9 Proven Safety Countermeasures

MODULE 10

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APRIL 12, 2016

Good morning!

Agenda

History and Purpose

- Guidance Memorandum on Consideration and Implementation of Proven Safety Countermeasures
- First Round of Countermeasures (2008)
- Changes between 2008 and 2012
- First Round of Countermeasures (Illustrated)

Agenda

General Considerations

- Traffic Safety Studies
- Education and Outreach
- Costs and Benefits
- Areas of Emphasis

Agenda:
9 Proven Safety Countermeasures of 2012

1. Roundabouts
2. Corridor Access Management
3. Backplates With Retroreflective Borders
4. Rumble Strips and Stripes on Two-Lane Roads
5. Enhanced Delineation and Friction for Horizontal Curves
6. Safety Edge^{SM}
7. Medians and Pedestrian Crossing Islands in Urban and Suburban Areas
8. Pedestrian Hybrid Beacon
9. Road Diet

List of Acronyms and Abbreviations

- ✓**AASHTO:** American Association of State Highway and Transportation Officials
- ✓**ACT:** Autoridad de Carreteras y Transportación
- ✓**CMF:** Crash Modification Factors
- ✓**CIAPR:** Colegio de Ingenieros y Agrimensores de Puerto Rico
- ✓**CSP:** Comisión para la Seguridad en el Tránsito
- ✓**DOT:** Department of Transportation
- ✓**DTOP:** Departamento de Transportación y Obras Públicas
- ✓**FHWA:** Federal Highway Administration

List of Acronyms and Abbreviations

- ✓**IHSDM:** Interactive Highway Safety Design Model
- ✓**ITE:** Institute of Transportation Engineers
- ✓**LTAP:** Local and Tribal Technical Assistance Program
- ✓**NHCRP:** National Cooperative Highway Research Program
- ✓**RSA:** Road Safety Audit
- ✓**SHSP:** Strategic Highway Safety Plan
- ✓**TRB:** Transportation Research Board
- ✓**T²:** Transportation Technology Transfer Center

History and Purpose

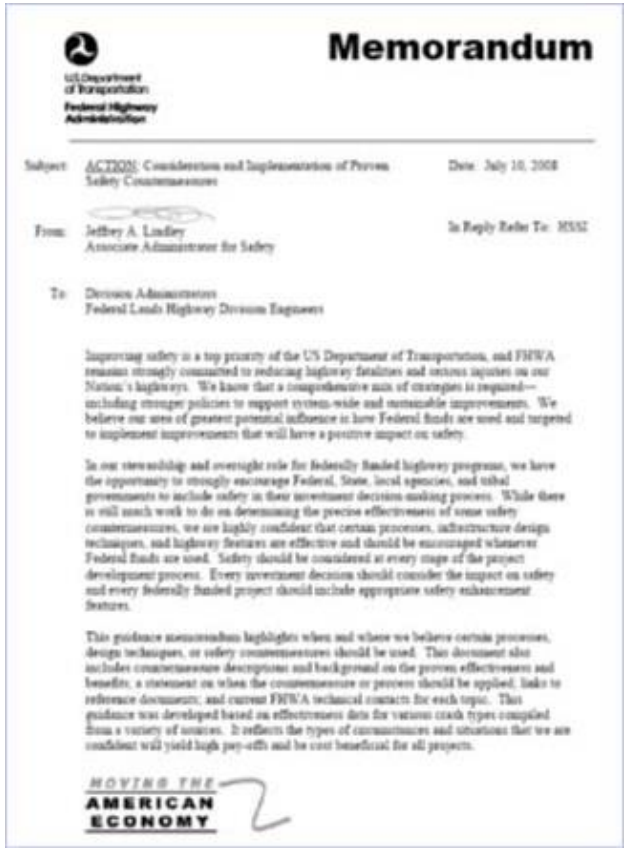
Guidance Memorandum on Consideration and Implementation of Proven Safety Countermeasures

Original document dates to ***July 2008***

Safety is a high priority for all federally assisted and federally funded transportation projects, and ***should be for all projects***

Highlights ***9 processes and designs*** considered to have a ***high impact***
(very favorable costs-benefits ratio) to enhance safety and the recommended circumstances for their use:

- Measures chosen based on ***favorable history of effectiveness***
- Studies based on ***traffic safety data***
- Contribute to promote safety at ***all stages of highway projects***
- Contribute to promote ***safety for all users*** of the road network



Memorandum

U.S. Department of Transportation
Federal Highway Administration

Subject: ACTION: Consideration and Implementation of Proven Safety Countermeasures

Date: July 10, 2008

From: Jeffrey A. Lindley
Associate Administrator for Safety

In Reply Refer To: HSSI

To: Division Administrators
Federal Lands Highway Division Engineers

Improving safety is a top priority of the US Department of Transportation, and FHWA remains strongly committed to reducing highway fatalities and serious injuries on our Nation's highways. We know that a comprehensive mix of strategies is required—including stronger policies to support system-wide and sustainable improvements. We believe our area of greatest potential influence is how Federal funds are used and targeted to implement improvements that will have a positive impact on safety.

In our stewardship and oversight role for federally funded highway programs, we have the opportunity to strongly encourage Federal, State, local agencies, and tribal governments to include safety in their investment decision-making process. While there is still much work to do on determining the precise effectiveness of some safety countermeasures, we are highly confident that certain processes, infrastructure design techniques, and highway features are effective and should be encouraged whenever Federal funds are used. Safety should be considered at every stage of the project development process. Every investment decision should consider the impact on safety and every federally funded project should include appropriate safety enhancement features.

This guidance memorandum highlights when and where we believe certain processes, design techniques, or safety countermeasures should be used. This document also includes countermeasure descriptions and background on the proven effectiveness and benefits; a statement on when the countermeasure or process should be applied; links to reference documents; and current FHWA technical contacts for each topic. This guidance was developed based on effectiveness data for various crash types compiled from a variety of sources. It reflects the types of countermeasures and situations that we are confident will yield high pay-offs and be cost beneficial for all projects.

MOVING THE AMERICAN ECONOMY

Guidance Memorandum on Consideration and Implementation of Proven Safety Countermeasures

All levels of government are encouraged to consider safety components in their investment plans

- Federal
- States, Territories and Commonwealths
- Tribes
- Counties, cities and municipalities

Further information available within the document and its references:

http://safety.fhwa.dot.gov/legislationandpolicy/policy/memo071008/

First Round of Proven Countermeasures (2008)

1. Road Safety Audits
2. Rumble Strips and Rumble Stripes
3. Median Barriers
4. Safety Edge[SM]
5. Roundabouts
6. Left and Right Turn Lanes at Stop-Controlled Intersections
7. Yellow Change Intervals
8. Medians and Pedestrian Refuge Areas in Urban and Suburban Areas
9. Walkways

First Round of Proven Countermeasures (2008)
Road Safety Audits (RSA)

Source:
http://luvit.ced.lu.se/LUCE/Utils/StreamFile.aspx?type=courseobjectimage&param=21\safety_audit_liten.jpg

Source:
http://www.mtu.edu/news/images/2014/april/image105170-horiz.jpg

First Round of Proven Countermeasures (2008)

Rumble Strips and Rumble stripes

Source: http://www.rumblestrips.com/wp-content/uploads/2015/02/119_1997-opt1.jpg

Median barriers

Source: http://safety.fhwa.dot.gov/geometric/pubs/mitigationstrategies/chapter8/images/figure_120.jpg

First Round of Proven Countermeasures (2008)

SAFETY EDGE[SM]

Source: http://www.dot.state.mn.us/stateaid/images/safety-edge.jpg

ROUNDABOUTS

Source: https://mw2.google.com/mw-panoramio/photos/medium/104874560.jpg

First Round of Proven Countermeasures (2008)

LEFT & RIGHT TURN LANES AT
STOP- CONTROLLED INTERSECTIONS

Source: Alexander Molano Santiago

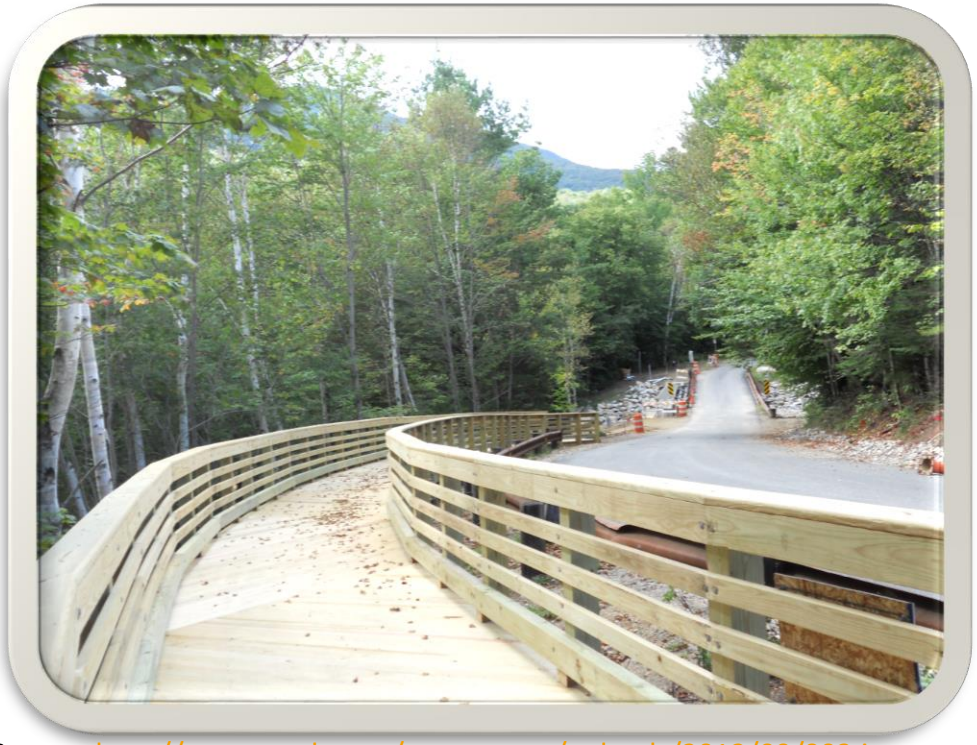
YELLOW CHANGE INTERVALS

Source: http://theexpiredmeter.com/wp-content/uploads/2010/03/Yellow-Light.jpg

First Round of Proven Countermeasures (2008)

MEDIAN WITH PEDESTRIAN CROSSING REFUGE

WALKWAYS



Source: http://www.wvnh.com/wp-content/uploads/2012/09/003.jpg

Changes between 2008 and 2012

Four (4) of the original nine (9) countermeasures continue in place for further promotion and implementation. Five (5) were added in the 2012 revision.

ORIGINAL STILL IN PROGRAM

1. Rumble Strips and Rumble Stripes
2. Safety Edge[SM]
3. Roundabouts
4. Medians and Pedestrian Refuge Areas in Urban and Suburban Areas

2012 REVISION ADDS

1. Corridor Access Management
2. Backplates with retroreflective borders
3. Enhanced delineation and friction for horizontal curves
4. Pedestrian Hybrid Beacon
5. Road diets

The 2012 countermeasures consist of:

1. Roundabouts
2. Corridor Access Management
3. **Backplates with Retroreflective Borders** 

4. Longitudinal Rumble Strips and Stripes ***On Two-Lane Roads***
5. **Enhanced Delineation and Friction for Horizontal Curves** 

6. Safety Edge^{SM}
7. Medians and Pedestrian Crossing Islands in Urban and Suburban Areas
8. **Pedestrian Hybrid Beacon** 

9. **Road Diet** 

General Considerations

Traffic Safety Studies

The 9 proven safety countermeasures address traffic safety problems on roads and their different users. When choosing their use:

- Consider existing safety problems (***traffic safety study required***)
- Do not limit only to federally funded projects → ***benefits are for everyone***
- Consider ***combining*** related or complementary ***measures***
- Consider impacts to ***other aspects related to the project*** (traffic operations, land use, pollution…)

Traffic Safety Studies

Address safety needs for ***different classes of users***

- Pedestrians
- Cyclists
- Passenger vehicle drivers
- Local *versus* non-local drivers
- Heavy vehicles
- Vulnerable users (the elderly, school children…)
- Mass/public transit systems (buses, taxis, public cars, trolleys)

Traffic Safety Studies

Crash Modification Factors Clearinghouse

- Database stores road design elements with their corresponding safety improving impacts → for use in traffic safety studies
- Constantly updated as new research is submitted by users for consideration and addition to database

Design elements have their effects classified by location, severity type, crash type and countermeasure type

Visit http://www.cmfclearinghouse.org/

Education and Outreach

All countermeasures are innovative and unknown or unusual for the general public → proven but not widely used

- ***Consult stakeholders*** of the affected place
- Provide information and engage in ***familiarizing the public*** with the countermeasures
- Ensure the ***countermeasure(s) is/are relevant*** to the traffic safety problems found → avoid unnecessary expenses, maximize benefits
- Provide ***training to professionals*** in charge and/or related to countermeasure's implementation

Costs and benefits

Low cost:

Simple countermeasures that involve minimal changes and which can be implemented as part of routine maintenance operations

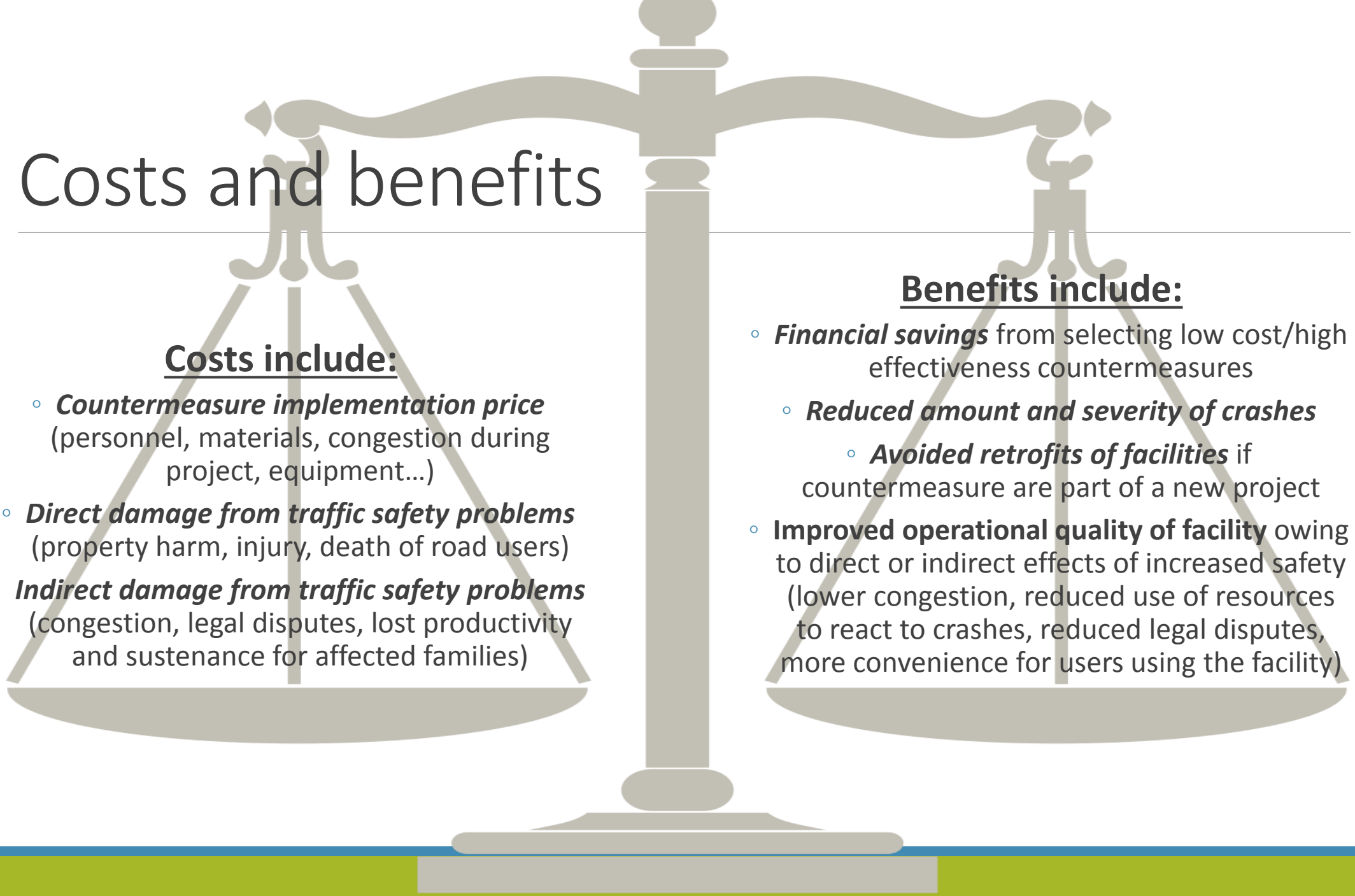
Medium cost:

More elaborate countermeasures to implement as specialized features for critical sites, use for short to medium term changes.

High cost:

Major changes of the roadway component and are best implemented as part of long term rehabilitation, expansion, reconstruction or new projects.

Costs and benefits



Costs include:

- ***Countermeasure implementation price*** (personnel, materials, congestion during project, equipment…)
- ***Direct damage from traffic safety problems*** (property harm, injury, death of road users)
- ***Indirect damage from traffic safety problems*** (congestion, legal disputes, lost productivity and sustenance for affected families)

Benefits include:

- ***Financial savings*** from selecting low cost/high effectiveness countermeasures
- ***Reduced amount and severity of crashes***
- ***Avoided retrofits of facilities*** if countermeasure are part of a new project
- **Improved operational quality of facility** owing to direct or indirect effects of increased safety (lower congestion, reduced use of resources to react to crashes, reduced legal disputes, more convenience for users using the facility)

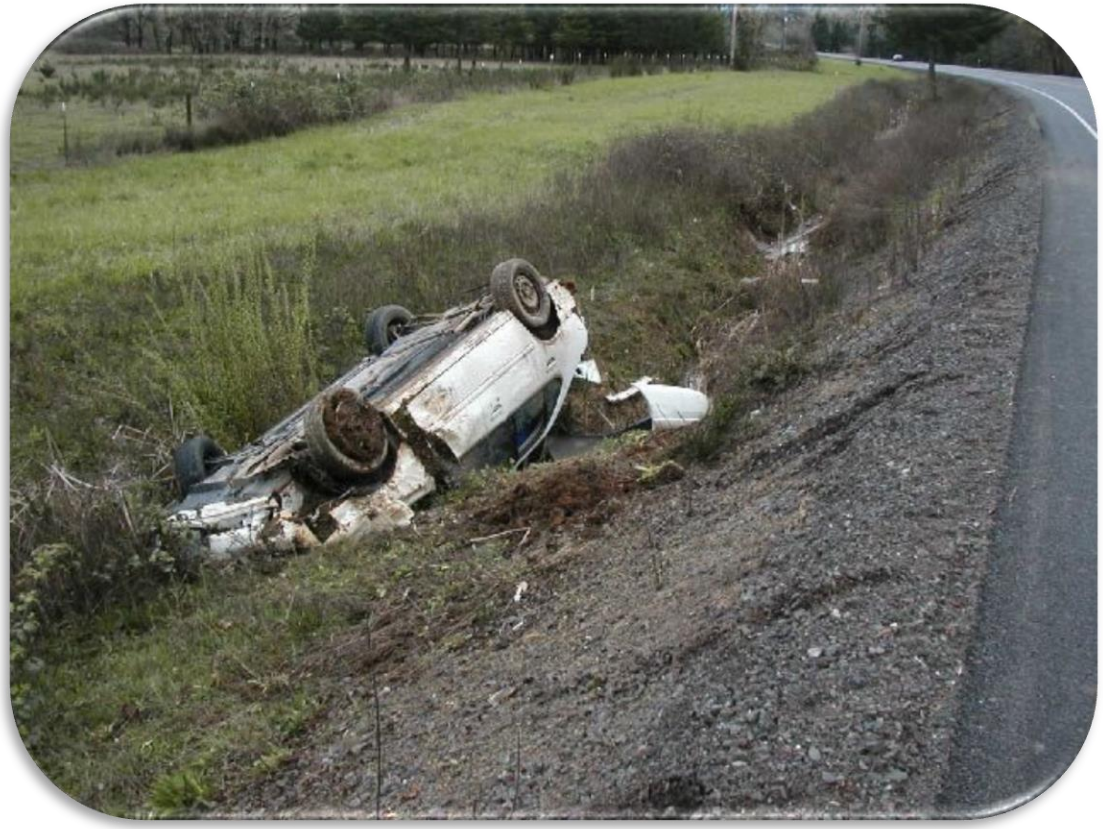
Areas of Emphasis

Pedestrians: situations involving the safety of people walking along or across the road, often extended to cyclists

Areas of Emphasis

- **Intersections:** locations and situations involving the connection between different roads or roads with adjoining users

Areas of Emphasis



Roadway departure: dangerous situations involving drivers exiting unintentionally out of their travel lane or intended travel path

Areas of Emphasis

- **Driver behavior:** situations in which drivers act in ways incompatible with safe use of roads

1. Roundabouts

A well-rounded design option

Definition

Geometric design for at-grade intersections and some grade-separated interchanges (freeways)

Simplifies traffic maneuvers to a series of right-way turns around a central island or reserved space

Creates ***safe and aesthetically pleasing environment***

- Channelization elements
- Low speeds
- Urbanistic focal point
- Transition between high speed and low speed facilities

When is it Best to Apply

Countermeasure impacts: ***intersections***

Can improve efficiency of traffic operations

Countermeasure is of ***higher cost***

- Consider for ***all new federally-funded*** intersection projects
- Consider for ***select locations*** with notorious ***crash history*** and/or ***operational difficulties***

When is it Best to Apply

Can be used in ***various geometries***: circular, teardrop, dumbbell

Compatible with freeway interchanges

Can fit intersections with existing channelized turns with limited use of eminent domain

Source (Top-right): http://assets.inhabitat.com/wp-content/blogs.dir/1/files/2011/05/Double-Teardrop-Roundabout-4.jpg

Source (Bottom-left): http://www.nh.gov/dot/org/projectdevelopment/highwaydesign/roundabouts/graphics/img_1816.jpg

Examples in Puerto Rico: Guaynabo

- Since 2004, the municipality of Guaynabo has constructed multiple roundabouts at the junctions of important municipal corridors
- ***21 roundabouts*** form part of the municipal road network
- Research conducted by UPRM student Jennifer Aponte (2015) found ***great success with traffic safety*** in all of Guaynabo's roundabouts—***no fatalities nor severe crashes*** registered to date!

Examples in Puerto Rico: Guaynabo

San Patricio Interchange (PR-2, PR-23, PR-165 and east entrance to Fort Buchanan, under construction) will include a roundabout as a geometric element

Examples in Puerto Rico: San Juan

PR-17 interchange with PR-181 combines loop ramps, flyovers and a roundabout

Examples in Puerto Rico: Cayey

Municipal transportation policy of Cayey includes the reconstruction of main intersections as roundabouts, replacing traffic lights along major corridors.

Cayey is scheduled to be the ***first municipality outside of San Juan's metropolitan area*** to utilize roundabouts as a major component of arterial roads, ***following all the proper FHWA design specifications.***

Price of each roundabout, including eminent domain, design and construction ***averages $1.7 million.*** The most expensive of such facilities is priced at $2.3 million (PR-1 with PR-184, concept drawing shown in picture).

Source: http://www.skyscrapercity.com/showpost.php?p=62274789&postcount=36

Summary of Traffic Safety Impact

Stop controlled
→ Roundabout

82% reduction
for severe crashes

44% reduction for all crashes

Roundabouts eliminate numerous conflict points and provide a low speed environment that enhances safety

Signalized intersection
→ Roundabout

78% reduction
for severe crashes

48% reduction for all crashes

Critical Reference Documents

Roundabouts: An Informational Guide, Second Edition (NCHRP Report 672)
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdfRoundabouts Outreach & Education Toolbox
http://safety.fhwa.dot.gov/intersection/roundabouts/roundabouttoolbox/

Roundabouts and Mini Roundabouts Technical Summaries
http://safety.fhwa.dot.gov/intersection/roundabouts/fhwasa10006/
http://safety.fhwa.dot.gov/intersection/roundabouts/fhwasa10007/

Roundabouts Informational Brochure and DVD
http://safety.fhwa.dot.gov/intersection/roundabouts/fhwasa08006/
http://safety.fhwa.dot.gov/intersection/roundabouts/#video

Critical Reference Documents (cont.)

Public Rights-of-Way Accessibility Guidelines (NPRM Edition) (July 2011)
http://www.access-board.gov/prowac/nprm.pdf

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities (NCHRP Report 674)
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_674.pdf

Highway Safety Manual, American Association of State Highway and Transportation Officials
http://www.highwaysafetymanual.org/Pages/default.aspx

Critical Reference Documents (cont.)

Crash Modification Factor (CMF) Clearinghouse [quick search "roundabout"]
http://www.cmfclearinghouse.org/

Evaluation of Safety Strategies at Signalized Intersections (NCHRP Report 705)
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_705.pdf

Roundabouts in the United States (NCHRP Report 572)
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_572.pdf

2. Corridor Access Management

Everything in its corresponding place

Definition

Corridor Access Management is a design practice for arterial roadways to ***reduce conflicts between adjoining uses and the main road's users,*** by means of ***controlling entry and exit points along the road***

Ensures ***accessibility to pedestrians***

Definition

Eliminates turning maneuvers outside intersections

- Reduced access conflicts
- Increased throughway operation quality

Reduces need for signalized intersections for small hierarchy streets and adjacent users

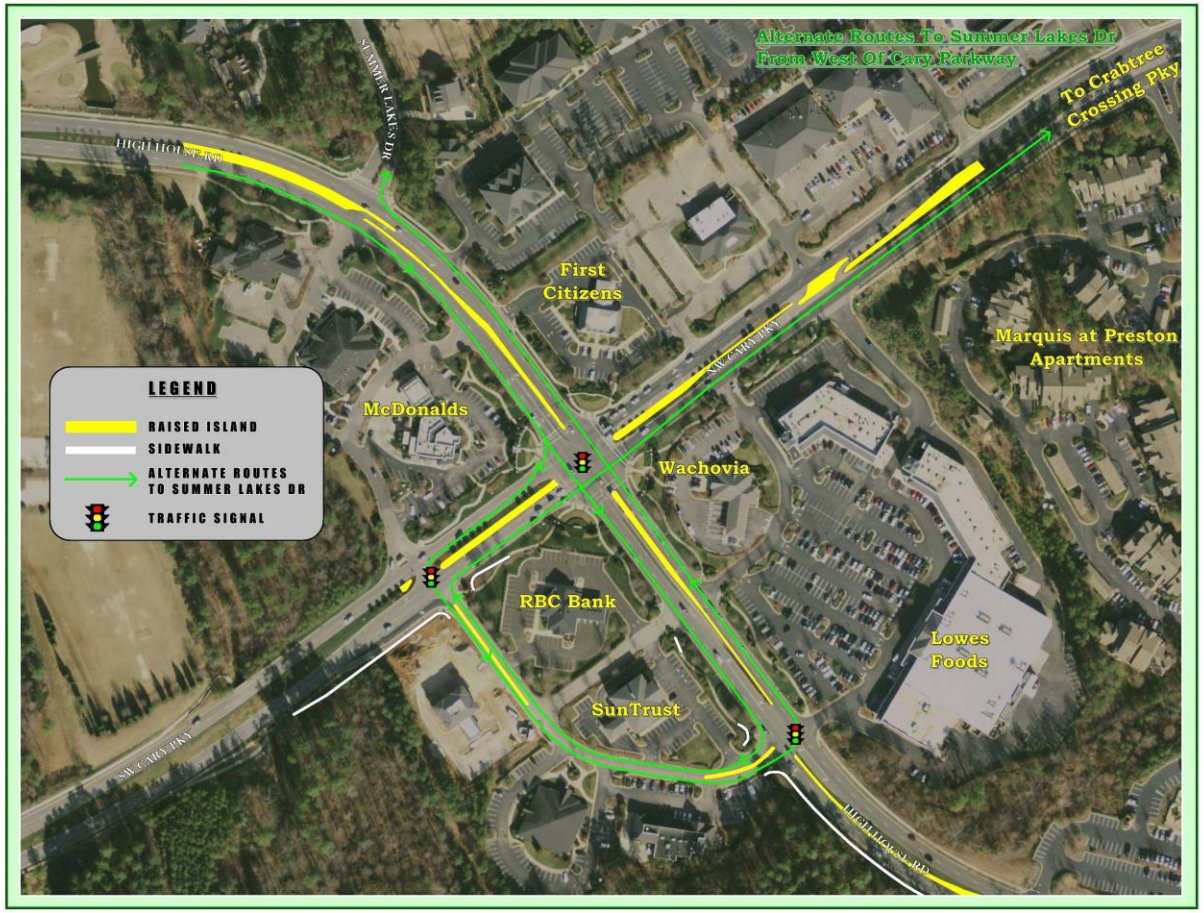
Reduces amount of conflict points for vehicle paths

Definition

Implementation can consist of various elements

- Frontage roads ***(most common in Puerto Rico)***
- Restricting or forbidding turning movements of minor roads and lot access points
- Pedestrian crossing spaces
- Roundabouts for lot access points

Definition



- Relocation of intersecting roads
- ***Raised medians when previously not present (shown)***
- Auxiliary turn lanes
- Alternative designs for intersections
  - ***Quadrant (shown)***
  - U-turns
  - Jug handle
- Channelized turns, entries and exits

When is it Best to Apply

Countermeasure addresses: ***intersections, pedestrians, driver behavior***

Countermeasure is of ***higher cost***, requires careful consideration, best to implement as part of:

- New construction projects
- Reconstruction
- Road expansions
- Roads with ***medium to high*** traffic volumes

When is it Best to Apply

Consider safety problems related to ***turning maneuvers***

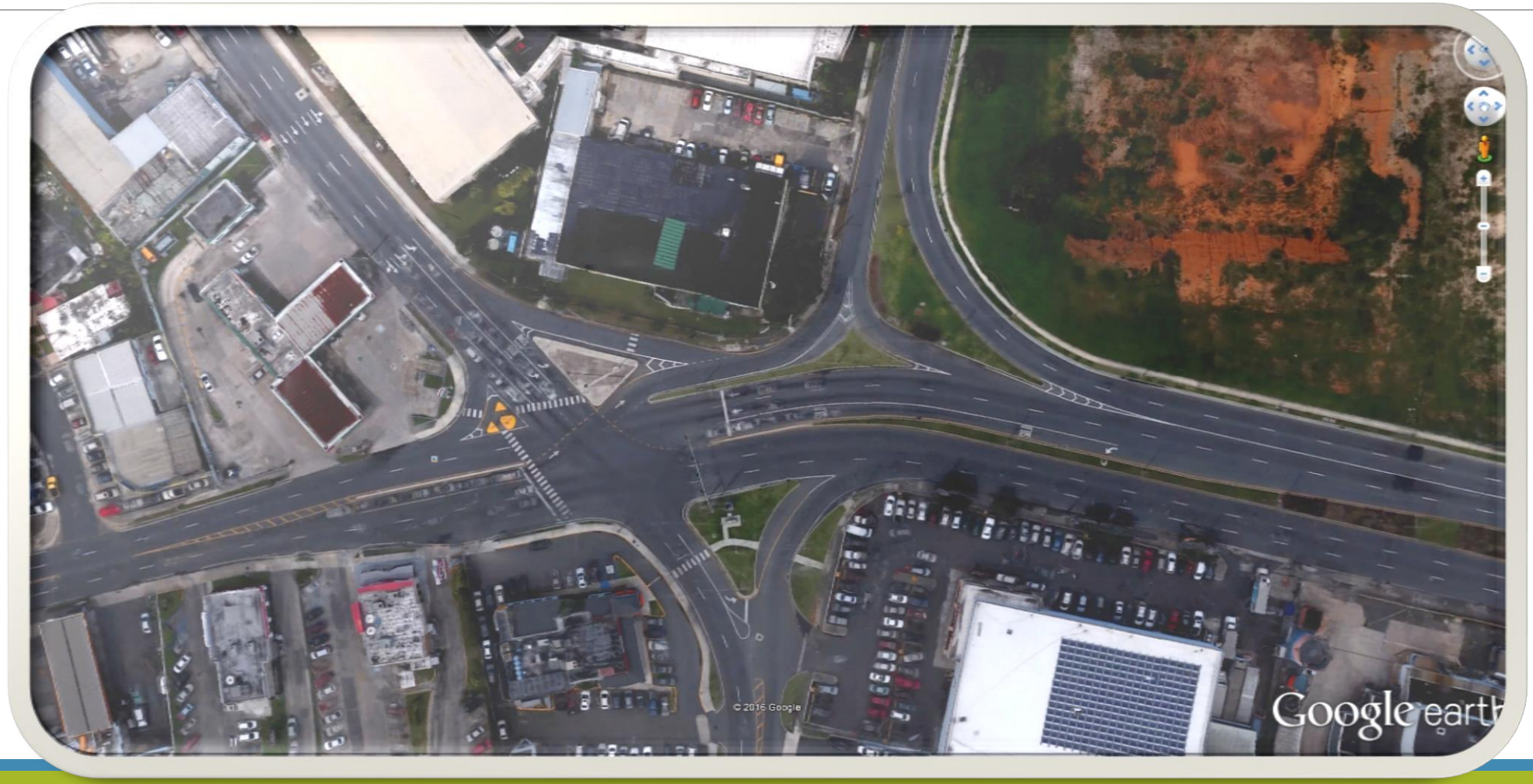
- 5-23% crash reduction (rural highways, all types)
- 25-31% crash reduction (urban/suburban arterials, severe)

Examples

1. ***5-way*** intersection simplified
2. Right-in, right-out lot entry points
3. Channelized turns
4. Auxiliary Turn Lanes
5. Converting two-way roads to one-way roads
6. Pedestrian corridors
7. Quadrant Roadway

PR-174/PR-177/Lomas Verdes/Main Avenues: *Before* and After

PR-174/PR-177/Lomas Verdes/Main Avenues:
Before and *After*

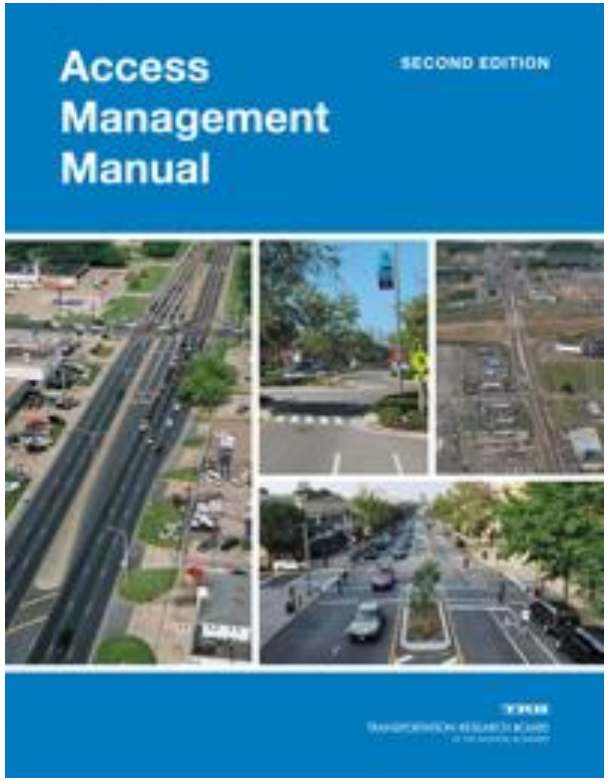


Critical Reference Documents

Access Management Manual, 2nd Ed. (Transportation Research Board, book) http://www.trb.org/PlanningForecasting/Blurbs/171852.aspx

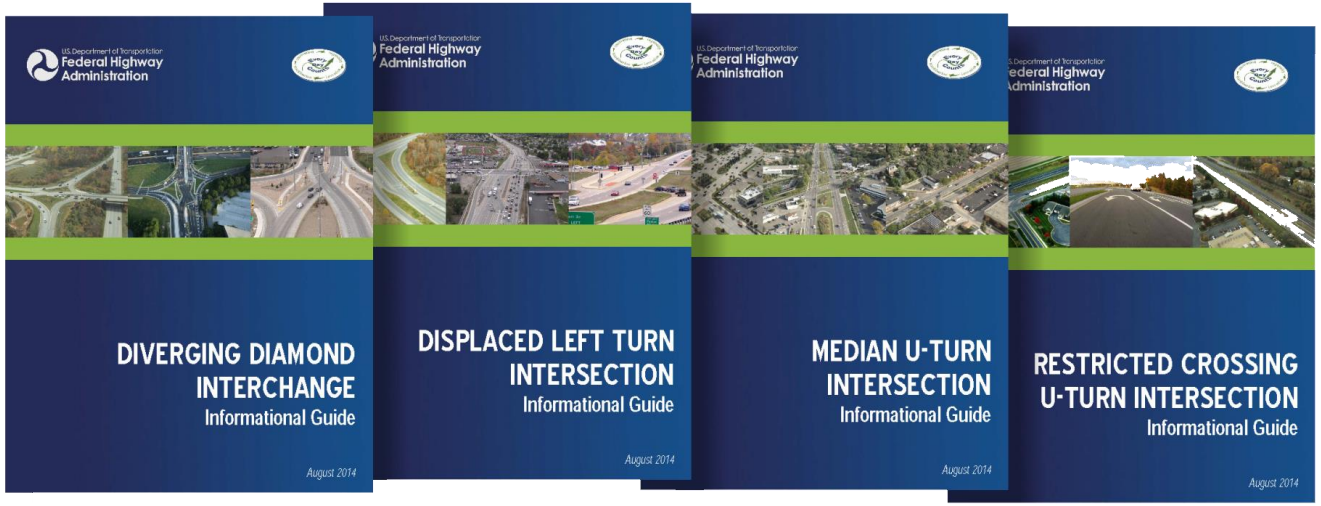
AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities (book)

Access Management in the Vicinity of Intersections Technical Summary http://safety.fhwa.dot.gov/intersection/resources/fhwasa10002/



Source: http://www.trb.org/Resource.ashx?sn=AccessMgtManualcover

Critical Reference Documents (cont.)



Access Management Principles
http://ops.fhwa.dot.gov/access_mgmt/presentations/am_principles_intro/

Alternative Intersections/Interchanges Resources
http://safety.fhwa.dot.gov/intersection/alter_design/#resources

"Safe Access is Good for Business" Brochure
http://ops.fhwa.dot.gov/publications/amprimer/access_mgmt_primer.htm

Critical Reference Documents (cont.)

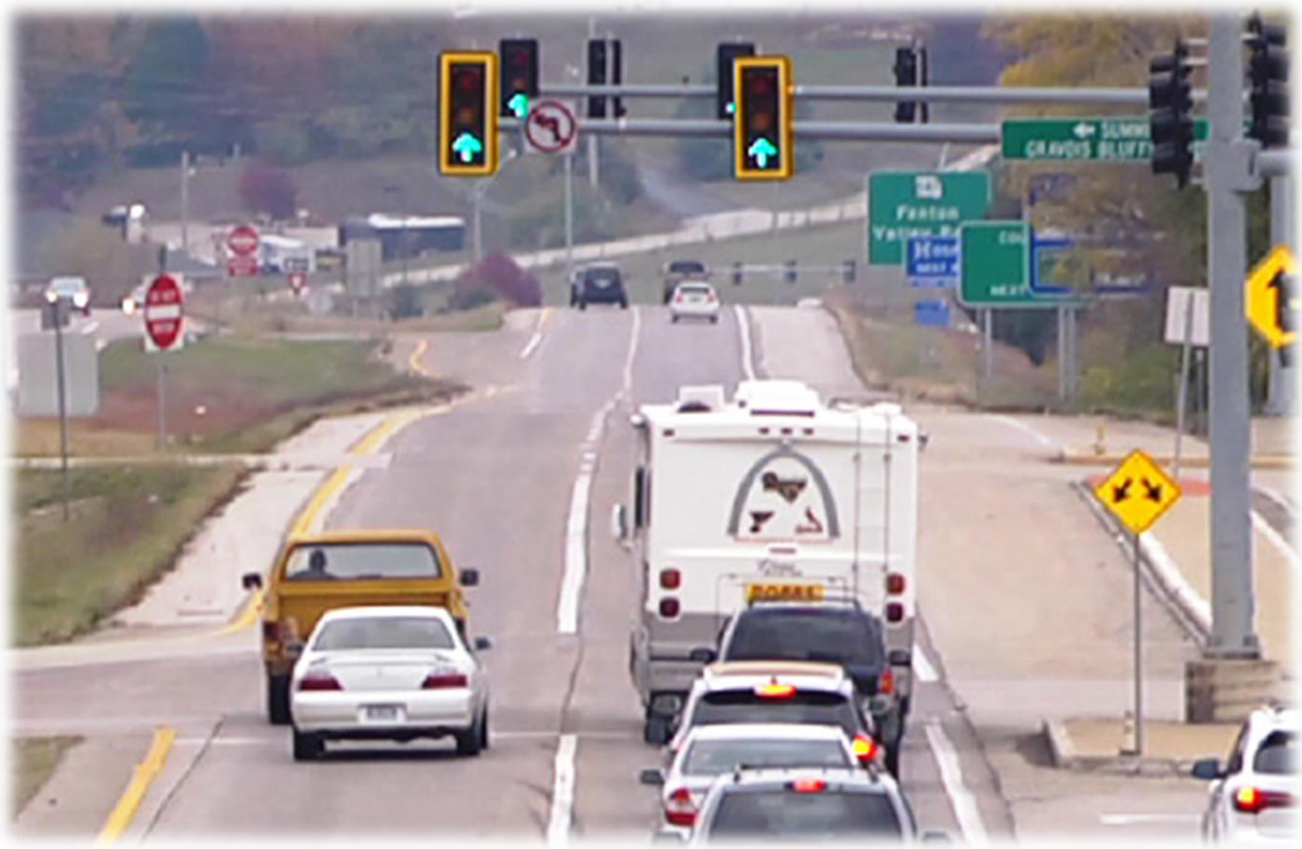
Transportation Research Board Access Management Website
http://www.accessmanagement.info/

Guidebook for Incorporating Access Management in Transportation Planning (NCHRP Report 548)
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_548.pdf

Highway Safety Manual, American Association of State Highway and Transportation Officials
http://www.highwaysafetymanual.org/Pages/default.aspx

Crash Modification Factor (CMF) Clearinghouse [quick search "access management"]
http://www.cmfclearinghouse.org/

3. Backplates with Retroreflective Borders



Definition

Surface overlay for traffic light backplates

Uses a ***highly reflective*** yellow border to delineate the traffic light

Enhances traffic signal visibility, particularly:

- Night time
- Power Outages
- Locations with drivers with visual disabilities (elderly, colorblind)
- Adverse weather (fog, rain, dust)

Reduces ***unintentional red light running***

When is it Best to Apply

Countermeasure addresses: ***intersections, driver behavior***

For use in crossings with traffic lights/signalized intersections, especially those with crashes related to ***low visibility***

Countermeasure is of ***very low cost*** ($1,500 to $3,000 per signalized intersection)

- Can be implemented in all new signals
- Can be added as part of normal maintenance operations
- Only limitation may come from limited structural capacity of traffic signal assembly
- Can provide ***crash reduction of at least 15%***

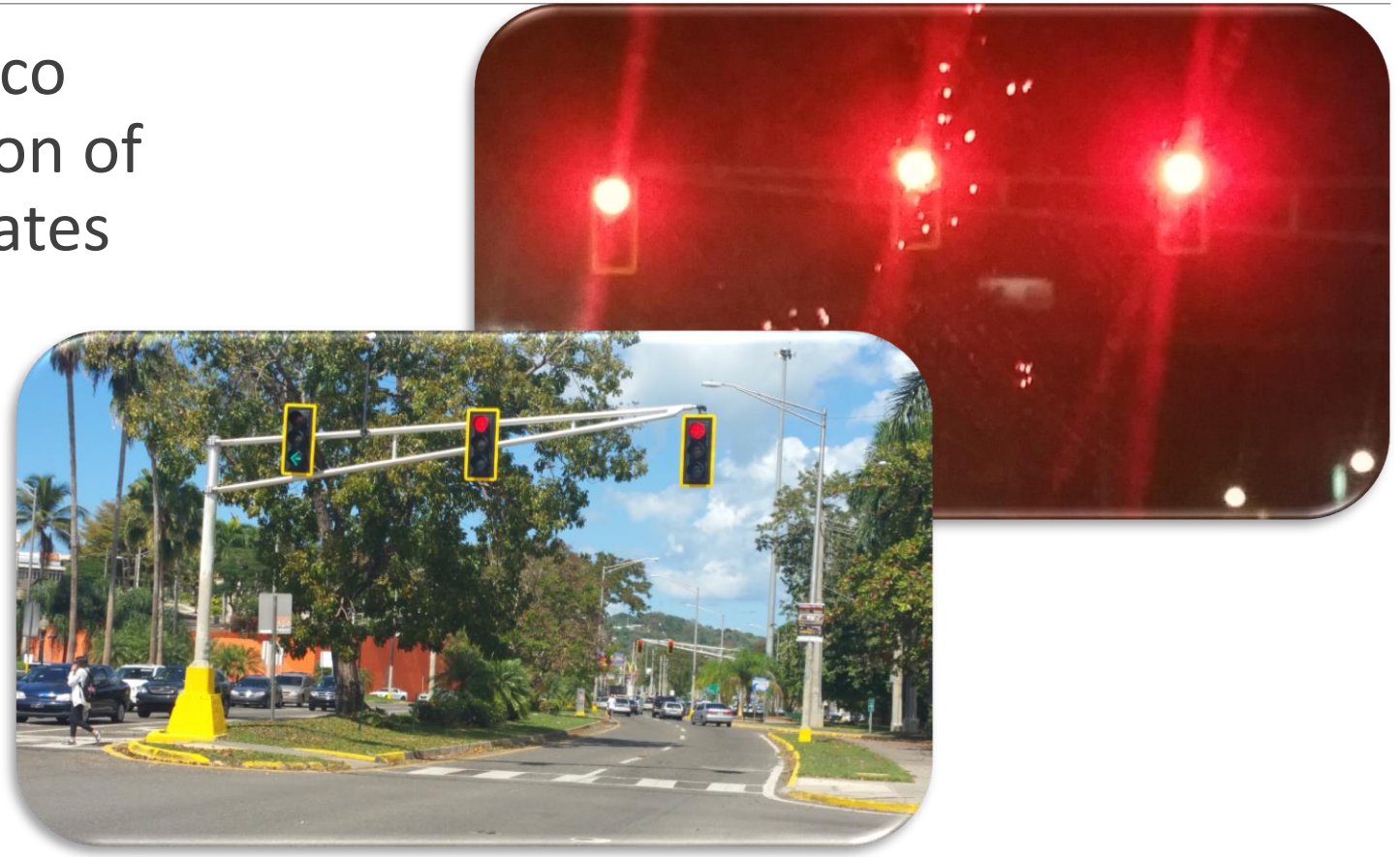
Examples: Day and Night Comparison

Source: http://safety.fhwa.dot.gov/intersection/conventional/signalized/case_studies/fhwasa09011/images/f2.jpg (Original from South Carolina DOT)

Traffic Lights With Retroreflective Backplates in Puerto Rico

Highways in Puerto Rico impacted by application of retroreflective backplates in traffic signals

- PR-1
- PR-2 (shown)
- PR-3
- PR-100



Critical Reference Documents

Retroreflective Borders on Traffic Signal Backplates - A South Carolina Success Story
http://safety.fhwa.dot.gov/intersection/resources/casestudies/fhwasa09011/

Manual on Uniform Traffic Control Devices (2009 Edition), Part 4D Traffic Control Signal Features
http://mutcd.fhwa.dot.gov/htm/2009/part4/part4d.htm#section4D12

FHWA Interim Approval for Use of Retroreflective Border on Signal Backplates (prior to 2009 Edition)
http://mutcd.fhwa.dot.gov/pdfs/ia_retroborder.pdf

Florida Department of Transportation, Plan Preparation Manual, Chapter 7 Traffic & ITS Design (Section 7.4.17)
http://www.dot.state.fl.us/rddesign/PPMManual/2009/Volume1/zChap07.pdf

Critical Reference Documents (cont.)

Senior Mobility Series: Article 4 - Marking the Way to Greater Safety, FHWA Public Roads Volume 70/No. 1
http://www.fhwa.dot.gov/publications/publicroads/06jul/08.cfm

Crash Modification Factor (CMF) Clearinghouse [quick search "retroreflective backplate"]
http://www.cmfclearinghouse.org/

Evaluating Impact on Safety of Improved Signal Visibility at Urban Signalized Intersections
http://pubsindex.trb.org/view.aspx?id=800943

Road Safety Performance Associated with Improved Traffic Signal Design and Increased Signal Conspicuity
http://mutcd.fhwa.dot.gov/texts/miska/miska02.htm#toc

4. Longitudinal Rumble Strips and Stripes on Two-Lane Roads

Definition

Indentations or raised elements on pavement surface ***along the edge of travel lanes***

Located along outer edge (shoulder line) or centerline

Cause a loud vibration on the body of a vehicle passing over them

Noise warning can alert drivers of a ***potential or imminent roadway departure***

Built with specialized equipment and can be applied to both new and existing pavements

Effective in situations involving ***distracted drivers***

When is it Best to Apply

Countermeasure addresses: ***roadway departure***

2012 revision emphasizes use in ***two-lane roads***

- Lower traffic volumes and perceived importance lead to ***neglected safety***
- Higher risk of road departure crashes related to less strict traffic safety components

Examples: PR-114 in Hormigueros and San Germán

Centerline rumble strips applied

Road characteristics:

- Rural
- high AADT
- no shoulder
- no night illumination
- Speeding
- Roadside vegetation

Crash reduction study still pending

Critical Reference Documents

NCHRP Report 641, Guidance for the Design and Application of Shoulder and Centerline Rumble Strips, 2009
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_641.pdf

Technical Advisory 5040.39, Shoulder and Edge Line Rumble Strips http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/t504039/

Technical Advisory 5040.40, Center Line Rumble Strips http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/t504040/

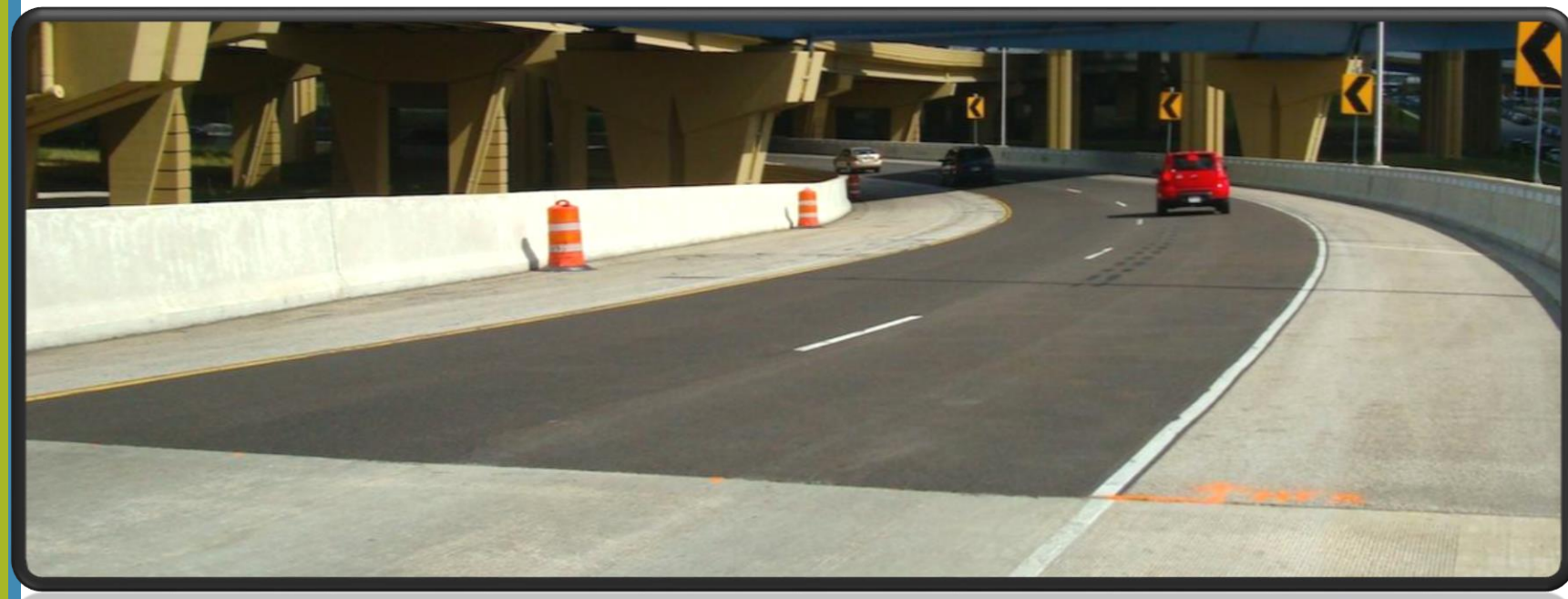
Critical Reference Documents (cont.)

FHWA Guidance: Revisions to T 5040.39 Shoulder and Edge Line Rumble Strips and T 5040.40 Center Line Rumble Strips
http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/t5040_memo/

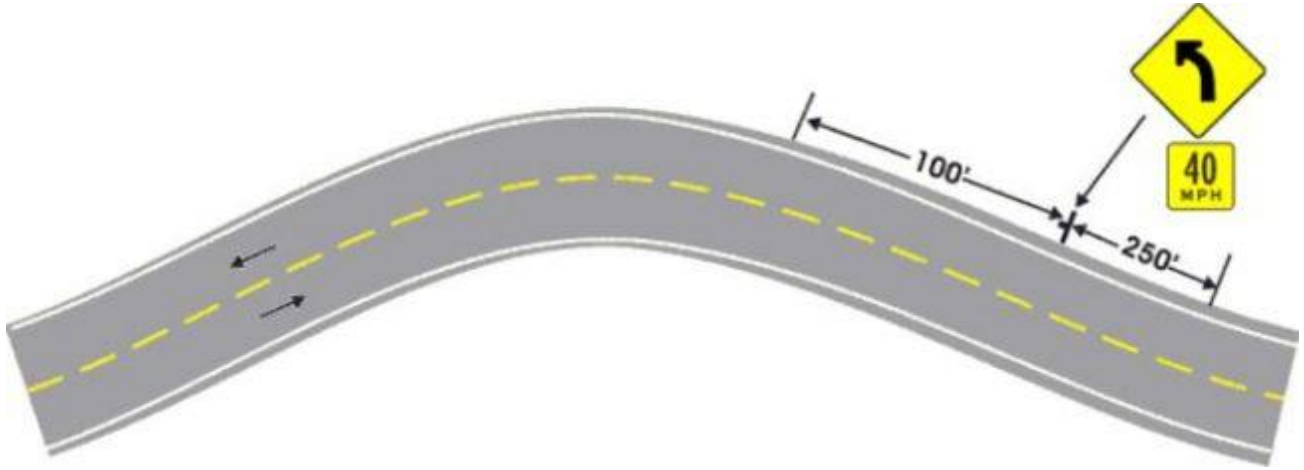
AASHTO Highway Safety Manual (available for purchase)
http://www.highwaysafetymanual.org/pages/default.aspx

Crash Modification Factor (CMF) Clearinghouse [quick search “rumble strips”]
http://www.cmfclearinghouse.org

5. Enhanced Delineation and Friction for Horizontal Curves



Definition



Delineation for increased visibility and awareness

- Signs
- Markings
- Retroreflective devices
- Advanced warning

Existing delineation may be insufficient → replace for increased visibility

- Larger
- Retroreflective
- Greater amount of devices

Definition

High surface friction treatments

- Consist of surface overlay (epoxies, resins with abrasion-resistant and rough aggregates)
- Counteract lateral acceleration
- Reduced roadway departure
- ***Increased safety*** when pavement ***conditions are adverse*** (wet surface, insufficient superelevation)
- Beneficial for ***difficult topographies and locations*** (hill, mountain roads, fast urban roads, loop ramps, roads built with older geometric standards)

Application of Friction-Enhancing Surface Treatment

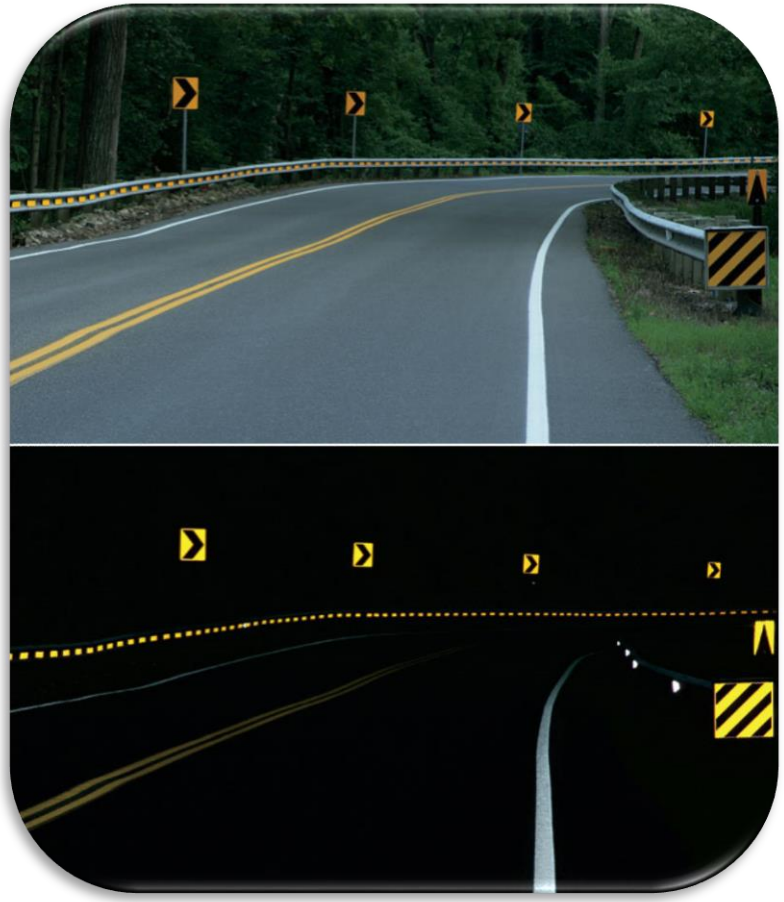
When is it Best to Apply

Countermeasure addresses: ***roadway departure***

Locations in which a ***full redesign*** of the road curve may be too expensive or impractical, particularly ***in the short term***

Locations in which ***properly designed curves*** still experience road departure crash problems

When is it Best to Apply



Locations prone to adverse conditions

- Mountain areas (rain, fog, steep slopes)
- Loop ramps in freeway interchanges (users need high speed travel within ramps)

Locations in which public illumination isn't practical (rural areas, places prone to vandalism)

Critical Reference Documents

American Association of State Highway and Transportation Officials, *A Policy on the Geometric Design of Highways and Streets, 6th Edition (2011). Print*

American Association of State Highway and Transportation Officials, *Highway Safety Manual, 1st Edition (2010). Print*

Federal Highway Administration, *Manual on Uniform Traffic Control Devices (2009) http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/mutcd2009r1r2edition.pdf*

6. Safety Edge℠

Definition

Diagonal geometry of pavement edge at 30°

Pavement edge acts as a ramp for wheels of vehicles

Dramatically reduces risk of ***vehicle overturning/rollover***

Reduces occurrence of ***head-on collisions*** on divided roadways with medians but not barriers

Facilitates re-entry of vehicle after roadway departure incident

Protects pavement edge from ingress of water and raveling

When is it Best to Apply

Countermeasure addresses: ***roadway departure***

Countermeasure is of ***very low cost***—only requires special device for asphalt paving machine or modified formwork for PCC pavement

Can be done as part of ***normal*** new and resurfacing ***paving operations***

Any road with clear zones

- Grass medians
- Border of travel way includes shoulder
- ***Not applicable*** for roads with ***curbs or sidewalks***

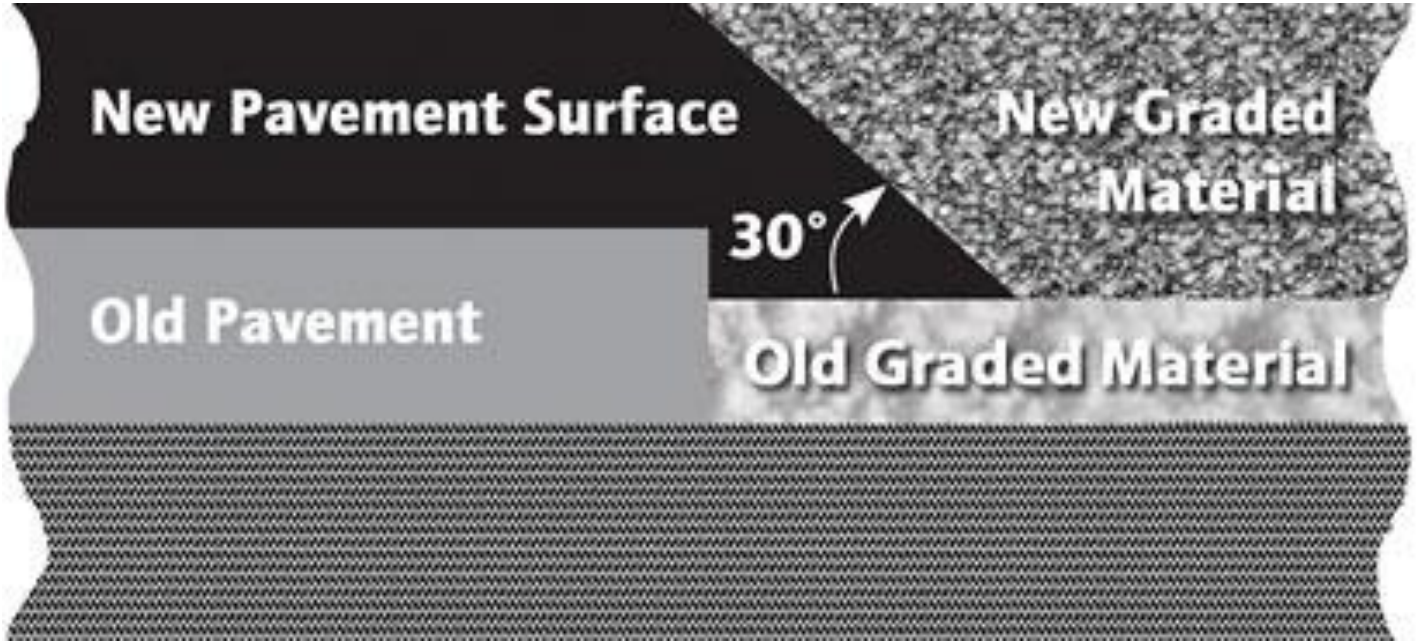
Doable in both Portland Cement and Asphalt-based pavements

Proper cross-section of Safety Edge^{SM}

New pavement edge extends beyond previous pavement edge

Grading material for clear zone (earth fill) covers safety edge

Grading material for clear zone is at same elevation of adjacent pavement → if not, bring earth fill for levelling



Source: http://safety.fhwa.dot.gov/provencountermeasures/images/new_old_pavement.jpg

Examples

Source:
http://safety.fhwa.dot.gov/provencountermeasures/images/sa12_010.jpg

Source:
http://safety.fhwa.dot.gov/provencountermeasures/images/new_old_pavement.jpg

Construction of Safety Edge^{SM} in Asphalt Pavement

Safety Edge^{SM} in Action With Trucks

Critical Reference Documents

The Safety Edge: A Pavement Edge Drop-Off Treatment, FHWA-SA-10-034
http://www.fhwa.dot.gov/everydaycounts/technology/safetyedge/brochure/brochure.pdf

FHWA Guide Specification for the Safety Edge
http://www.fhwa.dot.gov/everydaycounts/technology/safetyedge/specs.cfm

Frequently Asked Questions about the Safety Edge
http://www.fhwa.dot.gov/everydaycounts/technology/safetyedge/faqs.cfm

Safety Evaluation of the Safety Edge Treatment, HSIS Summary Report, FHWA-HRT-11-025
http://www.fhwa.dot.gov/publications/research/safety/hsis/11025/

Critical Reference Documents (cont.)

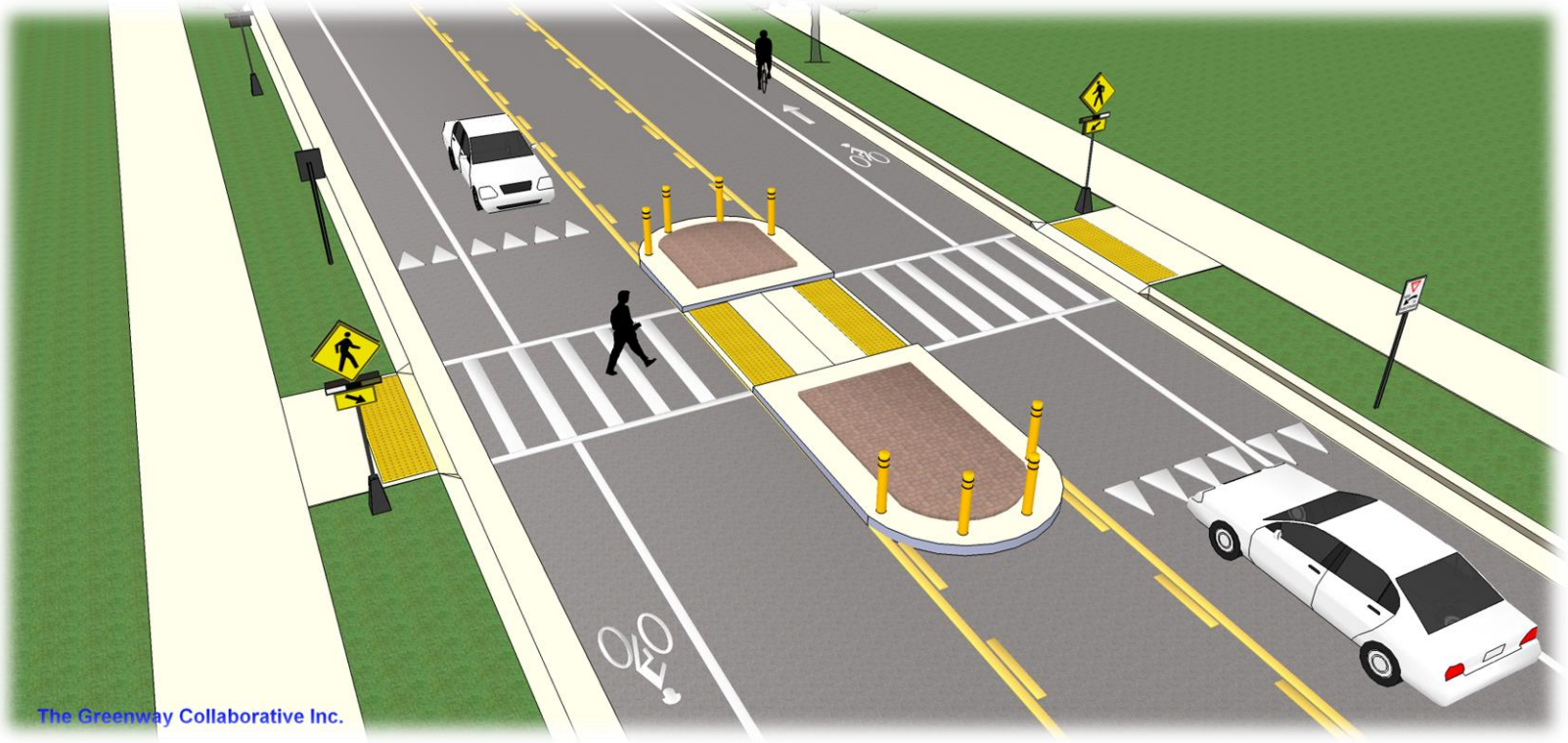
Safety Evaluation of the Safety Edge Treatment, FHWA-HRT-11-024
http://www.fhwa.dot.gov/publications/research/safety/11024/

Influence of Roadway Surface Discontinuities on Safety, State of the Art Report, Transportation Research Circular, Number E-C134
http://onlinepubs.trb.org/onlinepubs/circulars/ec134.pdf

Safety Impacts of Pavement Edge Drop-offs
http://www.aaafoundation.org/pdf/PEDO_report.pdf

Construction of a Safe Pavement Edge: Minimizing the Effects of Shoulder Drop-off
http://www.transtechsys.com/pdf/trb%20swm.pdf

7. Medians and Pedestrian Crossing Islands in Urban and Suburban Areas



Definition

For use in divided roadways with raised median or where medians can be added to enhance safety

Crossing path through median at same level of pavement

Space is ***sufficiently large*** to accommodate pedestrians waiting for traffic gaps before crossing safely

- ***Minimum*** width of median: 4 ft / 1.22m
- ***Optimal*** width of median: 8 ft / 2.44m
- Long enough to accommodate crossing pedestrian volumes

Definition

Can provide ***crossing spaces*** away from road intersections

Enhances safety by ***dividing one large crossing stretch*** into two or more smaller, more ***manageable portions***

Being entirely at the same level or elevation of the pavement facilitates use by people with disabilities

When is it Best to Apply

Countermeasure addresses: ***pedestrians***

Multilane, divided roadways with ***raised median and/or sidewalks*** (urban and suburban setting)

Significant combination of pedestrian and vehicular traffic ***(Average Daily Traffic, ADT, greater than 12,000)***

Medium to high travel speeds

Mid-block portions or urban roads or next to intersections

When is it Best to Apply

Places with well-defined destinations

- Transit stops (ex. Bus, public car, taxi)
- Large or important destination (schools, stores, parking lots, offices…)

Such that the median gap guides pedestrians to a safer crossing location

Good proven countermeasures for combination

- Road Diet
- Pedestrian Hybrid Beacon
- Corridor Access Management

Examples: Puerto Rico Convention Center, San Juan

Location has high pedestrian traffic and wide roads

Raised medians with crosswalk gaps serve as pedestrian refuge

Critical Reference Documents

AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities

A Review of Pedestrian Safety Research in the United States and Abroad, p. 85-86
http://www.walkinginfo.org/library/details.cfm?id=13

Pedestrian Facility User's Guide: Providing Safety and Mobility, p. 56
http://katana.hsrc.unc.edu/cms/downloads/PedFacility_UserGuide2002.pdf

Guide for the Planning, Design, and Operation of Pedestrian Facilities, American Association of State Highway and Transportation Officials, 2004 [Available for purchase from AASHTO]
https://bookstore.transportation.org/item_details.aspx?id=119

Pedestrian Road Safety Audits and Prompt Lists
http://www.walkinginfo.org/library/details.cfm?id=3955

Critical Reference Documents (cont.)

FHWA Office of Safety Bicycle and Pedestrian Safety
http://safety.fhwa.dot.gov/ped_bike/

Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations, p. 55
http://www.walkinginfo.org/library/details.cfm?id=54

Handbook of Road Safety Measures
http://www.cmfclearinghouse.org/study_detail.cfm?stid=14

Analyzing Raised Median Safety Impacts Using Bayesian Methods
http://www.cmfclearinghouse.org/study_detail.cfm?stid=213

8. Pedestrian Hybrid Beacon

Making road crossing better for everyone

Definition

Also known as HAWK (High Intensity Activated Crosswalk)

Signalized crossing for pedestrians

Default setting permits passage of motor vehicles

When pedestrians want to cross they request it with a button

Signal changes to stop motor vehicle traffic with initial warning

Clearance is granted for pedestrian crossing

Signal changes again to permit once more the passage of motor vehicle traffic

When is it Best to Apply

Countermeasure addresses: ***pedestrians***

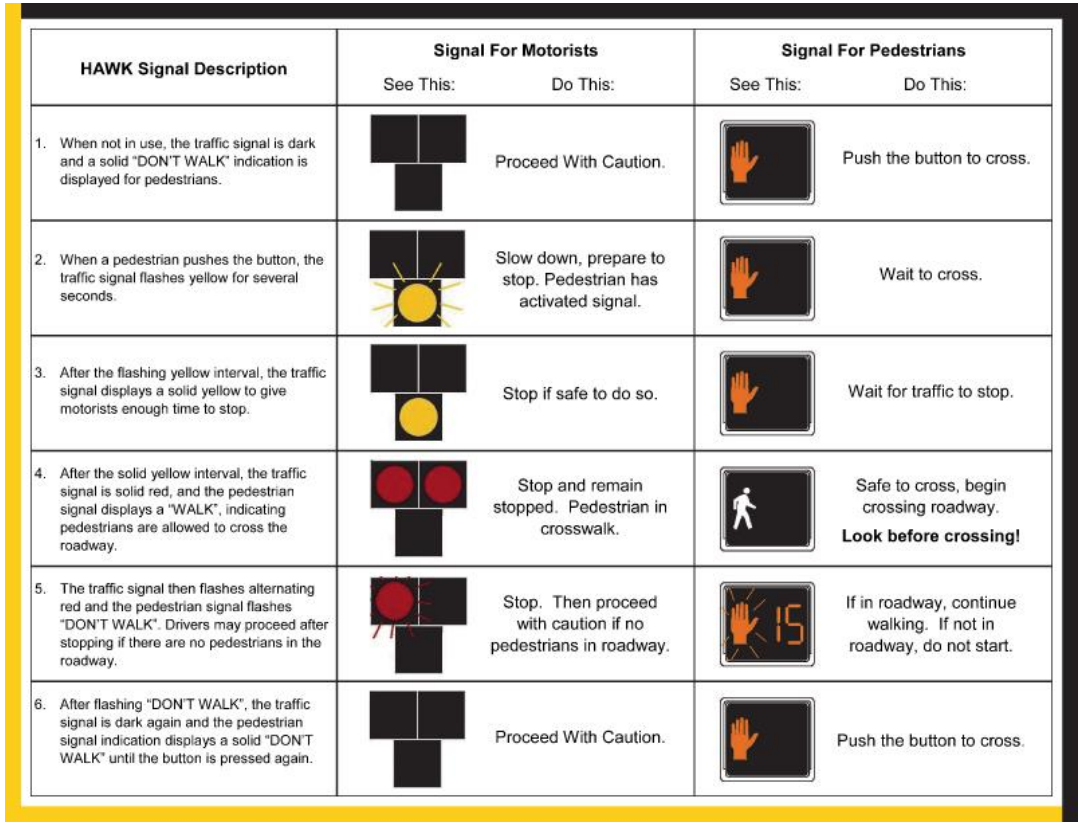
Mid-block portions of urban and suburban roads

Areas with moderate to high pedestrian traffic not needing nor suitable for traffic lights

Areas with conditions that make pedestrian crossing difficult

- Motor vehicles travelling at high speed
- Limited visibility (vegetation, dense construction, urban furniture)
- Long city blocks

When is it Best to Apply



HAWK Signal Description	Signal For Motorists		Signal For Pedestrians	
	See This:	Do This:	See This:	Do This:
1. When not in use, the traffic signal is dark and a solid "DON'T WALK" indication is displayed for pedestrians.		Proceed With Caution.		Push the button to cross.
2. When a pedestrian pushes the button, the traffic signal flashes yellow for several seconds.		Slow down, prepare to stop. Pedestrian has activated signal.		Wait to cross.
3. After the flashing yellow interval, the traffic signal displays a solid yellow to give motorists enough time to stop.		Stop if safe to do so.		Wait for traffic to stop.
4. After the solid yellow interval, the traffic signal is solid red, and the pedestrian signal displays a "WALK", indicating pedestrians are allowed to cross the roadway.		Stop and remain stopped. Pedestrian in crosswalk.		Safe to cross, begin crossing roadway. **Look before crossing!**
5. The traffic signal then flashes alternating red and the pedestrian signal flashes "DON'T WALK". Drivers may proceed after stopping if there are no pedestrians in the roadway.		Stop. Then proceed with caution if no pedestrians in roadway.		If in roadway, continue walking. If not in roadway, do not start.
6. After flashing "DON'T WALK", the traffic signal is dark again and the pedestrian signal indication displays a solid "DON'T WALK" until the button is pressed again.		Proceed With Caution.		Push the button to cross.

Application **must be done** together with

- Educational campaign (unconventional traffic control device) ***before and during implementation***
- Marked crosswalk (signs, painted crossing)
- Guidance of the Manual on Uniform Traffic Control Devices (MUTCD) for best location and identification practices

Pedestrian Hybrid Beacon in Action

Examples in Puerto Rico: San Juan

Touristic area commands high pedestrian traffic

Crossing area ***does not form part of signalized intersection***, consists of five lane cross-section

Implementation includes signs explaining critical operation rules

- Stop line
- Pedestrian crossing area
- Stop with red light

Education for the general public still necessary to ensure its use

Critical Reference Documents

AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities

Manual on Uniform Traffic Control Devices

A Review of Pedestrian Safety Research in the United States and Abroad
http://www.walkinginfo.org/library/details.cfm?id=13

Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations
http://www.walkinginfo.org/library/details.cfm?id=54

Critical Reference Documents (cont.)

Guide for the Planning, Design, and Operation of Pedestrian Facilities, American Association of State Highway and Transportation Officials, 2004 [Available for purchase from AASHTO]
https://bookstore.transportation.org/item_details.aspx?id=119

Pedestrian Road Safety Audits and Prompt List
http://www.walkinginfo.org/library/details.cfm?id=3955

FHWA Office of Safety Bicycle and Pedestrian Safety
http://safety.fhwa.dot.gov/ped_bike/

Critical Reference Documents (cont.)

Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities (NCHRP Report 674)
http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_674.pdf

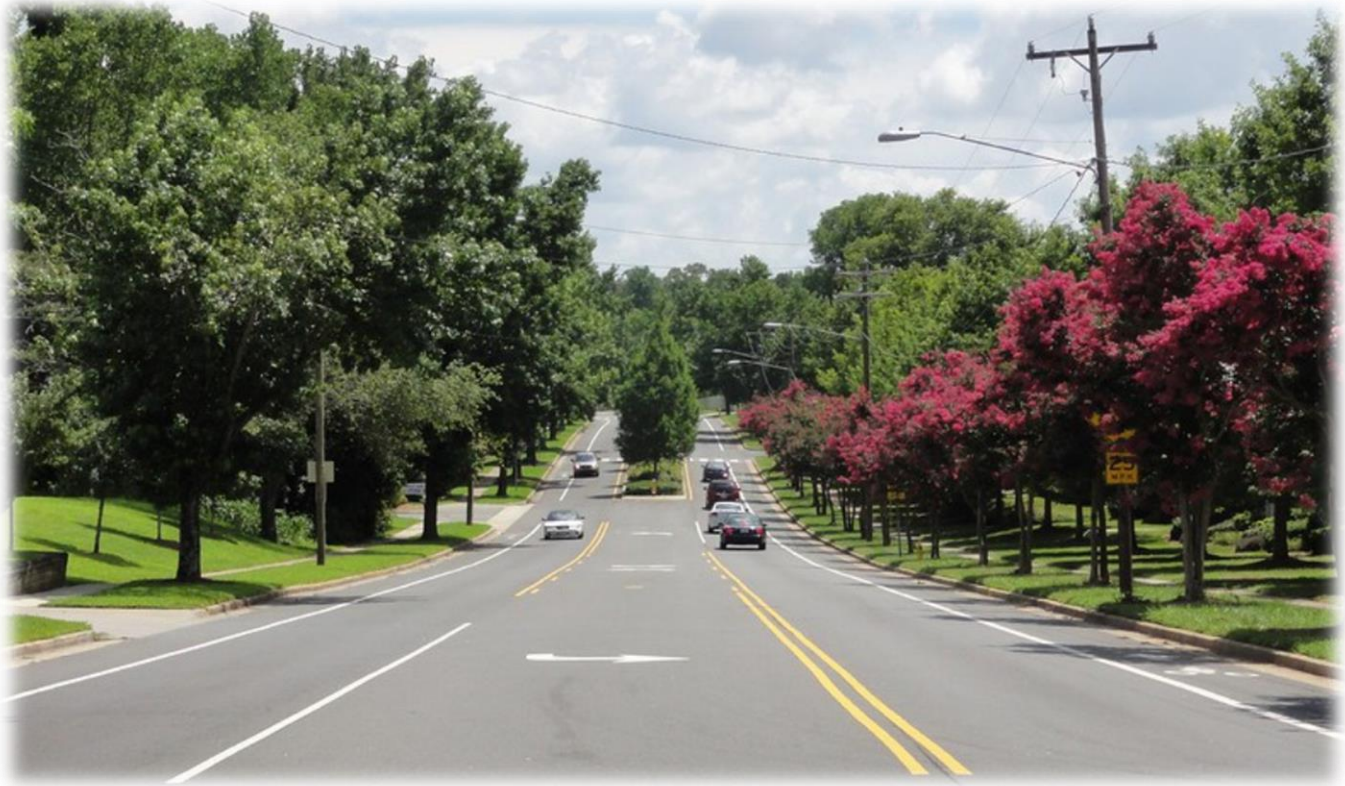
Manual on Uniform Traffic Control Devices, Chapter 4F. Pedestrian Hybrid Beacons
http://mutcd.fhwa.dot.gov/htm/2009/part4/part4f.htm

Safety Effectiveness of the HAWK Pedestrian Crossing Treatment
http://www.fhwa.dot.gov/publications/research/safety/10042/10042.pdf

Crash Modification Factors (CMF) Clearinghouse [quick search "HAWK"]
http://www.cmfclearinghouse.org/

9. Road Diet

There is such a thing as too big roads



Definition

Redesign of road cross-section

Reduces width and even amount of traffic lanes

Provides space for pedestrian, cycling, parking and safety uses

Design elements with a ***traffic calming*** purpose

- Lower speed
- Safe space for turning maneuvers
- Aesthetic and functional components to create pedestrian and cyclist friendly environment

Does not need additional right-of-way acquisition

When is it Best to Apply

Countermeasure addresses: ***driver behavior, roadway departure***

Multilane roadways (4-lane and 6-lane facilities), particularly those undivided (no median)

Incompatible uses with existing road

- Road operates as high speed facility
- Land uses include residential, commercial, educational or touristic facilities (high pedestrian and cyclist use, frequent entry/exit of drivers)

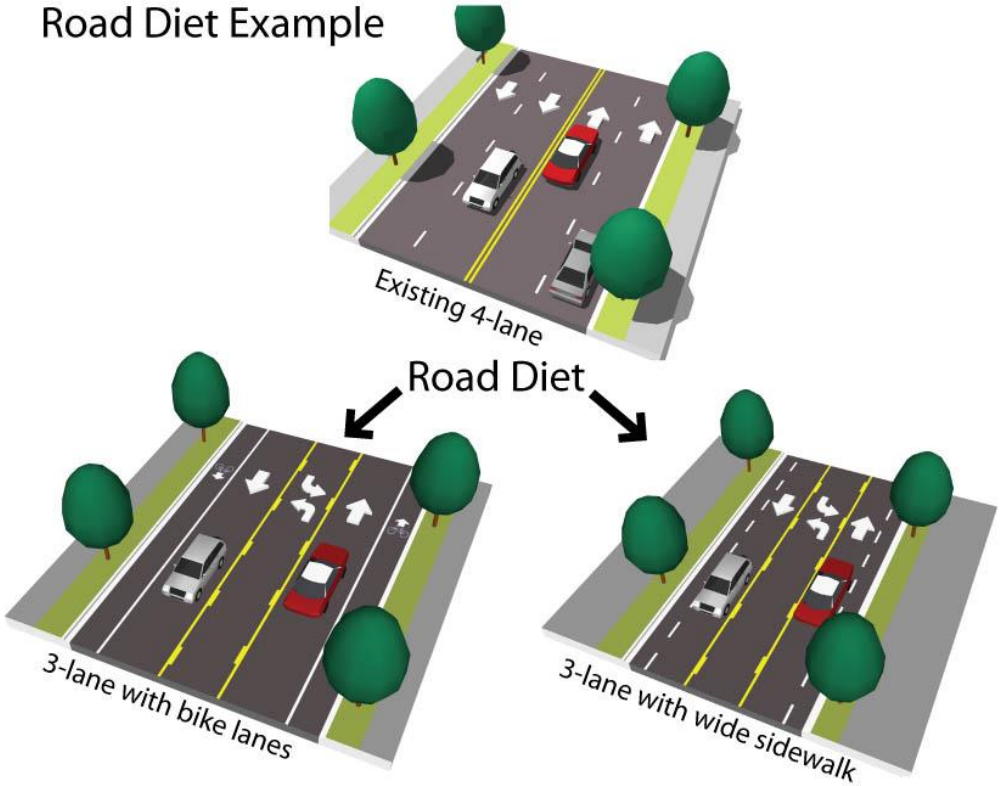
Frequent left turns across roads (undivided, multilane roads) leading to frequent head-on crashes and side-swipe crashes (lane-shifting)

When is it Best to Apply

As part pavement repair/overlay operations → minimal additional costs for construction

Road ***lacks proper safety*** and non-motorized user components. Cross-section redesign can help add/improve:

- Shoulders
- Sidewalks
- Cycling facilities
- Public transit routes



When is it Best to Apply

Urban roads can benefit from Road Diets in multiple ways:

Traffic calming

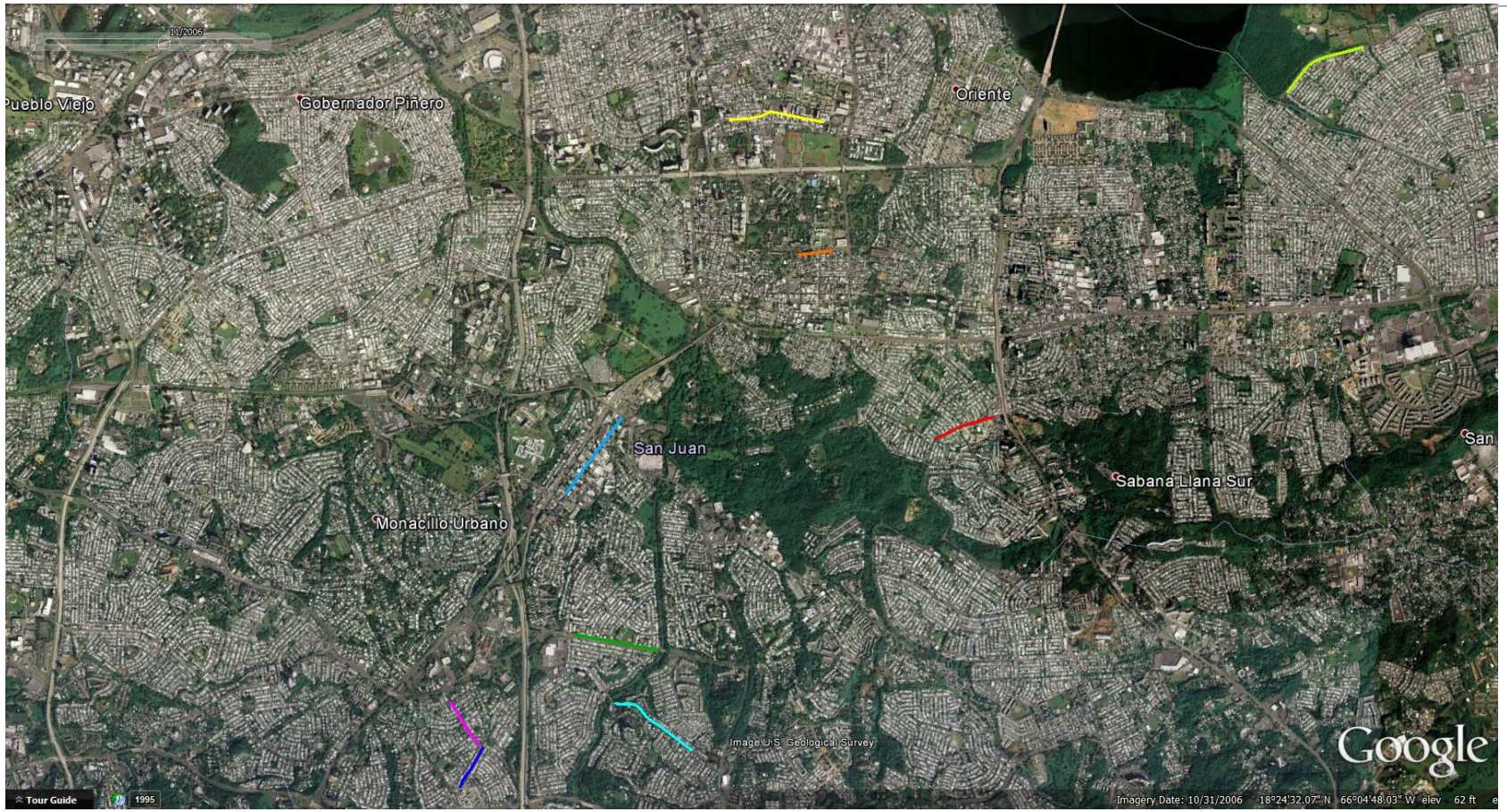
Accommodating mass transit (bus, BRT, street car, light rail traffic)

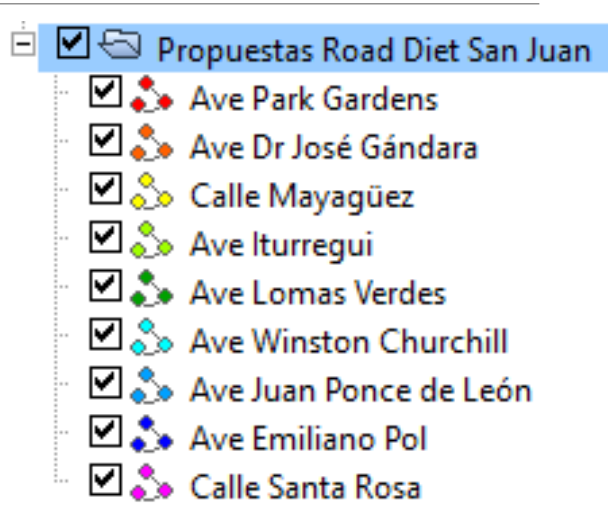
Accommodating vulnerable users (pedestrians and cyclists)

Streets and avenues with local commercial and residential activity

Caution: roads having AADT greater than 30,000 vehicles per day (vpd) not advised for Road Diet use

Road Diet Proposals in San Juan, PR



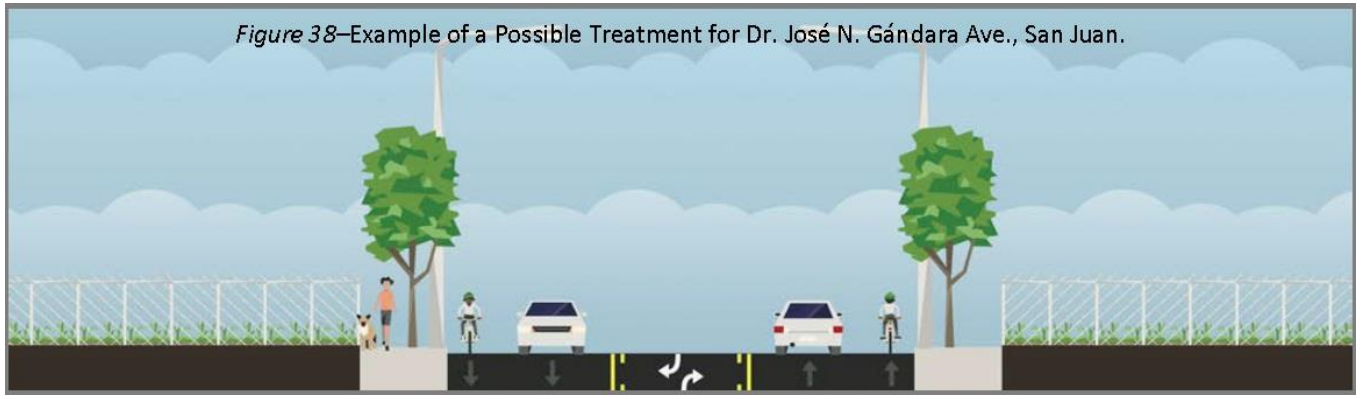


Study performed by PRLTAP during 2015

Road Diet Proposals in San Juan, PR: Park Gardens Avenue

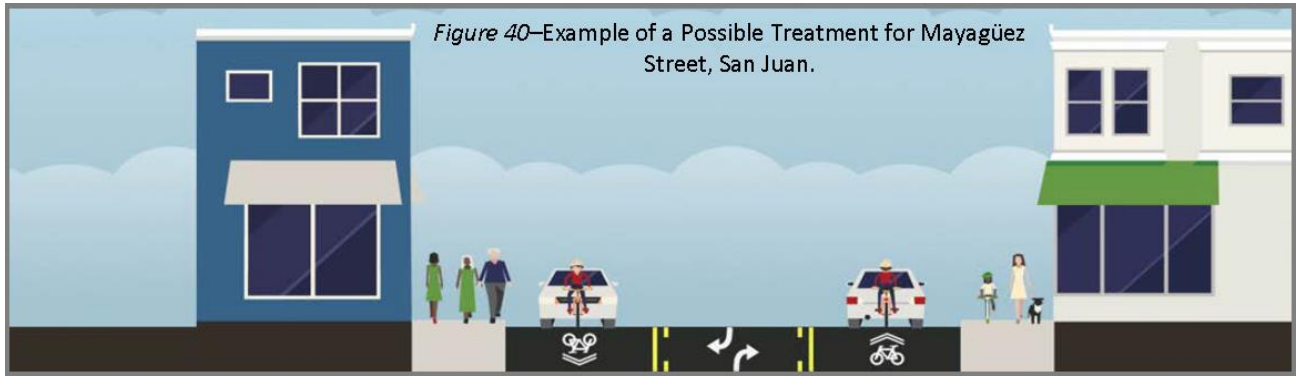
- Length: 800 m
- AADT: 16,000 vpd
- Characteristics: high bicycle and pedestrian activity, bus traffic

Road Diet Proposals in San Juan, PR: Dr. José Gándara Avenue



- Length: 290 m
- AADT: 13,644 vpd
- Characteristics: high bicycle and pedestrian activity, bus traffic, UPR campus

Road Diet Proposals in San Juan, PR: Mayagüez Street

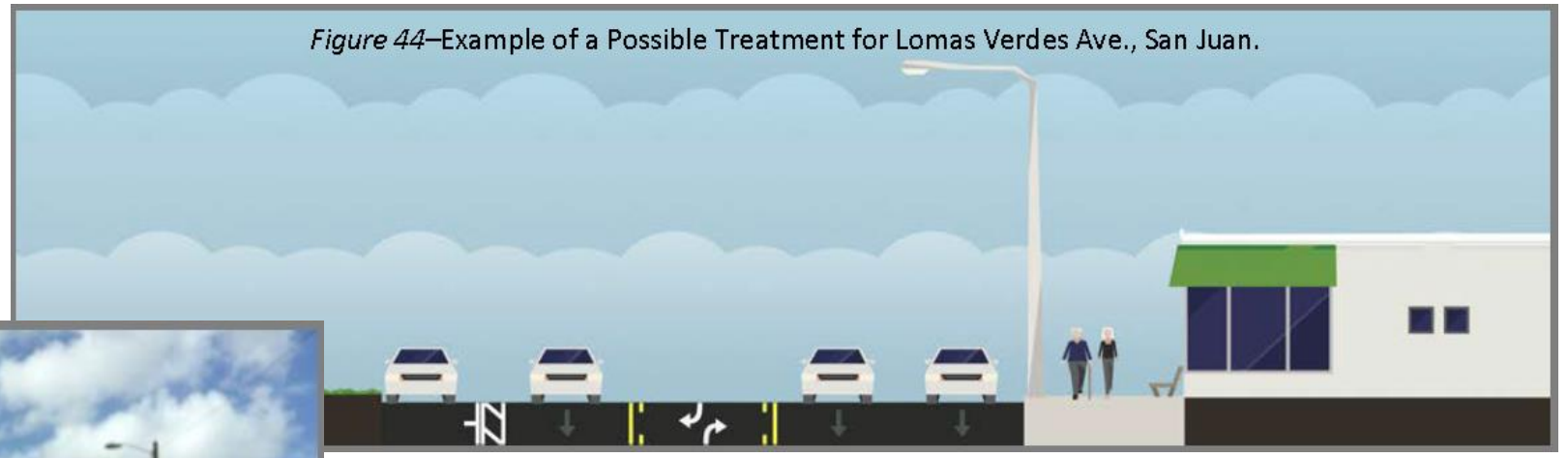


- Length: 900 m
- Characteristics: moderate bicycle and pedestrian activity; university and hospital nearby

Road Diet Proposals in San Juan, PR: Iturregui Avenue

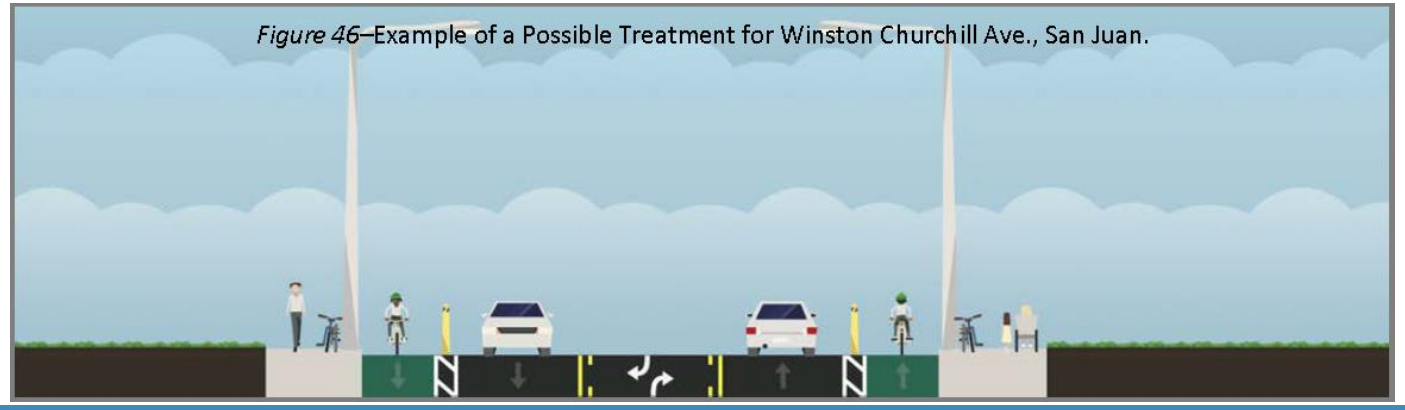
- Length: 800 m
- AADT: 23,300 vpd
- Characteristics: no lane division, high speeds, moderate bicycle and pedestrian traffic

Road Diet Proposals in San Juan, PR: Lomas Verdes Avenue (PR-177)



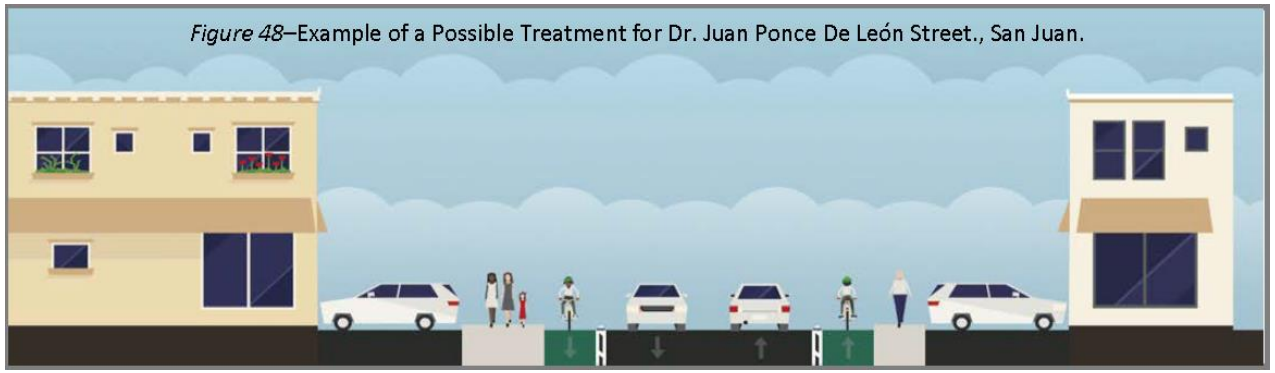
- Length: 750 m
- AADT: 31,317 vpd
- Characteristics: high bicycle and pedestrian traffic, frequent rear end collisions

Road Diet Proposals in San Juan, PR: Winston Churchill Avenue



- Length: 800 m
- AADT: 25,000 vpd
- Characteristics: moderate bicycle and pedestrian traffic, mall and school nearby

Road Diet Proposals in San Juan, PR: Juan Ponce de León Avenue



- Length: 800 m
- AADT: 14,614 vpd
- Characteristics: moderate bicycle and pedestrian traffic, train station nearby

Road Diet Proposals in San Juan, PR: Emiliano Pol Avenue

- Length: 350 m
- Characteristics: high bicycle and pedestrian traffic, university and school nearby

Road Diet Proposals in San Juan, PR: Santa Rosa Street

- Length: 350 m
- Characteristics: high bicycle and pedestrian traffic, university and school nearby

Critical Reference Documents

AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities

Access Management Manual (Transportation Research Board)

FHWA "Road Diet Informational Guide." November 2014.

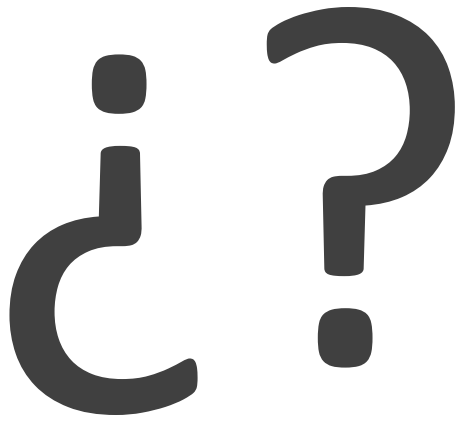
FHWA "Evaluation of Lane Reduction 'Road Diet' Measures on Crashes." FHWA Report No. FHWA-HRT-10-053. (Washington, D.C: 2010)

Stout, Thomas B., Before and After Study of Some Impacts of 4-Lane to 3-Lane Roadway Conversions. March 2005.

Final summary

Countermeasure	Cost range	Areas of Emphasis
Roundabouts	High	Intersections
Corridor Access Management	Medium to High	Intersections, Pedestrians, Driver Behavior
Backplates With Retroreflective Borders	Low	Intersections
Rumble Strips for Two-Lane Roads	Low	Roadway Departure, Driver Behavior
Enhanced Delineation and Friction for Horizontal Curves	Low to Medium	Roadway Departure
Safety Edge^{SM}	Low	Roadway Departure
Pedestrian Crossing Island	Low	Pedestrians
Pedestrian Hybrid Beacon	Low to Medium	Pedestrians
Road Diet / Roadway Reconfiguration	Low to Medium	Driver Behavior, Roadway Departure

Questions, Answers and Discussion



Thank you!