SS4A PLAN

WAMPO Comprehensive Safety Action Plan Engineering Toolbox

SAFETY ENGINEERING TOOLBOX

A Comprehensive Safety Action Plan (CSAP) looks at the entire road network in a geographic area, in this case the Wichita Area (WAMPO Region) and studies crash data and factors to make countermeasure recommendations with the eventual goal of zero road deaths and serious injuries.

This Toolbox was developed to support implementation of the WAMPO CSAP through providing countermeasures for the key goals of: reducing conflicts at intersections, creating safer roads for all road users, and employing tactics to reduce vehicle speeds. This Toolbox was created with the guidance of FHWA Proven Safety Countermeasures and follows Safe System Approach (SSA) principles. It acknowledges that severe crash outcomes are preventable, despite the inevitability of human error, and integrates this mindset in the pursuit of zero fatalities and serious injuries on WAMPO-area roads. The SSA is structured around the following five complementary objectives: Safe Roads, Safe Speeds, Safe Road Users, Safe Vehicles, and Post-Crash Care. Layering these together creates redundancy, so that if one component fails, the others are still in place to prevent severe outcomes. Metropolitan Planning Organizations such as WAMPO have limited ability to influence Safe Vehicles or Post-Crash Care, so this toolbox focuses on the other three SSA elements: Safe Roads, Safe Speeds, and Safe Road Users.

To support the goals of the SSA, The Transportation Safety Technical Advisors (TSTA) identified safety solutions for each of the SSA elements. This includes Safe Roads strategies for **Roadway Departure**, and Safe Road User strategies for enforcement and education.

In addition to the SSA safety solutions, the TSTA chose three Emphasis Areas. Emphasis Areas focus on specific types of crashes to help direct resources and guide safety improvements where there is the greatest need. These were identified in the development of the CSAP through a data review process and organized discussions with the TSTA. Ultimately three Emphasis Areas were chosen to focus resources and efforts: **Intersections, Speed, and Vulnerable Road Users (VRUs).**

The Toolbox provides engineering recommendations for each of these Emphasis Areas and SSA additional areas of focus. Efforts are intended to focus on fatal and serious injury crashes rather than looking to prevent property damage only crashes.

The TSTA identified “priority countermeasures” as the best for implementing systemically to move toward Vision Zero goals. Additional infrastructure countermeasures were identified for consideration on a case-by-case basis of the site as well as education and enforcement opportunities.

The toolbox below includes:

- a photo or graphic of each type of infrastructure countermeasure,
- a description of the safety benefit each tool can provide,
- information about which emphasis areas are addressed by each tool

- estimated costs -
  - **$** less than $20,000
  - **$$** less than $250,000
  - **$$$** less than $1,000,000
  - **$$$$** more than $1,000,000
- a Crash Modification Factor (CMF), which is the potential anticipated reduction in overall crashes expected after implementing the countermeasure,
- any other information or related web links, and
- anticipated effectiveness (for education and enforcement countermeasures).

WAMPO Priority Countermeasures

The WAMPO TSTA identified the following priority countermeasures as ones that given the data, drivers, and location, would be best for implementing systemically to move toward Vision Zero goals.

Countermeasure:	Leading Pedestrian Interval	High-Visibility Crosswalk	Backplates with Retroreflective Boarders	Turning Vehicles Yield to Pedestrian Signage at Intersections with High Pedestrian Traffic
Image/Graphic:				
How it Works:	A leading pedestrian interval (LPI) gives pedestrians the opportunity to enter the crosswalk at an intersection 3-7 seconds before vehicles are given a green indication. Pedestrians can better establish their presence in the crosswalk before vehicles have priority to turn right or left. There is also a secondary benefit as this increased all-red time for motorized traffic can also help reduce angle crashes between vehicles.	High-visibility crosswalks use patterns (i.e., bar pairs, continental, ladder) that are visible to both the driver and pedestrian from farther away compared to traditional transverse line crosswalks. They should be considered at all midblock pedestrian crossings and uncontrolled intersections. Agencies should use materials such as inlay or thermoplastic tape, instead of paint or brick, for highly reflective crosswalk markings.	Backplates added to a traffic signal head improve the visibility of the illuminated face of the signal by introducing a controlled-contrast background. The improved visibility of a signal head with a backplate is made even more conspicuous by framing it with a 1- to 3-inch yellow retroreflective border. Signal heads that have backplates equipped with retroreflective borders are more visible and conspicuous in both daytime and nighttime conditions.	Adding signage to increase driver attention of high-volume pedestrian movements may help assist in visibility of vulnerable road users.
Emphasis Areas Addressed:	Vulnerable Road Users (VRUs)	VRUs	Intersections	VRUs
Estimated Cost:	**$** (existing signal), **$$** (new signal)	**$**	**$**	**$**
Anticipated CMF:	0.41	0.60	0.85	Not Studied
Other Information:	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Leading%20Pedestrian%20Interval_508.pdf	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Crosswalk%20Visibility%20Enhancements_508.pdf	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Backplates%20with%20Retroreflective%20Borders_508.pdf	FWHA: https://mutcd.fhwa.dot.gov/htm/2009/part2/part2b.htm#figure2B27

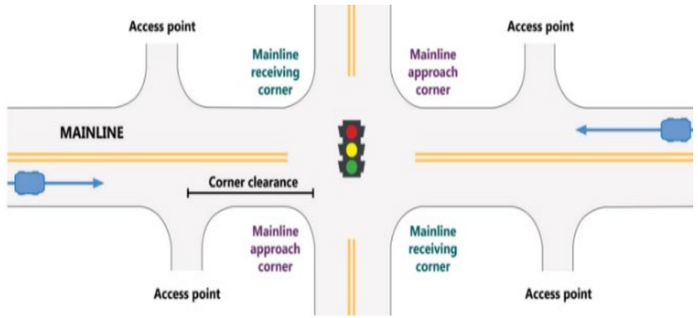
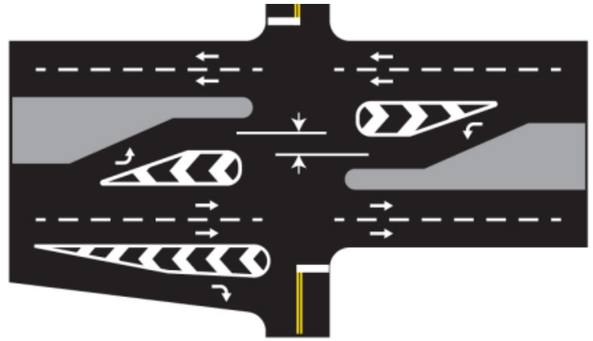
WAMPO Priority Countermeasures

The WAMPO TSTA identified the following priority countermeasures as ones that given the data, drivers, and location, would be best for implementing systemically to move toward Vision Zero goals.

Countermeasure:	VRU Education	Advanced Warning Signs Where Contextually Logical	Improved Pavement Markings for Vehicle Travel Lanes	Curb Extensions/Bulb Outs/Refuge Islands
Image/Graphic:				
How it Works:	Most of the educational components have revolved around the Share the Road program. The purpose of Share the Road programs is to increase drivers' awareness of bicyclists or other pedestrian rights and the need for mutual respect of VRU's on the roadway. Campaign education efforts are intended to improve the safety of all road users, including bicyclists and to enhance the understanding and compliance with relevant traffic laws. Bikes may use full lane signage clearly communicates roadway rules.	Advanced warning signs, especially around curves or other sight limiting areas, or where crash problems exist, allow drivers advance warning of decisions to changing conditions that they will need to make.	Clearly delineating travel lanes allows vehicles to better understand where they need to be located within the roadway. Enhancing retro-reflectivity provides better visual cues for drivers, especially during adverse conditions (nighttime, rain, snow, etc.).	Shortening the distance that a pedestrian must cross decreases the time they are in the roadway exposed to moving traffic. The "bulb outs" also increase the visibility of the pedestrian getting ready to cross a street. 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 and enables them to cross one direction of moving vehicular traffic at a time.
Emphasis Areas Addressed:	VRUs	Intersections	Roadway Departure	VRUs, Speed, Roadway Departure
Estimated Cost:	**$**	**$**	**$/mi**	**$ - $$**
Anticipated CMF:	CMF not defined	0.65	6" edge line 0.64 – 0.88 4" centerline 0.76	0.44
Other Information:	NHTSA Countermeasures Guide: https://www.nhtsa.gov/book/countermeasures/countermeasures/42-share-road-awareness-programs	Some are included (Stop Ahead, Curve Warning, etc.) in FHWA proven countermeasures and the CMF Clearinghouse depending on the application.	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Medians%20and%20Pedestrian%20Refuge%20Islands_508.pdf

WAMPO Priority Countermeasures

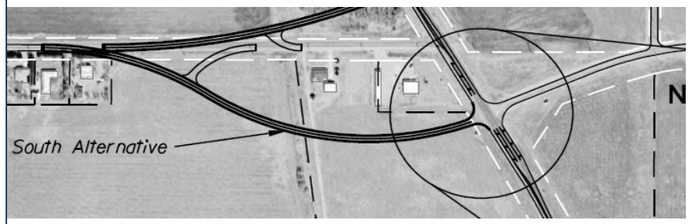
The WAMPO TSTA identified the following priority countermeasures as ones that given the data, drivers, and location, would be best for implementing systemically to move toward Vision Zero goals.

Countermeasure:	Complete Streets/Designing for all Users	Access Control Through Medians	Dedicated Left-Turn Lanes & Left Turn Signal Phasing on Appropriate Roadways
Image/Graphic:			
How it Works:	Complete Streets are streets for everyone. Complete Streets is an approach to planning, designing, building, operating, and maintaining streets that enables safe access for all people who need to use them, including pedestrians, bicyclists, motorists and transit riders of all ages and abilities.	Thoughtful access management along a corridor can simultaneously enhance safety for all modes, facilitate walking and biking, and reduce trip delay and congestion.	Auxiliary turn lanes—either for left turns or right turns—provide physical separation between turning traffic that is slowing or stopped and adjacent through traffic at approaches to intersections. Turn lanes can be designed to provide for deceleration prior to a turn, as well as for storage of vehicles that are stopped and waiting for the opportunity to complete a turn.
Emphasis Areas Addressed:	VRUs, Speed, Intersections	VRUs, Speed, Roadway Departure	Intersections
Estimated Cost:	Varies depending on treatments	**$$** / 100 feet	**$-$$$** /leg
Anticipated CMF:	Varies depending on treatments	0.69-0.95	0.52-0.72
Other Information:	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php?qst=complete%20streets	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Corridor%20Access%20Management_508.pdf	CMF changes depending on configuration; FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Left-%20and%20Right-Turn%20Lanes_508.pdf

Intersection Countermeasures

Emphasis Area

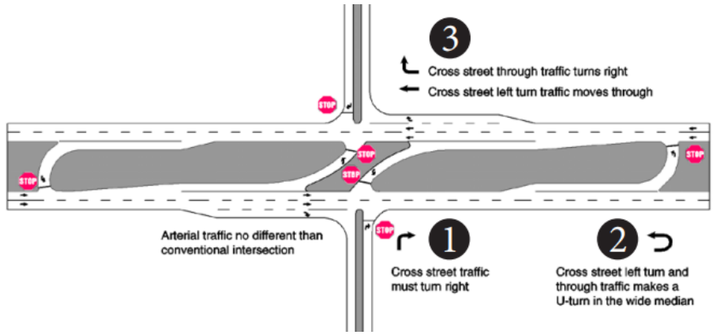
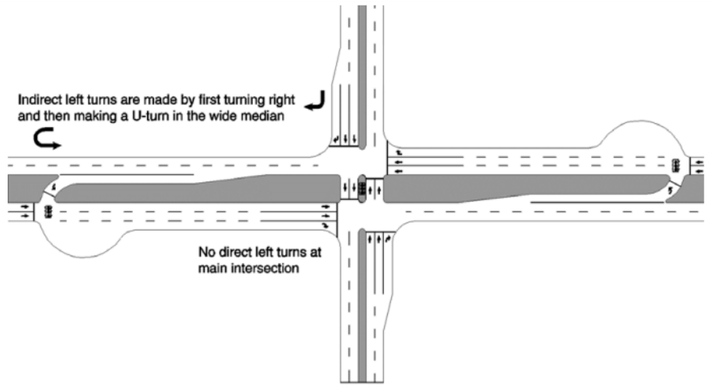
Intersections are defined as two or more roads that intersect and can be signalized or unsignalized. Intersections create several conflict points, resulting in a higher likelihood of a crash.

Countermeasure:	Improved Geometry	Roundabout	Consistent Yellow and All-Red Timings	Improved Signal Phasing/Timing Plans
Image/Graphic:				
How it Works:	Geometry improvements such as positive offset of left turn lanes, skew elimination, and sight distance improvements all can have great effects on the number of crashes in the intersection.	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. The net result of lower speeds and reduced conflicts at roundabouts is an environment where crashes that cause injury or fatality are substantially reduced.	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. Consistent yellow and all red time throughout a region can help motorists to gauge when to begin braking as they approach a changing signal.	Traffic signal coordination could decrease total crashes by 21%, injury crashes by 52% and property-damage-only crashes by 21%. Signal coordination has also been shown to improve speed harmonization due to drivers learning the speed that the signals are coordinated for.
Emphasis Areas Addressed:	VRUs, Speed, Intersections, Roadway Departure	Speed, Intersections	Intersections	Speed, Intersections
Estimated Cost:	**$$-$$$$**	**$$$$**	**$**	**$**
Anticipated CMF:	Varies	0.18	0.5-0.6	0.79
Other Information:	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Roundabouts_508.pdf	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Yellow%20Change%20Intervals_508.pdf	CMF Clearinghouse: https://www.cmfclearinghouse.org/detail.php?facid=9870

Intersection Countermeasures

Emphasis Area

Intersections are defined as two or more roads that intersect and can be signalized or unsignalized. Intersections create several conflict points, resulting in a higher likelihood of a crash.

Countermeasure:	Restricted Crossing U-Turn (RCUT)	Median U-Turn (MUT)	Turbo Roundabout
Image/Graphic:			
How it Works:	The restricted crossing U-turn (RCUT) intersection, also known as a J-Turn, Superstreet, or Reduced Conflict Intersection, modifies the direct left-turn and through movements from cross-street approaches. Minor road traffic makes a right turn followed by a U-turn at a designated location—either signalized or unsignalized—to continue in the desired direction.	The median U-turn (MUT) intersection modifies direct left turns from the major approaches. Vehicles proceed through the main intersection, make a U-turn a short distance downstream, followed by a right turn at the main intersection. The U-turns can also be used for modifying the cross-street left turns, similar to the RCUT. The MUT is an excellent choice for intersections with heavy through traffic and moderate left-turn volumes. Studies have shown a 20 - 50% improvement in intersection throughput for various lane configurations as a result of implementing the MUT design. When implemented at multiple intersections along a corridor, the efficient two-phase signal operation of the MUT can reduce delay, improve travel times, and create more crossing opportunities for pedestrians and bicyclists.	A turbo roundabout has the same operating characteristics as modern roundabouts but utilizes notably different geometrics to address the conflicts associated with the common crash types in multilane roundabouts.
Emphasis Areas Addressed:	Intersections	VRUs, Intersections	Speed, Intersections
Estimated Cost:	**$$$-$$$$**	**$$$-$$$$**	**$$$$**
Anticipated CMF:	0.46	0.70	0.24
Other Information:	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Reduced%20Left-Turn%20Conflict%20Intersections_508.pdf	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Reduced%20Left-Turn%20Conflict%20Intersections_508.pdf	CMF Clearinghouse: https://www.cmfclearinghouse.org/detail.php?facid=2121 FHWA guide: https://highways.dot.gov/sites/fhwa.dot.gov/files/2022-06/fhwasa19027_0.pdf

Intersection Countermeasures

Emphasis Area

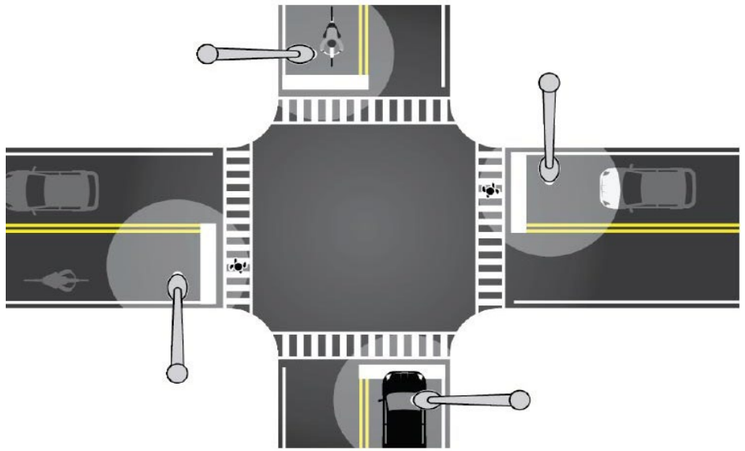
Intersections are defined as two or more roads that intersect and can be signalized or unsignalized. Intersections create several conflict points, resulting in a higher likelihood of a crash.

Countermeasure:	Diverging Diamond Interchange (DDI)	Rectangular Rapid Flashing Beacon (RRFB)	Traffic Calming	Flashing Beacons on Warning Signs (Intersection)
Image/Graphic:				
How it Works:	The diverging diamond interchange (DDI), also known as double crossover diamond, is a new design that is a variation of the conventional diamond interchange. The main difference between a DDI and a conventional diamond interchange is the crossing (or channelizing) of the traffic on the crossroad to the left side between the ramp terminals.	To enhance pedestrian conspicuity and increase driver awareness at uncontrolled, marked crosswalks, transportation agencies can install a pedestrian actuated Rectangular Rapid Flashing Beacon (RRFB) to accompany a pedestrian warning sign. RRFBs consist of two, rectangular- shaped yellow indications, each with a light-emitting diode (LED)-array-based light source. RRFBs flash with an alternating high frequency when activated to enhance conspicuity of pedestrians at the crossing to drivers.	Traffic calming reduces automobile speeds or volumes, mainly through the use of physical measures, to improve the quality of life in both residential and commercial areas and increase the safety and comfort of walking and bicycling.	Adding flashing beacons on warning signs increases driver awareness and recognition of upcoming problems and potential conflicts.
Emphasis Areas Addressed:	Intersections	VRUs, Intersections	Speed, Intersections, VRUs	Intersections
Estimated Cost:	**$$$$**	**$$**	**$-$$**	**$**
Anticipated CMF:	0.42-0.85	0.53	Varies Depending on Treatment	Varies Depending on Application
Other Information:	MF Varies depending on existing condition; CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/RRFB_508.pdf	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php

Intersection Countermeasures

Emphasis Area

Intersections are defined as two or more roads that intersect and can be signalized or unsignalized. Intersections create several conflict points, resulting in a higher likelihood of a crash.

Countermeasure:	Intersection Conflict Warning System	Street Lighting	Retroreflective Strips on Signposts
Image/Graphic:			
How it Works:	Providing an automated real-time system to inform drivers of suitability of available gaps for making turning and crossing maneuvers is a recommended strategy in Volume 5 of the NCHRP 500 Series Guidebooks. These systems may be installed on the major and/or minor approaches of unsignalized intersections with stop-control on the minor approaches. They employ vehicle detectors to alert motorists of conflicting vehicles on an adjacent approach. Current installation practices use warning signs on the major approaches alerting motorists with a message.	At nighttime, vehicles traveling at higher speeds may not have the ability to stop once a hazard or change in the road ahead becomes visible by the headlights. Therefore, lighting can be applied continuously along segments and at spot locations such as intersections and pedestrian crossings in order to reduce the chances of a crash.	Retroreflective strips on signposts increase the visibility of the signpost. Adjusting the height and angle of the retro-reflectivity, can also increase viewability. Initial studies have shown great efficacy, but CMF's have not been adopted by the FHWA.
Emphasis Areas Addressed:	Intersections	VRUs, Intersections, Roadway Departure	Roadway Departure, Intersections
Estimated Cost:	**$$**	**$-$$**/each	**$**
Anticipated CMF:	0.7	0.58	CMF not defined
Other Information:	FHWA: https://www.fhwa.dot.gov/publications/research/safety/15076/ CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Lighting_508.pdf	https://safety.fhwa.dot.gov/hsip/hrrr/manual/sec48.cfm

Vulnerable Road User Countermeasures

Emphasis Area

Pedestrians and bicyclists are referred to as vulnerable road users because they are not protected by the outer shell of a vehicle.

Countermeasure:	Pedestrian Crossing Signals	Raised Crosswalk/Raised Intersection/Speed Table	Pedestrian Hybrid Beacons	Multi-Use Paths
Image/Graphic:				
How it Works:	Pedestrians typically cross streets based on perceptions of gaps between crossing traffic. Traffic signals allow gaps to be forced by stopping traffic and allowing pedestrians to cross at locations where traffic volumes are higher and do not allow for natural gaps between oncoming vehicles.	Raised crosswalks are ramped speed tables in the road that allow pedestrians to cross at the same level with the sidewalk, reducing vehicle speeds as they travel over the ramp and enhancing the pedestrian crossing environment.	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. The beacon head consists of two red lenses above a single yellow lens. The lenses remain “dark” until a pedestrian desiring to cross the street pushes the call button to activate the beacon, which then initiates a yellow to red lighting sequence consisting of flashing and steady lights that directs motorists to slow and come to a stop and provides the right-of-way to the pedestrian to safely cross the roadway before going dark again.	Shared use paths should be thought of as a complementary system of off-road transportation routes for vulnerable road users that serves as a necessary extension to the roadway network. Shared use paths provide a lower-stress, separate space for non-motorists of all ages. This separated space is most critical on higher volume, higher speed streets.
Emphasis Areas Addressed:	VRUs	Speed, VRUs	VRUs, Intersections	VRUs
Estimated Cost:	**$-$$**	**$**	**$$**	**$$$-$$$$**
Anticipated CMF:	Varies (formula based on ADT and area type)	0.64	0.45	0.75
Other Information:	CMF Clearinghouse: https://www.cmfclearinghouse.org/detail.php?facid=8480	CMF Clearinghouse: https://www.cmfclearinghouse.org/study_detail.php?stid=14	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Pedestrian%20Hybrid%20Beacons_508.pdf	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php

Vulnerable Road User Countermeasures

Emphasis Area

Pedestrians and bicyclists are referred to as vulnerable road users because they are not protected by the outer shell of a vehicle.

Countermeasure:	Shared Lane Markings	Buffered Bike Lanes/Bike Lanes	Calibrate Bike Detection for Bike Lanes
Image/Graphic:			
How it Works:	Sharrows are road markings that designate a space for both motorists and bicyclists. This allows for the combined use of bikes and motor vehicles, and can designate the best position within the lane for bicyclists to ride.	Providing bicycle facilities can mitigate or prevent interactions, conflicts, and crashes between bicyclists and motor vehicles, and create a network of safer roadways for bicycling. Bicycle lanes align with the Safe System Approach principle of recognizing human vulnerability—where separating users in space can enhance safety for all road users.	Bicycle detection is used at actuated signals to alert the signal controller of bicycle crossing demand on a particular approach. Bicycle detection occurs either through the use of push-buttons or by automated means (e.g., in-pavement loops, video, microwave, etc). Inductive loop vehicle detection at many signalized intersections is calibrated to the size or metallic mass of a vehicle. For bicycles to be detected, the loop must be adjusted for bicycle metallic mass. Otherwise, undetected bicyclists must either wait for a vehicle to arrive, dismount and push the pedestrian button (if available), or cross illegally.
Emphasis Areas Addressed:	VRUs	VRUs	VRUs, Intersections
Estimated Cost:	$	$-$$	$
Anticipated CMF:	Not Fully Studied	0.47	Not studied
Other Information:	https://cycling4safety.com/what-is-a-sharrow-are-they-safe/#:~:text=According%20to%20NACTO%20sharrows%20are%20road%20markings%20that,that%20the%20road%20could%20be%20safer%20for%20both	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Bicycle%20Lanes_508.pdf	https://nacto.org/publication/urban-bikeway-design-guide/bicycle-signals/signal-detection-and-actuation/

Vulnerable Road User Countermeasures

Emphasis Area

Pedestrians and bicyclists are referred to as vulnerable road users because they are not protected by the outer shell of a vehicle.

Countermeasure:	Bicycle Boulevard	Cycle Tracks	Curb Ramps
Image/Graphic:			
How it Works:	Signs and pavement markings create the basic elements of a bicycle boulevard. They indicate that a roadway is intended as a shared, slow street, and reinforce the intention of priority for bicyclists along a given route. Signs and pavement markings alone do not create a safe and effective bicycle boulevard, but act as reinforcements to other traffic calming and operational changes made to the roadway.	Cycle tracks are bikeways that are at street level and use a variety of methods for physical protection from passing traffic. A protected cycle track may be combined with a parking lane or other barrier between the cycle track and the motor vehicle travel lane.	Title II of the Americans with Disabilities Act (ADA) of 1990 requires that public entities, including state and local governments, ensure that persons with disabilities have access to the pedestrian routes in the public right of way. A curb ramp provides a flush, gradual transition from the sidewalk to the street level. It also includes detectable warnings (small truncated domes) where the ramp meets the vehicular area to serve as a warning to visually impaired pedestrians that they are about to leave the pedestrian space and enter the street.
Emphasis Areas Addressed:	Speed, VRUs	VRUs	VRUs
Estimated Cost:	**$**	**$$-$$$**	**$/ ramp**
Anticipated CMF:	Not Studied - Individual CMF's may be available	CMF: 0.55 - 2-5 meters from traveled way	CMF not Defined
Other Information:	NACTO: https://nacto.org/publication/urban-bikeway-design-guide/bicycle-boulevards/signs-and-pavement-markings/#design Small Town and Rural Design Guide: https://ruraldesignguide.com/mixed-traffic/bicycle-boulevard	CMF Clearinghouse: https://www.cmfclearinghouse.org/detail.php?facid=4034	https://www.access-board.gov/prowag/

Vulnerable Road User Countermeasures

Emphasis Area

Pedestrians and bicyclists are referred to as vulnerable road users because they are not protected by the outer shell of a vehicle.

Countermeasure:	Pedestrian Countdown Signals	Accessible Pedestrian Signals	Road Diet
Image/Graphic:			 
How it Works:	Pedestrian countdown signals show the walking man during the time a person walking may begin crossing the street. A hand comes up with the countdown of time remaining to cross. Pedestrians should not begin crossing during the countdown phase. The timing for each phase is based on the crossing time as indicated in the MUTCD.	Accessible pedestrian signals (APS) translate the pedestrian signal into audio information for people with visual impairments. Every time the APS is activated, the audio beacon indicates that the DON'T WALK phase has turned into the WALK phase.	A roadway reconfiguration known as a road diet offers several high-value improvements at a low cost by reallocating vehicular lanes. The primary benefits of a road diet include enhanced safety, mobility and access for all road users and a "complete streets" environment to accommodate a variety of transportation modes. A road diet can better align left turning vehicles, encourage safer speeds, and potentially add separated space for cyclists or transit.
Emphasis Areas Addressed:	VRUs	VRUs	Speed, VRUs
Anticipated CMF:	0.92	CMF not Defined	0.53
Estimated Cost:	**$**	**$**	**$$** (no resurfacing)
Other Information:	FHWA: https://highways.dot.gov/sites/fhwa.dot.gov/files/FHWA-HRT-19046.pdf#:~:text=This%20document%20is%20a%20technical%20summary%20of%20the,as%20part%20of%20its%20strategic%20highway%20safety%20effort.	https://www.access-board.gov/prowag/	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php

Speed Countermeasures

Emphasis Area

The speed that a motorist drives is heavily influenced by the roadway design, and crashes are more likely to be serious or fatal at improper speeds.

Countermeasure:	On-Pavement Markings for Speed Control	Transverse Rumble Strips	Enhanced Signing and Delineation	Road Safety Audits
Image/Graphic:				
How it Works:	By varying transverse pavement marking or chevrons closer together, a visual illusion of increased speed causes drivers to slow down.	Transverse rumble strips are used to alert drivers of a need to slow down or stop, or to other upcoming changes that may not be anticipated by an inattentive driver. These rumble strips are placed in the travel lane perpendicular to the direction of travel. They are typically used in non-residential areas as they can be noisy.	Enhanced delineation treatments can alert drivers to upcoming curves, the direction and sharpness of the curve, and appropriate operating speed.	While most transportation agencies have established traditional safety review procedures, a road safety audit (RSA) or assessment is unique. RSAs are performed by a multidisciplinary team independent of the project. RSAs consider all road users, account for human factors and road user capabilities, are documented in a formal report, and require a formal response from the road owner.
Emphasis Areas Addressed:	Speed, Roadway Departure	Speed, Roadway Departure	Speed, Roadway Departure	Speed, Roadway Departure, VRUs, Intersections
Estimated Cost:	**$**	**$/location**	**$/curve**	**$$/each**
Anticipated CMF:	0.68	0.66-0.73	0.8	Varies: 0.4-0.9
Other Information:	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Enhanced%20Delineation%20for%20Curves_508.pdf	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Road%20Safety%20Audits_508.pdf

Roadway Departure Countermeasures

SSA principal of Safer Roads

For roadway segments, if countermeasures can be implemented to prevent leaving the roadway or making it more recoverable if the motorist leaves the roadway, it will allow safer driving.

Countermeasure:	Relocating/Moving/Shielding Fixed objects.	Post Mounted Delineators	Paved Shoulders
Image/Graphic:			
How it Works:	Roadside design improvements can be implemented alone or in combination and are particularly recommended at horizontal curves—where data indicates a higher risk for roadway departure fatalities and serious injuries. Roadside design improvements provide for a safe recovery by providing a clear zone that is an unobstructed, traversable roadside area that allows a driver to stop safely or regain control of a vehicle that has left the roadway. Agencies should avoid adding new fixed objects such as trees and utility cabinets or poles in the clear zone.	Improving curve delineations helps prevent roadway departures from the mainline pavement by showing drivers where the edge of shoulder is. This is also helpful at night.	Paving shoulders has shown good decreases in crashes; allowing better recovery for roadway departures. Paved shoulders are often combined with edgeline rumble strips.
Emphasis Areas Addressed:	Roadway Departure	Roadway Departure	Roadway Departure
Estimated Cost:	**$-$$/object**	**$**	**$$**
Anticipated CMF:	0.56	0.72-0.82	Varies
Other Information:	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Roadside%20Design%20Improvements%20at%20Curves_508.pdf	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Roadside%20Design%20Improvements%20at%20Curves_508.pdf

Roadway Departure Countermeasures

SSA principal of Safer Roads

For roadway segments, if countermeasures can be implemented to prevent leaving the roadway or making it more recoverable if the motorist leaves the roadway, it will allow safer driving.

Countermeasure:	High Friction Surface Treatment	6" Retroreflective Edgeline	6" Retroreflective Centerline
Image/Graphic:			
How it Works:	High friction surface treatment (HFST) involves the application of very high-quality aggregate to the pavement using a polymer binder to restore and/or maintain pavement friction at existing or potentially high crash areas. The higher pavement friction helps motorists maintain better control in both dry and wet driving conditions. HFST results in more efficient and effective installations when using continuous pavement friction data along with crash and roadway data.	If drivers cannot clearly identify the edge of the travel lanes and see the road alignment ahead, the risk of roadway departure may be greater. Wider edge lines enhance the visibility of travel lane boundaries compared to traditional edge lines. Edge lines are considered “wider” when the marking width is increased from the minimum normal line width of 4 inches to the maximum normal line width of 6 inches.	If drivers cannot clearly identify the edge of the travel lanes and see the road alignment ahead, the risk of crossing to adjacent lanes is greater. Wider centerlines enhance the visibility of travel lane boundaries compared to traditional edge lines. Centerlines are considered “wider” when the marking width is increased from the minimum normal line width of 4 inches to the maximum normal line width of 6 inches.
Emphasis Areas Addressed:	Roadway Departure	Roadway Departure	Roadway Departure
Estimated Cost:	**$$**	**$**	**$**
Anticipated CMF:	0.37	0.63	0.33
Other Information:	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Pavement%20Friction%20Management_508.pdf	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Wider%20Edge%20Lines_508.pdf	CMF Clearinghouse: https://www.cmfclearinghouse.org/detail.php?facid=1692

Roadway Departure Countermeasures

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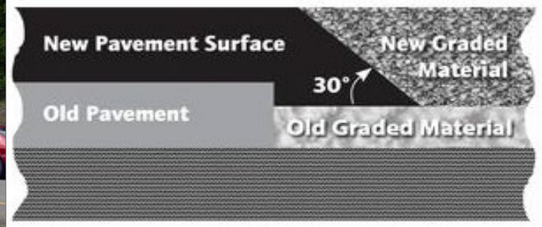
Countermeasure:	Flattening and Widening Foreslopes	Median Barrier	2' Paved Shoulder with Safety Edge	Longitudinal Rumble Strips
Image/Graphic:				
How it Works:	Flattening and widening foreslopes allows a more recoverable slope when a vehicle runs off the road, can help prevent roll-over, and potentially can decrease the clear zone distance required.	Median barriers are longitudinal barriers 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.	The SafetyEdgeSM technology shapes the edge of the pavement at approximately 30 degrees from the pavement cross slope during the paving process. This safety practice eliminates the potential for vertical drop-off at the pavement edge, helping to reduce instability of vehicles as they leave the pavement edge and/or attempt to recover back to the pavement. Additionally, this feature has minimal effect on project cost, and can improve pavement durability by reducing edge raveling of asphalt.	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. These are typically used in non-urban areas due to noise levels.
Emphasis Areas Addressed:	Roadway Departure	Roadway Departure	Roadway Departure	Roadway Departure
Estimated Cost:	**$$**	**$$**	**$$**	**$**
Anticipated CMF:	Varies	Varies; depending on crash types	0.65-0.9	Varies
Other Information:	FHWA Proven Countermeasures: https://highways.dot.gov/sites/fhwa.dot.gov/files/Enhanced%20Delineation%20for%20Curves_508.pdf	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Median%20Barriers_508.pdf	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/SafetyEdge_508.pdf	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Longitudinal%20Rumble%20Strips_508.pdf

Roadway Departure Countermeasures

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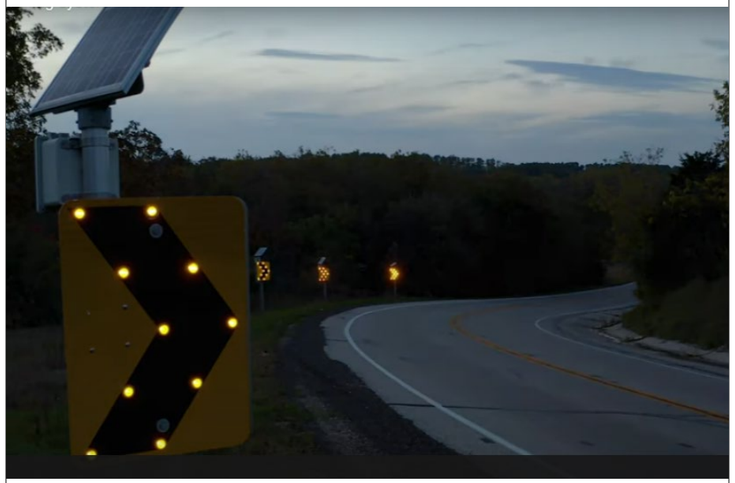
Countermeasure:	Install or Update Curve Signage and Chevron Placement	Speed Activated Flashers	Superelevation Correction
Image/Graphic:			
How it Works:	Enhanced delineation at horizontal curves includes a variety of potential strategies that can be implemented in advance of or within curves, in combination, or individually. Chevrons can be retro-reflective and improve visibility of the curve in both light and dark conditions.	Speed activated flashers on chevrons in a curve have shown significant decreases in crashes although the study CMF's have not yet been adopted by the FHWA. By activating the flashers dynamically, it keeps drivers from getting used to them constantly being on.	Correcting and reshaping the roadway superelevation (banking of the curve) to meet posted speed, or where crashes have occurred, allows an increased friction with pavement.
Emphasis Areas Addressed:	Roadway Departure	Roadway Departure	Roadway Departure, Speed
Estimated Cost:	$	$	$$-$$$
Anticipated CMF:	0.65	CMF not currently defined	Varies: Formula based
Other Information:	FHWA Proven Countermeasure: https://highways.dot.gov/sites/fhwa.dot.gov/files/Enhanced%20Delineation%20for%20Curves_508.pdf	https://www.tapconet.com/product/blinkerchevron-dynamic-curve-warning-system	CMF Clearinghouse: https://www.cmfclearinghouse.org/results.php

The National Highway Traffic Safety Administration (NHTSA) created a rating scale to rank the effectiveness of non-infrastructure countermeasures. The ratings are as follows:
★★★★★Demonstrated to be effective by several high-quality evaluations with consistent results
★★★★ Demonstrated to be effective in certain situations
★★★ Likely to be effective based on balance of evidence from high-quality evaluations or other sources
★★ Effectiveness still undetermined; different methods of implementing this countermeasure produce different results
★ Limited or no high-quality evaluation evidence
NHTSA Documentation

Education Countermeasures

SSA principal of Safer Road Users

NHTSA has developed a number of countermeasures associated with education campaigns.

Countermeasure:	Safe Routes to School Program	Pedestrian Safety Zones	Enforcement, Communications, and Outreach	Outreach Strategies for Low-Seatbelt Use Groups
How it Works:	The goal of Safe Routes to School (SRTS) programs is to increase the amount of bicycling and walking trips to and from school while simultaneously improving safety for children bicycling or walking to school.	The pedestrian safety zone concept was developed in a joint effort study by NHTSA and FHWA (Blomberg & Cleven, 1998). The idea is to strive for large decreases in pedestrian crashes and injuries by more effectively targeting resources to problem areas. Specifically, the objective of pedestrian safety zones is to increase cost-effectiveness of interventions by targeting education, enforcement, and engineering measures to geographic areas and audiences where significant portions of the pedestrian crash problem exist (NHTSA, 2008).	Effective, high-visibility communications and outreach are an essential part of successful traffic safety programs. Paid advertising can be a critical part of the media strategy. Paid advertising brings with it the ability to control message content, timing, placement, and repetition.	Communications and outreach campaigns directed at low-belt-use groups have been demonstrated to be effective for targeted programs that support, and are supported by, enforcement.
Emphasis Areas Addressed:	VRUs	VRUs	VRUs, Speed	Unrestrained Occupants
Anticipated Effectiveness:	★★★	★★★★	★★★★★	★★★★
Other Information:	https://www.nhtsa.gov/book/countermeasures/countermeasures/12-safe-routes-school	https://www.nhtsa.gov/book/countermeasures/countermeasures/41-pedestrian-safety-zones	https://www.nhtsa.gov/book/countermeasures/countermeasures/31-supporting-enforcement	https://www.nhtsa.gov/book/countermeasures/countermeasures/32-strategies-low-belt-use-groups

Enforcement Countermeasures **SSA principal of Safer Road Users** NHTSA has developed a number of countermeasures associated with enforcement campaigns.				
Countermeasure:	**Reduce and Enforce Speed Limits**	**Communications and Outreach Supporting Enforcement**	**High-Visibility Cell Phone/Text Messaging Enforcement**	**Short Term, High-Visibility Seat Belt Law Enforcement**
How it Works:	The goal of reducing motorist travel speeds is to increase reaction time for both drivers and pedestrians to avoid crashes, as well as reduce the severity of pedestrian injuries when these crashes occur. Higher vehicle speeds produce more frequent and more serious crashes and casualties.	The objective should be to provide information about the program, including expected safety benefits, and to persuade motorists that detection and punishment for violations is likely. Communications and outreach programs urging drivers to behave courteously or not to speed are unlikely to have any effect unless they are tied to enforcement. Campaign messages that are pre-tested to ensure they are relevant to the target audience and that reach the audience with sufficient intensity and duration to be perceived and noticed are most likely to be effective.	Similar to sobriety checkpoints, the objective is to deter cell phone use by increasing the perceived risk of a ticket. The High Visibility Enforcement (HVE) model combines dedicated law enforcement with paid and earned media supporting the enforcement activity.	The most common high-visibility seat belt law enforcement method consists of short (typically lasting 2 weeks), intense, highly publicized periods of increased belt law enforcement, frequently using checkpoints (in states where checkpoints are permitted), saturation patrols, or enforcement zones.
Emphasis Areas Addressed:	Speed	Speed	Distracted Driving	Unrestrained Occupants
Anticipated Effectiveness:	★★★	★★★	★★★★	★★★★★
Other Information:	https://www.nhtsa.gov/book/countermeasures/countermeasures/42-reduce-and-enforce-speed-limits	https://www.nhtsa.gov/book/countermeasures/countermeasures/41-communications-and-outreach-supporting-enforcement	https://www.nhtsa.gov/book/countermeasures/countermeasures/13-high-visibility-cell-phone-and-text-messaging-enforcement	https://www.nhtsa.gov/book/countermeasures/countermeasures/21-short-term-high-visibility-seat-belt-law-enforcement