

## Appendix F: Crossing Countermeasure Matrices

This section contains excerpts from the [NCHRP Research Report 926: Guidance to Improve Pedestrian and Bicyclist Safety at Intersections](#). This report published in 2020 by the Transportation Research Board (TRB) with sponsorship from the American Association of State Highway and Transportation Officials (AASHTO) and in cooperation with the Federal Highway Administration (FHWA). Resources within this report were chosen above others for their comprehensive and consolidated nature. Use of the following matrices (**Figure AF-2: Countermeasure Summary Matrix** and **Figure AF-4: Design Trade-Offs of Countermeasures Matrix**) assume previous knowledge of the 34 countermeasures references. Key information about individual countermeasures begins on page 117 in the Appendix of NCHRP Research Report 926 and other important supplemental information can be found throughout the report. Other resources found in **Appendix A: Resource Library** also include bicycle and/or pedestrian crossing guidance. Multiple countermeasures may be appropriate for a given crash type. Not all countermeasures listed in the matrices are MUTCD compliant.

### Figure AF-1: Key for Figure AF-2

- **Countermeasure description.** A brief description of the countermeasure and how it works.
- **Crash Modification Factor (CMF)/rating.** If a CMF is available, it is listed, along with the crash types to which it is applicable. If no CMF is available, a summary of the latest understanding from research is presented.
- **Example applications.** Photos or illustrations showing the countermeasure in use.
- **Applicable crash types.** Common crash types that may be addressed by the countermeasure; note that the countermeasure may also be applicable to less-common crash types not listed.
- **Applicable contexts.** Contexts in which the countermeasure is appropriate for use.
- **Complementary countermeasures.** Other countermeasures that should accompany the countermeasure; other countermeasures that may accompany the countermeasure.
- **Considerations.** Design considerations to maximize the countermeasure's effectiveness, potential non-safety effects, situations where the countermeasure may be unsuitable, and other information to consider when evaluating the countermeasure.
- **Systemic safety potential.** Information about whether the countermeasure is appropriate for use systemically, or better used as a spot treatment.
- **Estimated cost.** Approximate cost to design and install the countermeasure, as of the time of writing, provided as one of four cost ranges:
  - \$ = <2,500
  - \$\$ = 2,500–49,999
  - \$\$\$ = 50,000–150,000
  - \$\$\$\$ = >150,000
- **Potential effects on travel modes.** A brief listing of potential positive and negative effects to each travel mode.
- **Alternative treatments.** A listing of alternatives to the countermeasure, if applicable.
- **Additional information.** A listing of additional resources to learn more about the countermeasure.

Figure AF-2: Countermeasure Summary Matrix

Countermeasure	Effectiveness			Public Process 1 to 5 scale: 1 = no public process and 5 = extensive public process	Motorist Traveling Straight						Motorist Turning				
	Tier 1: Supports motorist yielding	Tier 2: Requires intervention to induce motorist yielding	Tier 3: Separate modes or require motorists to stop		Motorist failed to yield to pedestrian	Pedestrian failed to yield	Pedestrian dash	Bike crossing paths with uncontrolled motorist	Bike rides through/out - STOP sign	Motorist drives out into bike - STOP controlled	Bike rides through/out - signalized intersection	Motorist left turning into pedestrian parallel path	Motorist right turning into pedestrian parallel path	Motorist right turning into bike - same direction	Motorist left turning into bike - opposite direction
Active Warning Beacons	M	M	L	1	●	●	●	●	●			●	●	●	●
Advance Stop/Yield Lines	H	M	L	1	●	●	●	●	●						
All-Walk Phase	M	H	H	3	●	●	●					●	●		
Bicycle Lane Extension through Intersections	M	L	L	1				●		●				●	●
Bicycle Signals	M	M	H	1							●			●	●
Bike Boxes	M	M	M	1										●	
Continuous Raised Medians	H	H	H	4	●	●	●	●	●		●	●			●
Hardened Centerlines	H	H	H	1								●			●
Crossing Barriers	L	M	H	5	●	●	●	●							

Note: H = High, M = Medium, L = Low

(Continued) Figure AF-2: Countermeasure Sumamary Matrix

Countermeasure	Effectiveness			Public Process 1 to 5 scale: 1 = no public process and 5 = extensive public process	Motorist Traveling Straight						Motorist Turning			
	Tier 1: Supports motorist yielding	Tier 2: Requires intervention to induce motorist yielding	Tier 3: Separate modes or require motorists to stop		Motorist failed to yield to pedestrian	Pedestrian failed to yield	Pedestrian dash	Bike crossing paths with uncontrolled motorist	Bike rides through/out - STOP sign	Motorist drives out into bike - STOP controlled	Bike rides through/out - signalized intersection	Motorist left turning into pedestrian parallel path	Motorist right turning into pedestrian parallel path	Motorist right turning into bike - same direction
Crossing Islands	H	H	H	3	●	●	●	●	●		●	●		●
Curb Extensions	M	M	M	1	●	●	●	●	●	●	●	●	●	●
Curb Radius Reduction	M	M	M	1								●	●	
Gateway Treatments (R1-6 Signs)	H	M	L	1	●	●	●	●						
Grade-Separated Crossings	L	M	H	5	●	●	●	●	●	●	●	●	●	●
High-Visibility Crosswalk Markings	H	H	H	1	●	●	●	●	●		●	●	●	●
In-Street Pedestrian Crossing Signs	H	M	L	1	●	●	●	●	●					
Leading Bicycle Interval	H	H	H	1							●	●	●	●
Leading Pedestrian Interval	H	H	H	1							●	●	●	●
Lighting	H	H	H	4	●	●	●	●	●	●	●	●	●	●
Mini-Traffic Circles	M	M	M	4	●	●	●	●	●	●	●	●	●	●
Mixing Zone Treatments	M	L	L	3									●	
No Turn on Red Signs	H	H	H	1								●	●	

Note: H = High, M = Medium, L = Low

(Continued) Figure AF-2: Countermeasure Sumamary Matrix

Countermeasure	Effectiveness			Public Process 1 to 5 scale: 1 = no public process and 5 = extensive public process	Motorist Traveling Straight						Motorist Turning			
	Tier 1: Supports motorist yielding	Tier 2: Requires intervention to induce motorist yielding	Tier 3: Separate modes or require motorists to stop		Motorist failed to yield to pedestrian	Pedestrian failed to yield	Pedestrian dash	Bike crossing paths with uncontrolled motorist	Bike rides through/out - STOP sign	Motorist drives out into bike - STOP controlled	Bike rides through/out - signalized intersection	Motorist left turning into pedestrian parallel path	Motorist right turning into pedestrian parallel path	Motorist right turning into bike - same direction
Parking Restrictions at Crossing Locations/ Daylighting	H	H	H	2	●	●	●	●	●	●	●	●	●	●
Passive Bicycle Signal Detection	H	H	H	1						●				
Pedestrian Countdown Signals	H	H	H	1		●	●				●	●		
Pedestrian Hybrid Beacon	M	H	H	1	●	●	●	●	●					
Protected Intersections	H	H	H	3						●	●	●	●	●
Protected Phases	M	H	H	4							●	●	●	●
Raised Crossings	M	H	H	3	●	●	●	●	●	●	●	●	●	●
Rectangular Rapid Flash Beacon	H	M	L	1	●	●	●	●						
Road Diet/Rechannelization	H	H	H	5	●	●	●	●	●	●	●	●	●	●
Roundabout	H	H	H	5	●	●	●	●	●	●	●	●	●	●
Signal Timing	H	H	H	3	●	●	●	●		●	●	●	●	●
Traffic Signals	M	M	M	3	●	●	●	●		●	●	●	●	●
Two-Stage Bicycle Turn Queue Boxes	M	M	M	1									●	

Note: H = High, M = Medium, L = Low

Figure AF-3: Key for Figure AF-4

<p><b>KEY</b></p> <ul style="list-style-type: none"> <li>++ very positive benefit</li> <li>+ positive benefit</li> <li>+/- neutral</li> <li>- disbenefit</li> <li>-- strong disbenefit</li> </ul>	<p><b>Relative Cost</b></p> <ul style="list-style-type: none"> <li>\$ = &lt;2,500</li> <li>\$\$ = 2,500–49,999</li> <li>\$\$\$ = 50,000–150,000</li> <li>\$\$\$\$ = &gt;150,000</li> </ul>	<p><b>Public Process</b></p> <ul style="list-style-type: none"> <li>1. No public process, engineering decision</li> <li>2. Public notice, engineering decision</li> <li>3. Minimal public process, engineering decision</li> <li>4. Moderate public process needed to build partner agency</li> <li>5. Extensive public process needed to build community and political support</li> </ul>
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Figure AF-4: Design Trade-Offs of Countermeasures Matrix

	Spatial Impact	Estimated Cost	Maintenance Cost	Public Process	Motorists			Pedestrians			Bicyclists		
					Operations	User Comfort	Safety	Operations	User Comfort	Safety	Operations	User Comfort	Safety
Active Warning Beacons	Small	\$\$	\$\$	1	+/-	+/-	+/-	+/-	+	+	+/-	+	+
Advance Stop/Yield Lines	Small	\$	\$	1	+/-	+/-	+	+/-	++	++	+/-	++	++
All-Walk Phase	Small	\$	\$	3	--	++	++	--	++	++	--	++	++
Bicycle Lane Extension through Intersections	Moderate	\$	\$	1	+/-	+	+/-	+/-	+/-	+/-	+/-	+	+
Bicycle Signals	Small	\$\$	\$\$	1	+/-	+/-	+/-	+/-	+/-	+/-	+/-	++	+
Bike Boxes	Moderate	\$\$	\$\$	1	-	+	+/-	+/-	++	+	+	++	+
Continuous Raised Medians	Moderate	\$\$	\$\$	4	+/-	+/-	+	-	+	++	-	+	++
Hardened Centerlines	Small	\$	\$	1	+/-	+/-	+	-	+	++	-	+	++
Crossing Barriers	Moderate	\$\$	\$\$	5	++	++	++	--	--	++	--	--	++
Crossing Islands	Moderate	\$\$	\$\$	3	+/-	+/-	+	++	++	++	++	++	++
Curb Extensions	Moderate	\$\$	\$\$	1	+/-	++	+/-	++	++	+	++	++	+
Curb Radius Reduction	Moderate	\$\$	\$\$	1	--	-	+	++	++	++	++	++	++
Gateway Treatments (R1-6 Signs)	Small	\$	\$	1	+/-	-	+/-	+	+	++	+	+	++
Grade-Separated Crossings	Large	\$\$\$\$	\$\$\$\$	5	+/-	++	++	--	--	++	--	--	++

(Continued) Figure AF-4: Design Trade-Offs of Countermeasures Matrix

	Spatial Impact	Estimated Cost	Maintenance Cost	Public Process	Motorists			Pedestrians			Bicyclists		
					Operations	User Comfort	Safety	Operations	User Comfort	Safety	Operations	User Comfort	Safety
High-Visibility Crosswalk Markings	Small	\$	\$	1	+/-	+	+/-	+	+	+	+	+	+
In-Street Pedestrian Crossing Signs	Small	\$	\$	1	+/-	-	+/-	+	+	+	+	+	+
Leading Bicycle Interval	Small	\$\$	\$\$	1	-	+	+/-	+	+	+	+	+	+
Leading Pedestrian Interval	Small	\$	\$	1	-	+	+/-	+	++	+	+	++	+
Lighting	Small	\$\$	\$\$	4	+	+	++	+	+	++	+	+	++
Mini-Traffic Circles	Large	\$\$	\$\$	4	-	-	+	-	-	+	-	-	+/-
Mixing Zone Treatments	Moderate	\$\$	\$\$	3	+	+/-	+/-	+/-	+/-	+/-	+/-	-	+
No Turn on Red Signs	Small	\$	\$	1	--	+/-	++	++	++	++	++	++	++
Parking Restrictions at Crossing Locations/Daylighting	Moderate	\$	\$	2	+/-	+	++	+	+	++	+	+	++
Passive Bicycle Signal Detection	Small	\$\$	\$\$	1	+/-	+/-	+/-	+/-	+/-	+/-	++	++	+
Pedestrian Countdown Signals	Small	\$\$	\$\$	1	+/-	+/-	+/-	+	++	++	+	++	++
Pedestrian Hybrid Beacon	Small	\$\$\$	\$\$\$	4	-	+	+	+	++	++	+	++	++
Protected Intersections	Large	\$\$\$\$	\$\$\$\$	3	-	++	+	+	++	++	++	++	++
Protected Phases	Small	\$	\$	4	--	++	+	--	++	++	--	++	++
Raised Crossings	Moderate	\$\$	\$\$	3	-	-	+	++	++	++	++	++	++

(Continued) Figure AF-4: Design Trade-Offs of Countermeasures Matrix

	Spatial Impact	Estimated Cost	Maintenance Cost	Public Process	Motorists			Pedestrians			Bicyclists		
					Operations	User Comfort	Safety	Operations	User Comfort	Safety	Operations	User Comfort	Safety
Rectangular Rapid Flash Beacon	Small	\$\$	\$\$	1	+/-	+/-	+/-	+/-	+	+	+	+	+
Road Diet/Rechannelization	Large	\$\$	\$\$	5	-	+/-	++	++	++	++	++	++	++
Roundabout	Large	\$\$\$\$	\$\$\$\$	5	++	+	++	+	-	+/-	+	-	+/-
Signal Timing	Small	\$	\$	3	+/-	+/-	+	+	+	+	+	+	+
Traffic Signals	Small	\$\$\$\$	\$\$\$\$	3	+/-	+	+/-	+/-	+	+/-	+/-	+	+/-
Two-Stage Bicycle Turn Queue Boxes	Small	\$	\$	1	+/-	+	+/-	+/-	+	+/-	+/-	+	+/-