproportionately high when exposure is considered. In Colorado, interstate highways account for 15% of all fatal crashes, while accounting for 28% of all VMT. On a miles traveled basis, interstate highways are safer than arterials. The Principal Arterial and Minor Arterial roadway environment and how it contributes to speeding and other crash contributing factors are key subjects of this Focus Area.

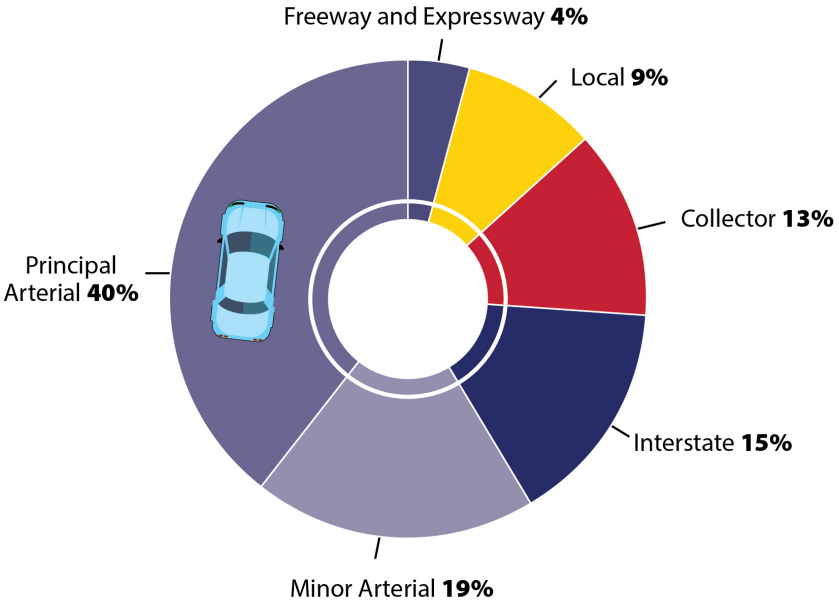


Figure 8-11: Fatal Crashes by Roadway Classification

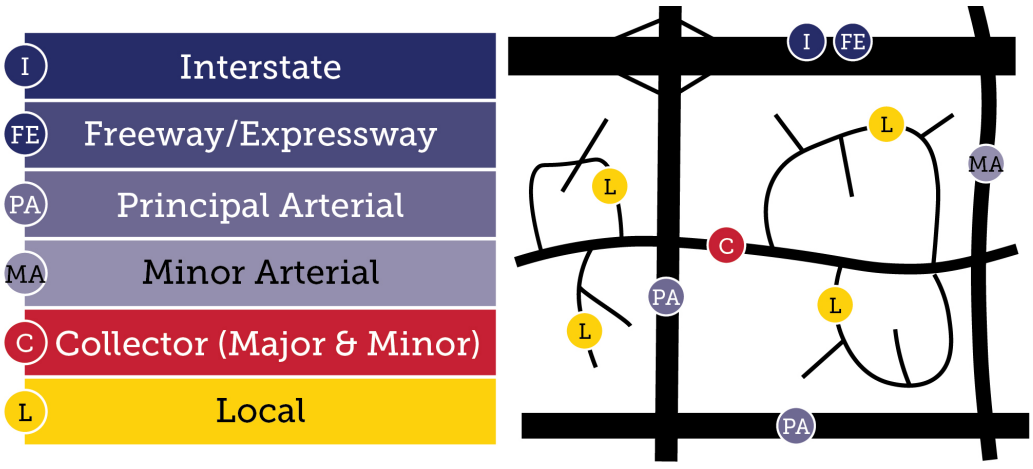


Figure 8-12: Typical Features of Roadway Functional Classifications

Speed Management Strategies

SR10: Promote appropriate speeds

Modify the transportation system to promote appropriate vehicle speeds at locations where higher speeds contribute to severe crashes.

Higher speeds carry more kinetic energy and decrease response times by drivers, which results in higher crash severities, especially in crashes involving VRUs. This strategy considers the design of the roadway environment and how it contributes to driver behavior. The goal is to implement transportation system improvements that encourage safer speeds. Some examples include bump-outs where there are pedestrian crossings or narrowing the perceived width of a roadway on high-speed segments.

SR11: Set safe and realistic speed limits

Set safe and realistic speed limits by considering contextual factors such as road function, land use, traffic volume, active transportation activity, crash history, environmental conditions, and road design.

This strategy encourages the use of context-sensitive speed limit setting practices. Context-sensitive speed limits consider factors such as road function, land use, traffic volume, pedestrian activity, crash history, environmental conditions, and road design. While lower speed limits generally improve crash outcomes, areas where drivers feel comfortable traveling at higher speeds require careful consideration to prevent speed differentials that contribute to increased crash risk.