ODOT's HSIP Countermeasures and Crash Reduction Factors

The intent of the Crash Reduction Factor (CRF) countermeasure table is to provide safety practitioners intending to use HSIP funding with a list of effective countermeasures that are appropriate remedies to many common safety issues. The countermeasures have been sorted into 2 primary categories: countermeasures eligible for Systemic Funding and countermeasures eligible for Hotspot Funding. Systemic Funding is further divided into Roadway Departure, Intersection or Bicycle & Pedestrian for informational use only. *It is important to note that all Systemic countermeasures may be used for Hotspot projects but Hotspot countermeasures cannot be used for Systemic projects*

The CRF Appendix describes in more detail where the countermeasure should be used, why they are effective and potential impediments to the implementation. The tables also include information on the type of crashes where the countermeasure is best used, the CRF value to use in the benefit-cost analysis and the acknowledged range of their overall effectiveness based on the research available.

The fixed set of CRFs included in these tables are intended to allow for all projects to be evaluated consistently and fairly throughout the project selection process. ODOT recognizes that there are many non-infrastructure and Bicycle/Pedestrian countermeasures that are not included on the list where CRF's have not been established yet. This list will be periodically reevaluated by ODOT to include more recent and/or reliable CRF countermeasures and values as new safety research data becomes available. ODOT is interested in any feedback and suggestions from safety practitioners on the overall countermeasure list as well as specific details of individual countermeasures. During the STIP Development Process, ODOT will take suggestions for countermeasures not on the list for Hotspot projects only. Please use the form provided at this website to submit your suggestion: http://www.oregon.gov/ODOT/HWY/TRAFFIC-ROADWAY/Pages/ARTS.aspx#Crash_Recuction_Factors. Please send all other feedback and suggestions to Zahidul Siddique (Zahidul.Q.Siddique@odot.state.or.us). They will be considered for inclusion in the next HSIP process for the next STIP cycle.

Where not otherwise specified, ODOT used the following references to establish the summarized CRF List and Appendix. Safety Practitioners are encouraged to utilize these references to better understand the listed countermeasures and the details surrounding their conception.

The Crash Modification Factors Clearinghouse
http://www.cmfclearinghouse.org/

Highway Safety Manual (HSM), First Edition, 2010
http://www.highwaysafetymanual.org

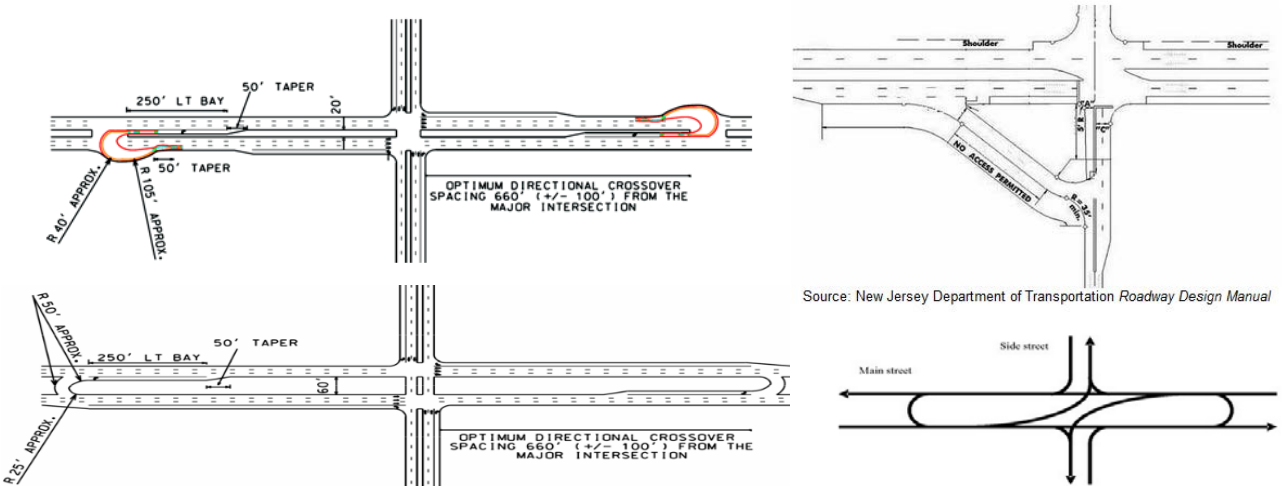
FHWA Desktop Reference for Crash Reduction Factors
http://safety.fhwa.dot.gov/tools/crf/resources/fhwasa08011/

A majority of our countermeasure guidance is taken directly from FHWA's website and the 2014 FHWA Publication: Manual for Selecting Safety Improvements on High Risk Rural Roads
This publication can be found at: http://safety.fhwa.dot.gov/hsip/hrrr/manual/hrrr_2014.pdf

HOTSPOT COUNTERMEASURES

Name: Median U-Turn Intersection Treatment	ODOT Countermeasure Number: H1

What is it: Can be J turns, loons or jug handle turns (see photo depictions below). Median U-Turn treatments are characterized by eliminating the direct left turn movement at an intersection. Depending on the type of median U-turn treatment, there could be further restrictions of directional movements at the intersection. The median U-turn treatment accommodates these movements by requiring drivers to turn right onto the main road and then make a U-turn maneuver at a one-way median opening.



Source: New Jersey Department of Transportation *Roadway Design Manual*

Photos from FHWA

Where to use: Can be implemented for signalized or unsignalized intersections. Median U- turn intersection treatments are typically implemented as part of a corridor treatment; however, they can be used at isolated intersections. Unsignalized median U-turn intersections preserve corridor capacity and can be installed without the adverse effects of signal control. Scenarios where J-turn intersections are most applicable include the following:

- Relatively low to medium side-street through volumes and heavy left turn volumes from the major road.
- The minor road total volume to total intersection volume ratio is typically less than or equal to 0.20.
- Areas where median widths are greater than 40 feet. For narrower medians, loons or bulb-outs on the shoulders need to be constructed.

For intersections with very high left turn and through volumes from the side road approaches, the J-turn intersection design is not the optimal choice.

Why it works: It reduces the number of conflict points at the intersection and preserves corridor capacity.

Impediments to Implementation: Requires a substantial amount of right of way which could be costly and have significant environmental and/or drainage impacts too.

General Notes: *This countermeasure shall be paired with turning restrictions at the intersection*

Crash Types Addressed	Severity Type Addressed
All	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
30%	**30%**

Name: Right Turn Lane on Single Major Road Approach: Unsignalized Intersection (3- or 4-leg)	ODOT Countermeasure Number: H2

What is it: A right turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of right turn vehicles as they approach an intersection.

Photo from ODOT

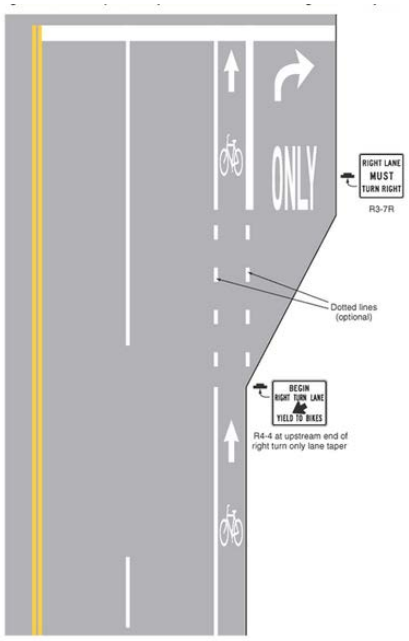


Photo from FHWA

Where to use: At intersections with a high frequency of rear end crashes resulting from conflicts between a) vehicles turning right and following vehicles and b) vehicles turning right and through vehicles coming from the left on the cross street.

Why it works: Providing a right turn lane at an intersection can reduce rear-end crashes by allowing vehicles to proceed through the intersection without having to stop or slow down for vehicles making a right turn.

Impediments to Implementation: This countermeasure may require a significant amount of right of way. Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes.

General Notes: This countermeasure CRF value can only be used for installation of a right turn lane on ONE major road approach at a 3-leg or 4-leg UNSIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
14 - 26%	**14%**

Name: Right Turn Lane on Both Major Road Approaches: Unsignalized Intersection (3- or 4-leg)	ODOT Countermeasure Number: H3

What is it: A right turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of right turn vehicles as they approach an intersection.

Photo from Google

Where to use: At intersections with a high frequency of rear end crashes resulting from conflicts between a) vehicles turning right and following vehicles and b) vehicles turning right and through vehicles coming from the left on the cross street.

Why it works: Providing a right turn lane at an intersection can reduce rear-end crashes by allowing vehicles to proceed through the intersection without having to stop or slow down for vehicles making a right turn.

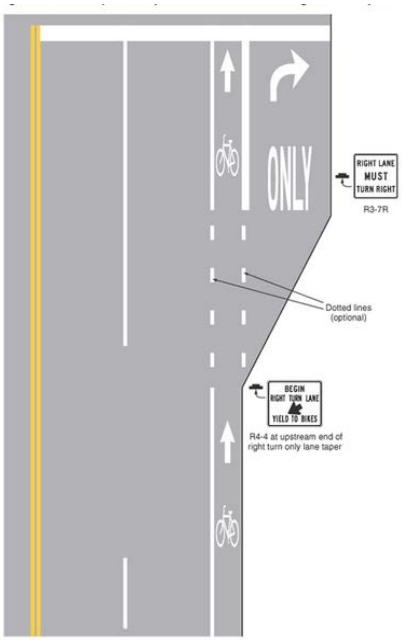
Impediments to Implementation: This countermeasure may require a significant amount of right of way. Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes.

General Notes: This countermeasure CRF value can only be used for installation of right turn lanes on BOTH major road approaches at a 4-leg UNSIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
14 - 26%	**26%**

Name: Right Turn Lane on Single Major Road Approaches: Signalized Intersection (3- or 4-leg)	ODOT Countermeasure Number: H4

What is it: A right turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of right turn vehicles as they approach an intersection.



Photos from FHWA

Where to use: At intersections with a high frequency of rear end crashes resulting from conflicts between a) vehicles turning right and following vehicles and b) vehicles turning right and through vehicles coming from the left on the cross street.

Why it works: Providing a right turn lane at an intersection can reduce rear-end crashes by allowing vehicles to proceed through the intersection without having to stop or slow down for vehicles making a right turn.

Impediments to Implementation: This countermeasure may require a significant amount of right of way. Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes.

General Notes: This countermeasure CRF value can only be used for installation of a right turn lane on ONE major road approach at a 3-leg or 4-leg SIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
4 - 9%	**4%**

Name: Right Turn Lane on Both Major Road Approaches: Signalized Intersection (3- or 4-leg)	ODOT Countermeasure Number: H5

What is it: A right turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of right turn vehicles as they approach an intersection.

Photo from Google

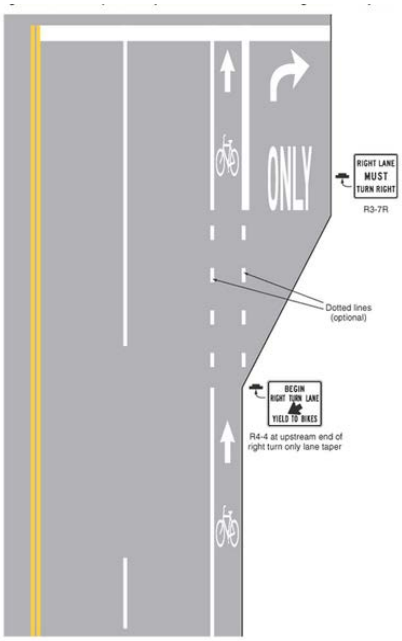


Photo from FHWA

Where to use: At intersections with a high frequency of rear end crashes resulting from conflicts between a) vehicles turning right and following vehicles and b) vehicles turning right and through vehicles coming from the left on the cross street.

Why it works: Providing a right turn lane at an intersection can reduce rear-end crashes by allowing vehicles to proceed through the intersection without having to stop or slow down for vehicles making a right turn.

Impediments to Implementation: This countermeasure may require a significant amount of right of way. Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes.

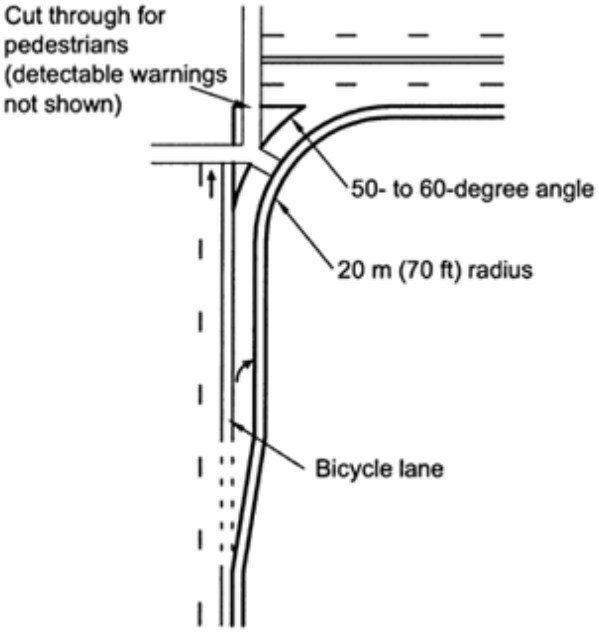
General Notes: This countermeasure CRF value can only be used for installation of right turn lanes on BOTH major road approaches at a 4-leg SIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
4 - 9%	**8%**

Name: Channelized Right Turn Lane with Raised Median	ODOT Countermeasure Number: H6

What is it: A right turn lane separated from the through and left turn lanes on the approach by a raised island and has separate traffic control from the primary intersection. The channelized right turn lane may or may not have a deceleration lane entering it and it may have a merge or an auxiliary lane at the existing end.

Photo from Google



Where to use: Where you want to minimize the number of potential turning conflicts at an intersection, where you want to shorten pedestrian crossing distances and/or where you need a larger turning radius.

Why it works: This countermeasure can provide better clarity to the minor street traffic of which vehicles are in the through lanes on the major street and minimizes the number of conflict points within an intersection. It can create a pedestrian refuge for two stage crossings and it minimizes lane encroachment.

Impediments to Implementation: Creates a wider intersection footprint and may require additional right of way.

General Notes: This countermeasure CRF applies to BOTH signalized and unsignalized intersections. This countermeasure requires a concrete/raised island, it does NOT apply to painted islands.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
25 - 50%	**35%**

Name: Left Turn Lane on Single Major Road Approach: Urban, Unsignalized Intersection (3-leg)	ODOT Countermeasure Number: H7

What is it: A left turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of left turn vehicles as they approach an intersection. This countermeasure is also known as a channelized left turn lane.

Photo from FHWA

Where to use: Use this countermeasure where you have a higher frequency of rear end crashes resulting from the conflicts between vehicles turning left and following vehicles. Crash frequencies between vehicles turning left and opposing through vehicles are also candidates for the installation of left turn lanes - drivers feel less pressure to take insufficient gaps when they have their own lane to wait in.

Why it works: Left turn lanes allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes.

General Notes: This countermeasure CRF value can only be used for installation of a left turn lane on ONE major road approach at an URBAN 3-leg UNSIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
33 - 55%	**33%**

Name: Left Turn Lane on Both Major Road Approaches: Urban, Unsignalized Intersection (4-leg)	ODOT Countermeasure Number: H8

What is it: A left turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of left turn vehicles as they approach an intersection. This countermeasure is also known as a channelized left turn lane.

Photo from Google

Where to use: Use this countermeasure where you have a higher frequency of rear end crashes resulting from the conflicts between vehicles turning left and following vehicles. Crash frequencies between vehicles turning left and opposing through vehicles are also candidates for the installation of left turn lanes - drivers feel less pressure to take insufficient gaps when they have their own lane to wait in.

Why it works: Left turn lanes allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes.

General Notes: This countermeasure CRF value can only be used for installation of left turn lanes on BOTH major road approaches at an URBAN 4-leg UNSIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
47 - 58%	**47%**

Name: Left Turn Lane on Single Major Road Approach: Rural, Unsignalized Intersection (3-leg)	ODOT Countermeasure Number: H9

What is it: A left turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of left turn vehicles as they approach an intersection. This countermeasure is also known as a channelized left turn lane.

Photo from FHWA

Where to use: Use this countermeasure where you have a higher frequency of rear end crashes resulting from the conflicts between vehicles turning left and following vehicles. Crash frequencies between vehicles turning left and opposing through vehicles are also candidates for the installation of left turn lanes - drivers feel less pressure to take insufficient gaps when they have their own lane to wait in.

Why it works: Left turn lanes allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes.

General Notes: This countermeasure CRF value can only be used for installation of a left turn lane on ONE major road approach at a RURAL 3-leg UNSIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
33 - 55%	**44%**

Name: Left Turn Lane on Both Major Road Approaches: Rural, Unsignalized Intersection (4-leg)	ODOT Countermeasure Number: H10

What is it: A left turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of left turn vehicles as they approach an intersection. This countermeasure is also known as a channelized left turn lane.

Photo from FHWA

Where to use: Use this countermeasure where you have a higher frequency of rear end crashes resulting from the conflicts between vehicles turning left and following vehicles. Crash frequencies between vehicles turning left and opposing through vehicles are also candidates for the installation of left turn lanes - drivers feel less pressure to take insufficient gaps when they have their own lane to wait in.

Why it works: Left turn lanes allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes.

General Notes: This countermeasure CRF value can only be used for installation of left turn lanes on BOTH major road approaches at a RURAL 4-leg UNSIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
47 - 58%	**48%**

Name: Left Turn Lane on Single Major Road Approach: Urban, Signalized Intersection (3-leg)	ODOT Countermeasure Number: H11

What is it: A left turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of left turn vehicles as they approach an intersection. This countermeasure is also known as a channelized left turn lane.

Photo from Google

Where to use: Use this countermeasure where you have a higher frequency of rear end crashes resulting from the conflicts between vehicles turning left and following vehicles. Crash frequencies between vehicles turning left and opposing through vehicles are also candidates for the installation of left turn lanes - drivers feel less pressure to take insufficient gaps when they have their own lane to wait in.

Why it works: Left turn lanes allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes. Installing turn lanes after a signal has been in place may result in the need to relocate signal poles in order to accommodate the standard width of the turn lane.

General Notes: This countermeasure CRF value can only be used for installation of a left turn lane on ONE major road approach at an URBAN 3-leg SIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
7 - 15%	**7%**

Name: Left Turn Lane on Both Major Road Approaches: Urban, Signalized Intersection (4-leg)	ODOT Countermeasure Number: H12

What is it: A left turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of left turn vehicles as they approach an intersection. This countermeasure is also known as a channelized left turn lane.

Photo from FHWA

Where to use: Use this countermeasure where you have a higher frequency of rear end crashes resulting from the conflicts between vehicles turning left and following vehicles. Crash frequencies between vehicles turning left and opposing through vehicles are also candidates for the installation of left turn lanes - drivers feel less pressure to take insufficient gaps when they have their own lane to wait in.

Why it works: Left turn lanes allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes. Installing turn lanes after a signal has been in place may result in the need to relocate signal poles in order to accommodate the standard width of the turn lane.

General Notes: This countermeasure CRF value can only be used for installation of left turn lanes on BOTH major road approaches at a URBAN 4-leg SIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
17 - 48%	**19%**

Name: Left Turn Lane on Single Major Road Approach: Rural, Signalized Intersection (3-leg)	ODOT Countermeasure Number: H13

What is it: A left turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of left turn vehicles as they approach an intersection. This countermeasure is also known as a channelized left turn lane.

Photo from Google

Where to use: Use this countermeasure where you have a higher frequency of rear end crashes resulting from the conflicts between vehicles turning left and following vehicles. Crash frequencies between vehicles turning left and opposing through vehicles are also candidates for the installation of left turn lanes - drivers feel less pressure to take insufficient gaps when they have their own lane to wait in.

Why it works: Left turn lanes allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes. Installing turn lanes after a signal has been in place may result in the need to relocate signal poles in order to accommodate the standard width of the turn lane.

General Notes: This countermeasure CRF value can only be used for installation of a left turn lane on ONE major road approach at an RURAL 3-leg SIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
7 - 15%	**15%**

Name: Left Turn Lane on Both Major Road Approaches: Rural, Signalized Intersection (4-leg)	ODOT Countermeasure Number: H14

What is it: A left turn lane is an auxiliary lane for storage and to accommodate the decreasing speed of left turn vehicles as they approach an intersection. This countermeasure is also known as a channelized left turn lane.

Photo from Google

Where to use: Use this countermeasure where you have a higher frequency of rear end crashes resulting from the conflicts between vehicles turning left and following vehicles. Crash frequencies between vehicles turning left and opposing through vehicles are also candidates for the installation of left turn lanes - drivers feel less pressure to take insufficient gaps when they have their own lane to wait in.

Why it works: Left turn lanes allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Turns lane(s) shall be of adequate storage length so vehicles will not be stopped in the travel lanes. Installing turn lanes after a signal has been in place may result in the need to relocate signal poles in order to accommodate the standard width of the turn lane.

General Notes: This countermeasure CRF value can only be used for installation of left turn lanes on BOTH major road approaches at a RURAL 4-leg SIGNALIZED intersection.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
17 - 48%	**33%**

Name: Channelized Left Turn Lane with Raised Median on All Approaches (3- or 4-leg)	**ODOT Countermeasure Number: H15**

What is it: Channelized left turn lanes provide a median separation between the designated left turn lane and opposing through lanes at an intersection. This treatment is a basic curb separator that can also include a positive offset where sufficient median widths exist.

Photo from Google

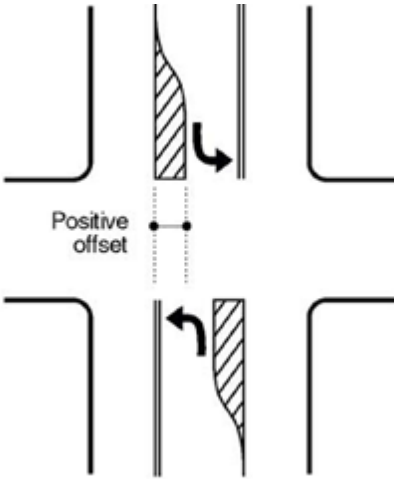


Photo from FHWA

Where to use: This countermeasure applies to locations where a) there is a high frequency of intersection crashes between vehicles turning left and opposing through vehicles and/or b) there is a higher than expected frequency of turning movements from adjacent business accesses conflicting with intersection movements.

Why it works: Channelized left turn lanes provide the left turning motorist a line of sight to opposing through vehicles, allowing them to clearly see oncoming traffic. This countermeasure can also serve to protect the designated left turn lane from vehicles turning into and out of adjacent business accesses.

Impediments to Implementation: Having sufficient pavement width and the potential impacts to restricting business accesses.

General Notes: This countermeasure CRF can be applied to signalized and unsignalized intersections. This countermeasure requires a concrete/raised median, it does NOT apply to painted medians.

Crash Types Addressed	**Severity Type Addressed**
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
4 - 27%	**27%**

Name: Install Roundabout from Minor Road Stop Control	ODOT Countermeasure Number: H16

What is it: A modern roundabout is a type of circular intersection defined by the basic operational principle that entering traffic yields to vehicles on the circular roadway.

Photo from FHWA

Where to use: Roundabouts should be considered for all existing unsignalized intersections that have been identified as needing major safety or operational improvements. Typical crash patterns that could be resolved with a roundabout are higher than expected speed related, angle and/or turning crashes.

Why it works: Roundabout intersections eliminate a number of vehicle conflict points (up to 75%) typically associated with traditional intersections. They also enhance safety by reducing vehicle speeds (more typical in rural settings) both in and through the intersection and by changing the crash type from angle to sideswipe, which typically results in less severe crashes.

Impediments to Implementation: Roundabouts require a significant amount of public outreach and education in addition to requiring a larger geometric footprint than a typical intersection.

General Notes: Map-21 Legislation declares a National focus to reduce Fatalities and Severe (Injury A) crashes on our roadways. Roundabouts are one of the primary tools we can use to reduce severity of crashes and meet this National goal.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
19 - 82%	**82%**

Name: Install Roundabout from Signalized Intersection	ODOT Countermeasure Number: H17

What is it: A modern roundabout is a type of circular intersection defined by the basic operational principle that entering traffic yields to vehicles on the circular roadway.

Photo from FHWA

Where to use: Roundabouts should be considered for all existing signalized intersections that have been identified as needing major safety or operational improvements that cannot be resolved by signalized intersection modifications. Typical crash patterns that could be resolved with a roundabout are higher than expected speed related, angle and/or turning crashes.

Why it works: Roundabout intersections eliminate a number of vehicle conflict points (up to 75%) typically associated with traditional intersections. They also enhance safety by reducing vehicle speeds (more typical in rural settings) both in and through the intersection and by changing the crash type from angle to sideswipe, which typically results in less severe crashes.

Impediments to Implementation: Roundabouts require a significant amount of public outreach and education in addition to requiring a larger geometric footprint than a typical signalized intersection.

General Notes: Map-21 Legislation declares a National focus to reduce Fatalities and Severe (Injury A) crashes on our roadways. Roundabouts are one of the primary tools we can use to reduce severity of crashes and meet this National goal.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
48 - 78%	**78%**

Name: Convert to All-Way Stop Control (From Urban 2-Way or Yield Control)	ODOT Countermeasure Number: H18

What is it: Modifying an intersection with minor road stop or yield control intersection to an intersection where the major legs have to stop in addition to the minor legs.

Photo from FHWA

Where to use: Unsignalized 2-Way Stop or Yield controlled intersections with a pattern of right-angle and turning crashes and relatively balanced volumes on the intersection approaches.

Why it works: All-way stop control can reduce right-angle and turning collisions at unsignalized intersections by providing more orderly movement at an intersection, reducing through and turning speeds, and minimizing the safety effect of any sight distance restrictions that may be present.

Impediments to Implementation: Identify moderate volume situations where all-way stop control will operate efficiently without substantially more delay than a signalized intersection. Not every two-way stop-controlled intersection should be considered as a candidate for all-stop control. This strategy should be used selectively, recognizing traffic volumes and patterns and potentially adverse reaction by the driving population to being stopped for no apparent reason. If drivers encounter substantial delays, they may become impatient and act irrationally, which can lead to crash patterns of the type that the strategy is intended to correct.

General Notes: This CRF value is for URBAN intersections.

The MUTCD lists guidance for the placement of All-Way (Multi-Way) Stop Sign applications, which should be reviewed as installation of this treatment is considered.

Crash Types Addressed	Severity Type Addressed
Angle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
18 - 75%	**75%**

Name: Convert to All-Way Stop Control (From Rural 2-Way or Yield Control)	ODOT Countermeasure Number: H19

What is it: Modifying an intersection with minor road stop or yield control intersection to an intersection where the major legs have to stop in addition to the minor legs.

Photo from FHWA

Where to use: Unsignalized 2-Way Stop or Yield controlled intersections with a pattern of right-angle and turning crashes and relatively balanced volumes on the intersection approaches.

Why it works: All-way stop control can reduce right-angle and turning collisions at unsignalized intersections by providing more orderly movement at an intersection, reducing through and turning speeds, and minimizing the safety effect of any sight distance restrictions that may be present.

Impediments to Implementation: Identify moderate volume situations where all-way stop control will operate efficiently without substantially more delay than a signalized intersection. Not every two-way stop-controlled intersection should be considered as a candidate for all-stop control. This strategy should be used selectively, recognizing traffic volumes and patterns and potentially adverse reaction by the driving population to being stopped for no apparent reason. If drivers encounter substantial delays, they may become impatient and act irrationally, which can lead to crash patterns of the type that the strategy is intended to correct.

General Notes: This CRF value is for RURAL intersections.

The MUTCD lists guidance for the placement of All-Way (Multi-Way) Stop Sign applications, which should be reviewed as installation of this treatment is considered.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
18 - 75%	**48%**

Name: Install Urban Traffic Signal	ODOT Countermeasure Number: H20

What is it: Traffic Signals are a traffic control device positioned on roadways to efficiently control and manage competing flows of traffic (vehicles, pedestrians and/or bicycles).

Photo from Google

Where to use: Where an intersection is experiencing a higher than expected frequency of right angle crashes with adequate sight distance to that intersection from all approaches.

Why it works: Traffic signals help to assign right of way to traffic movements which helps to reduce right angle crashes at intersections.

Impediments to Implementation: It is important that the existing intersection crash patterns are related to failing to yield to right of way as opposed to failing to yield to slowing traffic as a signal installation will likely increase the latter.

General Notes: While signals decrease the potential for angle crashes, simultaneously they increase the potential for rear end crashes. It is also important to note that rear end crashes in high speed corridors typically result in more severe crashes than in lower speed corridors. Benefit/Cost Analysis using this countermeasure shall include BOTH CRF values listed below, one for decreasing angle crashes and the other for increasing rear end crashes, to best represent the expected changes in safety with installation.

The MUTCD lists nine warrants for the placement of traffic signals, which should be reviewed as installation of this treatment is considered. State Traffic Engineer Approval and warrant analysis is REQUIRED for all potential signal installations on the State Highway.

Crash Types Addressed	Severity Type Addressed
Angle & Rear End	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
-143 - 77%	**67% (Angle) & -143% (Rear End)**

Name: Install Rural Traffic Signal	ODOT Countermeasure Number: H21

What is it: Traffic Signals are a traffic control device positioned on roadways to efficiently control and manage competing flows of traffic (vehicles, pedestrians and/or bicycles).

Photo from Google

Where to use: Where an intersection is experiencing a higher than expected frequency of right angle crashes with adequate sight distance to that intersection from all approaches.

Why it works: Traffic signals help to assign right of way to traffic movements and have been shown to reduce angle crashes at intersections.

Impediments to Implementation: It is important that the existing intersection crash patterns are related to failing to yield to right of way as opposed to failing to yield to slowing traffic as a signal installation will likely increase the latter.

General Notes: While signals decrease the potential for angle crashes, simultaneously they increase the potential for rear end crashes. It is important to note that rear end crashes in high speed corridors typically result in more severe crashes than in lower speed corridors. It is also important to consider local driver expectations for a signal in a rural corridor that might not have any other signals nearby. Benefit/Cost Analysis using this countermeasure shall include BOTH CRF values listed below, one for decreasing angle crashes and the other for increasing rear end crashes, to best represent the expected changes in safety with installation.

The MUTCD lists nine warrants for the placement of traffic signals, which should be reviewed as installation of this treatment is considered. State Traffic Engineer Approval and warrant analysis is REQUIRED for all potential signal installations on the State Highway.

Crash Types Addressed	Severity Type Addressed
Angle & Rear End	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
-143 - 77%	**77% (Angle) & -58% (Rear End)**

Name: Convert 4-Leg Intersection to Two 3-Leg Intersections (Minor St ADT is 15-30% of Total Entering Traffic)	**ODOT Countermeasure Number: H22**

What is it: Realignment of a 4-leg intersection to two 3-leg intersections in an appreciable distance along the major street.

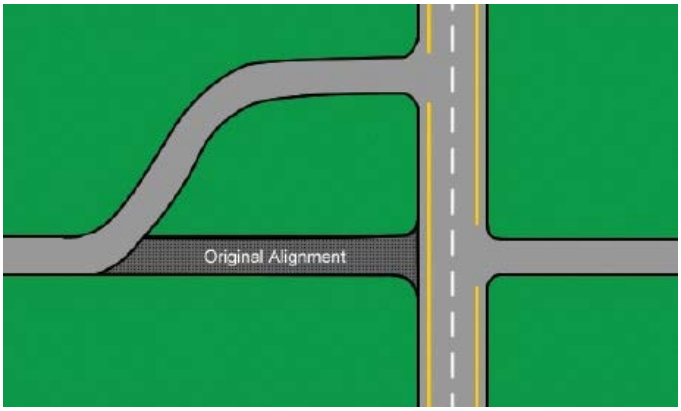


Photo from FHWA

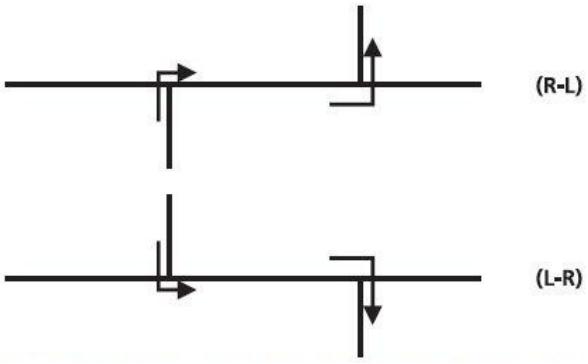


Photo from HSM

Where to use: Where an intersection is experiencing a higher than expected frequency and/or severity of right angle and/or turning crashes and the minor street volumes are relatively low compared to the major street. This countermeasure should be considered in areas where a signal or roundabout is not feasible.

Why it works: By creating two 3-leg intersections you create two intersections with fewer conflict points than at a single, 4-leg intersection.

Impediments to Implementation: If the intersections are not spaced far enough apart, two problems can occur. First, there may not be enough storage length for the left turning vehicles between the intersections. Second, the operations of the intersections may interfere with one another. In addition, this countermeasure usually requires a significant amount of right of way as you are building an entire new roadbed.

General Notes: Per HSM Guidance, this countermeasure is specifically for minor street ADT that is 15-30% of the total entering traffic. The two intersections can be right-left staggered (R-L image seen above) or left-right staggered (L-R image seen above).

Crash Types Addressed	**Severity Type Addressed**
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
10 - 33%	**25%**

Name: Convert 4-Leg Intersection to Two 3-Leg Intersections (Minor St ADT is 30% + of Total Entering Traffic)	ODOT Countermeasure Number: H23

What is it: Realignment of a 4-leg intersection to two 3-leg intersections in an appreciable distance along the major street.

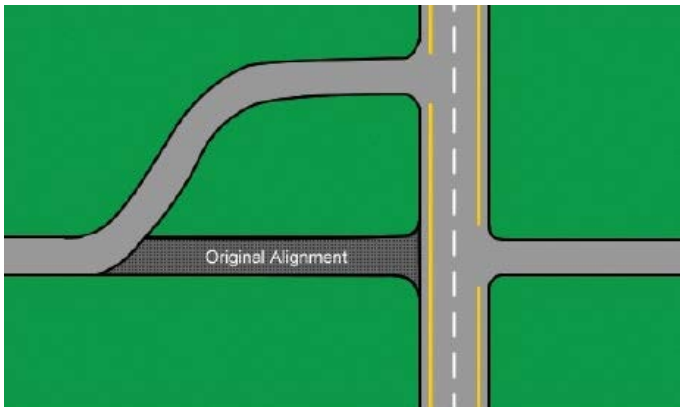


Photo from FHWA

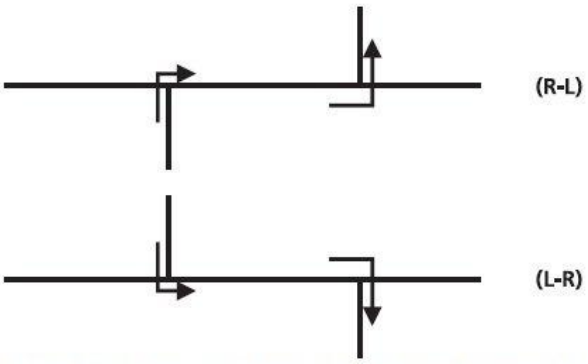


Photo from HSM

Where to use: Where an intersection is experiencing a higher than expected frequency and/or severity of right angle and/or turning crashes and the minor street volumes are relatively low compared to the major street. This countermeasure should be considered in areas where a signal or roundabout is not feasible.

Why it works: By creating two 3-leg intersections you create two intersections with fewer conflict points than at a single, 4-leg intersection.

Impediments to Implementation: If the intersections are not spaced far enough apart, two problems can occur. First, there may not be enough storage length for the left turning vehicles between the intersections. Second, the operations of the intersections may interfere with one another. In addition, this countermeasure usually requires a significant amount of right of way as you are building an entire new roadbed.

General Notes: Per HSM Guidance, this countermeasure is specifically for minor street ADT that is 15-30% of the total entering traffic. The two intersections can be right-left staggered (R-L image seen above) or left-right staggered (L-R image seen above).

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
10 - 33%	**33%**

Name: Install Rural Median Acceleration Lane	ODOT Countermeasure Number: H24

What is it: A left turn auxiliary or speed change lane that allows vehicles to accelerate to highway speeds before entering the through traffic lanes of a roadway.

Photo from FHWA

Photo from Google

Where to use: At unsignalized intersections that are experiencing a high proportion of crashes related to speed differential caused by vehicles turning left onto the highway. They may also be used where intersection sight distance is inadequate or where there are high volumes of trucks entering from the minor road onto the major road. Typically they are used on divided roadways but have also seen success on undivided roadways when paired with concrete lane separators.

Why it works: Drivers turning onto a roadway accelerate until the desired highway speed is reached. When acceleration by entering traffic takes place directly on the traveled way, it may disrupt the flow of through traffic and create potential conflicts. Median acceleration lanes can help to minimize this operational problem at rural intersections.

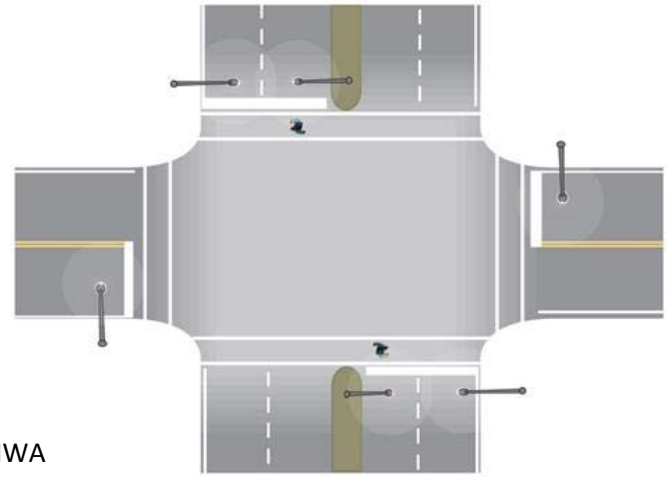
Impediments to Implementation: Acceleration lanes should be of sufficient length to permit adjustments in speeds of both through and entering vehicles so that the driver of the entering vehicle can safely maneuver into a gap before reaching the end of the acceleration lane. Acceleration lanes can establish an add lane that does not require merging, when feasible. In addition, if a left-turn acceleration lane is excessively long or poorly marked, through drivers may mistake it for an additional through lane.

General Notes: This countermeasure can only be applied to rural areas. Verify that acceleration lanes are operationally warranted by relatively high left turn volumes. Design the median opening area to minimize conflicts between vehicles entering the left turn acceleration lane and other through and turning vehicles using the median opening.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
20 - 79%	**45%**

Name: Install Lighting at Intersection	ODOT Countermeasure Number: H25, I1

What is it: A permanent source of artificial light installed at an intersection that provides greater visibility of the intersection.



Photos from FHWA

Where to use: Intersections that are experiencing a high instance of dark or nighttime crashes. Particularly for unsignalized intersections, rear-end, right-angle, or turning crashes on the major road approaches may indicate that approaching drivers are unaware of the presence of the intersection.

Why it works: Intersection lighting allows for greater visibility of the intersection, making signs and markings more visible and helping drivers determine a safe path through the intersection. This can be especially helpful at rural intersections where the only source of lighting for the roadway is often provided by vehicle headlights.

Impediments to Implementation: In rural areas it may be difficult to locate a power source. In addition, it is important to determine, upfront, the jurisdiction responsible for paying the ongoing utility costs.

General Notes: This countermeasure is for new lighting only, not to replace existing, substandard lighting. This CRF value can be applied to signalized and unsignalized intersections. For ODOT Highways, please refer to the ODOT Lighting Policy and Guidelines for further guidance on lighting warrants.

Crash Types Addressed	Severity Type Addressed
Nighttime	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
31 - 38%	**38%**

Name: Install Lighting on a Roadway Segment	ODOT Countermeasure Number: H26

What is it: A permanent source of artificial light installed on a segment of roadway that provides greater visibility of the roadway.

Photo from American Electric Lighting

Photo from Google

Where to use: Segments of roadway that are experiencing a high instance of dark or nighttime crashes, particularly crashes related to missed visual roadway queues.

Why it works: Segment lighting allows for greater visibility of the roadway and the visual cues that help drivers determine a safe path along the roadway. This can be especially helpful in rural areas where the only source of lighting for the roadway is often provided by vehicle headlights.

Impediments to Implementation: In rural areas it may be difficult to locate a power source. In addition, it is important to determine, upfront, the jurisdiction responsible for paying the ongoing utility costs.

General Notes: This countermeasure is for new lighting, not to replace existing, substandard lighting. This CRF value applies to roadway segments only. For ODOT Highways, please refer to the ODOT Lighting Policy and Guidelines for further guidance on lighting warrants.

Crash Types Addressed	Severity Type Addressed
Nighttime	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
17 - 29%	**28%**

Name: Install Any Type of Median Barrier	ODOT Countermeasure Number: H27

What is it: Median barriers are longitudinal barriers most commonly used to separate opposing directions of traffic on a divided highway.



Photos from FHWA

Where to use: On divided highways with high speeds and high volumes and/or on divided highways with a high frequency of fatal or serious injury median crossover crashes.

Why it works: While these systems may not reduce the frequency of crashes due to roadway departure, they do help prevent a median crash from becoming a median crossover head-on collision which has a high chance of resulting in a fatality or severe injury.

Impediments to Implementation: Ease and costs of maintenance and repair for these barrier systems is an important consideration.

General Notes: There are three basic categories of median barriers that each have their own set of pros and cons. Consideration of vehicle types, roadway geometry and potential severity of median crossover crashes must be considered when choosing a median barrier type. The three types are rigid barrier systems (i.e. concrete barrier), semi-rigid barrier systems (i.e. guardrail) and flexible barrier systems (i.e. cable barrier).

Rigid barriers have a high installation cost but a low life-cycle cost. They are associated with more severe injury crashes relative to other barrier types but are proven highly effective in locations with heavy truck traffic and insufficient median widths for the other barrier types.

Semi-Rigid barriers are most suitable for use in traversable medians having no or little change in grade and cross slope. Initial cost is lower than rigid barriers but it generally has a higher life cycle cost due to repair needs. Typical installation of semi-rigid median barrier is on divided roadways with 20,000 ADT or more and medians less than 50 feet wide.

Flexible barriers are the most forgiving barrier systems available for reducing the severity of median crossover crashes. They generally have a lower installation cost than rigid and semi-rigid barriers but typically have a higher life cycle cost due to repair needs. Typical installations of flexible median barriers are in medians less than 50 feet wide.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
-24 - 43%	**30%**

Name: Install New Guardrail (Not Median Barrier Application)	ODOT Countermeasure Number: H28

What is it: A semi-rigid barrier typically consisting of connected segments of metal railing supported by posts and blocks.

Photos from FHWA

Where to use: Guardrails should be installed where there is evidence (i.e. crash history) of the need to shield motorists from a roadside hazard that has a higher risk for fatal or serious injury crashes than the guardrail itself. Potential roadside hazards could be point hazards (such as a bridge pier or utility pole), medium-sized hazards (such as roadside culverts), and long hazards (such as steep roadside slopes).

Why it works: Because guardrail systems are designed to absorb energy during a crash, and the entire assembly is designed to move or deflect during an impact, guardrail systems usually minimize potential injuries in run off the road or roadway departure crashes.

Impediments to Implementation: Guardrails themselves are a roadside obstacle that a motorist can potentially strike (subsequently creating a lot of potential maintenance costs as well) so it is important to minimize guardrail installation to locations where you are protecting a motorist from roadside hazards that have a higher risk for fatal or serious injury crashes.

General Notes: For more guidance on installation of guardrails please see NCHRP Report 638.

Crash Types Addressed	Severity Type Addressed
Run Off The Road	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
44 - 47%	**47%**

Name: Install Two Way Left Turn Lane on 2-Lane Road	ODOT Countermeasure Number: H29

What is it: A type of traversable median reserved for the exclusive use of vehicles turning left from both directions.

Photos from FHWA

Where to use: On two-lane roadways where you have frequent accesses and a high frequency of rear end crashes related to vehicles turning left.

Why it works: Reduces the need for vehicles to slow down for vehicles waiting to turn left by separating the left turning vehicles from the through lanes. In areas with frequent accesses, this countermeasure could significantly reduce these potential conflicts along an entire corridor in addition to increasing capacity of the facility. This countermeasure can also provide vehicles with the ability to make two-stage turning maneuvers from accesses.

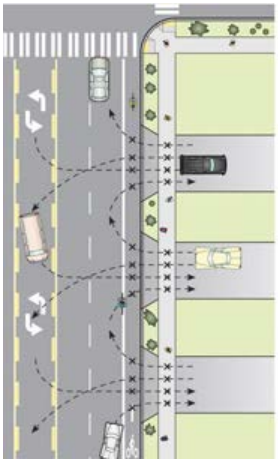
Impediments to Implementation: If the pavement width doesn't already exist, this countermeasure could have significant costs associated with adding more impervious surface. Typical examples are right of way acquisition, drainage impacts and environmental mitigation.

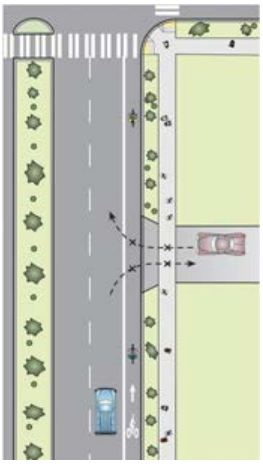
General Notes: On arterials with higher volumes (above 20,000 ADT) and frequent access, it may be advantageous to consider a non-traversable (curbed) median, rather than a TWLTL. On higher volume or higher speed roadways, the TWLTL loses much of its safety advantage, which the non-traversable medians retain.

Crash Types Addressed	Severity Type Addressed
Rear End	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
-5 - 53%	**39%**

Name: Reduce Urban Driveways from 48 to 26 - 48 per mile	ODOT Countermeasure Number: H30

What is it: Driveways can be defined as private roads that provide access between public ways and activities or buildings on abutting land. Reducing the number of driveways intersecting public roadways is an access management technique - the method of control of entry and exit points along a roadway.





Photos from FHWA

Where to use: Where you have a high frequency of driveway related crashes on an urban corridor.

Why it works: Reducing driveways manages the frequency and magnitude of conflict points at driveways by altering access patterns.

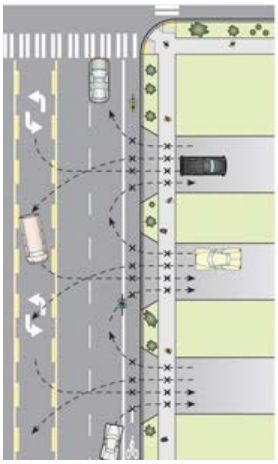
Impediments to Implementation: It can be difficult to get public support and can be costly to retrofit an existing road with this access management technique.

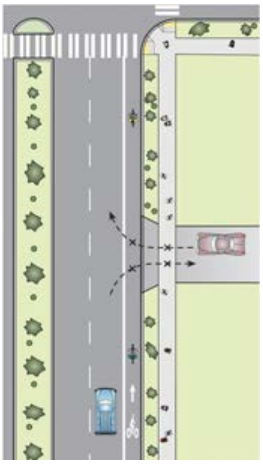
General Notes: This CRF value can only be applied to reducing driveway from 48 to 26 - 48 per mile. Successful access management seeks to simultaneously provide accessibility while enhancing safety, preserving capacity and providing for pedestrian and bicycle needs. For more guidance, please refer to the Highway Safety Manual.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
25 - 31%	**29%**

Name: Reduce Urban Driveways from 26 - 48 to 10 - 24 per mile	ODOT Countermeasure Number: H31

What is it: Driveways can be defined as private roads that provide access between public ways and activities or buildings on abutting land. Reducing the number of driveways intersecting public roadways is an access management technique - the method of control of entry and exit points along a roadway.





Photos from FHWA

Where to use: Where you have a high frequency of driveway related crashes on an urban corridor.

Why it works: Reducing driveways manages the frequency and magnitude of conflict points at driveways by altering access patterns.

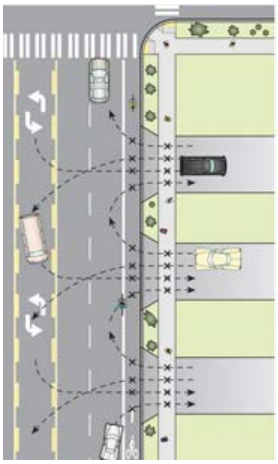
Impediments to Implementation: It can be difficult to get public support and can be costly to retrofit an existing road with this access management technique.

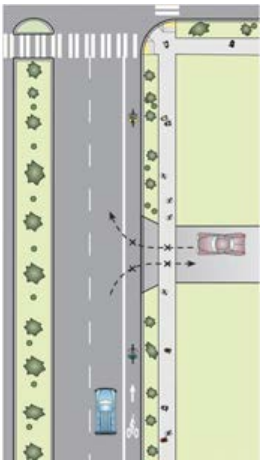
General Notes: This CRF value can only be applied to reducing driveway from 26 - 48 to 10 - 24 per mile. Successful access management seeks to simultaneously provide accessibility while enhancing safety, preserving capacity and providing for pedestrian and bicycle needs. For more guidance, please refer to the Highway Safety Manual.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
25 - 31%	**31%**

Name: Reduce Urban Driveways from 10 - 24 to less than 10 per mile	ODOT Countermeasure Number: H32

What is it: Driveways can be defined as private roads that provide access between public ways and activities or buildings on abutting land. Reducing the number of driveways intersecting public roadways is an access management technique - the method of control of entry and exit points along a roadway.





Photos from FHWA

Where to use: Where you have a high frequency of driveway related crashes on an urban corridor.

Why it works: Reducing driveways manages the frequency and magnitude of conflict points at driveways by altering access patterns.

Impediments to Implementation: It can be difficult to get public support and can be costly to retrofit an existing road with this access management technique.

General Notes: This CRF value can only be applied to reducing driveway from 10 - 24 to less than 10 per mile. Successful access management seeks to simultaneously provide accessibility while enhancing safety, preserving capacity and providing for pedestrian and bicycle needs. For more guidance, please refer to the Highway Safety Manual.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
25 - 31%	**25%**

Name: Provide a Raised Median, Urban 2-Lane Road	ODOT Countermeasure Number: H33

What is it: A concrete median separation between opposing through lanes on a segment of roadway. This countermeasure can include periodic pedestrian refuges and/or designated left turn lanes at major driveways or intersections.

Photo from PedBikeSafe

Where to use: On roadways with higher traffic volumes and driveway densities with a history of access related crashes.

Why it works: The primary function of raised medians is to manage the frequency and magnitude of conflict points at driveways and intersections by altering access patterns. Additionally they can protect pedestrians by providing a refuge area and shorter exposed crossing distances and can include designated left turn lanes to allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: On 2-Lane facilities, if the pavement width doesn't already exist, this countermeasure could have significant costs associated with adding more impervious surface. Typical examples are right of way acquisition, drainage impacts and environmental mitigation. In addition, raised medians limit property accesses which can be perceived by business owners as deterrence to potential customers and to residents as an inconvenience. It is important to involve stakeholders as soon as possible if you plan to implement this countermeasure. Raised medians also concentrate left turns and can increase the frequency of U-turns. It is important to accommodate and/or manage these potential movements accordingly. Lastly, medians create "pinch points" in the roadway that could prevent certain heavy vehicles from traveling through the facility. It is important that appropriate considerations are made for the types of heavy vehicles using the facility in order to provide them the maximum lane widths they need.

General Notes: This CRF value is specifically for 2-Lane Urban facilities. Two additional advantages of raised medians, they can prevent head-on or sideswipe meeting crashes and can provide space for landscaping and other aesthetic treatments.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
39%	**39%**

Name: Provide a Raised Median, Urban Multi-Lane Road	ODOT Countermeasure Number: H34

What is it: A concrete median separation between opposing through lanes on a segment of roadway. This countermeasure can include pedestrian refuges and/or designated left turn lanes at major driveways or intersections.

Photos from FHWA

Where to use: On roadways with higher traffic volumes and driveway densities with a history of access related crashes.

Why it works: The primary function of raised medians is to manage the frequency and magnitude of conflict points at driveways and intersections by altering access patterns. Additionally they can protect pedestrians by providing a refuge area and shorter exposed crossing distances and can include designated left turn lanes to allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Raised medians limit property accesses which can be perceived by business owners as deterrence to potential customers and to residents as an inconvenience. It is important to involve stakeholders as soon as possible if you plan to implement this countermeasure. Raised medians also concentrate left turns and can increase the frequency of U-turns. It is important to accommodate and/or manage these potential movements accordingly. In addition, medians create "pinch points" in the roadway that could prevent certain heavy vehicles from traveling through the facility. It is important that appropriate considerations are made for the types of heavy vehicles using the facility in order to provide them the maximum lane widths they need.

General Notes: This CRF value is specifically for Multi-Lane Urban facilities. Two additional advantages of raised medians, they can prevent head-on or sideswipe meeting crashes and can provide space for landscaping and other aesthetic treatments.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
0 - 22%	**22%**

Name: Provide a Raised Median, Rural Multi-Lane Road	ODOT Countermeasure Number: H35

What is it: A concrete median separation between opposing through lanes on a segment of roadway. This countermeasure can include pedestrian refuges and/or designated left turn lanes at major driveways or intersections.

Photo from Google

Photo from FHWA

Where to use: On roadways with higher traffic volumes and driveway densities with a history of access related crashes.

Why it works: The primary function of raised medians is to manage the frequency and magnitude of conflict points at driveways and intersections by altering access patterns. Additionally they can protect pedestrians by providing a refuge area and shorter exposed crossing distances and can include designated left turn lanes to allow vehicles to proceed through the intersection without having to stop or slow down for vehicles waiting to make a left turn.

Impediments to Implementation: Raised medians limit property accesses which can be perceived by business owners as deterrence to potential customers and to residents as an inconvenience. It is important to involve stakeholders as soon as possible if you plan to implement this countermeasure. Raised medians also concentrate left turns and can increase the frequency of U-turns. It is important to accommodate and/or manage these potential movements accordingly. In addition, medians create "pinch points" in the roadway that could prevent certain heavy vehicles from traveling through the facility. It is important that appropriate considerations are made for the types of heavy vehicles using the facility in order to provide them the maximum lane widths they need.

General Notes: This CRF value is specifically for Multi-Lane Rural facilities. Two additional advantages of raised medians, they can prevent head-on or sideswipe meeting crashes and can provide space for landscaping and other aesthetic treatments.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
0 - 22%	**12%**

Name: Install Traversable Median (4 ft. or more)	ODOT Countermeasure Number: H36

What is it: Traversable medians provide separation between opposing flows of traffic and where wide enough, are striped to prohibit its use as a Two Way Left Turn Lane. Traversable medians are delineated by pavement markings ONLY.

Photo from East Arlington Livable Streets Coalition

Photos from Google

Where to use: They can be used as an access management tool to prohibit turning movements into and out of accesses where you have a high frequency of access related crashes and are unable to place a raised median. They can also be used as a buffer zone or recovery area where you have a high frequency of head on or sideswipe meeting crashes and can be supplemented with centerline rumble strips in rural areas.

Why it works: For access management, traversable medians manage the frequency and magnitude of conflict points at driveways and intersections by altering access patterns. For head-on and side-swipe meeting crashes, traversable medians create a larger recovery area for errant vehicles.

Impediments to Implementation: If the pavement width doesn't already exist, this countermeasure could have significant costs associated with adding more impervious surface. Typical examples are right of way acquisition, drainage impacts and environmental mitigation.

General Notes: This CRF value can be used for urban and rural areas. Compared to non-traversable medians, safety benefits of traversable medians for access management have less research available to prove their effectiveness. In addition, vehicle compliance of traversable medians is expected to be significantly less than non-traversable medians because of the lack of physical restriction.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
12 - 30%	**12%**

Name: Install Passing Lane on Rural, 2-Lane Roadway	ODOT Countermeasure Number: H37

What is it: An auxiliary lane provided in a short segment to accommodate the passage of single-directional traffic.

Photo from FHWA

Photo from MODOT

Where to use: This countermeasure should be provided in a segment location where head-on collisions occur as a result of passing vehicles or locations where there are crashes related to slow moving traffic.

Why it works: Providing passing opportunities with a climbing lane reduces the probability of risky passing maneuvers that could lead to various lane departure crashes.

Impediments to Implementation: It is important to provide optimum passing lane lengths to ensure that vehicles have enough distance to make a safe passing maneuver. There could also be significant costs associated with adding more impervious surface. Typical examples are right of way acquisition, drainage impacts and environmental mitigation.

General Notes: This countermeasure also improves overall traffic operations by breaking up traffic platoons and by reducing delays caused by inadequate passing opportunities over substantial lengths of roadway.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
35 - 42%	**42%**

Name: Widen Rural Paved Lane Width by 1 foot	ODOT Countermeasure Number: H38

What is it: Increasing the paved width of the travel lanes.

Photo from FHWA

Where to use: Where you have a high frequency of run off the road crashes.

Why it works: Wider lane widths provide more recovery area for errant vehicles drifting in their lane.

Impediments to Implementation: There could be significant costs associated with adding more impervious surface. Typical examples are right of way acquisition, drainage impacts and environmental mitigation.

General Notes: This treatment should be used at locations where the width of the travel lane is less than 12 feet.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
5%	**5%**

Name: Flatten Horizontal Curve (Increase Radius)	ODOT Countermeasure Number: H39

What is it: Increasing the radius of the horizontal curvature of the roadway.

Photo from FHWA

Where to use: On curves where you have a high frequency of run off the road crashes like head-on or fixed object crashes.

Why it works: Increased radii means an increase in sight distance, providing a more complete visual to drivers of the upcoming alignment of the roadway. Increased radii also decreases the speed differential between the approach tangent and the horizontal curve, subsequently reducing crash risk.

Impediments to Implementation: Many locations have minimum curve radii because of geometric restrictions like rock cliffs and/or steep slopes. Removing areas of rock and filling slopes can be costly in order to accommodate a realigned horizontal curve with an increased radius. Since this treatment could potentially be costly, it is important to make sure all other potential countermeasures for curve crashes have been considered, tried or proven ineffective before considering this countermeasure.

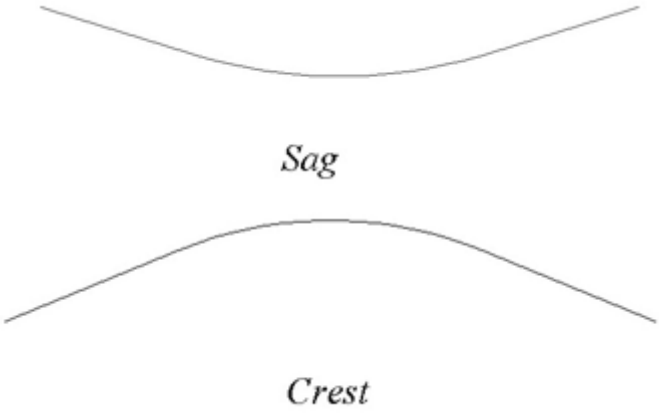
General Notes: Use the table below to select your crash reduction factor ("percent reduction in total" column) based on existing and proposed radii.

Original Degree of Curve	New Degree of Curve	Percent Reduction in Total
30	25	15
	20	31
	15	46
	10	61
	5	78
25	20	17
	15	35
	10	53
	5	72
20	15	20
	10	41
	5	64
15	10	24
	5	50
	3	63
10	5	28
	3	42

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
15 - 78%	**See Table Shown Above**

Name: Flatten Crest Vertical Curve	ODOT Countermeasure Number: H40

What is it: Reducing the vertical curvature of the roadway either by flattening a crest curve or reducing the grade of a sag curve.



Photos from FHWA

Where to use: Where you have a high frequency of crashes related to limited sight distance or speed related crashes on steep grades.

Why it works: Flattening a crest vertical curve provides a more complete visual to drivers of the upcoming alignment of the roadway and subsequently more stopping sight distance. In addition, when vehicles are behind slow moving vehicles ascending or descending a grade, there could be rear-end conflicts and in some cases risky passing maneuvers leading to head-on crashes. In a sag vertical curve, there is the risk of vehicles descending a grade at speeds too fast for conditions, increasing the risk of high speed rear-end crashes and potentially run off the road crashes.

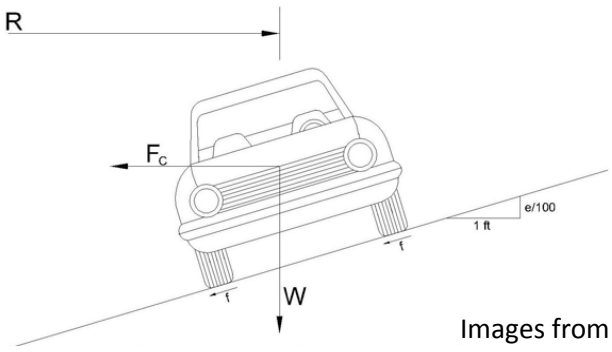
Impediments to Implementation: Flattening crest curves could significantly impact driveway or intersection approaches to the roadway. This treatment could potentially be very costly. It is important to make sure all other potential countermeasures for vertical curve crashes have been considered, tried or proven ineffective before considering this countermeasure.

General Notes: This countermeasure can also be applied to unsignalized intersections with restricted sight distance due to vertical geometry and with patterns of crashes related to that lack of sight distance that cannot be ameliorated by less expensive methods.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
20 - 51%	**20%**

Name: Improve Superelevation Variance (SV) on Rural Curves (Between 0.01 and 0.02)	ODOT Countermeasure Number: H41

What is it: Superelevation is the rotation of the pavement on the approach to and through a horizontal curve. It is intended to assist the driver in negotiating the curve by counteracting the lateral acceleration produced by tracking.



Images from FHWA

$$0.01e + f = \frac{V^2}{15R} \quad \text{(Equation 2)}$$

Where:
e = rate of superelevation, percent;
f = side friction (demand factor);
V = vehicle speed, mph;
R = radius of curve, ft.

Where to use: Use at a curve where you have a higher than expected number of vehicle or truck crashes at a curve that could be attributed to inadequate superelevation. Inadequate superelevation can cause vehicles to skid as they travel through a curve, potentially resulting in a run-off-road crash. Trucks and other large vehicles with high centers of mass are more likely to roll over at curves with inadequate superelevation.

Why it works: Superelevation offsets the horizontal sideways momentum of the approaching vehicle, minimizing the risk a vehicle of running off the road around a curve.

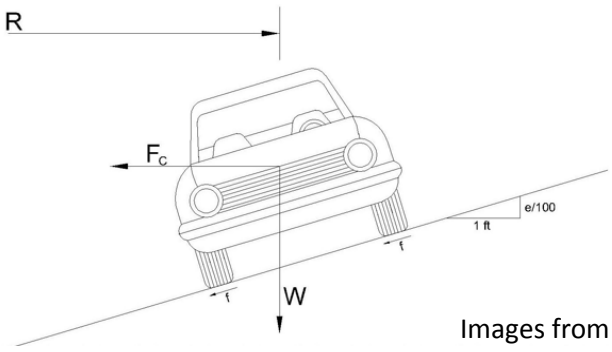
Impediments to Implementation: This treatment could potentially be very costly. It is important to make sure all other potential countermeasures for curve crashes have been considered, tried or proven ineffective before considering this superelevation countermeasure.

General Notes: The base condition is an SV value that is less than 0.01 and the proposed reconstructed SV will fall between 0.01 and 0.02. Superelevation is expressed as a decimal representing the ratio of the pavement slope to width ranging from 0 - 0.12. Typical maximum superelevations range from 0.04 to 0.12 and determined by individual State's. Selection of a maximum superelevation rate is based on several variables such as climate, terrain, highway location (urban vs. rural) and frequency of very slow moving vehicles.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
N/A	**CRF = -600 (SV - 0.01)**

Name: Improve Superelevation Variance (SV) on Rural Curves (More than 0.02)	**ODOT Countermeasure Number: H42**

What is it: Superelevation is the rotation of the pavement on the approach to and through a horizontal curve. It is intended to assist the driver in negotiating the curve by counteracting the lateral acceleration produced by tracking.



Images from FHWA

$$0.01e + f = \frac{V^2}{15R} \quad \text{(Equation 2)}$$

Where:
e = rate of superelevation, percent;
f = side friction (demand factor);
V = vehicle speed, mph;
R = radius of curve, ft.

Where to use: Use at a curve where you have a higher than expected number of vehicle or truck crashes at a curve that could be attributed to inadequate superelevation. Inadequate superelevation can cause vehicles to skid as they travel through a curve, potentially resulting in a run-off-road crash. Trucks and other large vehicles with high centers of mass are more likely to roll over at curves with inadequate superelevation.

Why it works: Superelevation offsets the horizontal sideways momentum of the approaching vehicle, minimizing the risk a vehicle of running off the road around a curve.

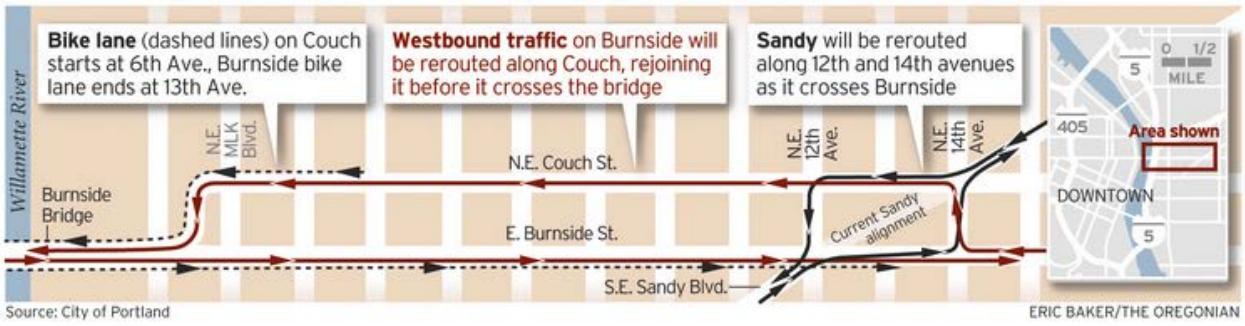
Impediments to Implementation: This treatment could potentially be very costly. It is important to make sure all other potential countermeasures for curve crashes have been considered, tried or proven ineffective before considering this superelevation countermeasure.

General Notes: The base condition is an SV value that is less than 0.01 and the proposed reconstructed SV will fall above 0.02. Superelevation is expressed as a decimal representing the ratio of the pavement slope to width ranging from 0 - 0.12. Typical maximum superelevations range from 0.04 to 0.12 and determined by individual State's. Selection of a maximum superelevation rate is based on several variables such as climate, terrain, highway location (urban vs. rural) and frequency of very slow moving vehicles.

Crash Types Addressed	**Severity Type Addressed**
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
N/A	**CRF = -300*SV**

Name: Convert from Urban Two-Way to One-Way Traffic	ODOT Countermeasure Number: H43

What is it: A segment of roadway that restricts vehicles to one direction travel.



Where to use: Preferably in a grid street system where you have a high frequency of intersection crashes along an urban segment and/or crashes related to capacity limitations.

Why it works: Reduces the number of potential conflicts at an intersection.

Impediments to Implementation: A one-way street system often forces drivers to take out-of-direction routes to their destinations.

General Notes: One-way streets allow for a less number of signal phases potentially increasing capacity and minimizing delay of various intersections along a segment of roadway. There are benefits to pedestrians with one-way streets too, they only need to look for traffic in one direction and there are often more gaps in traffic due to platooning.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
47%	**47%**

Name: Increase Pavement Friction by Installing High Friction Surface Treatment - Intersection or Segment Application	ODOT Countermeasure Number: H44, I11, RD4

What is it: Pavement surfacing systems with exceptional skid-resistant properties not typically provided by conventional materials.

Images from FHWA

Where to use: In locations where you have frequent crashes where insufficient friction is a contributing factor (i.e. wet weather). These are generally locations where drivers are braking excessively; for example, when going around curves or ramps, down hills or steep grades, or when approaching an intersection. The road surface can become prematurely polished, reducing the pavement friction and allowing vehicles to skid or hydroplane.

Why it works: It uses aggregates that are both polish- and wear-resistant and develop channels to prevent water buildup on wet surfaces creating an exceptionally durable surface capable of withstanding extreme roadway friction demands.

Impediments to Implementation: It is costly to install and could be costly to maintain so it's important to reserve this treatment for the most needed locations. It is important to closely follow the manufacturer's installation instructions in order to reduce any chances of product failure. For more information on High Friction Surface Treatment, please refer to the FHWA website. They have provided many informational materials on the subject.

General Notes: There is some concern over the effect of the treatment on motorcyclists if they were to crash so use caution if you have a history of motorcycle crashes at the location you are looking to install the treatment. This treatment can be an intersection or segment application.

Crash Types Addressed	Severity Type Addressed
Wet Road	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
20 - 68%	**57%**

Name: Install Urban Variable Speed Limit Signs	ODOT Countermeasure Number: H45

What is it: Speed limits that change based on road, traffic, and/or weather conditions.

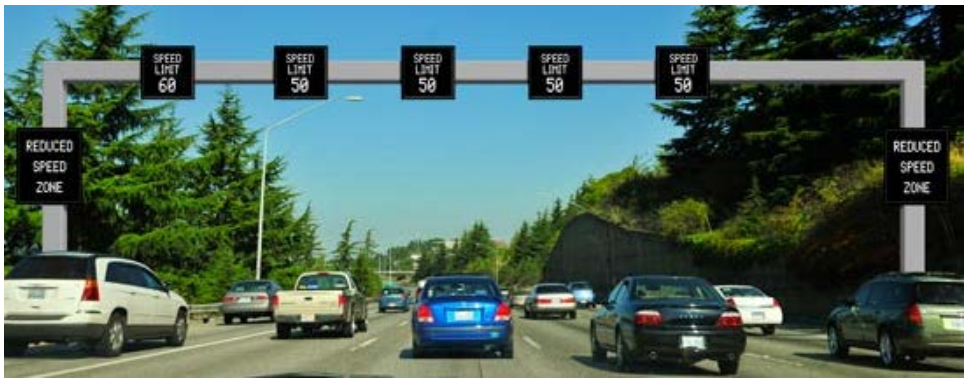


Image from WSDOT

Image from Oregonlive

Where to use: In locations where you have a high frequency of crashes related to weather conditions or congestion (peak hour or incident related).

Why it works: Improves safety by decreasing the risks associated with traveling at speeds that are higher than appropriate for the conditions. Variable Speed Limits can take into account traffic volume, operating speeds, weather information, sight distance, and roadway surface condition when posting speed limits.

Impediments to Implementation: Could be costly depending on the length of the corridor you are applying this countermeasure to due to the real time data collection and communication expenses.

General Notes: There is still ongoing research being done to evaluate the effectiveness of variable speed limits through work zones. Black on white variable speed limit signs shall only be installed in combination with agreement with law enforcement to actively enforce the speed limit(s). Otherwise the signs should be black on yellow.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
8%	**8%**

Name: Install Rural Variable Speed Limit Signs	ODOT Countermeasure Number: H46

What is it: Speed limits that change based on road, traffic, and/or weather conditions.

Images from ODOT

Where to use: In locations where you have a high frequency of crashes related to weather conditions or congestion (peak hour or incident related).

Why it works: Improves safety by decreasing the risks associated with traveling at speeds that are higher than appropriate for the conditions. Variable Speed Limits can take into account traffic volume, operating speeds, weather information, sight distance, and roadway surface condition when posting speed limits.

Impediments to Implementation: Could be costly depending on the length of the corridor you are applying this countermeasure to due to the real time data collection and communication expenses.

General Notes: There is still ongoing research being done to evaluate the effectiveness of variable speed limits through work zones. Black on white variable speed limit signs shall only be installed in combination with agreement with law enforcement to actively enforce the speed limit(s). Otherwise the signs should be black on yellow.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
20 - 30%	**20%**

Name: Install Individual Changeable Speed Warning Signs	ODOT Countermeasure Number: H47

What is it: Dynamic speed displays that provide drivers with feedback about their speed in relationship to the posted speed limit.

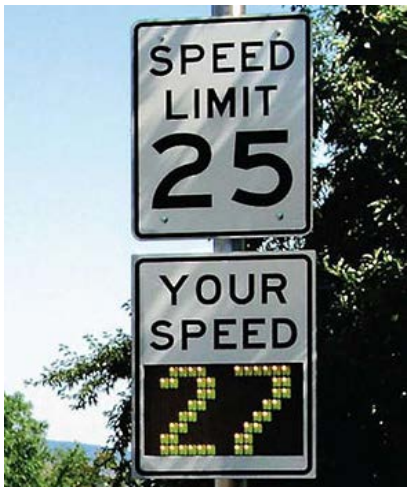


Image from FHWA

Where to use: In locations with a high frequency of speed related crashes (potentially related to careless/reckless driving or speed differential).

Why it works: When paired with enforcement, it helps to manage driving speeds and reduces the risk of speed related crashes.

Impediments to Implementation: These signs should be appropriately supplemented with police enforcement. It is important to consider setting a maximum speed that's being reported back to the driver to discourage the potential "how fast can you go" driving competition.

General Notes: For Vehicle Speed Feedback Signs on the State Highway, it is required that you follow the installation criteria stated in the ODOT Traffic Manual.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
41%	**41%**

Name: Convert 4-Lane Roadway to 3-Lane Roadway with Center Turn Lane (Road Diet)	ODOT Countermeasure Number: H48, BP16

What is it: A road diet involves converting an undivided four-lane roadway into three lanes consisting of two through lanes and a center two-way left turn lane (TWLTL).

Image from FHWA

Where to use: Where you have a high frequency of the following crash types: rear-end crashes from left turns, sideswipe overtaking, left turning crashes, and multiple-threat pedestrian crashes from a vehicle stopped for a pedestrian, blocking the view of the driver in the adjacent lane. Typical candidate four-lane roadways have 20,000 ADT or less.

Why it works: Reducing the number of through lanes and providing a TWLTL addresses crashes by (1) separating left-turning traffic from through traffic, (2) reducing the number of oncoming lanes through which a left-turning driver must search for a gap, and (3) removing the multiple-threat situation because there is no longer an adjacent lane. Road diets can decrease other incidents by providing designated spaces -- sidewalks and bicycle lanes -- that reduce opportunities for conflicts between motor vehicles and other road users.

Impediments to Implementation: The most common concern with proposed road diets is the potential increase in traffic delays during peak periods. It is important to involve stakeholders during the very early stages of a road diet discussion to ensure the best solution for all users.

General Notes: The reduction of lanes in a road diet allows for the roadway to be reallocated for other uses such as bike lanes, pedestrian crossing islands and/or parking. Road diets can be low cost if planned in conjunction with reconstruction or simple overlay projects since a road diet mostly consists of restriping.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
29%	**29%**

Name: Install Truck Escape Ramp	ODOT Countermeasure Number: H49

What is it: An emergency area located adjacent to a downgrade roadway to provide a location for out-of-control vehicles to slow and stop away from other vehicles on the road. They are generally located near the middle or the end of long, steep downgrades. The two most common types of truck escape ramps are: gravity ramps built with an upgrade to use the forces of gravity to slow a runaway vehicle and aggregate arrestor bed ramps using special sized rock in a gravel bed to slow a runaway vehicle. These ramps may have either an upward or downward grade.

Image from FHWA

Where to use: Where you have a high frequency of speed related truck crashes on steep grades.

Why it works: Truck escape ramps enable vehicles that are having braking issues to safety stop, avoiding potential run off the road and rear end crashes.

Impediments to Implementation: Potentially a very costly countermeasure as you need significant amount of extra surface area to accommodate the truck escape ramp.

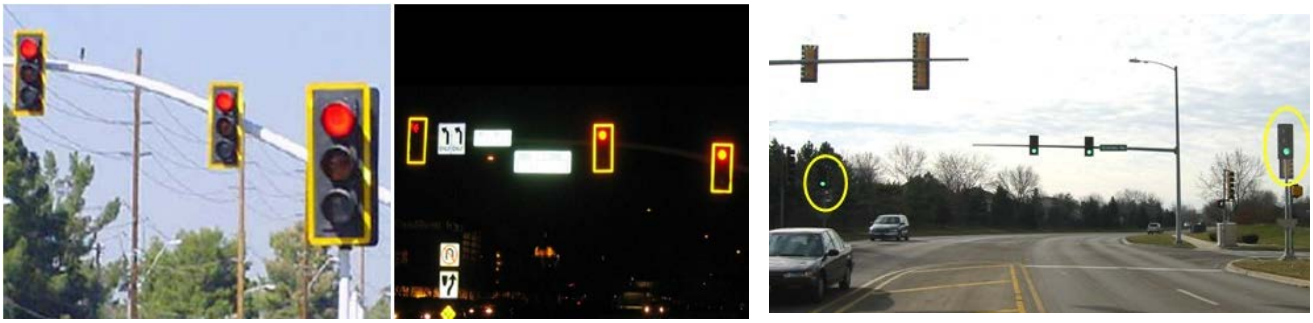
General Notes: This countermeasure is most appropriate in mountainous areas. The guidance listed is partially provided by Nevada DOT.

Crash Types Addressed	Severity Type Addressed
Truck Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
33 - 75%	**20%**

SYSTEMIC COUNTERMEASURES

Name: Improve Signal Hardware: Lenses, Reflectorized Back plates, Size, and Number	ODOT Countermeasure Number: I2

What is it: This countermeasure includes a set of proven, low-cost countermeasures that can be implemented at signals along a corridor. These countermeasures include the following options:
• Twelve-inch signal lenses
• LED lenses on all signal heads
• Reflectorized back plates on all signal heads
• Supplemental signal heads (recommended a minimum of one traffic signal head per approach lane)
• Elimination of any late night flashing operations
• Traffic signal yellow change interval and all red interval timing adjusted to be in accordance with the Institute of Transportation Engineers (ITE) timing standards



Images from FHWA

Where to use: On signalized corridors with a higher than expected frequency of intersection crashes, particularly angle and turning crashes related to red light running.

Why it works: All of the listed treatments are proven countermeasures that reduce intersection crashes and increase visibility of the signal and its operations.

Impediments to Implementation: It is highly recommended that these treatments be applied systemically. Structural analysis should be done to verify existing signal poles can withstand loading from additional signal heads. Switching out to 12" signal heads could create vehicle height restrictions.

General Notes: FHWA recommends these countermeasures to be used as a package so it is important to include as many of the listed countermeasures as possible. FHWA estimated the crash reduction factor for the combined basic countermeasures as 30% reduction in all crashes. This estimate was developed by an expert intersection safety panel using past effectiveness research findings for individual countermeasures combined with engineering judgment. ODOT is aware that it may not be possible to install all six countermeasures so we have used engineering judgment to adjust the crash reduction for installing less than all six countermeasures.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
0 - 46%	**20% for 1-2 Countermeasures from List** **25% for 3-4 Countermeasures from List** **30% for 5-6 Countermeasures from List**

Name: Replace Doghouse with Flashing Yellow Arrow Signal Heads	ODOT Countermeasure Number: I3

What is it: Replacing the 5-Section "doghouse" protected/permissive left turn signal head with a 4- or 3-Section flashing yellow arrow protected/permissive left turn signal.

Doghouse Signal

Flashing Yellow Arrow

Courtesy of ODOT Photo and Video Services

Where to use: Where you have doghouse signal heads and a high frequency of left turning crashes.

Why it works: Previous NCHRP studies (493 and Web-Only Document 123) have proven that the flashing yellow arrow is more intuitive with fewer "false positive" reactions as compared to the green ball indication on the doghouse signal head, resulting in a reduction of left turn crashes.

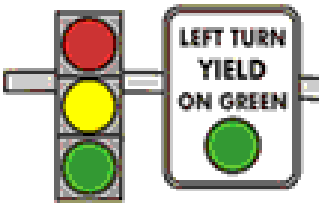
Impediments to Implementation: Signal software may need to be changed in order to be compatible with the flashing yellow arrow. If you are using a 4-Section flashing yellow arrow head, structural limitations and height restrictions will need to be considered.

General Notes: This countermeasure does not apply to doghouse signal heads for right turns. In addition, please consider that the 3-Section head for the flashing yellow arrow only has interim approval from FHWA. The flashing yellow arrow is a protected-permissive left turn phase that can allow for more flexibility of left turn phasing throughout peak and non-peak periods.

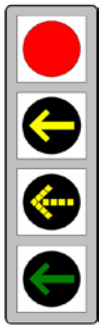
Crash Types Addressed	Severity Type Addressed
Left Turning	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
25%	**25%**

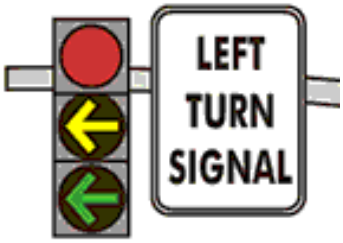
Name: **Replace Urban Permissive or Protected/Permissive Left Turns to Protected Only**	**ODOT Countermeasure Number: I4**

What is it: In a "permissive" mode, a green signal permits vehicles to turn left when an appropriate gap becomes available. In a "protected/permissive" mode, the permissive left-turn phase is immediately followed by an exclusive, protected left-turn phase, initiated by a green arrow signal indication. This countermeasure removes the permissive left-turn phase and provides the exclusive protected left-turn phase only.



OR





Images from FHWA & Becuo

Where to use: Where you have a high frequency of left turning crashes.

Why it works: "Protected-only" phasing consists of providing a separate phase for left-turning traffic and allowing left turns to be made only on a green left arrow signal indication, with no pedestrian movement or vehicular traffic conflicting with the left turn. As a result, left-turn movements with "protected-only" phasing have fewer potential conflicts than those with "permissive-only" or "protected/permissive" phasing.

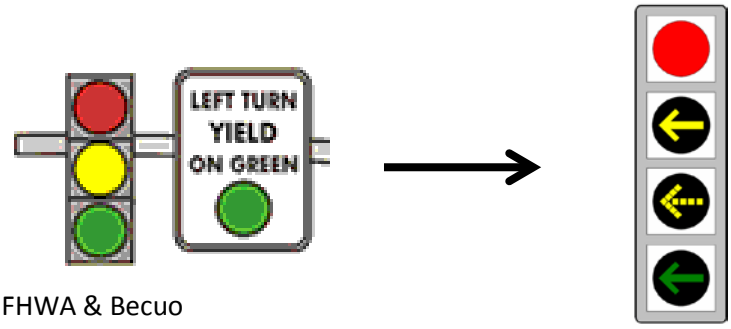
Impediments to Implementation: Protected-only left-turn phases may reduce delay for turning vehicles but are likely to increase overall intersection delay. If your signal is within a coordinated system, it is recommended that proper analysis and timing adjustments are made to accommodate the potential impact to the corridor's capacity by implementing this countermeasure.

General Notes: Other factors that may warrant the use of protected-only left-turn phases include delay, visibility and distance of the intersection.

Crash Types Addressed	Severity Type Addressed
Left Turning	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
6 - 99%	**99%**

Name: **Replace Urban Permissive Left Turns to Protected/Permissive**	**ODOT Countermeasure Number: I5**

What is it: In a "permissive" mode, a green signal permits vehicles to turn left only when an appropriate gap becomes available. In a "protected/permissive" mode, the permissive left-turn phase is immediately followed by an exclusive, protected left-turn phase, initiated by a green arrow signal indication.



Images from FHWA & Becuo

Where to use: Where you have a high frequency of left turning crashes and protected-only phasing is not justified.

Why it works: While permissive-only left turn operations may reduce delay for the intersection, it may adversely affect intersection safety as it requires motorists to choose acceptable gaps. protected/permissive left turn phasing provides an exclusive phase for left turning vehicles that reduces the number of potential left turning conflicts. Protected-permissive left turn phases can offer a good compromise between safety and efficiency and allows for more flexibility of left turn phasing throughout peak and non-peak periods.

Impediments to Implementation: Considerations should be made to driver expectations and if your signal is within a coordinated system. It is recommended that proper analysis and timing adjustments are made to accommodate the potential impact to the corridor's capacity by implementing this countermeasure.

General Notes: Some additional benefits to providing protected/permissive left turn phasing:
• Average delay per left-turn vehicle is reduced.
• Protected green arrow time is reduced.
• There is potential to omit or provide an exclusive protected left-turn phase.
• Arterial progression can be improved, particularly when special signal head treatments are used to allow lead-lag phasing.

Crash Types Addressed	Severity Type Addressed
Left Turning	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
6 - 99%	**16%**

Name: Install Coordination or Adaptive Signal Timing of Urban Traffic Signals	ODOT Countermeasure Number: I6

What is it: Coordination is the ability to synchronize multiple intersections to enhance the operation of one or more directional movements in a system. Adaptive Signal Timing is coordination that adjusts the timing of red, yellow and green lights to accommodate changing traffic patterns in real time and ease traffic congestion.

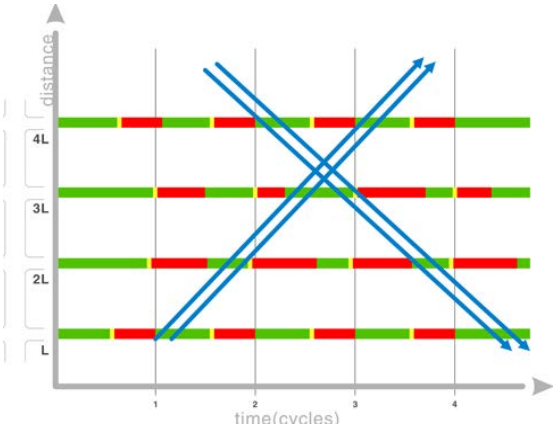


Image from FHWA

Where to use: Signalized intersections located close to each other where traffic volumes between the adjacent intersections are large. It should also be considered on corridors with a high frequency of rear end crashes and red light running crashes.

Why it works: Coordinated signals produce platoons of vehicles that can proceed without stopping at multiple intersections. Reducing the number and frequency of required stops and maintaining constant speeds for all vehicles reduce rear-end conflicts. In addition, signal coordination can improve the operation of turning movements. Drivers may have difficulty making permitted turning maneuvers because of a lack of gaps in through traffic. Crashes may occur when drivers become impatient and accept a gap that is smaller than needed. Such crashes could be reduced if longer gaps were made available.

Impediments to Implementation: Signals too close together can present problems related to drivers focusing on a downstream signal and not noticing the signal they are approaching, or proceeding through a green signal and not being able to stop for a queue at an immediate downstream signal. Dispersion of platoons can occur if signals are spaced too far apart, resulting in inefficient use of the signal coordination. Achieving a coordinated system along a corridor may be complicated by signal requirements associated with crossing facilities, any of which may also require signal coordination. The need for long signal cycles associated with multiphase operation and long clearance intervals will dictate the cycle length on which progression will be based. Such a cycle length may produce additional delays for pedestrians and side street traffic.

General Notes: Signals up to 3/4 mile of each other should be considered for coordination. Factors that should be considered include geographic boundaries, volume/capacity ratios, and characteristics of traffic flow. This countermeasure includes controllers, detection and communications. It is important to note that adaptive signal systems typically require additional detection beyond the standard

FHWA requires, for all federally funded projects, an Engineering Systems Document for ITS devices such as adaptive signal timing.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
7 - 32%	**7%**

Name: **Install Actuated Advance Warning Dilemma Zone Protection System at High Speed Signals (Microwave Detection)**	**ODOT Countermeasure Number: I7**

What is it: The dilemma zone is that portion of the approach where a driver suddenly facing a yellow indication must make a decision whether to stop safely or to proceed through the intersection. This countermeasure provides microwave radar that detects the speed and distance of a vehicle from the intersection and extends the green interval if the vehicle is within the dilemma zone.

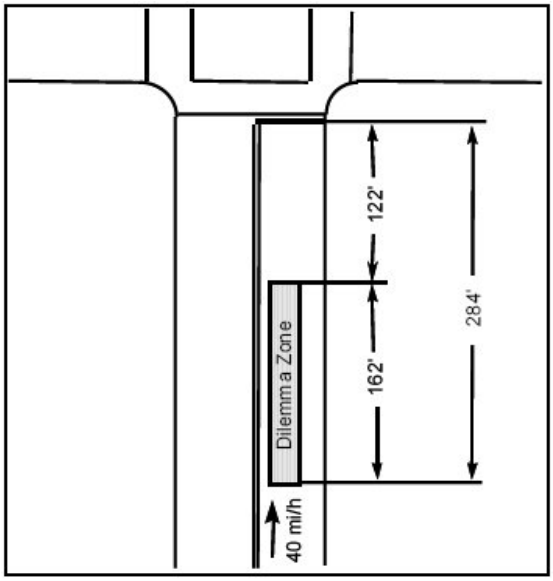


Image from FHWA

Where to use: At locations with a high frequency of crashes associated with the traffic signal phase change (e.g., rear-end and angle crashes) and high frequencies of red-light violations. This countermeasure should also be considered at high speed signalized intersections.

Why it works: The Advance Dilemma-Zone Detection system enhances safety at signalized intersections by modifying traffic control signal timing to reduce the number of drivers that may have difficulty deciding whether to stop or proceed during a yellow phase. This may reduce rear-end crashes associated with unsafe stopping and angle crashes due to illegally continuing into the intersection during the red phase.

Impediments to Implementation: On older signals there may be conduit capacity issues and structural issues related to where you need to mount the detection system.

General Notes: This countermeasure can only be used on higher speed facilities (45 mph +). In the past, dilemma zone protection has been provided through loop and/or camera detection. Microwave radar is a newer technology that more easily incorporates individual vehicle speeds in the dilemma zone detection. Additional benefits of this treatment include reducing delay and stop frequency on the major road and maintaining or reducing overall intersection delay. It is important to consider both truck and passenger vehicle stopping distances when implementing this countermeasure. Please refer to this TRB document for additional guidance for accommodating trucks when implementing this countermeasure: http://trb.metapress.com/content/45400327184n3838/fulltext.pdf

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
0 - 44%	**8%**

Name: Install Flashing Beacons as Advance Warning at Intersections (Not Coordinated with Signal Timing)	ODOT Countermeasure Number: I8

What is it: A flashing beacon installed on a signal ahead or intersection ahead warning sign. This feature flashes at all times.

Image from Google

Where to use: At intersections with patterns of right-angle or turning crashes related to lack of driver awareness of the upcoming intersection (e.g. first signal upon entering an urban area or intersection with limited sight distance).

Why it works: It helps to bring more awareness to drivers of an upcoming intersection where it might not be expected. For example, where there may be long stretches between intersections or locations where intersection visibility is an issue (e.g. limited sight distance or during nighttime conditions).

Impediments to Implementation: In rural areas, it may be difficult to find a source of power for the beacon(s).

General Notes: This countermeasure can include a single flashing beacon or dual flashing beacons that flash alternately ("wig-wag").

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
10 - 13%	**13%**

Name: Install Actuated/Coordinated Flashing Beacons as Advance Warning for Signalized Intersections	ODOT Countermeasure Number: I9

What is it: A flashing beacon on an advance warning sign for a signalized intersection that activates at a predetermined time before the end of the green interval.

Image from Shari Lewis

Where to use: At locations with a high frequency of crashes associated with the traffic signal phase change (e.g., rear-end and angle crashes) and high frequencies of red-light violations. This countermeasure could also be used at locations with a high frequency of crashes related to limited sight distance.

Why it works: It notifies drivers that the green interval is about to end in order to help reduce indecision and volatility in driver behavior during the yellow interval.

Impediments to Implementation: Some studies have shown that this countermeasure could inadvertently encourage some drivers to accelerate in order to make it through the green interval so use this countermeasure with caution.

General Notes: Additional potential benefits of this treatment include reducing delay and stop frequency on the major road and maintaining or reducing overall intersection delay.

Crash Types Addressed	Severity Type Addressed
Rear End	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
36 - 62%	**36%**

Name: Increase Triangle Sight Distance	ODOT Countermeasure Number: I10

What is it: Removal of sight distance restrictions (e.g., vegetation, parked vehicles, signs, buildings) from the sight triangles at an intersection.

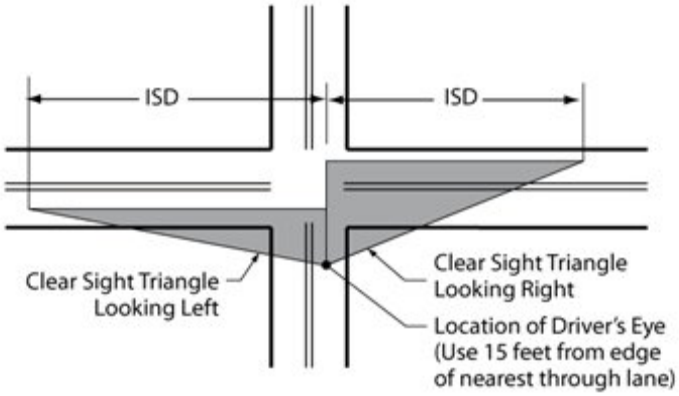


Image from FHWA

Where to use: At intersections with restricted sight distance and patterns of crashes related to lack of sight distance where sight distance can be improved by clearing roadside obstructions without major construction.

Why it works: Drivers will be able see approaching vehicles on the main line without obstruction and therefore make better decisions about entering the intersection safely.

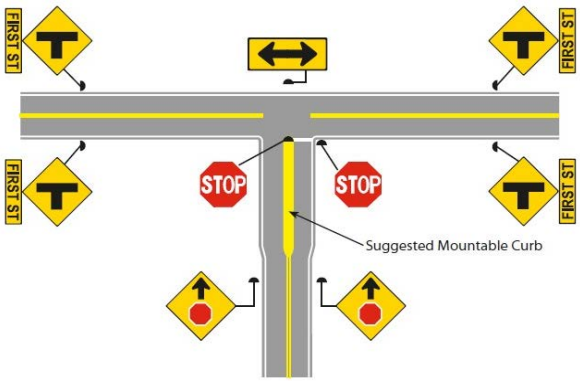
Impediments to Implementation: Removing or relocating obstacles can often be restricted and/or costly. Removing parking needs to have local community support.

General Notes: While countermeasure can be applied to signalized or unsignalized intersections, it is more likely to make a significant impact at unsignalized intersections as there is more driver response needed to judge gap sizes before deciding whether to initiate a roadway entry or a turning maneuver.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
11 - 56%	**48%**

Name: Improve Intersection Warning: Stop Ahead Pavement Markings, Stop Ahead Signs, Larger Signs, Additional Stop Signs and/or Other Intersection Warning or Regulatory Signs	**ODOT Countermeasure Number: I12**

What is it: FHWA has compiled a list of proven low cost countermeasures that can be implemented at unsignalized intersections. They are listed below:
▪ Doubled up (left and right), oversize advance intersection warning signs, with street name sign plaques on the through approach
▪ Doubled up (left and right), oversize advance "Stop Ahead" intersection warning signs
▪ Doubled up (left and right), oversize STOP signs
▪ Installation of a minimum 6 ft. wide raised splitter island on the stop approach (if no pavement widening is required)
▪ Properly placed stop bar
▪ Removal of any foliage or parking that limits sight distance
▪ Double arrow warning sign at stem of T-intersections



Images from FHWA

Where to use: At unsignalized intersections with a high frequency of angle or turning crashes.

Why it works: These countermeasures can be used to increase drivers' alertness to the presence of an unsignalized intersection and reduce potential conflicts with other entering vehicles.

Impediments to Implementation: If the width is not already available to place a splitter island, this countermeasure will require widening and the appropriate accommodations for adding impervious surface.

General Notes: FHWA recommends these countermeasures to be used as a package so it is important to include as many of the listed countermeasures as possible. FHWA estimated the crash reduction factor for the combined basic countermeasures as 30% reduction in all crashes. This estimate was developed by an expert intersection safety panel using past effectiveness research findings for individual countermeasures combined with engineering judgment. ODOT is aware that it may not be possible to install all seven countermeasures so we have used engineering judgment to adjust the crash reduction for installing less than all seven countermeasures.

Crash Types Addressed	**Severity Type Addressed**
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
11 - 55%	**20% for 1-2 Countermeasures from List** **25% for 3-4 Countermeasures from List** **30% for 5-7 Countermeasures from List**

Name: **Provide Flashing Beacons at All-Way Stop Controlled Intersections**	ODOT Countermeasure Number: **I13**

What is it: Red flashing beacons placed on the top of the stop signs at an all-way stop controlled intersection.

Image from FHWA

Where to use: At unsignalized intersections with patterns of right-angle crashes related to lack of driver awareness of the Stop sign on a stop-controlled approach.

Why it works: Flashing beacons provide a visible signal indicating the presence of an intersection and can be very effective in rural areas where there may be long stretches between intersections. They may also improve safety at locations where nighttime visibility of intersections is an issue.

Impediments to Implementation: In rural areas, it may be difficult to find a source of power for the beacons.

General Notes: This countermeasure only applies to all-way stop controlled intersections.

Crash Types Addressed	Severity Type Addressed
Angle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
5 - 58%	**28%**

Name: Provide Flashing Beacons at Minor Road Stop Controlled Intersections	**ODOT Countermeasure Number: I14**

What is it: At minor road stop controlled intersections, red flashing beacons installed on top of Stop signs on the minor, controlled road and/or yellow flashing beacons installed on top of Advance Intersection Warning Signs on the major, uncontrolled road.

Image from Sebastian Chavez

Where to use: At unsignalized intersections with patterns of right-angle crashes related to lack of driver awareness of the Stop sign on a stop-controlled approach.

Why it works: Flashing beacons provide a visible signal indicating the presence of an intersection and can be very effective in rural areas where there may be long stretches between intersections. They may also improve safety at locations where nighttime visibility of intersections is an issue.

Impediments to Implementation: In rural areas, it may be difficult to find a source of power for the beacons.

General Notes: This countermeasure only applies to minor road stop controlled intersections. You can choose to place flashing beacons on the major road, minor road or on all approaches.

Crash Types Addressed	**Severity Type Addressed**
Angle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
5 - 58%	**13%**

Name: Provide Actuated Flashing Beacons Triggered by Approaching Vehicles at Unsignalized Intersections	ODOT Countermeasure Number: I15

What is it: Flashing beacons that only flash when a sensor detects a vehicle approaching the intersection. ODOT encourages the installation of the type of actuated beacon that provides enhanced warning to the through driver that there is a vehicle on a cross road stop approach that may enter the intersection. Research has shown that this actuated beacon has seen the most effectiveness.

Image from Kevin Haas

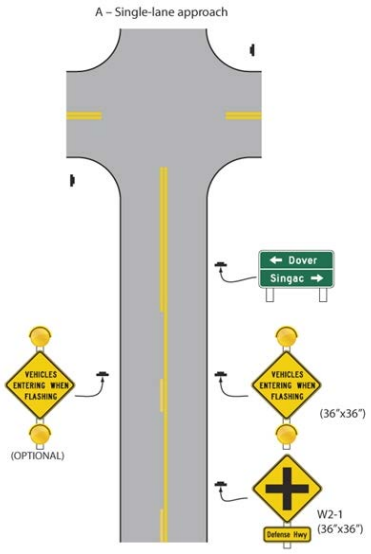


Image from FHWA

Where to use: At unsignalized intersections that experience severe intersection-related crashes due to speed, low visibility, or insufficient gaps. This countermeasure should be used where other signing enhancements have been shown to be ineffective.

Why it works: These systems provide enhanced safety warning information for approaching drivers, making them aware that vehicles are or may be entering the intersection.

Impediments to Implementation: In rural areas, it may be difficult to find a source of power for the beacons. Consider potential maintenance costs/impacts when deciding between camera or loop detection.

General Notes: This countermeasure only applies to unsignalized intersections. For more information please refer to the following two FHWA publications:
- Stop-Controlled Intersection Safety: Through Route Activated Warning Systems (FHWA-SA-11-015)
- Safety Evaluation of Flashing Beacons at STOP-Controlled Intersections (FHWA-HRT-08-044)

FHWA requires, for all federally funded projects, an Engineering Systems Document for ITS devices such as intersection conflict warning systems.

Crash Types Addressed	Severity Type Addressed
Angle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
5 - 58%	**14%**

Name: Install Transverse Rumble Strips on Approach(es)	ODOT Countermeasure Number: I16

What is it: Rumble strips that are milled-in or rolled-in patterns placed across the roadway that provide both an audible warning (rumbling sound) and physical vibration to alert drivers of an upcoming intersection.

Image from Google

Where to use: Where you have a high frequency of crashes as a result of vehicles failing to stop at a stop sign (e.g. limited visibility of an approaching intersection) and where other signing enhancements have been shown to be ineffective.

Why it works: Transverse rumble strips have been proven to be effective at reducing the number of vehicles disregarding a stop sign by using an audible alert as they are approaching an intersection.

Impediments to Implementation: Considerations should be made to existing pavement quality and potential noise impacts to neighboring residents.

General Notes: Transverse rumble strips are typically installed at rural, unsignalized intersections. This feature should be considered when a splitter island cannot be installed.

Crash Types Addressed	Severity Type Addressed
All Crashes	Fatal & Injury A
CRF Range of Effectiveness	**ODOT CRF Value**
21 - 39%	**39%**

Name: Install 6 ft. or greater Raised Divider on Stop Approach (Splitter Island)	ODOT Countermeasure Number: I17

What is it: A channelizing island that separates traffic in opposing directions of travel at a stop approach of an unsignalized intersection and contains a left side, supplemental Stop sign.

Image from FHWA

Where to use: Where you have a high frequency of crashes as a result of vehicles failing to stop at a stop sign (e.g. limited visibility of an approaching intersection) and where other signing enhancements have been shown to be ineffective. The strategy is particularly appropriate for intersections where the speeds on the minor road are high and/or on approaches to skewed intersections.

Why it works: The installation of splitter islands allows for the addition of a stop sign in the median to make the intersection more conspicuous.

Impediments to Implementation: If the width is not already available to place a splitter island, this countermeasure will require widening and the appropriate accommodations for adding impervious surface.

General Notes: This feature should be considered when transverse rumble strips cannot be installed.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
15%	**15%**

Name: Install Pedestrian Countdown Timer(s)	ODOT Countermeasure Number: BP1

What is it: Pedestrian signal heads are traffic signal indications exclusively intended for controlling pedestrian traffic. They consist of the illuminated symbols of a walking person (symbolizing Walk) and an upraised hand (symbolizing Don't Walk). Pedestrian countdown timers are pedestrian signal heads that include a countdown during the flashing Don't Walk phase that provides pedestrians with the remaining seconds available before the pedestrian phase ends.

Image from FHWA

Where to use: Where you have a high frequency of pedestrian crashes at signalized intersections.

Why it works: The countdown timer enables pedestrians to make better decisions on when to safely cross the road, effectively reducing the exposure of pedestrians to vehicular traffic at a signalized intersection.

Impediments to Implementation: Depending on the age of the signal, you may need to replace the entire pedestrian signal head as opposed to just the LED module, which could increase your installation costs.

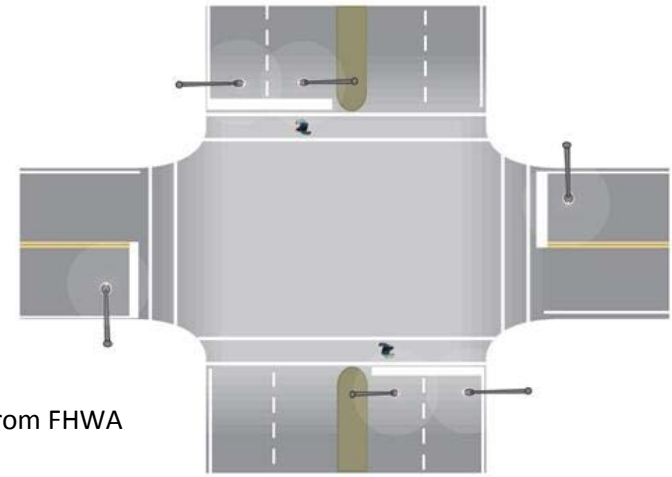
General Notes: This type of pedestrian signal head is the 2009 MUTCD standard and shall be installed at all new signal installations if flashing don't walk time is 7 seconds or more. It is encouraged that this countermeasure be applied systemically along a signalized corridor to create consistency for the pedestrians as they travel along the corridor.

This countermeasure may be included in an application for a Signalized Intersection Systemic project.

Crash Types Addressed	Severity Type Addressed
Pedestrian	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
0 - 70%	**70%**

Name: Provide Intersection Illumination (Bike & Ped)	ODOT Countermeasure Number: BP2

What is it: A permanent source of artificial light installed at an intersection that provides greater visibility of the intersection and its potential multi-modal users.



Images from FHWA

Where to use: At intersections where you have a high frequency of bicycle and pedestrian crashes at night.

Why it works: Intersection lighting allows for greater visibility of the intersection. Roadway users and features are more visible and help all users determine a safe path through the intersection. This can be especially helpful at rural intersections where the only source of lighting for the roadway is often provided by vehicle headlights.

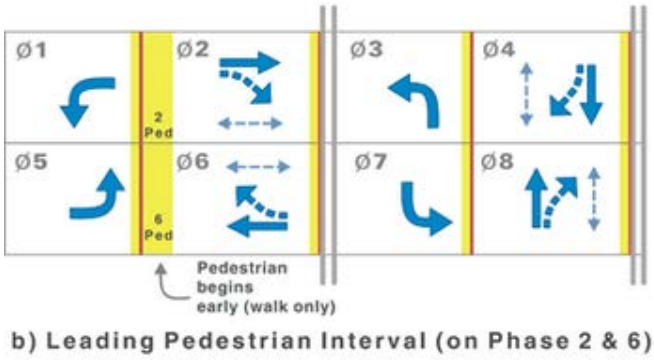
Impediments to Implementation: In rural areas it may be difficult to locate a power source. In addition, it is important to determine, upfront, the jurisdiction responsible for paying the ongoing utility costs. For signalized intersections, retrofitting illumination onto existing signal poles could result in an entire signal rebuild.

General Notes: This countermeasure may be used at a midblock pedestrian crossing location. This countermeasure is for new lighting only, not to replace existing, substandard lighting. This CRF value can be applied to signalized and unsignalized intersections. For ODOT Highways, please refer to the ODOT Lighting Policy and Guidelines for further guidance on lighting warrants.

Crash Types Addressed	Severity Type Addressed
Nighttime Pedestrian and Bicycle	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
42%	**42%**

Name: Install Urban Leading Pedestrian or Bicycle Interval at Signalized Intersection	ODOT Countermeasure Number: BP3

What is it: Leading pedestrian interval (LPI) gives pedestrians and bicycles using the marked crosswalk an advance walk signal before the motorists get a green indication, giving the pedestrian or bicyclist several seconds to start crossing before vehicles start proceeding through the intersection.



b) Leading Pedestrian Interval (on Phase 2 & 6)

Image from FHWA

Where to use: Where you have a high frequency of motorized users failing to yield to the right of way of non-motorized users at a signalized intersection.

Why it works: Provides better notice of the presence of pedestrian or bicyclists in the roadway/crosswalk for permissive left-turning or right-turning drivers. It makes non-motorized users more visible to motorized users and motorized users more likely to yield to them.

Impediments to Implementation: It is important to consider the potential intersection capacity and delay impacts to implementing this countermeasure.

General Notes: This treatment could also be beneficial in areas where you have a high number of older pedestrians who tend to be slower to start into the intersection. It could also be particularly effective where there is a dual lane turning movements.

This countermeasure may be included in an application for a Signalized Intersection Systemic project.

Crash Types Addressed	Severity Type Addressed
Pedestrian and Bicycle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
37 - 45%	**37%**

Name: Install No Pedestrian Phase Feature with Flashing Yellow Arrow	ODOT Countermeasure Number: BP4

What is it: The separation of the pedestrian walk phase from the flashing yellow arrow (permissive) left turn phase. When an intersection has pedestrian pushbutton activation and the pedestrian phase is activated, the flashing yellow arrow indication is not displayed for the duration of the pedestrian walk phase. The flashing yellow arrow is either delayed or suppressed.

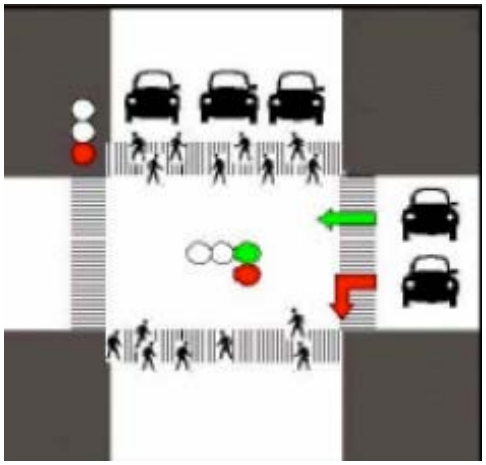


Image from PedBikeSafe

Where to use: Where the volume of pedestrians crossing the crosswalk, in conflict with the left turning traffic, is high or where you have a high frequency of left turning vehicles failing to yield to pedestrians during the flashing yellow arrow indication.

Why it works: This separation allows the pedestrian to cross the approach entirely before the flashing yellow arrow indication is displayed, thereby reducing potential vehicle to pedestrian conflicts.

Impediments to Implementation: It is important to consider the potential delay to left turning vehicles by implementing this countermeasure. In order to implement this countermeasure, you will need to verify that your existing signal software will be able to support it.

General Notes: You cannot implement this countermeasure without push button activation for pedestrians. If pedestrian push buttons do not already exist, installing them can be included as part of this countermeasure.

This countermeasure may be included in an application for a Signalized Intersection Systemic project.

Crash Types Addressed	Severity Type Addressed
Pedestrian	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
43%	**43%**

Name: Install Urban Green Bike Lanes at Conflict Points	ODOT Countermeasure Number: BP5

What is it: Green bike lanes are green-colored pavement placed on the roadway to enhance visibility of a bicycle lane.

Image from BTA Oregon

Where to use: In locations that have a high frequency of bicycle to vehicle conflicts where enhanced awareness of the presence of a bicycle lane could decrease the potential number of conflicts.

Why it works: It helps to bring awareness of the presence of potential bicyclists in locations where drivers may not be expecting them.

Impediments to Implementation: It is important to consider the added maintenance costs to installing this kind of treatment, especially in locations where vehicles may be regularly passing over the markings.

General Notes: This countermeasure has limited available research on its effectiveness so it should be used where other more proven countermeasures have shown to not be effective. For additional guidance, please refer to the MUTCD Interim Approval for green bike lanes.

Crash Types Addressed	Severity Type Addressed
Bicycle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
39%	**39%**

Name: Install Bike Box at Conflict Points	ODOT Countermeasure Number: BP6

What is it: The bike box is a designated space for bicyclists at an intersection (often painted green) that allows bicyclists to position themselves ahead of vehicle traffic.

Image from Portland Mercury

Where to use: Where you have a high frequency of right turning vehicles failing to yield to through moving bicyclists at an intersection.

Why it works: Bike boxes make bicyclists more visible to motorists by placing them in their direct line of sight when stopped at an intersection. They alert vehicles to the presence of bicyclists at an intersection and can serve as a reminder to drivers to yield to bicyclists when they are turning right.

Impediments to Implementation: It is important to consider the added maintenance costs to installing this kind of treatment, especially in locations where vehicles may be regularly passing over the markings.

General Notes: This countermeasure has limited available research on its effectiveness so it should be used where other more proven countermeasures have shown to not be effective.

Experimental approval from FHWA is REQUIRED for use of this countermeasure.

Crash Types Addressed	Severity Type Addressed
Bicycle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
35%	**35%**

Name: Install Raised Median with Marked Crosswalk	ODOT Countermeasure Number: BP7

What is it: Concrete pedestrian refuge islands with crosswalk markings placed on a street at unsignalized intersections or midblock locations to separate crossing pedestrians from motor vehicles and provide pedestrians with the ability to cross one direction of traffic at a time.

Image from FHWA

Where to use: Where you have a higher than expected frequency of pedestrian crashes or vehicles crashes caused by pedestrians that could be reduced by minimizing the crossing distance and maximizing the visibility of pedestrians.

Why it works: Pedestrians are able to more safely make a two-stage crossing by having to only look for a gap in one direction of traffic at a time while being protected by a concrete curbed island.

Impediments to Implementation: It is important to provide sufficient pavement width to accommodate the largest size of vehicles expected to travel on the road in question. It is also important to consider the potential impact to turning movements at any nearby accesses as a result of the median island.

General Notes: The following is guidance from FHWA on pedestrian raised median islands. Raised medians should be considered on sections of multi-lane roadways in urban and suburban areas, particularly in areas where there are mixtures of significant pedestrian and vehicle traffic (more than 12,000 Average Daily Traffic (ADT)) and intermediate or high travel speeds (40 mph or more). Medians/refuge islands should be at least 4 feet wide (preferably 8 feet wide to accommodate pedestrian comfort and safety) and of adequate length to allow the anticipated number of pedestrians to stand and wait for gaps in traffic before crossing the second half of the street.

On the State Highway System, marked crosswalks at uncontrolled (unsignalized) locations require State Traffic Engineer approval

Crash Types Addressed	Severity Type Addressed
Pedestrian	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
46%	**46%**

Name: Install Rectangular Rapid Flashing Beacon (2-Lane Road)	ODOT Countermeasure Number: BP8

What is it: Rectangular Rapid Flash Beacons (RRFBs) are user-actuated amber Light Emitting Diodes (LEDs) that supplement warning signs at unsignalized intersections or mid-block crosswalks. The signals rest in the dark phase until activated by a push button and then flash in a rapid stutter flash pattern.

Image from Frank Ockenfels

Where to use: On 2-lane roads where crash data indicates a need to provide additional notification to motorists of the presence of crossing pedestrians or where there are insufficient gaps in vehicle traffic to provide a pedestrian a crossing opportunity.

Why it works: RRFB's can enhance safety by reducing crashes between vehicles and pedestrians by increasing driver awareness of potential pedestrian conflicts.

Impediments to Implementation: It may be important to provide educational outreach to the community on safe use of RRFB's. There are instances where pedestrians have been shown to blindly trust that vehicles will immediately yield to them once they activate the RRFB. Their failure to check for oncoming traffic can result in a pedestrian crash regardless of the presence of an RRFB.

General Notes: RRFB's are meant to supplement standard pedestrian crossing warning signs and crosswalk markings. Typically, pedestrian crossing warning signs are placed on the left and right sides of the road at the crossing. Placing advanced stop bars are optional. It is important to remember that RRFB's have limited available research on their effectiveness on crashes so they should be used where other more proven countermeasures have shown to not be effective.

On the State Highway System, RRFB's and marked crosswalks at uncontrolled locations require State Traffic Engineer approval

Crash Types Addressed	Severity Type Addressed
Pedestrian	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
10 - 56%	**10%**

Name: Install Rectangular Rapid Flashing Beacon without Median (3-Lane or More Roadway)	ODOT Countermeasure Number: BP9

What is it: Rectangular Rapid Flash Beacons (RRFBs) are user-actuated amber Light Emitting Diodes (LEDs) that supplement warning signs at unsignalized intersections or mid-block crosswalks. The signals rest in the dark phase until activated by a push button and then flash in a rapid stutter flash pattern.

Image from Google

Where to use: On multi-lane roads where crash data indicates a need to provide additional notification to motorists of the presence of crossing pedestrians or where there are insufficient gaps in vehicle traffic to provide a pedestrian a crossing opportunity.

Why it works: RRFB's can enhance safety by reducing crashes between vehicles and pedestrians by increasing driver awareness of potential pedestrian conflicts.

Impediments to Implementation: It may be important to provide educational outreach to the community on safe use of RRFB's. There are instances where pedestrians have been shown to blindly trust that vehicles will immediately yield to them once they activate the RRFB. Their failure to check for oncoming traffic can result in a pedestrian crash regardless of the presence of an RRFB.

General Notes: RRFB's are meant to supplement standard pedestrian crossing warning signs and crosswalk markings. Typically, pedestrian crossing warning signs are placed on the left and right sides of the road at the crossing. Placing advanced stop bars highly recommended on multi-lane facilities. It is important to remember that RRFB's have limited available research on their effectiveness on crashes so they should be used where other more proven countermeasures have shown to not be effective.

On the State Highway System, RRFB's and marked crosswalks at uncontrolled locations require State Traffic Engineer approval

Crash Types Addressed	Severity Type Addressed
Pedestrian	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
10 - 56%	**10%**

Name: Install Rectangular Rapid Flashing Beacon with Median (3-Lane or More Roadway)	ODOT Countermeasure Number: BP10

What is it: Rectangular Rapid Flash Beacons (RRFBs) are user-actuated amber Light Emitting Diodes (LEDs) that supplement warning signs at unsignalized intersections or mid-block crosswalks. The signals rest in the dark phase until activated by a push button and then flash in a rapid stutter flash pattern. This countermeasure includes installation of a pedestrian refuge island in addition to the RRFB.

Image from Washington County (OR)

Where to use: On multi-lane roads where crash data indicates a need to provide additional notification to motorists of the presence of crossing pedestrians or where there are insufficient gaps in vehicle traffic to provide a pedestrian a crossing opportunity.

Why it works: RRFB's can enhance safety by reducing crashes between vehicles and pedestrians by increasing driver awareness of potential pedestrian conflicts. With a pedestrian refuge island, pedestrians are able to more safely make a two-stage crossing by having to only look for a gap in one direction of traffic at a time while being protected by a concrete curbed island.

Impediments to Implementation: If placed at an intersection with designated left turn lanes, a pedestrian refuge island will impact left turning movements. It may be important to provide educational outreach to the community on safe use of RRFB's. There are instances where pedestrians have been shown to blindly trust that vehicles will immediately yield to them once they activate the RRFB. Their failure to check for oncoming traffic can result in a pedestrian crash regardless of the presence of an RRFB. It is important to provide sufficient pavement width to accommodate the largest size of vehicles expected to travel on the road in question.

General Notes: This countermeasure is highly encouraged on higher speed facilities. RRFB's are meant to supplement standard pedestrian crossing warning signs and crosswalk markings. Typically, pedestrian crossing warning signs are placed on the left and right sides of the road at the crossing. Placing an RRFB in the pedestrian refuge island and advanced stop bars are highly recommended on multi-lane facilities. It is important to remember that RRFB's alone have limited available research on their effectiveness on crashes so they should be used where other more proven countermeasures have shown to not be effective or in combination with more proven countermeasures.

On the State Highway System, RRFB's and marked crosswalks at uncontrolled locations require State Traffic Engineer approval

Crash Types Addressed	Severity Type Addressed
Pedestrian	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
10 - 56%	**56%**

Name: **Install Continental Crosswalk Markings and Advance Pedestrian Warning Signs at Uncontrolled Locations**	**ODOT Countermeasure Number: BP11**

What is it: A crosswalk is a location where the pedestrian leaves the sidewalk and enters the roadway and the pedestrian's path of travel crosses the motorist's path of travel. Marked crosswalks use pavement markings to indicate optimal or preferred locations for pedestrians to cross and help designate right-of-way for motorists to yield to pedestrians.

Image from Google

Where to use: Where you have a higher than expected frequency of pedestrian crashes or vehicles crashes caused by pedestrians.

Why it works: Crosswalks help call attention to pedestrians crossing a road and provide a defined location in which to do so.

Impediments to Implementation: Pedestrians are sensitive to out-of-the-way travel, and reasonable accommodation should be made to make crossings both convenient and safe at locations with adequate visibility. Too many and unnecessary marked crosswalks on a segment of road has a high potential to result in driver complacency and reduced yielding compliance.

General Notes: This countermeasure can be applied at intersections or midblock locations. It is important to remember that all intersections are legal pedestrian crossings in Oregon, regardless if they are marked or not. Advanced stop bars are REQUIRED in multi-lane sections.

Consider marking a crosswalk at non-signalized locations where engineering judgment dictates that the number of motor vehicle lanes, pedestrian exposure, average daily traffic (ADT), posted speed limit, and geometry of the location would make the use of specially designated crosswalks desirable for traffic/pedestrian safety and mobility. Marked crosswalks alone (i.e., without traffic-calming treatments, traffic signals and pedestrian signals when warranted, or other substantial crossing improvement) are insufficient and should not be used under the following conditions:

▪ Where the speed limit exceeds 40 mph
▪ On a roadway with four or more lanes without a raised median or crossing island that has (or will soon have) an ADT of 12,000 or greater
▪ On a roadway with four or more lanes with a raised median or crossing island that has (or soon will have) an ADT of 15,000 or greater
For additional guidance, please refer to FHWA's Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations.
On the State Highway System, marked crosswalks at uncontrolled locations require State Traffic Engineer approval

Crash Types Addressed	Severity Type Addressed
Pedestrian	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
15%	**15%**

Name: Install Curb Ramps and Extensions with a Marked Crosswalk and Pedestrian Warning Signs	ODOT Countermeasure Number: BP12

What is it: Curb extensions (also known as bulb-outs) extend the sidewalk or curb line out into the parking lane, which reduces the effective street width.

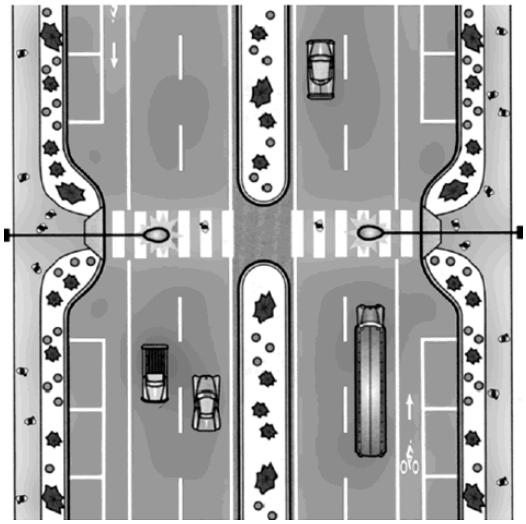


Image from FHWA

Where to use: Where you have a higher than expected frequency of pedestrian crashes or vehicles crashes caused by pedestrians that could be reduced by minimizing the crossing distance and maximizing the visibility of pedestrians.

Why it works: Curb extensions significantly improve pedestrian crossings by reducing the pedestrian crossing distance, improving the ability of pedestrians and motorists to see each other, and reducing the time that pedestrians are in the street.

Impediments to Implementation: It is important to provide sufficient pavement width to accommodate the largest size of vehicles expected to travel on the road in question. The new curb line should not encroach the traveled way where bicyclists or motor vehicles may be traveling either.

General Notes: This countermeasure can be used at intersections or midblock locations. Curb extensions should typically be used where there is a parking lane and where transit and cyclists will be traveling outside the curb edge for the length of the street.

On the State Highway System, marked crosswalks at uncontrolled locations require State Traffic Engineer approval

Crash Types Addressed	Severity Type Addressed
Pedestrian	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
37%	**37%**

Name: Install Advance Pedestrian or Bicycle Warning Signs	ODOT Countermeasure Number: BP13

What is it: Yellow warning symbol signs with appropriate supplemental plaques warning of pedestrian and/or bicycles (W11-1, W11-2, W11-15) potentially crossing the road.

Image from Google

Where to use: Where crash data indicates a need to provide additional notification to motorists of the presence of crossing pedestrians and/or bicyclists.

Why it works: It warns motorists of locations where unexpected entries into the roadway by pedestrians and/or bicycles might occur.

Impediments to Implementation: These signs should be reserved for use in locations that have shown a need through crash data to avoid sign clutter and driver complacency.

General Notes: The combined Bicycle/Pedestrian (W11-15) sign may be used where both bicyclists and pedestrians might be crossing the roadway, such as at an intersection with a shared-use path. Please refer to the 2009 MUTCD for additional guidance on placement of these signs and the appropriate supplemental plaques that should be included.

This countermeasure cannot be used with any of the marked crosswalk countermeasures as signs are already included in those countermeasures

Crash Types Addressed	Severity Type Addressed
Pedestrian and Bicycle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
5 - 15%	**5%**

Name: Install Pedestrian Signal	ODOT Countermeasure Number: BP14

What is it: Traffic Signals are a traffic control device positioned on roadways to efficiently control and manage competing flows of traffic (vehicles, pedestrians and/or bicycles). A Pedestrian Signal controls the flow of traffic and provides sufficient time for safe and efficient pedestrian and/or bicycle crossings.

Image from Google

Where to use: Where you have a higher than expected frequency of pedestrian/bicycle crashes or vehicles crashes caused by pedestrians/bicycles and other less aggressive countermeasures have been proven to be ineffective.

Why it works: Pedestrian signals provide positive guidance to pedestrians regarding the permitted signal interval to cross a street and prohibit pedestrian crossings when conflicting traffic may impact pedestrian safety.

Impediments to Implementation: There should be discussions on which type of pedestrian activated traffic control device is the most appropriate countermeasure for the identified problem. Inappropriate placement of a Pedestrian Signal could result in an increase in vehicle crashes and a decrease in compliance from either vehicles or pedestrians.

General Notes: Pedestrian signals are appropriate where it is difficult to find a gap in traffic to make a crossing and there are a significant number of pedestrians wanting to cross at a particular location.

Half signals at intersections are NOT allowed on the State Highway System. Any half signal installations on the local system will be required to be stamped by a local agency engineer.

A pedestrian signal is warranted by MUTCD Warrant #4. State Traffic Engineer Approval and warrant analysis is REQUIRED for all potential signal installations on the State Highway.

Crash Types Addressed	Severity Type Addressed
Pedestrian and Bicycle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
15 - 69%	**55%**

Name: Install Pedestrian Hybrid Beacon	ODOT Countermeasure Number: BP15

What is it: The pedestrian hybrid beacon (PHB) - also known as the High intensity Activated crossWalK (or HAWK) - is a pedestrian-activated warning device located on the roadside or on mast arms over midblock pedestrian crossings. The beacon head consists of two red lenses above a single yellow lens. The beacon head is "dark" until the pedestrian desires to cross the street. When activated it displays a brief flashing and steady yellow intervals followed by a steady red indication to drivers and a "WALK" indication to pedestrians.

Image from FHWA

Where to use: Where you have a higher than expected frequency of pedestrian/bicycle crashes or vehicles crashes caused by pedestrians/bicycles and other less aggressive countermeasures have been proven to be ineffective. This treatment may be used at locations with a high number of pedestrian crashes where additional visibility of pedestrian crossings is needed.

Why it works: It displays a red indication to drivers when activated, which creates a gap for pedestrians to cross a major roadway. They provide positive guidance to pedestrians regarding the permitted signal interval to cross a street and prohibit pedestrian crossings when conflicting traffic may impact pedestrian safety.

Impediments to Implementation: There should be discussions on which type of pedestrian activated traffic control device is the most appropriate countermeasure for the identified problem. Inappropriate placement of a PHB could result in an increase in vehicle crashes and a decrease in compliance from either vehicles or pedestrians. Since the pedestrian hybrid beacon is a traffic control device many people are not yet familiar with, effort should be made to perform outreach to the public before implementation so there is no confusion about how the beacon operates and what drivers and pedestrians should do when encountering it.

General Notes: In general, PHB's should be used if gaps in traffic are not adequate to permit pedestrians to cross, if vehicle speeds on the major street are too high to permit pedestrians to cross, or if pedestrian delay is excessive. Hybrid beacons may be used at locations with lower volumes than what is required for a pedestrian signal.

The MUTCD guidance for the placement of PHB's should be reviewed as installation of this treatment is considered. State Traffic Engineer Approval is REQUIRED for all PHB installations on the State Highway.

Crash Types Addressed	Severity Type Addressed
Pedestrian and Bicycle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
15 - 69%	**69%**

Name: Install Bike Signal	ODOT Countermeasure Number: BP17

What is it: A bicycle signal face provided at a signalized intersection exclusively for bicycle use. Steady and flashing red, yellow and green bicycle signal indications shall have the same meanings as described in the 2009 MUTCD for steady and flashing circular red, yellow and green signal indications for motor vehicles.

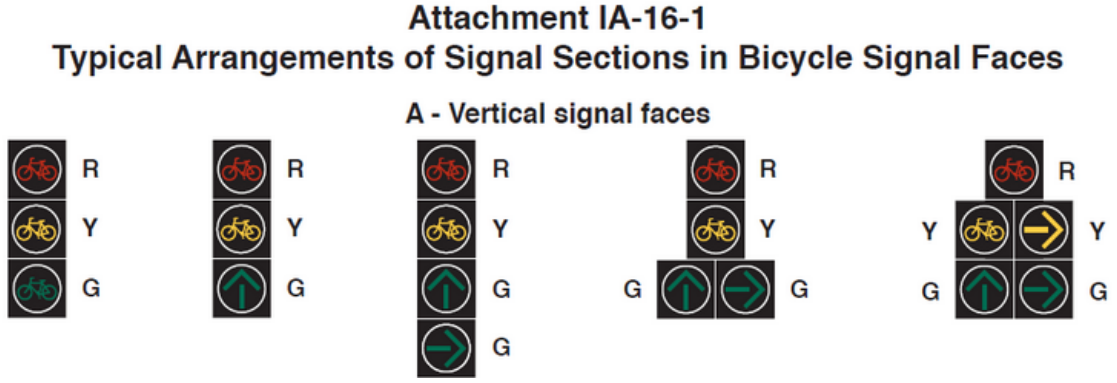


Image from MUTCD

Image from J. Maus

Where to use: At a signalized intersection where there is a higher frequency of bicycle crashes that could be mitigated with an exclusive bicycle signal phase.

Why it works: A bike signal provides a separate phase for bicycles and minimizes potential vehicle to bicycle right of way conflicts.

Impediments to Implementation: Where passive detection is used, it is important to consider the type of bicycle detection that will be the most appropriate for the location in question. On older signals there may be conduit capacity issues and structural issues related to where you need to mount the signal head(s).

General Notes: Bicycle signals are appropriate where conflicts between turning vehicles and bicycles occur enough to warrant exclusive bicycle phasing. Where the potential exists for a conflict between the bicycle phase and vehicles turning right on a red indication, it is required to prohibit right turn vehicle movements on red.

For more guidance on installing bike signals, please refer to the ODOT Signal Policy and Guidelines and the MUTCD Interim Approval Memo for Bike Signals. The MUTCD interim approval for the placement of bicycle signals should be reviewed as installation of this treatment is considered. State Traffic Engineer Approval and warrant analysis is REQUIRED for all potential signal installations on the State Highway.

Crash Types Addressed	Severity Type Addressed
Bicycle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
45%	**45%**

Name: Install Bike Lanes	ODOT Countermeasure Number: BP18

What is it: Bike lanes are defined as a portion of the roadway that has been designated by signing and pavement marking for the preferential or exclusive use by bicyclists. Typically, there is one bike lane provided on each side of the roadway and travels in the same direction as the motorized vehicle lane.

Image from FHWA

Where to use: Where you have a high frequency of bicycle crashes particularly where there is a high volume of bicycle traffic along a corridor, such as known or designated bicycle routes.

Why it works: Bicycle lanes make the movements of both motorists and bicyclists more predictable and provide a consistent separation between bicyclists and passing motorists.

Impediments to Implementation: This countermeasure can be costly depending on right of way acquisition needs and drainage impacts. It is important to provide adequate space between the bike lane and parked cars so that open doors do not create a hazard for bicyclists and to avoid termination of bike lanes where bicyclists are left in a vulnerable situation.

General Notes: For more guidance on bike lanes and their design standards, please refer to the AASHTO Guide for the Development of Bicycle Facilities, the Oregon Bicycle and Pedestrian Design Guide and Section 9C.04 of the Oregon Supplement to the MUTCD.

Crash Types Addressed	Severity Type Addressed
Bicycle	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
0 - 53%	**36%**

Name: Install Cycle Tracks	ODOT Countermeasure Number: BP19

What is it: A cycle track is a bike lane (one- or two-way) with a physical barrier between the bike and motor vehicle travel lanes, such as a curb or parking lanes.

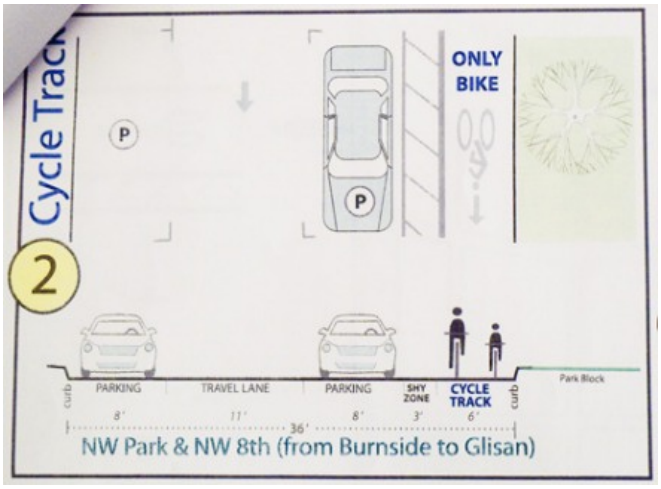


Image from City of Portland

Where to use: Where bicycle crash data indicates a need to provide additional separation between bicycles and vehicles (parked or moving).

Why it works: Provides a dedicated and protected space for bicyclists from vehicles and reduces the risk of a parked car opening their door in the path of a bicyclist.

Impediments to Implementation: This countermeasure can be costly depending on right of way acquisition needs and drainage impacts. Cycle tracks can also pose a crash risk at intersections where turning vehicles cannot see bicyclists emerging from behind parked cars or standing pedestrians.

General Notes: For more guidance, please refer to the Oregon Bicycle and Pedestrian Design Guide and the NACTO Urban Bikeway Design Guide.

Crash Types Addressed	Severity Type Addressed
Bicycle	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
59 - 74%	**59%**

Name: Install Buffered Bike Lanes	ODOT Countermeasure Number: BP20

What is it: A conventional bike lane with an adjacent buffer space (painted median) separating the bicycle lane from the vehicle travel lane and/or adjacent parking lane.

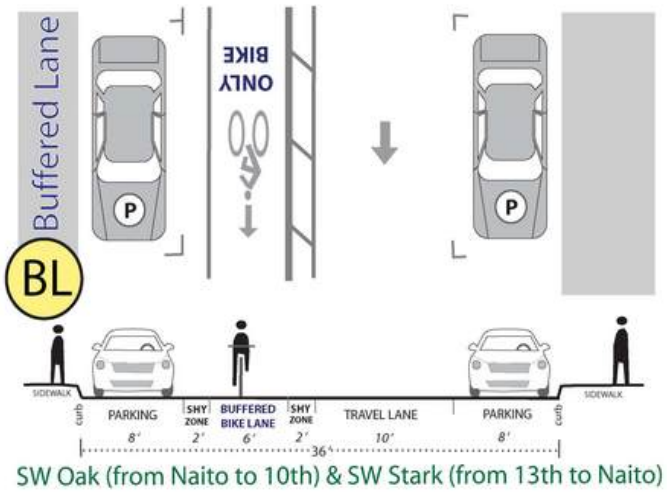


Image from City of Portland

Where to use: Where bicycle crash data indicates a need to provide additional separation between bicycles and vehicles (parked or moving).

Why it works: Provides a larger separation between bicyclists and motorists in the adjacent travel lane. It also provides more space for bicyclists to maneuver around a parked car with their door open.

Impediments to Implementation: This countermeasure can be costly depending on right of way acquisition needs and drainage impacts.

General Notes: For more guidance, please refer to the Oregon Bicycle and Pedestrian Design Guide and the NACTO Urban Bikeway Design Guide.

Crash Types Addressed	Severity Type Addressed
Bicycle	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
N/A	**47%**

Name: Increase Distance to Rural Roadside Obstacle from 3 ft. (1 m) to 16 ft. (5 m)	ODOT Countermeasure Number: RD1

What is it: Increasing the clear zone of a roadway by removing obstacles within 16 feet of the roadway.

Image from FHWA

Where to use: Where you have a high frequency of roadway departure crashes attributed to striking fixed objects, ditches, or other roadside obstacles.

Why it works: A clear zone is an unobstructed, traversable roadside area that allows a driver to stop safely or regain control of a vehicle that has left the roadway. By increasing the clear zone area, you increase the likelihood that a roadway departure results in a safe recovery rather than a crash.

Impediments to Implementation: Removing objects can be costly and the appropriate easements may be needed to remove objects outside of the agency's right of way.

General Notes: This countermeasure only applies to rural areas.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
22 - 44%	**22%**

Name: Increase Distance to Rural Roadside Obstacle from 16 ft. (5 m) to 30 ft. (9 m)	**ODOT Countermeasure Number: RD2**

What is it: Increasing the clear zone of a roadway by removing obstacles within 30 feet of the roadway.

Image from FHWA

Where to use: Where you have a high frequency of roadway departure crashes attributed to striking fixed objects, ditches, or other roadside obstacles.

Why it works: A clear zone is an unobstructed, traversable roadside area that allows a driver to stop safely or regain control of a vehicle that has left the roadway. By increasing the clear zone area, you increase the likelihood that a roadway departure results in a safe recovery rather than a crash.

Impediments to Implementation: Removing objects can be costly and the appropriate easements may be needed to remove objects outside of the agency's right of way.

General Notes: This countermeasure only applies to rural areas.

Crash Types Addressed	**Severity Type Addressed**
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
22 - 44%	**44%**

Name: Flatten Rural Side Slopes	ODOT Countermeasure Number: RD3

What is it: Flat areas adjacent to the travel way that are sloped to provide drainage and can provide a safe recovery area of vehicles departing their lane.

Image from FHWA

Potential Crash Effects on Total Crashes of Flattening Sideslopes (Table 13-18 of the Highway Safety Manual)

Treatment	Setting (Road Type)	Traffic Volume	Crash Type (Severity)	Crash Reduction Factor				
				Sideslope in Before Condition	Sideslope in After Condition			
					1V:4H	1V:5H	1V:6H	1V:7H
Flatten Sideslopes	Rural (Two-Lane Road)	Unspecified	All Types (Unspecified)	1V:2H	6%	9%	12%	15%
				1V:3H	5%	8%	11%	15%
				1V:4H		3%	7%	11%
				1V:5H			3%	8%
				1V:6H				5%

Base Condition: Existing sideslopes in *before* condition.

Note: Standard error of CRF is unknown.

Where to use: Where you have a high frequency of overturn crashes that could be mitigated with flattening the side slope (e.g. on the outside of curves with small radii or where the side slope has a slope of greater than 3:1).

Why it works: By reducing the amount of road side slope, vehicles are better able to recover after leaving the travel way. The flatter the slope, the more traversable the side slope becomes.

Impediments to Implementation: The provision of flattened side slopes may require erosion mitigation and may have property impacts, requiring extensive right of way acquisition.

General Notes: This countermeasure could be applied systemically and could be installed in conjunction with a paving project. This countermeasure could potentially be very costly depending on the type of roadside mitigation needed and the right of way impacts.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
3 - 15%	**See Table Above**

Name: Provide Safety Edge for Rural Pavement Edge Drop-Off	ODOT Countermeasure Number: RD5

What is it: Safety edge is a pavement edge sloped at an angle (30-35 degrees) to make it easier for a driver to safely reenter the roadway after inadvertently driving onto the shoulder.

Photo from FHWA

Where to use: It should be installed at locations where there is a high frequency of vehicle pavement edge drop-offs, particularly on rural roads with unpaved shoulders.

Why it works: It minimizes pavement drop-off crashes by providing a more manageable recovery area for vehicles departing their travel lane.

Impediments to Implementation: Installing the Safety Edge during the paving process is critical to achieving a durable pavement edge. Vegetation near the roadbed will need to be cleared for the machine needed to install safety edge.

General Notes: This countermeasure can only be applied in combination with a paving project. It should be applied systemically and should be generally considered on all paving projects.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
5 - 15%	**6%**

Name: Install RECOMMENDED Chevron Signs on Rural Horizontal Curves	ODOT Countermeasure Number: RD6

What is it: The chevron alignment sign (W1-8) defines a change in horizontal alignment of a roadway. The signs show the shape and degree of curvature and help to guide drivers through the curve or turn. This countermeasure applies to installing chevrons where the MUTCD only RECOMMENDS their installation.

Photos from MUTCD

Where to use: Chevrons shall be installed per the MUTCD guidelines. Where chevrons are not required, they should be installed at any curve or turn with a history of roadway departure crashes. They can be installed at locations where no chevrons currently exist, or to supplement chevrons that are already in place.

Why it works: Chevrons help to delineate an upcoming curve, helping drivers to be aware of the presence of an approaching curve and help navigate their path.

Impediments to Implementation: There may not be enough spacing to place a sufficient amount of chevrons around a curve or turn. Where engineering judgment determines the need, large turn arrow(s) can be used in place of chevrons. This is consistent with MUTCD guidance.

General Notes: The historic standard of practice for installing a large arrow is limited to locations with sharper curves or turns. One primary benefit of installing chevrons over one large arrow is that if one chevron in a set is displaced in a crash or other event, the other chevrons would still provide guidance around a curve until the chevron could be replaced. The displacement of one large arrow does not provide this benefit.

Crash Types Addressed	Severity Type Addressed
Run Off The Road	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
4 - 25%	**16%**

Name: Install REQUIRED Chevron Signs on Rural Horizontal Curves (Ballbanking and Revised Speed Riders Included)	**ODOT Countermeasure Number: RD7**

What is it: The chevron alignment sign (W1-8) defines a change in horizontal alignment of a roadway. The signs show the shape and degree of curvature and help to guide drivers through the curve or turn. This countermeasure applies to installing chevrons where the MUTCD REQUIRES their installation. This countermeasure includes ballbanking to the 2009 MUTCD standard and replacing speed riders where appropriate.

Photos from MUTCD

Where to use: Chevrons shall be installed per the MUTCD guidelines. They should be installed at any curve or turn with a history of roadway departure crashes. They can be installed at locations where no chevrons currently exist, or to supplement chevrons that are already in place.

Why it works: Chevrons help to delineate an upcoming curve, helping drivers to be aware of the presence of an approaching curve and help navigate their path.

Impediments to Implementation: There may not be enough spacing to place a sufficient amount of chevrons around a curve or turn. Where engineering judgment determines the need, large turn arrow(s) can be used in place of chevrons. This is consistent with MUTCD guidance.

General Notes: The historic standard of practice for installing a large arrow is limited to locations with sharper curves or turns. One primary benefit of installing chevrons over one large arrow is that if one chevron in a set is displaced in a crash or other event, the other chevrons would still provide guidance around a curve until the chevron could be replaced. The displacement of one large arrow does not provide this benefit.

Crash Types Addressed	**Severity Type Addressed**
Run Off The Road	All Injuries
CRF Range of Effectiveness	**ODOT CRF Value**
16%	**16%**

Name: Install Oversized, Doubled Up and/or Fluorescent Yellow Sheeting for Advance Curve Warning Signs	**ODOT Countermeasure Number: RD8**

What is it: "Doubled-up" refers to installing a second, identical sign on the left side of the roadway. Installing oversized signing refers to installing a larger sign than typically required. Fluorescent yellow sheeting is a high-intensity retroreflective sheeting that makes the sign more visible to motorists who can recognize and respond to it earlier.

Photo from FHWA

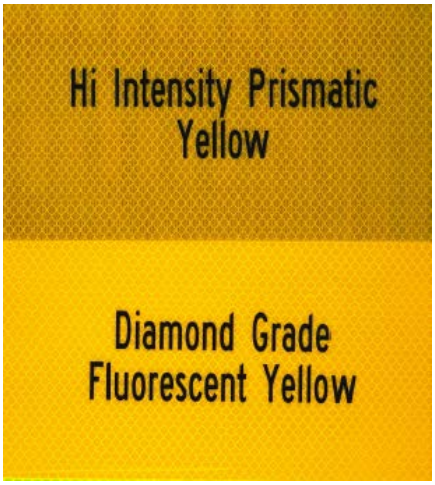


Photo from ODOT

Where to use: Where you have a higher than expected number of curve crashes.

Why it works: All of these signing enhancements can improve the effectiveness of curve warning and delineation signs by increasing the conspicuity, or prominent visibility, of the sign, especially during dark conditions.

Impediments to Implementation: It is encouraged that this countermeasure be used to enhance curves that have a crash history to help highlight the curves that need more driver attention.

General Notes: This countermeasure is encouraged to be applied systemically, on the curves with crash histories within a segment of roadway. More than one signing enhancement listed can be installed. The ODOT Roadway Departure Plan can provide guidance on recommended crash thresholds for implementing these countermeasures.

Crash Types Addressed	**Severity Type Addressed**
Run Off The Road	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
20%	**20%**

Name: Provide Static Combination Horizontal Alignment/Advisory Curve Warning Sign	ODOT Countermeasure Number: RD9

What is it: A combined Turn (W1-1) sign or the Curve (W1-2) sign with the Advisory Speed (W13-1) plaque to form a combination warning sign that is placed at the beginning of a turn or curve.

W1-1a W1-2a

Photos from MUTCD

Where to use: Use it as a supplement to (not a replacement for) the advance Horizontal Alignment sign and Advisory Speed plaque where crash history depicts a need for enhanced curve warning.

Why it works: The sign is intended to remind motorists of the need to slow down as they begin to negotiate the alignment change.

Impediments to Implementation: It is important, for curves with crash histories, to consider all curve warning enhancement options to determine which countermeasure is the most appropriate for the identified crash pattern(s).

General Notes: This sign is often used on sequential curves that have different advisory speeds and are spaced too closely to be signed separately with advance Horizontal Alignment signs. The slower curve often needs additional warning. See the 2009 MUTCD for additional guidance.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
13 - 29%	**13%**

Name: Install Advance Curve Warning Flashers (Curve Warning Signs Exist)	**ODOT Countermeasure Number: RD10**

What is it: A flashing beacon placed on the advance Horizontal Alignment signs for a horizontal curve.

Photos from FHWA

Where to use: Where you have a curve with a high frequency of roadway departure crashes and other more traditional, low cost treatments have not shown an improvement in safety.

Why it works: Using flashing beacons with a warning sign is another way to gain motorists' attention.

Impediments to Implementation: In rural areas it may be difficult to find a power source.

General Notes: If there are doubled up advance curve warning signs, flashing beacons can be placed on both signs and either flashing alternately or simultaneously.

Crash Types Addressed	**Severity Type Addressed**
Curve Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
10%	**10%**

Name: Install Dynamic Curve Speed Warning System	ODOT Countermeasure Number: RD11

What is it: Supplemental beacons and/or messages that activate when a motorist approaches the curve at a high speed.

Photo from FHWA

Photo from Road-Tech

Where to use: Where you have a curve with a high frequency of roadway departure crashes and other more traditional, low cost treatments have not shown an improvement in safety.

Why it works: It measures the speeds of approaching vehicles and provides messages to speeding drivers to slow down to an advisory speed. The advantage of this treatment is that the device has a much greater effect on high-speed vehicles than a static curve warning sign.

Impediments to Implementation: In rural areas it may be difficult to find a power source.

General Notes: There are many types of dynamic curve warning signs. It is important to do more research on the type of sign that would be most appropriate for the location in question.

FHWA requires, for all federally funded projects, an Engineering Systems Document for ITS devices such as dynamic curve speed warning systems.

Crash Types Addressed	Severity Type Addressed
Curve Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
39 - 44%	**40%**

Name: Install Raised or Recessed Pavement Markers	ODOT Countermeasure Number: RD12

What is it: Delineators placed on the roadway adjacent to the longitudinal pavement markings of a road. They are used to supplement the delineation provided by existing pavement markings.

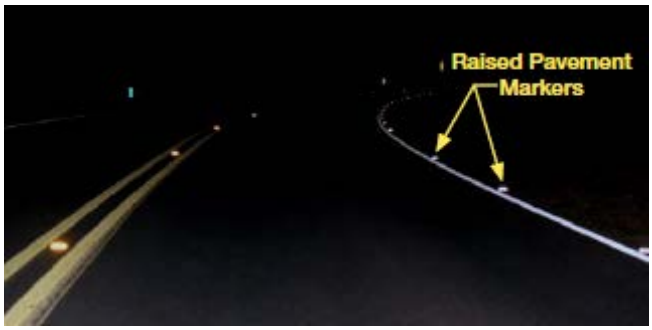


Photo from FHWA

Photo from Wikipedia

Where to use: Where you have a high frequency of roadway departure crashes, particularly during wet and/or nighttime conditions.

Why it works: By installing raised or recessed pavement markers, the pavement markings are much more prominent in adverse weather conditions, helping a driver to safely navigate the path of the roadway.

Impediments to Implementation: Raised pavement markers usually don't withstand regular snow plowing.

General Notes: Raised or recessed pavement markers should be installed on roads with sufficient pavement quality to hold the devices in place. The decision to place raised or recessed pavement markers is dependent on traffic volume and weather conditions typical of the road in question. The color of the pavement markers shall match the color of the adjacent pavement markings.

Crash Types Addressed	Severity Type Addressed
Nighttime Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
15%	**15%**

Name: Install Post-Mounted Delineators (Curve Application)	ODOT Countermeasure Number: RD13

What is it: A flexible fiber or aluminum post retroreflective device mounted above the roadway surface and along the side of the roadway in a series to show roadway alignment.

Photo from FHWA

Where to use: Delineators should be placed on curves with a history of crashes, particularly at nighttime. For best results, post-mounted delineators are to be installed on each chevron support post and coupled with edge line and center line pavement markings.

Why it works: Retroreflective material, such as post-mounted delineators, can be a highly effective treatment for delineating curves, especially at nighttime. They improve driver lane position both at the entry to the curve and at its midpoint.

Impediments to Implementation: Depending on the crash history of a curve, they may need to be replaced often.

General Notes: The MUTCD requires the color of the delineators to match the color of the adjacent edge line. Adjust spacing of delineators on approaches to and throughout the horizontal curves so that several delineators are always visible to the motorist.

Crash Types Addressed	Severity Type Addressed
Nighttime Curve Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
0 - 30%	**30%**

Name: Install Rural Edge line Striping (Tangent and/or Curve Application)	**ODOT Countermeasure Number: RD14**

What is it: Edge line markings separate the travel lane from the shoulder. A standard edge line marking is 4 inches wide.

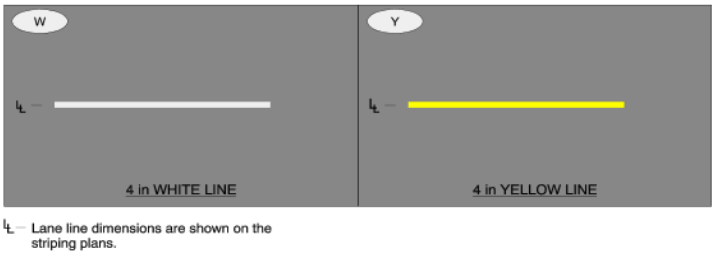


Figure 7 Edge Line Types

Photo from ODOT

Photo from FHWA

Where to use: On rural roadways with a traveled way of 20 ft or more in width where you have a high frequency of roadway departure crashes and edgeline striping is not already in place.

Why it works: Edge lines communicate the intended roadway alignment and travel path to the driver. This can be especially beneficial during nighttime or adverse weather conditions.

Impediments to Implementation: Adding in edge line striping where none has previously existed will increase maintenance costs.

General Notes: Please refer to the ODOT Traffic Line Manual for more guidance on when to place edge line striping.

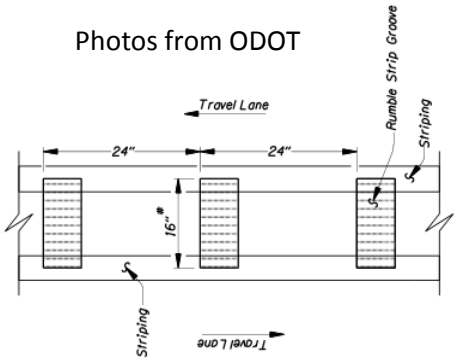
Crash Types Addressed	**Severity Type Addressed**
Run Off The Road	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
11 - 13%	**11%**

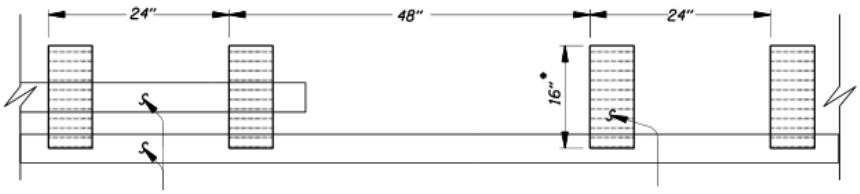
Name: Install Rural Centerline Rumble Strips	ODOT Countermeasure Number: RD15

What is it: Rumble strips are ground/milled in patterns on the roadway that provide both an audible warning (rumbling sound) and a physical vibration to drivers.

Photo from FHWA

Photos from ODOT





Where to use: Where you have a high frequency of roadway departure crashes, particularly head-on or sideswipe meeting crashes. This countermeasure may be applied to any roadways with rural characteristics.

Why it works: The audible warning and physical vibration inside the car alerts drivers that they are leaving their travel lane, allowing them time to make a safe recovery back into their lane.

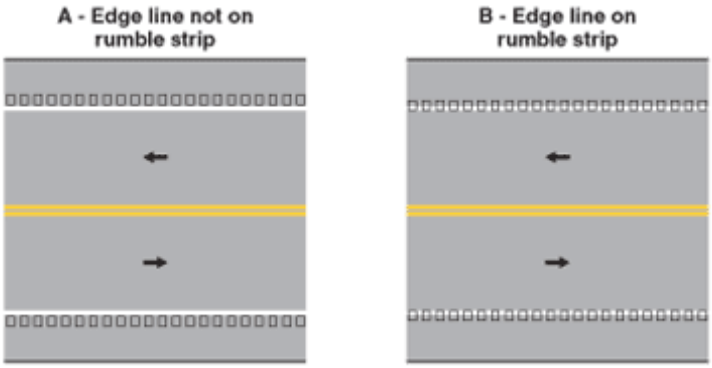
Impediments to Implementation: It is important to consider that there is adequate pavement/lane width to minimize the amount of external noise generated by rumble strips. It is also important to consider the potential noise impacts to nearby residential areas. Finally, pavement quality needs to be considered before placing rumble strips to avoid reducing the design life of the pavement.

General Notes: This countermeasure shall be applied systemically.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Injury (Not PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
9 - 45%	**12%**

Name: Install Shoulder Rumble Strips	ODOT Countermeasure Number: RD16

What is it: Rumble strips are ground/milled in patterns on the roadway that provide both an audible warning (rumbling sound) and a physical vibration to drivers.



Photos from FHWA

Where to use: Where you have a high frequency of roadway departure crashes, particularly fixed object and non-collision crashes.

Why it works: The audible warning and physical vibration inside the car alerts drivers that they are leaving their travel lane, allowing them time to make a safe recovery back into their lane.

Impediments to Implementation: It is important to consider that there is adequate pavement/lane width to minimize the amount of external noise generated by rumble strips and provide bicycles with adequate shoulder width to ride on. It is also important to consider the potential noise impacts to nearby residential areas. Finally, pavement quality needs to be considered before placing rumble strips to avoid reducing the design life of the pavement.

General Notes: This countermeasure shall be applied systemically. Shoulder rumble strips can be placed on or adjacent to the edge line pavement markings.

Crash Types Addressed	Severity Type Addressed
Run Off The Road	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
16-42%	**22%**

Name: Install Profiled Line Pavement Markings	ODOT Countermeasure Number: RD17

What is it: A type of pavement marking consisting of a base stripe with raised shapes located at regular and predetermined intervals.

Photo from Contrafed Publishing Co.

Where to use: Where you have a high frequency of roadway departure crashes and are unable to place ground/milled in rumble strips.

Why it works: Profiled line pavement markings produces a rumble effect and in addition to enhancing the visibility of the pavement markings. In addition, they provide better visibility during wet/rainy conditions.

Impediments to Implementation: Profiled line pavement markings do not withstand regular snow plowing. The effectiveness and design life of profiled line is considerably less than ground/milled in rumble strips as the markings are gradually worn down as vehicles travel over them.

General Notes: Profiled line pavement markings can be used for centerline or edge line markings.

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
10 - 25%	**10%**

Name: Widen Paved Shoulder by 1 ft.	ODOT Countermeasure Number: RD18

What is it: Increasing the width of the paved surface adjacent to/outside of the travel lanes by 1 foot.

Photo from FHWA

Where to use: Where you have a high frequency of roadway departure crashes.

Why it works: The primary roadway departure safety benefit of widening the paved shoulder on a roadway is that it provides a larger stable recovery area for errant drivers leaving their travel lane. Additional benefits to shoulder widening are listed below:
• A place to maneuver to avoid crashes;
• Improves stopping sight distance at horizontal curves by providing an offset to objects such as barrier and bridge piers;
• Improves bicycle accommodations; and
• Provides space for emergency storage of disabled vehicles.

Impediments to Implementation: This countermeasure could have significant costs associated with adding more impervious surface. Typical examples are right of way acquisition, drainage impacts and environmental mitigation.

General Notes: Per FHWA guidance, for narrow pavement widths, it is beneficial to provide narrower lanes with wider shoulders at low AADTs (less than 1,000 vpd), while the configuration with 12-foot lanes and no shoulders appears to be most beneficial for large AADTs (greater than 1,000 vpd).

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
3 - 6%	**6%**

Name: Widen Paved Shoulder by 2 ft.	ODOT Countermeasure Number: RD19

What is it: Increasing the width of the paved surface adjacent to/outside of the travel lanes by 2 feet.

Photo from FHWA

Where to use: Where you have a high frequency of roadway departure crashes.

Why it works: The primary roadway departure safety benefit of widening the paved shoulder on a roadway is that it provides a larger stable recovery area for errant drivers leaving their travel lane. Additional benefits to shoulder widening are listed below:
• A place to maneuver to avoid crashes;
• Improves stopping sight distance at horizontal curves by providing an offset to objects such as barrier and bridge piers;
• Improves bicycle accommodations; and
• Provides space for emergency storage of disabled vehicles.

Impediments to Implementation: This countermeasure could have significant costs associated with adding more impervious surface. Typical examples are right of way acquisition, drainage impacts and environmental mitigation.

General Notes: Per FHWA guidance, for narrow pavement widths, it is beneficial to provide narrower lanes with wider shoulders at low AADTs (less than 1,000 vpd), while the configuration with 12-foot lanes and no shoulders appears to be most beneficial for large AADTs (greater than 1,000 vpd).

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
5 - 13%	**13%**

Name: Widen Paved Shoulder by 3 ft.	ODOT Countermeasure Number: RD20

What is it: Increasing the width of the paved surface adjacent to/outside of the travel lanes by 3 feet.

Photo from FHWA

Where to use: Where you have a high frequency of roadway departure crashes.

Why it works: The primary roadway departure safety benefit of widening the paved shoulder on a roadway is that it provides a larger stable recovery area for errant drivers leaving their travel lane. Additional benefits to shoulder widening are listed below:
• A place to maneuver to avoid crashes;
• Improves stopping sight distance at horizontal curves by providing an offset to objects such as barrier and bridge piers;
• Improves bicycle accommodations; and
• Provides space for emergency storage of disabled vehicles.

Impediments to Implementation: This countermeasure could have significant costs associated with adding more impervious surface. Typical examples are right of way acquisition, drainage impacts and environmental mitigation.

General Notes: Per FHWA guidance, for narrow pavement widths, it is beneficial to provide narrower lanes with wider shoulders at low AADTs (less than 1,000 vpd), while the configuration with 12-foot lanes and no shoulders appears to be most beneficial for large AADTs (greater than 1,000 vpd).

Crash Types Addressed	Severity Type Addressed
All Crashes	All Severities (Including PDO's)
CRF Range of Effectiveness	**ODOT CRF Value**
6 - 18%	**18%**