Note to the Reader: All text in red shows example information and data that corresponding with information and data in the companion example Data Analysis Package and Straw Man Outline and/or the Example Intersection Safety Implementation Plan. This data/information should be replaced for use in your State.

Intersection Safety Implementation Plan Workshop

January 21-22, 2009

Example Presentation

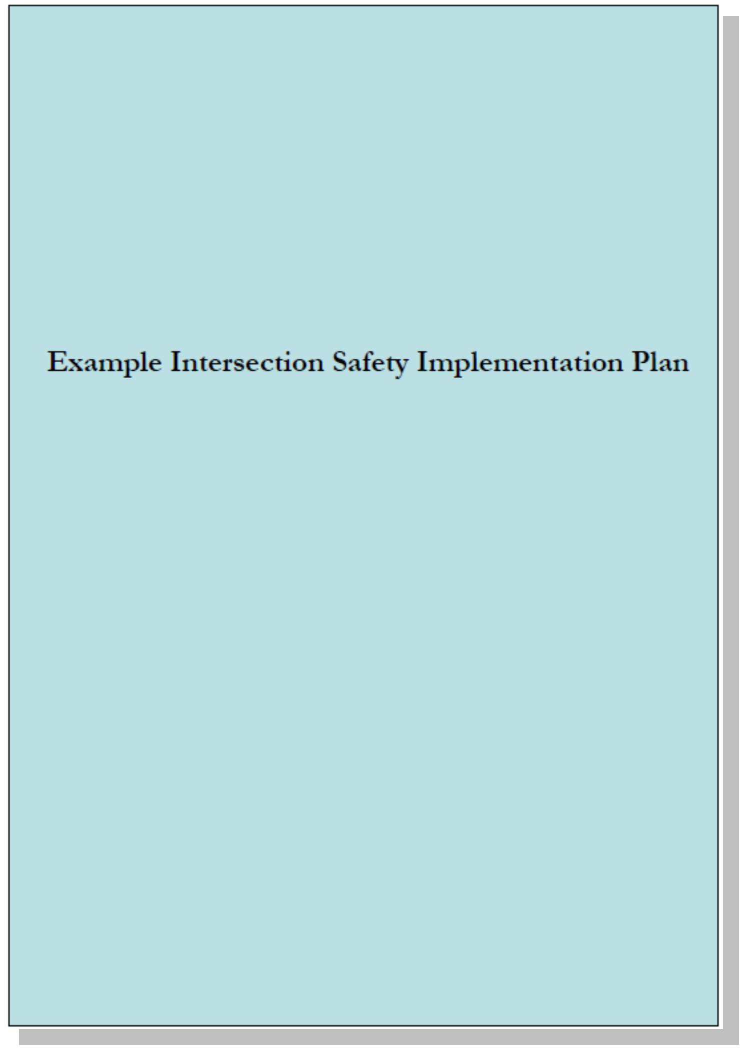
Workshop Goals and Objectives

- Examine the comprehensive and systematic approaches to reducing statewide intersection fatalities
- Identify sets of acceptable countermeasures and deployment characteristics that can reduce statewide intersection fatalities cost effectively and achieve the intersection safety goal
- Develop a preliminary strategic implementation or action plan to reduce statewide intersection fatalities cost effectively
- Identify strategic directions and steps needed to successfully implement the plan

Workshop Outcome

Preliminary Intersection Safety Implementation Plan to Reduce Statewide Intersection Fatalities Cost Effectively

Example Intersection Safety Implementation Plan


Example Intersection Safety Implementation Plan

Morning Agenda – Day 1

- 8:30 AM - Welcome and Introductions
  - Review of Workshop Goals, Objectives, and Outcome
  - Background on Reducing Intersection Safety Fatalities
- 8:45 AM - Module I: Intersection Goal, Data Analysis, and Countermeasure Identification
- ***10:00 AM - Break***
- 10:15 AM - Module I Continued
- ***12:00 PM - Lunch***

Afternoon Agenda – Day 1

- 1:00 PM - Module II: Putting It All Together
- ***2:45 PM - Break***
- 3:00 PM - Module II Continued
- Straw Man Set of Countermeasures, Deployment Characteristics, Costs, and Lives Saved
- 4:30 PM - Adjourn

Morning Agenda – Day 2

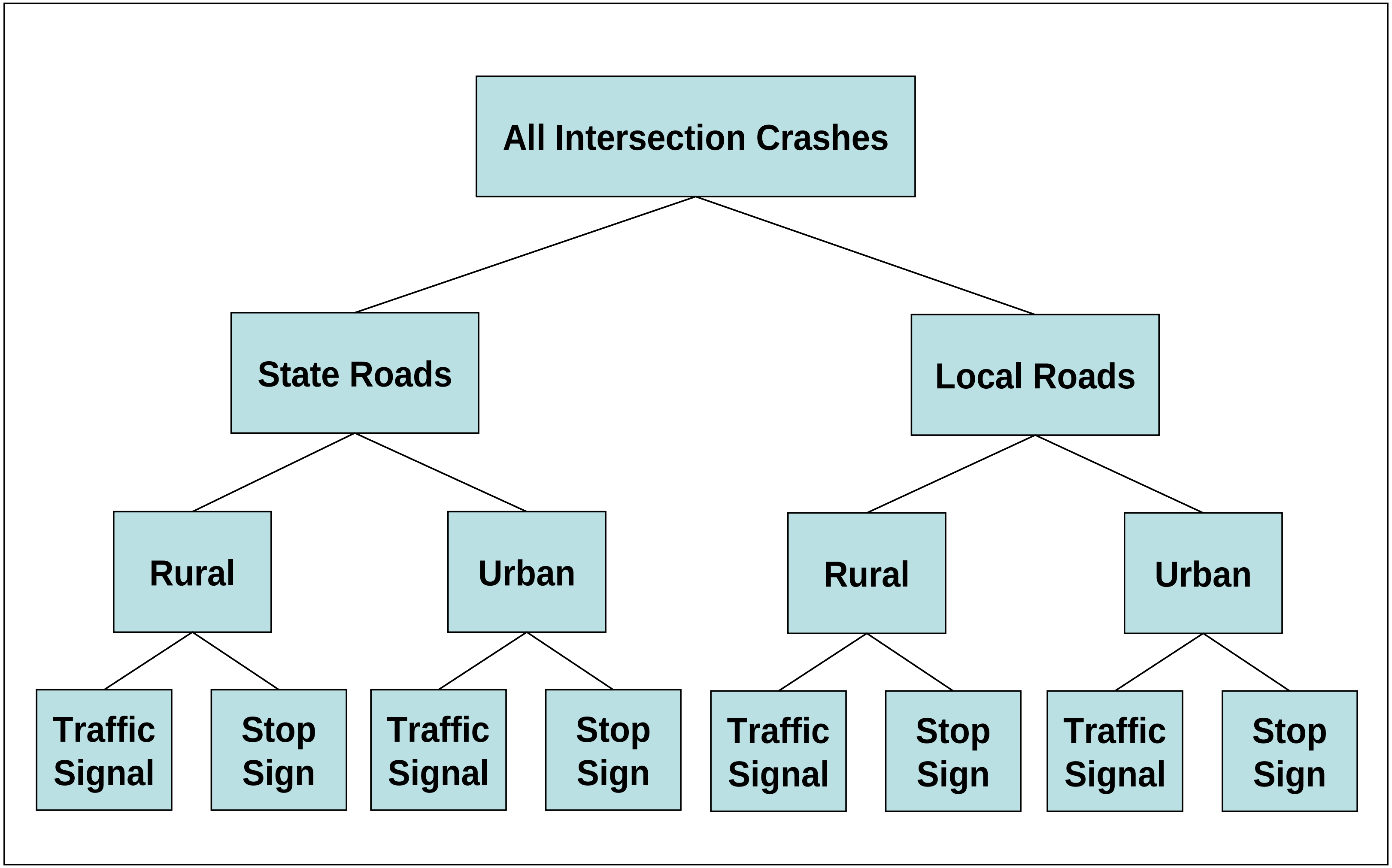
- 8:30 AM - Module II Reality Check
  - Review Day 1 results
  - Review and fine tune straw man
  - Check personal knowledge of high-crash intersections to determine if improvement types make sense
- ***9:45 AM - Break***
- 10:00 AM - Module III: Strategic Direction and Actions
  - Crosscutting barriers
  - Key countermeasure barriers
- ***12:00 PM - Lunch***

Afternoon Agenda – Day 2

- 1:00 PM - Module III: Strategic Direction and Actions (continued)
- 2:00 PM - Module IV: Action Items to Implement Components of Implementation Plan Outline
  - Key steps to implement countermeasures
  - Performance measures
  - Implementation plan outline
- 3:00 PM - Module V: Next Steps
- 3:15 PM - Adjourn

Approach for Reducing Intersection Safety Fatalities

Universe of Intersection Crashes



Reducing Intersection Fatalities

- Traditional Approach
  - Annual infrastructure improvements of 50-75 high-crash intersections statewide
  - Cost-effective but minimal statewide impact
- Systematic Approach
  - Improve substantial number of targeted intersections which have severe crashes with relatively low to moderate cost improvements
  - Rely on low-cost, cost-effective countermeasures
  - Improve 3-6% of intersections that have 25-45% of the statewide intersection crashes
  - Higher overall cost but greater impact in terms of statewide levels of lives saved
- Comprehensive Approach
  - Complement infrastructure improvements with targeted enforcement and education initiatives
  - 3E (engineering, education, and enforcement) coordinated initiatives on highway corridors and municipalities that have high numbers of intersection injuries and fatalities

Traditional Approach Improvement Categories

- High-crash intersections
  - Very high number of crashes per intersection (> 50 crashes in 5 years for rural intersections; 100 crashes per intersection for urban areas)
- Application of countermeasures with highest CRFs (e.g., roundabouts, left turn lanes)
  - Unfortunately, these also are the highest cost
- Individual intersection analyses required
- Few improvements
  - Usually less than 100 per year
- By itself, negligible impact on reducing statewide fatalities

Systematic Approach

- Reverse of the traditional approach
- Start with effective, low-cost countermeasures
- Find intersections with targeted crashes where countermeasures are cost-effective to install
- Install systematically at numerous intersections where they are cost-effective
  - Not limited to the highest crash locations
- Typically, treating 3-6% of the higher crash intersections can impact 25-45% of the statewide problem
- Systematic approach can reduce statewide fatalities

Systematic Improvement Characteristics

- Signalized and stop-controlled
- Urban and rural
- State and local
- Low-cost, cost-effective countermeasures
- Numerous widespread, cost-effective deployments

Comprehensive Approach

- Corridor Improvements
  - Routes that have a very high number of intersection fatalities and severe injuries
  - Engineering, education, and enforcement coordinated corridor-wide enforcement
- Area-Wide 3E Improvements
  - City-wide, system approach in cities with a disproportionate number of fatal or severe intersection crashes per capita or VMT
  - Engineering, education, and enforcement coordinated area-wide enforcement

Module I:
Intersection Goals, Data Analysis, and Countermeasure Identification

Module I Activities

- Review the goals and/or objectives for intersections identified in the Strategic Highway Safety Plan (SHSP)
- Discuss the results of intersection crash data analysis
- Review acceptable potential countermeasures to impact crash problems

Module I Outcomes

- Validation of State goals and objectives as they relate to intersections
- Better understanding of intersection crash characteristics particularly as they relate to intersection goals
- Identification of acceptable potential countermeasures to consider for cost-effective deployment to help achieve the goal

State Safety Goal

- Strategic Highway Safety Program Overall Goal
  - 850 or fewer fatalities by 2012
    - 992 in 2008
    - Probable lower fatalities in 2009 associated with the economy
  - 14.3% reduction in fatalities (2008-2012)
    - Economic downturn/upturn affects fatalities
    - By 2012, economy could be on upswing and have a negative impact on fatalities

Intersection Safety Goal

- 2003-2008 intersection fatalities – 214; 184; 187; 210; 187; 200 – no apparent trend
- Mean intersection fatalities – 197
- 14.3% reduction in intersection fatalities (proportional to total fatality reduction goal)
- Assumes downswing and upswing of economy between 2008 and 2012 will be neutral
- Target reduction in 2012 intersection fatalities = $197 \times 0.143 = 28$ fewer intersection fatalities in 2012

Intersection Safety Emphasis Strategies – SHSP

- Engineering
  - Improve intersection awareness
    - Install stop-approach rumble strips
    - Improve signage and intersection visibility
    - Improve sight distance
    - Install dynamic flashing beacons
    - Install or enhance intersection lighting
  - Implement innovative engineering designs
    - Install roundabouts
    - Install J-turns
    - Add offset turn lanes
    - Use traffic calming strategies (narrowing lanes)

Intersection Safety Emphasis Strategies – SHSP

- Engineering (continued)
  - Modify signal phasing and timing
    - Protect left-turn movement
    - Provide adequate clearance times (ITE guidelines)
    - Provide dilemma zone protection
  - Upgrade signal identification to assist officers in enforcing red-light violations
  - Remove unwarranted signals
  - Use proper planning and design of access to public roadways
  - Access management planning

Intersection Safety Emphasis Strategies – SHSP

- Education
  - Educate roadway users on intersection traffic controls (permissive left turn movement with traffic signals)
- Enforcement
  - Increase enforcement of intersection violations (red light running, regulatory signs)

SHSP Basic Phases

- Producing the SHSP
- Producing the Implementation Plan
- Implementation
- Evaluation and Updating

Six-Year Fatality Analysis

	2003	2004	2005	2006	2007	2008
Total Intersection Fatalities (FARS)	198	173	167	206	173	207
Total State Intersection Fatalities*	214	184	187	210	187	200

*** Fatalities from State data**

Intersection Crash Data Analysis

See Data Analysis Package and Straw Man Outline

State Intersection Crash Data Summary

	State Rural Signal	State Rural Stop-Controlled	State Urban Signal	State Urban Stop-Controlled	Local Rural Signal	Local Rural Stop-Controlled	Local Urban Signal	Local Urban Stop-Controlled
All Crashes								
Crashes	4,107	30,232	73,913	82,710	676	10,154	73,815	139,491
Fatalities	17	483	124	177	5	53	159	164
Incapacitating Injuries	227	3,769	2,482	2,734	11	531	2,160	3,275
Fatalities per 100 Crashes	0.41	1.60	0.17	0.21	0.74	0.52	0.22	0.12
Incapacitating Injuries per 100 Crashes	5.53	12.47	3.36	3.31	1.63	5.23	2.93	2.35
Divided Highway Crashes								
Crashes	829	3,799	21,266	17,814	6	6	909	1,185
Fatalities	8	142	54	65	-	-	5	4
Incapacitating Injuries	76	863	856	637	-	-	32	52
Fatalities per 100 Crashes	0.97	3.74	0.25	0.36	-	-	0.55	0.34
Incapacitating Injuries per 100 Crashes	9.17	22.72	4.03	3.58	-	-	3.52	4.37
Angle Crashes								
Crashes	1,588	14,393	27,278	28,677	238	4,066	31,643	54,978
Fatalities	11	346	66	129	5	26	86	97
Incapacitating Injuries	148	2,404	1,520	1,632	5	316	1,323	1,842
Fatalities per 100 Crashes	0.69	2.40	0.24	0.45	2.10	0.64	0.27	0.18
Incapacitating Injuries per 100 Crashes	9.32	16.70	5.57	5.69	2.10	7.77	4.18	3.35

State Intersection Crash Data Summary (continued)

	State Rural Signal	State Rural Stop-Controlled	State Urban Signal	State Urban Stop-Controlled	Local Rural Signal	Local Rural Stop-Controlled	Local Urban Signal	Local Urban Stop-Controlled
Left-Turn Crashes								
Crashes	1,266	-	21,172	-	196	-	19,742	-
Fatalities	5	-	35	-	1	-	39	-
Incapacitating Injuries	77	-	1,127	-	2	-	757	-
Fatalities per 100 Crashes	0.39	-	0.17	-	0.51	-	0.20	-
Incapacitating Injuries per 100 Crashes	6.08	-	5.32	-	1.02	-	3.83	-
Pedestrian Crashes								
Crashes	7	11	236	41	1	15	879	373
Fatalities	1	-	5	-	-	-	29	5
Incapacitating Injuries	3	2	66	4	0	4	170	56
Fatalities per 100 Crashes	-	-	2.12	-	-	-	3.30	1.34
Incapacitating Injuries per 100 Crashes	42.86	18.18	27.97	9.76	0	26.67	19.34	15.01

State Intersection Crash Data Summary (continued)

	State Rural Signal	State Rural Stop-Controlled	State Urban Signal	State Urban Stop-Controlled	Local Rural Signal	Local Rural Stop-Controlled	Local Urban Signal	Local Urban Stop-Controlled
Dark Crashes								
Crashes	721	5,050	17,840	13,234	110	1,618	17,814	28,118
Fatalities	7	111	54	29	3	13	81	73
Incapacitating Injuries	53	847	683	544	1	91	631	765
Fatalities per 100 Crashes	0.97	2.20	.30	0.22	-	0.80	0.47	0.28
Incapacitating Injuries per 100 Crashes	7.35	16.77	3.83	4.11	0.91	5.62	3.54	2.72
Wet Pavement Crashes								
Crashes	433	3,238	5,136	2,506	27	345	5,136	1,548
Fatalities	5	48	7	1	-	1	7	2
Incapacitating Injuries	31	428	154	246	2	46	25	28
Fatalities per 100 Crashes	-	1.48	0.14	-	-	-	0.14	-
Incapacitating Injuries per 100 Crashes	7.16	1.22	3.00	5.06	7.41	13.33	1.61	1.12

Reducing Intersection Fatalities
Crash Data

- Traditional Approach
  - Annual infrastructure improvements of 50-75 high-crash intersections statewide
  - Cost-effective but minimal statewide impact
- Systematic Approach
  - Improve substantial number of targeted intersections which have severe crashes with relatively low to moderate cost improvements
  - Rely on cost-effective countermeasures
  - Higher overall cost but greater impact in terms of lives saved
- Comprehensive Approach
  - Complement infrastructure improvements with targeted enforcement and education initiatives
  - 3E (engineering, education, and enforcement) coordinated initiatives on highway corridors and municipalities that have high numbers of intersection injuries and fatalities

Traditional Approach

- Usually highest intersection crash locations
- If a fatal crash occurred at an intersection in the recent past, it is unlikely that one will occur in the future even if no preventative action is taken

Fatal Crash Distribution – 2003-2008

Road Ownership	Number of Intersections with a Fatal Crash	Intersections with 1 Fatal Crash	Intersections with 2 Fatal Crashes	Intersections with 3 Fatal Crashes
State	683	647	34	2
Local	336	328	7	1

Factors that Impact the Difference Between Life and Death in an Intersection Crash

- Speed
- Type of crash
- Point of Impact
- Type and mass of involved vehicle(s)
- Safety belt usage
- Type of highway
- Weather and surface conditions
- Time of day
- Type of traffic control
- Crash location – urban or rural
- Age and health of drivers and occupants
- EMS capabilities
- Distance to nearest hospital
- Other variables

Traditional Approach Improvement Categories

- Highest state wide severe crash intersections
  - Very high number of crashes per intersection (> 50 crashes in 5 years for rural intersections; 100 crashes per intersection for urban areas)
- Ideally, application of countermeasures with highest CRFs (e.g., roundabouts, left turn lanes)
  - Unfortunately, these also are the highest cost
- Individual intersection analyses required
- Few improvements
  - Usually between 50 and 75 per year for an average size state
- By itself, negligible impact on reducing statewide fatalities

Reducing Intersection Fatalities Crash Data

- Traditional Approach
  - Annual infrastructure improvements of 50-75 high-crash intersections statewide
  - Cost-effective but minimal statewide impact
- Systematic Approach
  - Improve substantial number of targeted intersections which have severe crashes with relatively low to moderate cost improvements
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- Comprehensive Approach
  - Complement infrastructure improvements with targeted enforcement and education initiatives
  - 3E (engineering, education, and enforcement) coordinated initiatives on highway corridors and municipalities that have high numbers of intersection injuries and fatalities

Systematic Approach

- Reverse of the traditional approach
- Start with effective, low-cost countermeasures
- Find intersections with targeted crashes from the crash data base where countermeasures are cost-effective to install
- Install systematically at numerous intersections where they are cost-effective
  - Not limited to the highest crash locations
- Crash types with higher numbers of fatalities per 100 crashes
- Typically, treating 3-6% of the higher crash intersections can impact 25-45% of the statewide problem
- Systematic approach can reduce statewide fatalities

Intersection Crash Distribution Types – State and Local

Traffic Control	Locality	Total	Angle	Left Turn	Dark	Wet	Pedestrian	Speeding
Stop	Rural	X	X	X	X	X		X
Stop	Urban	X	X	X	X	X	X	X
Signal	Rural	X	X	X	X	X		X
Signal	Urban	X	X	X	X	X	X	X

Reducing Intersection Fatalities Crash Data

- Traditional Approach
  - Annual infrastructure improvements of 50-75 high-crash intersections statewide
  - Cost-effective but minimal statewide impact
- Systematic Approach
  - Improve substantial number of targeted intersections which have severe crashes with relatively low to moderate cost improvements
  - Rely on cost-effective countermeasures
  - Higher overall cost but greater impact in terms of lives saved
- Comprehensive Approach
  - Complement infrastructure improvements with targeted enforcement and education initiatives
  - 3E (engineering, education, and enforcement) coordinated initiatives on highway corridors and municipalities that have high numbers of intersection injuries and fatalities

Comprehensive Approach

- Corridor intersection safety
- Targeted municipal enforcement and education

Comprehensive Approach Corridors

See Data Analysis Package and Straw Man Outline

Top Severe Intersection Crash Corridors

County	On Location Street	Severity				Total Crashes
		Fatal	Incapacitating Injury	Evident Injury	Property Damage Only	
H	30	13	92	295	857	1,257
R	1	12	35	60	133	240
S	62	9	20	71	196	296
A	31	8	29	103	587	727
P	72	8	41	82	198	329
N	6	8	27	52	128	215
B	40	7	51	66	173	297
C	3	7	27	106	318	458
F	52	7	20	209	565	801
R	301	7	15	93	288	403
AA	5	7	43	377	1,068	1,495
CC	1012	7	42	423	1,310	1,782

Comprehensive Approach Municipalities

See Data Analysis Package and Straw Man Outline

Top Municipalities with Severe Intersection Crashes

City	Severity				Total Crashes
	Fatal	Incapacitating Injury	Evident Injury	Property Damage Only	
City P	106	701	11,909	42,490	55,206
City R	90	1,027	10,750	40,993	52,860
City B	34	395	6,842	15,851	23,122
City D	25	256	2,717	8,383	11,381

Applicable Countermeasures

- Systematic Approach – Stop-Controlled Intersections
  - Basic set of sign and marking improvements
  - Either a) flashing solar powered LED beacons on advance intersection warning signs and STOP signs or b) flashing overhead intersection beacons
  - J-turn modifications on high-speed divided arterials
- Systematic Approach – Signalized Intersections
  - Basic set of signal and sign improvement
  - Change of permitted and protected left-turn phase to protected-only
  - Advance detection control systems
  - Pedestrian countdown signals
  - Separate pedestrian phasing
  - Pedestrian ladder or cross-hatched crosswalk and advanced pedestrian warning signs
- Systematic Approach – Both Stop-Controlled and Signalized Intersections
  - New or upgraded lighting
  - High-friction surface
- Comprehensive Approach
  - Corridor 3E improvements on high-speed arterials with very high frequencies of severe intersection crashes
  - Municipal-wide 3E improvements in municipalities with high frequencies of severe intersection crashes
  - Enforcement-assisted lights
- Traditional Approach
  - Roundabouts

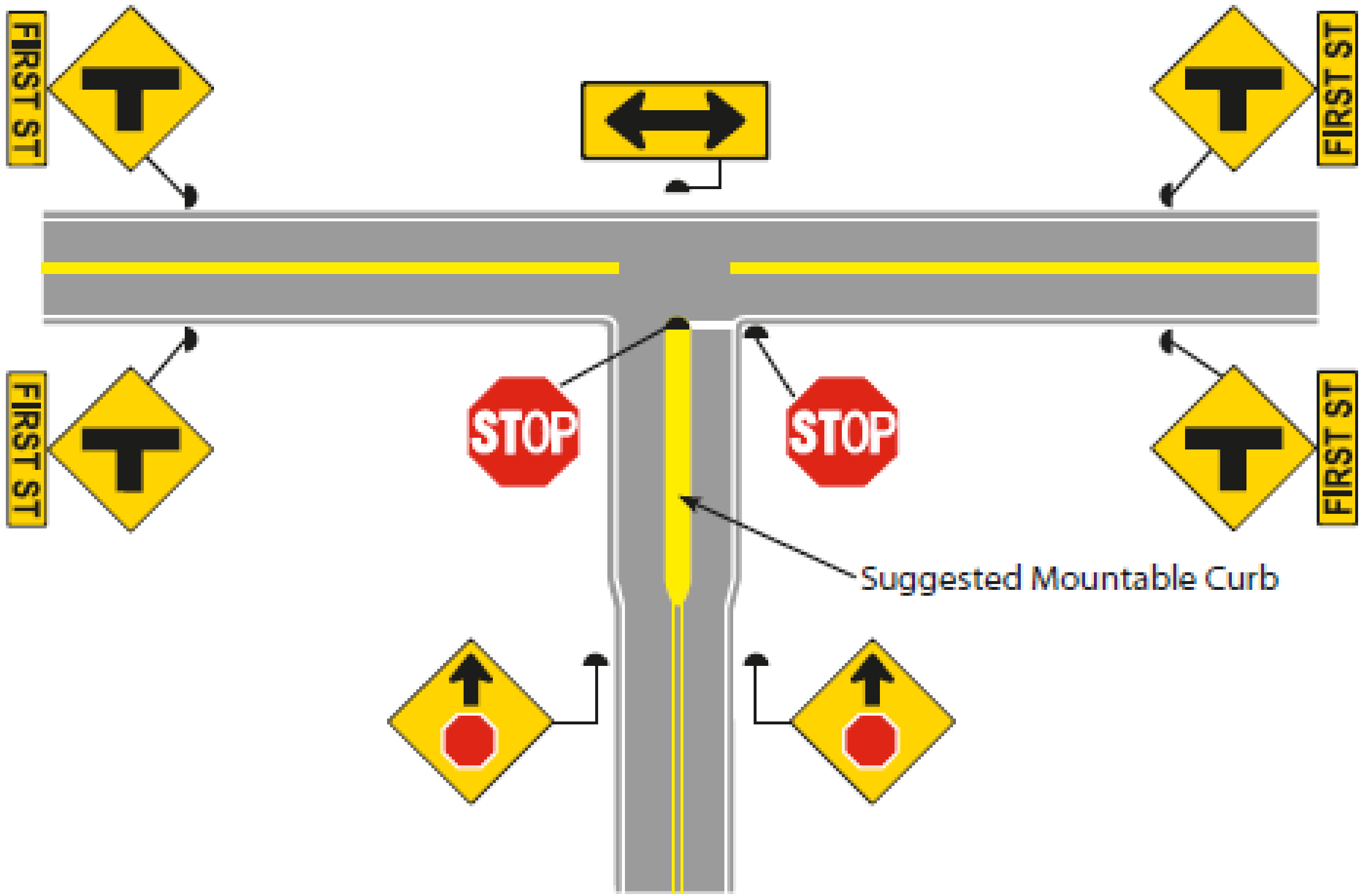
Countermeasures for Systematic Deployment – Stop-Controlled Intersections

- Basic Set of Sign and Marking Improvements
- Supplemental Enhancements

Stop-Controlled Intersections – Basic Set of Sign and Marking Improvements

- Low-Cost Countermeasures for the Through Approach
  - Doubled-up (left and right), oversize advance intersection warning signs, with street name sign plaques
- Low-Cost Countermeasures for the Stop 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 foot 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
  - Small, 6 foot splitter island

Stop-Controlled Intersections – Basic Set of Sign and Marking Improvements



Example of an Installation of a Minimum 6 Foot Wide Raised Splitter Island on the Stop Approach (No Pavement Widening Required)

Stop-Controlled Intersections – Supplemental Enhancements

- Installation of a 6 ft. or greater raised divider on stop approach (installed separately as a supplemental countermeasure)
  - See FHWA-HRT-08-063 for further design and performance information
- Flashing beacons
  - Solar powered LED beacons on advance intersection warning signs and STOP signs, or
  - Overhead intersection beacons
- Dynamic warning sign which advises through traffic that a stopped vehicle is at the intersection and may enter the intersection
- Transverse rumble strips across the stop approach lanes
  - In rural areas where noise is not a concern and running STOP signs is a problem
  - “Stop Ahead” pavement marking legend if noise is a concern

Stop-Controlled Intersections – Supplemental Enhancements (continued)

- Dynamic warning sign on the stop approach to advise high-speed approach traffic that a stopped condition is ahead
  - Use when vehicles running the "Stop" sign is a problem
- Extension of the through edge line using short skip pattern
  - May assist drivers to stop at the optimum point
  - Used on intersections with very wide throats in which stopped drivers have difficulty stopping at the correct location
- Reflective stripes on sign posts
  - Use on signs with degraded conspicuity due to sign clutter or competing background features to increase attention to the sign, particularly at night

Summary of Low-Cost Stop-Controlled Intersection Countermeasures

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Implementation Factors	Typical Implementation Cost Range per Intersection
Basic set of sign and marking improvements	40%	10 crashes in 5 years	4-5 crashes in 5 years	None	$5,000 to $8,000
Installation of a 6 ft. or greater raised divider on stop approach (installed separately as a supplemental counter measure)	15%	20 crashes in 5 years	10 crashes in 5 years	Widening required to install island	$25,000 to $75,000 (pavement widening but no ROW required)
Either a) flashing solar powered LED beacons on advance intersection warning signs and STOP signs or b) flashing overhead intersection beacons	10% (13% for right angle crashes)	15-20 crashes in 5 years	8-10 crashes in 5 years	None	$5,000 to $15,000
Dynamic warning sign which advises through traffic that a stopped vehicle is at the intersection and may enter the intersection	Unknown	20-30 crashes in 5 years	10-20 crashes in 5 years	5 angle crashes in 5 years and inadequate sight distance from the stop approach	$10,000 to $25,000

Summary of Low-Cost Stop-Controlled Intersection Countermeasures (continued)

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Implementation Factors	Typical Implementation Cost Range per Intersection
Transverse rumble strips across the stop approach lanes in rural areas where noise is not a concern and running STOP signs is a problem ("Stop Ahead" pavement marking legend if noise is a concern)	28% (transverse rumble strips) 15% ("Stop Ahead" pavement markings)	5 running STOP sign crashes in 5 years	3 running STOP sign crashes in 5 years	Inadequate stopping sight distance on the stop approach	$3,000 to $10,000
Dynamic warning sign on the stop approach to advise high-speed approach traffic that a stopped condition is ahead	Unknown	8 running STOP sign crashes in 5 years	5 running STOP sign crashes in 5 years	Inadequate stopping sight distance on the stop approach	$10,000 to $25,000
Extension of the through edge line using short skip pattern may assist drivers to stop at the optimum point	Unknown	10 crashes in 5 years	5 crashes in 5 years	Wide throat and observed vehicles stopping too far back from the intersection	Less than $1,000
Reflective stripes on sign posts may increase attention to the sign, particularly at night	Unknown	10 crashes in 5 years	5 crashes in 5 years	Sign visibility or conspicuity significantly degraded particularly at night	Less than $1,000

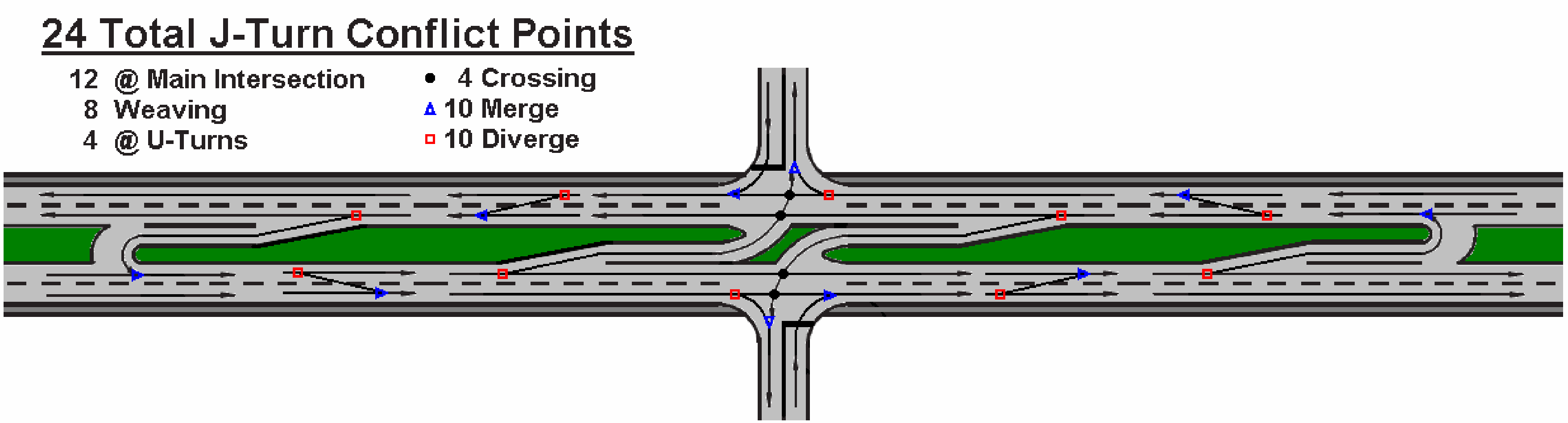
Example of a Flashing Solar Powered LED Beacon on an Advance Intersection Warning Sign

Example of a Flashing Overhead Intersection Beacon

Example of an Extension of the Through Edge Line Using Short Skip Pattern

Example of Reflective Stripes on Sign Posts

Stop-Controlled Intersections – J-Turn Modifications on High-Speed Divided Arterials



Stop-Controlled Intersections – J-Turn Modifications on High-Speed Divided Arterials

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Intersection Concern	Implementation Cost Range per Intersection
J-turn modifications on high-speed divided arterials	100% cross path, 72-84% frontal impact, 43-53% all crashes	4 angle crashes in 5 years*	4 angle crashes in 5 years*	Ability to make U-turn within about ¼ to ½ mile of intersection	$5,000 to $50,000

* If a highway section has a series of stop-controlled intersections with a high collective number of angle crashes, it is preferable to treat the problem on a system basis addressing all of the stop-controlled intersections rather than improving a few intersections that have isolated high numbers of angle crashes.

Countermeasures for Systematic Deployment – Signalized Intersections

- Basic Set of Signal and Sign Improvements
- Supplemental Enhancements for Special Conditions

Signalized Intersections – Basic Set of Signal and Sign Improvements

- Twelve-inch LED lenses on all signal heads
- Back plates on all signal heads (optional reflectorized border)
- A minimum of one traffic signal head per approach lane
- Traffic signal yellow change interval and all red interval timing adjusted to be in accordance with the ITE timing standards
- Elimination of any late night flashing operations

Example of 12-inch Heads, One Signal Head per Lane, and Back Plates

Traffic Signal Yellow Change Interval

$$Y = t + \frac{1.47 \times V_{85}}{2d + 2Gg}$$

Y = yellow duration in seconds

t = reaction time = 1s

V_{85} = 85th percentile speed in mi/h

d = deceleration = 10ft/s^2

G = grade in ft/ft

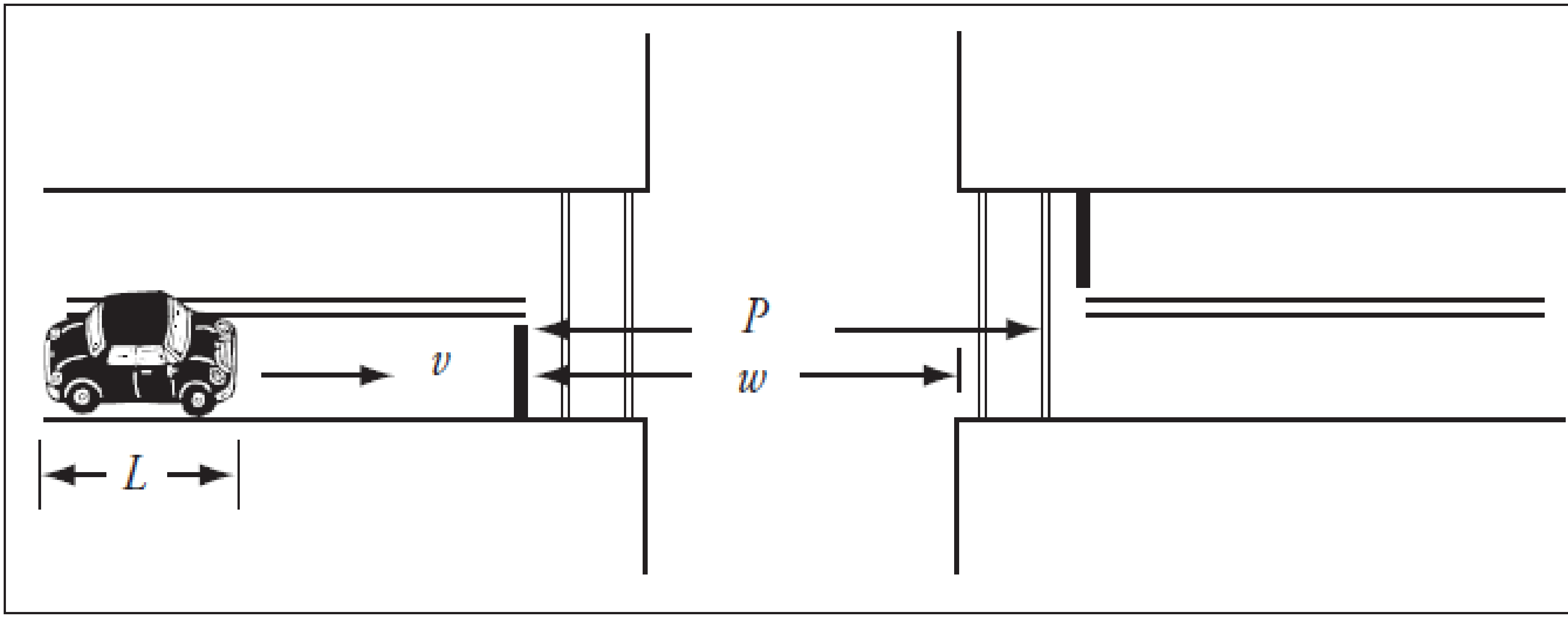
g = acceleration due to gravity = 32.2 ft/s^2

All Red Interval Timing

Equation	Usage
$r = (w + L) / v$ (1)	This red time places the vehicle outside the area of conflict with traffic that is about to receive the green indication (typically used when there is no pedestrian traffic)
$r = P / v$ (2)	This red time places the vehicle at a point directly in front of pedestrians waiting to use the crosswalk (typically used when there is very little pedestrian traffic, in which case the larger of Equations 1 or 2 is used).
$r = (P + L) / v$ (3)	This red time provides time for the vehicle to clear both the cross street and the pedestrian crosswalks.
* Note: *r* = all-red time; *v* = velocity. The terms *w, L* and *P* are defined in the Figure on the next slide.	

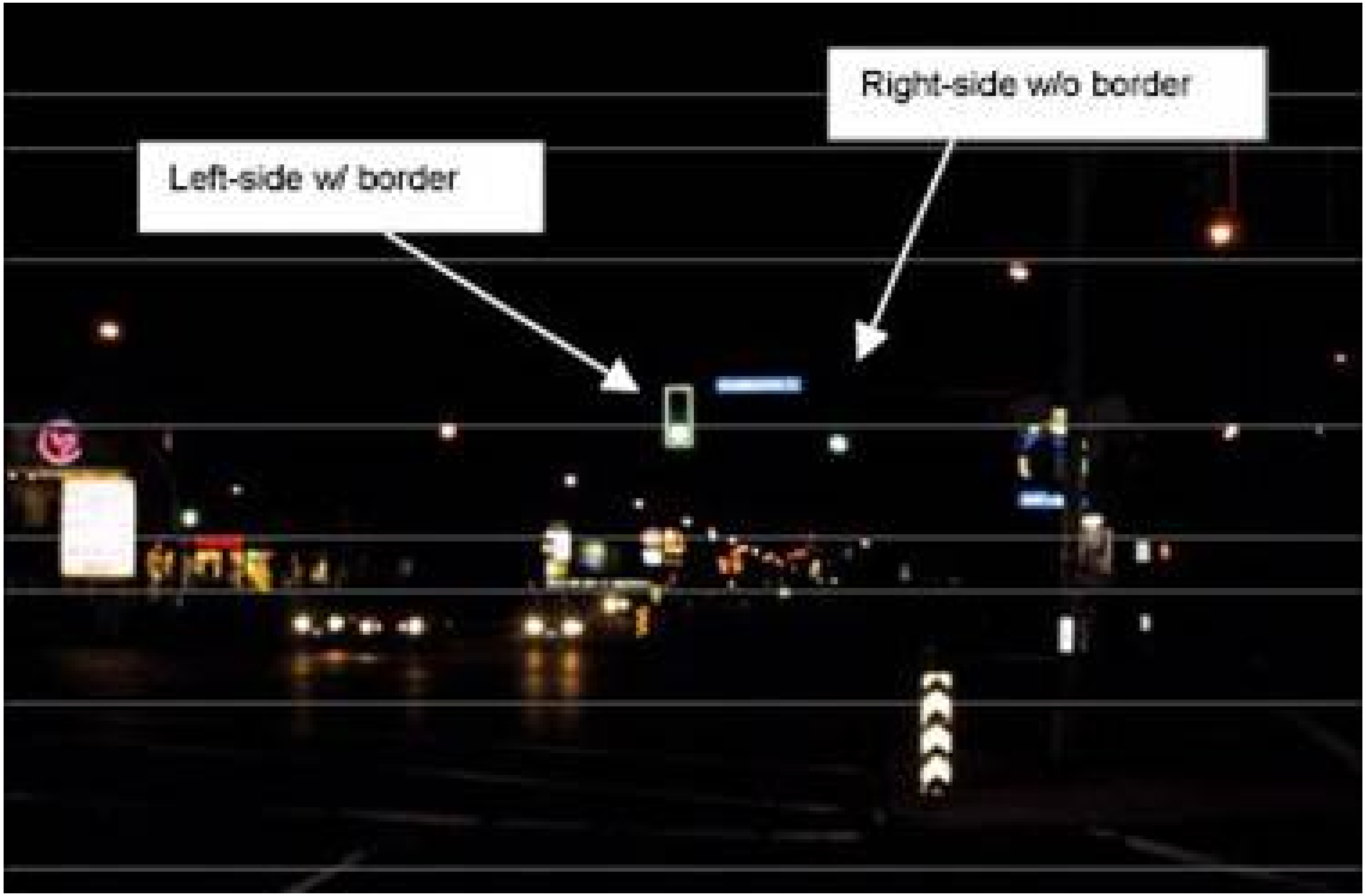
Source: Tarnoff, Phillip J., Traffic Signal Clearance Intervals, ITE Journal (Washington, DC: April 2004).

All Red Interval Timing (continued)



Example of Reflectorized Back Plates on All Signal Head (Daylight)

Example of Reflectorized Back Plates on All Signal Head (Night)



Signalized Intersections – Supplemental Enhancements for Special Conditions

- Change of permitted and protected left-turn phase to protected-only
  - For intersections with high numbers of left turn-opposing flow crashes, 3 or more opposing approach lanes, or high opposing volumes with few acceptable turning gaps
- Advance cross street name signs
  - For high-speed approaches on arterial highways
- Advance left and right “Signal Ahead” warning signs
  - For isolated traffic signals or intersections where the signal heads are not readily visible due to alignment or sight distance obstructions
- Supplemental signal face per approach
  - Where normally placed signal heads may be difficult to identify due to: sight distance limitations, horizontal curvature, or other obstructions
  - For exceptionally wide intersections where a near side signal is needed

Signalized Intersections –Supplemental Enhancements for Special Conditions (continued)

- Advance detection control systems
  - At isolated high-speed signalized intersections that have red light running angle crashes
- Signal coordination
  - On high-volume, high-speed arterials with closely spaced traffic signals and frequent mainline stopping due to poor or no signal coordination
- Pedestrian countdown signals
  - At intersections with high pedestrian activity or multiple pedestrian crashes
- Separate pedestrian phasing
  - At intersections with multiple pedestrian-turning vehicle conflicts
- Pedestrian ladder or cross-hatched crosswalk and advanced pedestrian warning signs
  - At intersections with high pedestrian activity or multiple pedestrian crashes

Example of Change of Permitted and Protected Left-Turn Phase to Protected-Only

Example of Advance Cross Street Name Signs

Example of Advance "Signal Ahead" Warning Sign

Example of Supplemental Signal Face per Approach

Example of Advance Detection Control System

Example of Signal Coordination

Example of Pedestrian Countdown Signal

Summary of Low-Cost Signalized Intersection Countermeasures

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Implementation Factor	Implementation Cost Range per Intersection
Basic set of signal and sign improvements	30%	20 crashes in 5 years	10 crashes in 5 years	None	$5,000 to $30,000
Change of permitted and protected left-turn phase to protected-only	41-48% of left turn crashes	5 left turn movement crashes; 3 or more opposing through lanes; minimal turning gaps available	5 left turn movement crashes; 3 or more opposing through lanes; minimal turning gaps available	None	$5,000 to $10,000
Advance cross street name signs for high-speed approaches on arterial highways	Unknown	20 crashes in 5 years	10 crashes in 5 years	High-speed approaches on four or more lane arterial highways	$1,000 to $5,000
Advance left and right “Signal Ahead” warning signs for isolated traffic signals	22%	20 crashes in 5 years	10 crashes in 5 years	Isolated traffic signal with one or more miles between signals; or traffic signals that are not readily visible due to highway alignment or obstructions	$1,000

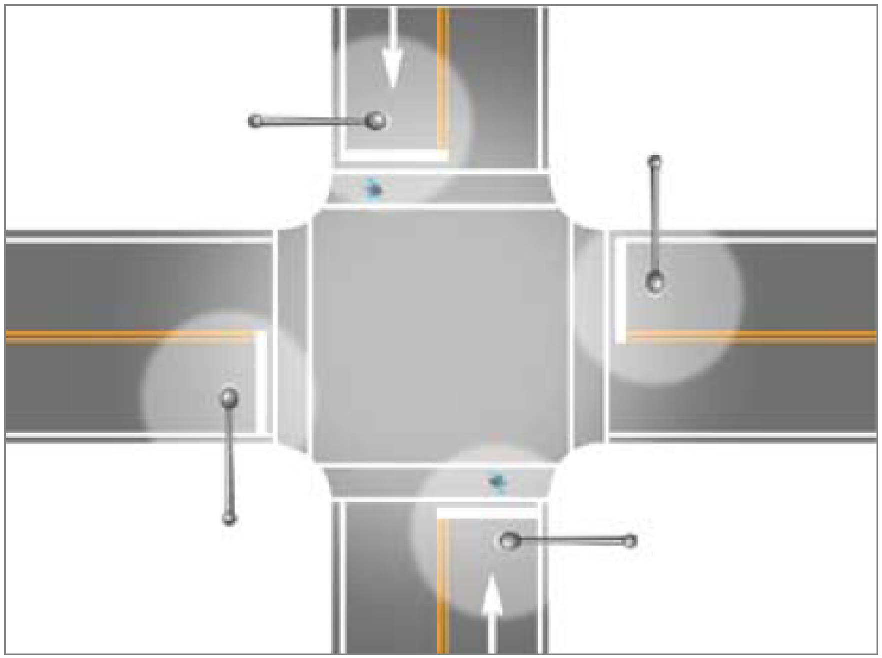
Summary of Low-Cost Signalized Intersection Countermeasures (continued)

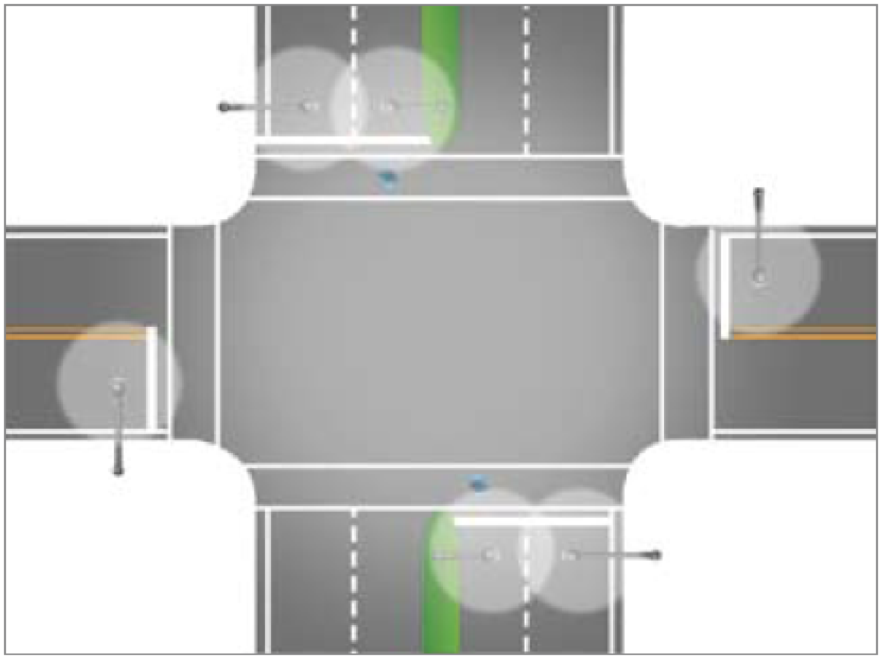
Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Implementation Factor	Implementation Cost Range per Intersection
Supplemental signal face per approach	28%	20 crashes in 5 years	10 crashes in 5 years	Signal faces obstructed by horizontal alignment; or exceptionally wide intersections (>100) where a near side signal is needed	$5,000 to $15,000
Advance detection control systems	40% (injuries)	5 angle crashes in 5 years	5 angle crashes in 5 years	Isolated high-speed (45mph or greater) signalized intersections	$15,000
Signal coordination	32%	20 crashes in 5 years per intersection	10 crashes in 5 years per intersection	Arterials with closely spaced (about 1/2 mile maximum) signals	$5,000 to $50,000

Summary of Low-Cost Signalized Intersection Countermeasures (continued)

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Implementation Factor	Implementation Cost Range per Intersection
Pedestrian countdown signals	25% (pedestrian crashes)	2 pedestrian crashes in 5 years	2 pedestrian crashes in 5 years	None	$5,000 to $15,000
Separate pedestrian phasing	34% (pedestrian crashes)	2 pedestrian crashes in 5 years involving a turning vehicle	2 pedestrian crashes in 5 years involving a turning vehicle	None	$5,000 to $15,000
Pedestrian ladder or cross-hatched crosswalk and advanced pedestrian warning signs	15% (pedestrian crashes) for signs Unknown for crosswalk	2 pedestrian crashes in 5 years	2 pedestrian crashes in 5 years	None	$1,000 to $3,000

Lighting Countermeasures at Unlit or Poorly Lit Intersections





Source: Federal Highway Administration, Informational Report on Lighting Design for Midblock Crosswalks, FHWA-HRT- 08-053 (Washington, DC: April 2008).

Lighting Countermeasures at Unlit or Poorly Lit Intersections

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Intersection Concern	Implementation Cost Range per Intersection
New or upgraded lighting	50% (NEW), 25% (UPGRADED) of night crashes	10 night crashes in 5 years and a night /total crash ratio above the statewide average for urban unlit intersections	5 night crashes in 5 years and a night/total crash ratio above the statewide average for rural unlit intersections	None	$5,000 to $15,000

Skid Resistance Countermeasures at Intersections with High Rates of Low-Friction Crashes

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Intersection Concern	Implementation Cost Range per Intersection
Skid resistance surface	50% (wet pavement crashes only)	8 wet pavement crashes in 5 years, a wet /total crash ratio above the statewide average wet/total crashes for intersections	8 wet pavement crashes in 5 years, a wet /total crash ratio above the statewide average wet/total crashes for intersections	High-speed approaches (45mph or greater) and a ribbed tire skid number of about 30 or less	$20,000 to $50,000

Countermeasures at Stop-Controlled Intersections with High-Speed Approaches

- Lane narrowing using pavement marking and shoulder rumble strips
  - See HRT-08-063, "Two Low-Cost Safety Concepts for Two-Way Intersections on High-Speed Two-Lane, Two-Way Roadways" for further design and performance information
- Lane narrowing using pavement marking and raised pavement markers
  - On approaches where noise issues or bicycle safety concerns associated with rumble strips cannot be addressed
- Peripheral transverse pavement markings
  - See "Peripheral Transverse Pavement Markings for Speed Control" (http://scholar.lib.vt.edu/theses/available/etd-05172007-135959/unrestricted/KatzPhDDissertation.pdf)

Countermeasures at Stop-Controlled Intersections with High-Speed Approaches (continued)

- Dynamic speed warning sign to reduce speed
  - On the through approach warning drivers traveling at speeds above a set threshold to slow down
- Slow pavement markings
  - Highlighted within a gray or black colored box on the pavement
  - Supplemented with advance intersection warning signs with advisory speed plates
  - See HRT-08-063 for further performance information
- High-friction surface
  - Applied to the approaches (approximately 300 feet in advance) and through the intersection

Example of Using Pavement Marking and Shoulder and Centerline Rumble Strips

Example of Peripheral Transverse Pavement Markings

Summary of Countermeasures at Stop-Controlled Intersections with High-Speed Approaches

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Intersection Concern	Implementation Cost Range per Intersection
Lane narrowing using rumble strips parallel to the edge lines	31%	10 speed-related crashes in 5 years	5 speed-related crashes in 5 years	Free of noise and bicycle issues-single through lane	$20,000 to $40,000
Lane narrowing using pavement marking and raised pavement markers	Unknown but probably less than 31%	10 speed-related crashes in 5 years	5 speed-related crashes in 5 years	Single through lane	$5,000 to $10,000
Peripheral transverse pavement markings	Unknown	10 speed-related crashes in 5 years	5 speed-related crashes in 5 years		$3,000 to $5,000
Dynamic speed warning sign to reduce speed	30%	10 speed-related crashes in 5 years	5 speed-related crashes in five years		$10,000

Summary of Countermeasures at Stop-Controlled Intersections with High-Speed Approaches (continued)

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Intersection Concern	Implementation Cost Range per Intersection
“Slow” pavement markings	Unknown	10 speed-related crashes in 5 years	5 speed-related crashes in 5 years		$2,000 to $5,000
High-friction surface	25% (All crashes)	10 speed-related crashes in 5 years	5 speed-related crashes in 5 years		$20,00 to $50,000

Corridor and Municipal Enforcement Countermeasures

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Intersection Concern	Implementation Cost Range
Corridor engineering, education, and enforcement (3E) improvements on high-speed arterials with very high frequencies of severe intersection crashes	25% of corridor intersection fatal and incapacitating injury crashes	10 or more intersection fatalities	10 or more intersection fatalities	Length of corridor should be in the 5-10 mile range	$1,000,000 per corridor + $100,000 education and enforcement annually per corridor
Municipal-wide 3E improvements in municipalities with high frequencies of severe intersection crashes	10% of all intersection crashes	Top 5 or so municipalities with the most intersection fatalities		Consider density of severe crashes per capita	$500,000 to 1,000,000 + $100,000 to 200,000 (dependent on the size of the city) education and enforcement annually per municipality

Countermeasures for Education-Enforcement Strategies at Signalized Intersections

- Automated red-light enforcement
- Enforcement-assisted lights

Examples of Automated Red-Light Enforcement

Example of Enforcement-Assisted Lights

Summary of Countermeasures for Education-Enforcement Strategies at Signalized Intersections

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Intersection	Implementation Cost Range per Intersection
Automated red-light enforcement	25% of angle crashes	8 angle crashes in 5 years	4 angle crashes in 5 years	Enabling legal authority required	Normally $0 if operated by contractor
Enforcement-assisted lights	15% of angle crashes	8 angle crashes in 5 years	4 angle crashes in 5 years	Enforcement commitment required	$1,000

Traditional Major Countermeasures

- Types
  - Roundabouts
  - Major channelization such as left-turn lanes
- High in effectiveness but high in cost
  - Roundabouts – 72% to 87% reduction in fatalities and injuries
  - Left-turn channelization
    - 13% to 24% for left-turn crashes at signalized intersections
    - 37% to 60% for left-turn crashes at stop-controlled intersections

Example of a Rural Roundabout

Example of a Suburban Roundabout

Roundabouts

- Are roundabouts a first consideration for new intersection design?

Summary of Traditional Major Countermeasures

Countermeasure	Crash Reduction Factor	Typical Urban Crash Threshold	Typical Rural Crash Threshold	Additional Intersection	Implementation Cost Range per Intersection
Roundabouts	72% to 87% (injuries and fatalities)	Intersections with the most frequent severe crashes statewide	Intersections with the most frequent severe crashes statewide	Right of way restrictions; individual intersection analysis required	$500,000 to $1 million each
Left-turn channelization	13% to 24% for left-turn crashes at signalized intersections 37% to 60% for left-turn crashes at stop-controlled intersections	Intersections with the most frequent severe crashes statewide	Intersections with the most frequent severe crashes statewide	Right of way restrictions; individual intersection analysis required	$350,000 to $400,000 each

Module II: Combining Data, Countermeasures, Costs, and Goal

Module II Activities

- Estimate total cost-effective improvements by countermeasure, estimated lives saved, and deployment and maintenance costs
- Determine the extent to which identified countermeasures enable you to achieve the goal
- Determine if additional countermeasures are required to meet goal
- Discuss various combinations of countermeasures, costs, and deployment levels to achieve intersection goal

Module II Outcomes

- Estimates of total improvements by countermeasure
  - Lives saved
  - Deployment costs
  - Enforcement and education costs
- Identification of most promising countermeasures to meet State intersection safety goal
- Identification of major barriers limiting deployment of promising countermeasures

Systematic Approach – Cost Effectiveness

- Improvements deployed on a systematic basis have to be cost effective
- A B/C analysis is used to make the determination
- Unlike a conventional analysis, the B/C is given or set
- The answer one seeks is the number of targeted crashes per intersection needed to make the improvement cost effective

Systematic Approach – Cost Effectiveness (continued)

- Formula
  - T = (Annual Cost × B/C) / (CRF × Average Crash Cost)
- Where
  - T = Threshold – Minimum number of targeted crashes per intersection needed to make the countermeasure cost-effective
  - Annual Cost = Annual cost of the improvement
    - If the improvement involves a construction project, annual cost is the construction cost averaged over the expected life of the project
    - If the improvement is an education or enforcement initiative, annual cost is the annual cost of a full year of enforcement and education
  - B/C = A set B/C ratio used to determine the threshold number of intersection crashes
    - In this case, a B/C value of 2.0 may be used
  - CRF = Estimated crash reduction factor, or effectiveness, of the strategy to reduce targeted crashes, expressed in terms of the percent of targeted crashes reduced
  - Average Crash Cost = Average cost of targeted crashes using the USDOT Fatality and Injury Costs (*Treatment of the Economic Value of a Statistical Life in Departmental Analyses*, http://ostpxweb.dot.gov/policy/reports/080205.htm) and the number of injury types for the targeted crashes

Cost Effectiveness Example for a Signal Update at State Urban Intersections

- Formula
  - T = (Annual Cost × B/C) / (CRF × Average Crash Cost)
- Where
  - T = Threshold
  - Annual Cost = $3,000 ($30,000 averaged over 10 years)
  - B/C = 2.0
  - CRF = 0.30
  - Average Crash Cost = $40,000 (estimated from the distribution of fatalities, injuries, and property damage crashes for State, urban, signalized intersections).
- Result
  - T= (3,000 × 2.0) / (0.30 × 40,000) = 0.50 crashes annually or between 2 and 3 crashes in 5 years

Countermeasure Cost, Effectiveness, and Expected Life

Hierarchy of Stop-Controlled Intersection Countermeasures

Countermeasure	Effectiveness (CRF)	Costs	Implementation Issues
Roundabouts	72% to 87% (injuries and fatalities)	$500,000 to $1 million each	Right of way restrictions; individual intersection analysis required
Left-turn channelization	13% to 24% for left-turn crashes at signalized intersections 37% to 60% for left-turn crashes at stop-controlled intersections	$350,000 to $400,000 each	Right of way restrictions; individual intersection analysis required
Dynamic warning signs (both types)	Unknown	$10,000 to 25,000	None
Basic set of sign and marking improvements	40%	$5,000 to $8,000	None

Hierarchy of Signalized Intersection Countermeasures

Countermeasure	Effectiveness (CRF)	Costs	Implementation Issues
Roundabouts	72% to 87% (injuries and fatalities)	$500,000 to $1 million each	Right of way restrictions; individual intersection analysis required
Left-turn channelization	13% to 24% for left-turn crashes at signalized intersections 37% to 60% for left-turn crashes at stop-controlled intersections	$350,000 to $400,000 each	Right of way restrictions; individual intersection analysis required
Advance detection control systems	40% (injuries)	$15,000	Isolated high-speed (45mph or greater) signalized intersections
Enforcement-assisted lights	15%	$1,000	Enforcement commitment required
Basic set of signal and sign improvements	30%	$5,000 to $30,000	None

Systematic Approach: Identify Promising Countermeasures for State Roads

- List low-cost State highway countermeasures that are acceptable to implement systematically
- For each countermeasure:
  - Review crash distribution data that the countermeasure impacts
  - Select threshold level that improvement will be considered for installation
  - Identify number of intersections which have as much or more than the threshold level of crashes
  - Identify the number of crashes that occurred at these intersections over the analysis period
  - Estimate the number of these intersections where the countermeasure may be able to be applied
  - Estimate the construction costs of improving using countermeasures identified above
  - Identify the type of crash reduced
  - Select a crash reduction factor estimate for the countermeasure and estimate the annual number of crashes reduced
  - Estimate the annual reduction in fatal crashes using the fat/100 crashes values and the estimated annual number of crashes reduced
- Sum up costs, crash reductions, and fatality reductions for each countermeasure
- Discuss a process to validate/invalidate countermeasure application at crash sites identified

Example Crash Distribution – State Rural Stop-Controlled Intersections

NUMBER OF CRASHES PER INTERSECTION	NUMBER OF INTERSECTIONS	CUMULATIVE		CUMULATIVE	
		INTERSECTIONS	PERCENT	CRASHES	PERCENT
50 and greater	7	7	0.07%	428	1.42%
30 - 49	26	33	0.31%	1,390	4.60%
20 - 29	91	124	1.16%	3,506	11.60%
10 - 19	389	513	4.82%	8,601	28.45%
5 - 9	1,033	1,546	14.51%	15,347	50.76%
4	576	2,122	19.92%	17,651	58.39%
3	1,008	3,130	29.38%	20,675	68.39%
2	2,034	5,164	48.47%	24,743	81.84%
1	5,489	10,653	100.00%	30,232	100.00%
Total	**10,653**	**10,653**	**100.00%**	**30,232**	**100.00%**

Straw Man Template – Systematic Approach Countermeasures

Counter-measure	Threshold Crash Level (Analysis Period)	Number of Statewide Intersections	Number of Targeted Crashes in the Intersections	Estimated Number of Improvements	Construc-tion Costs ($ Million)	Fatalities per 100 Crashes	Annual Targeted Crash Reduction	Annual Estimated Fatality Reduction
Total								

Example of Straw Man – Basic Set of Sign and Marking Improvements – State Stop-Controlled Intersections

Countermeasure	Threshold Crash Level (6 Years)	Number of Statewide Crash Intersections	Number of Targeted 6 Year Crashes in the Intersections	Estimated Number of Improvements[1]	Construc-tion Costs ($ Million)[2]	Fatalities per 100 Crashes	Annual Targeted Crash Reduction[3]	Annual Estimated Fatality Reduction
Basic Set of Sign and Marking Improvements – Rural	6	1,221	13,722	977	7.82	1.60	732	11.71
Basic Set of Sign and Marking Improvements – Urban	30	474	23,795	379	3.03	0.21	1,269	2.67
Total				1,356	10.85			14.38

[1] Assumes 80% of locations can be improved.
[2] Assumes an average cost of $8,000 per intersection.
[3] A CRF of 0.40 is used.

Systematic Approach: Identify Promising Countermeasures for Local Roads

- Discuss types of countermeasures that local governments may or may not consider for application at local intersections
- Employ the same process as that used for State roads to project costs and crash impacts for those countermeasures locals may find acceptable

Comprehensive Approach

- Corridors
- City-wide

Comprehensive Approach: Identify Promising Countermeasures for Corridors

- Use top severe intersection crash corridor listing to identify corridors with significant numbers of fatal and incapacitating injury crashes
- Identify tentative number of corridors State would like to proceed with a 3E corridor intersection safety program
- List corridors and their injuries and fatalities to be considered for implementation
- Estimate cost and impact of corridor component

Top Severe Intersection Crash Corridors

County	On Location Street	Severity				Total Crashes
		Fatal	Incapacitating Injury	Evident Injury	Property Damage Only	
H	30	13	92	295	857	1,257
R	1	12	35	60	133	240
S	62	9	20	71	196	296
A	31	8	29	103	587	727
P	72	8	41	82	198	329
N	6	8	27	52	128	215
B	40	7	51	66	173	297
C	3	7	27	106	318	458
F	52	7	20	209	565	801
R	301	7	15	93	288	403
AA	5	7	43	377	1,068	1,495
CC	1012	7	42	423	1,310	1,782

Straw Man Template – Comprehensive Approach Corridor Improvements

Corridor	Annual Incapacitating Injuries	Annual Fatalities	Annual Education and Enforcement Costs	Construction Costs	Crash Reduction Factor	Annual Fatalities Reduced
Total						

Comprehensive Approach: Identify Promising Countermeasures for Municipal-Wide Enforcement

- Use top municipalities with severe intersection crashes listing by municipality to identify municipalities with large numbers of intersection fatalities and incapacitating injuries
- Identify the municipalities to approach for area-wide intersection enforcement
  - Consider systematic deployment of low-cost, cost-effective countermeasures on an area-wide basis such as enforcement-assisted lighting if automated enforcement is not an acceptable countermeasure
- Compile results and compare to goal

Top Municipalities with Severe Intersection Crashes

City	Severity				Total Crashes
	Fatal	Incapacitating Injury	Evident Injury	Property Damage Only	
City P	106	701	11,909	42,490	55,206
City R	90	1,027	10,750	40,993	52,860
City B	34	395	6,842	15,851	23,122
City D	25	256	2,717	8,383	11,381

Top Municipalities for Pedestrian Crashes

City	Pedestrian Crashes
City P	624
City R	240
City B	56
City F	47
City D	32

Tabulation of Corridor and City 3E Costs and Impacts by Category

Category	Construction Costs	Annual Enforcement and Education Costs	Estimated Annual Reduction of Fatalities
Total			

Traditional Approach

- Number of intersections to be converted to roundabouts
- Number of intersections for left turn channelization

Summary Straw Man – Countermeasures, Costs, Lives Saved

Category	Approach	Number of Intersections	Construction Cost ($ Million)	Enforcement, Education and EMS Costs (Annual $ Thousand)	Estimated Annual Fatalities Reduced	Millions Expended Per Annual Life Saved
Basic Set of Sign and Marking Improvements –State Stop-Controlled Intersections	Systematic	1,356	10.85		14.38	0.75
Flashing Solar Powered LED Beacons on Advance Intersection Warning Signs and STOP Signs or Flashing Overhead Intersection Beacons – State Stop-Controlled Intersections	Systematic	69	0.69		0.44	1.56
J-Turn Modifications on High-Speed Divided Arterials – State Rural Stop-Controlled Intersections	Systematic	239	9.55		5.65	1.69
J-Turn Modifications on High-Speed Divided Arterials – State Urban Stop-Controlled Intersections	Systematic	109	4.35		1.31	3.32
Basic Set of Sign and Marking Improvements – Local Stop-Controlled Intersections	Systematic	236	1.89		0.71	2.48
Basic Set of Signal and Sign Improvements – State Signalized Intersections	Systematic	354	10.62		2.31	4.60
Change of Permitted and Protected Left-Turn Phase to Protected Only – State Signalized Intersections	Systematic	536	2.67		1.49	1.79
Advance Detection Control Systems – State Signalized Intersections	Systematic	67	1.00		0.31	3.22

Summary Straw Man – Countermeasures, Costs, Lives Saved (continued)

Category	Approach	Number of Intersections	Construction Cost ($ Million)	Enforcement, Education and EMS Costs (Annual $ Thousand)	Estimated Annual Fatalities Reduced	Millions Expended Per Annual Life Saved
Basic Set of Signal and Sign Improvements – Local Signalized Intersections	Systematic	263	7.89		2.27	3.47
Change of Permitted and Protected Left-Turn Phase to Protected Only – Local Signalized Intersections	Systematic	387	1.94		1.27	1.52
Pedestrian Improvements –State Urban Intersections	Systematic	55	0.75		0.08	9.37
Pedestrian Improvements –Local Urban Intersections	Systematic	142	4.98		0.81	6.15
New or Upgraded Lighting – State Intersections	Systematic	204	2.74		1.78	1.54
New or Upgraded Lighting – Local Intersections	Systematic	82	1.23		0.42	2.93
High-Friction Surface – State Intersections	Systematic	133	6.65		2.85	2.33

Summary Straw Man – Countermeasures, Costs, Lives Saved (continued)

Category	Approach	Number of Intersections	Construction Cost ($ Million)	Enforcement, Education and EMS Costs (Annual $ Thousand)	Estimated Annual Fatalities Reduced	Millions Expended Per Annual Life Saved
Enforcement-Assisted Lights	Systematic	5 Cities	0.69	0.25	1.72	0.40
Corridor 3E Improvements on High-Speed Arterials with Very High Frequencies of Severe Intersection Crashes	Comprehensive	6 Corridors	6.00	0.60	2.08	2.88
Municipal-Wide 3E Improvements in Municipalities with High Frequencies of Severe Intersection Crashes	Comprehensive	4 Cities	5.00	0.50	3.75	1.33
Roundabouts	Traditional	5	4.00		0.45	8.88
Total		**4,237**	**83.49**	**1.35**	**43.98**	

Estimated Cumulative Countermeasure Impact Compared to Goal

- Statewide Intersection Goal:
- Sum of Countermeasure Impact:
- Difference:

- If countermeasure impact is greater than goal, should goal be increased or level of implementation be decreased to be compatible to goal?
- If countermeasure impact is less than goal, should level of implementation be increased or goal decreased?

Straw Man Changes

Discussion: What changes to straw man countermeasures, costs, and safety impacts are needed?

End of Day One

- Questions?
- Next Steps

Summary Straw Man – Countermeasures, Costs, Lives Saved – Revised

Category	Approach	Number of Intersections	Construction Cost ($ Million)	Enforcement, Education and EMS Costs (Annual $ Thousand)	Estimated Annual Fatalities Reduced	Millions Expended Per Annual Life Saved
Basic Set of Sign and Marking Improvements –State Stop-Controlled Intersections	Systematic	1,356	10.85		14.38	0.75
Flashing Solar Powered LED Beacons on Advance Intersection Warning Signs and STOP Signs or Flashing Overhead Intersection Beacons – State Stop-Controlled Intersections	Systematic	69	0.69		0.44	1.56
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Basic Set of Signal and Sign Improvements – State Signalized Intersections	Systematic	354	10.62		2.31	4.60
Change of Permitted and Protected Left-Turn Phase to Protected Only – State Signalized Intersections	Systematic	536	2.67		1.49	1.79
Advance Detection Control Systems – State Signalized Intersections	Systematic	67	1.00		0.31	3.22

Summary Straw Man – Countermeasures, Costs, Lives Saved – Revised (continued)

Category	Approach	Number of Intersections	Construction Cost ($ Million)	Enforcement, Education and EMS Costs (Annual $ Thousand)	Estimated Annual Fatalities Reduced	Millions Expended Per Annual Life Saved
Basic Set of Signal and Sign Improvements – Local Signalized Intersections	Systematic	263	7.89		2.27	3.47
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High-Friction Surface – State Intersections	Systematic	133	6.65		2.85	2.33

Summary Straw Man – Countermeasures, Costs, Lives Saved – Revised (continued)

Category	Approach	Number of Intersections	Construction Cost ($ Million)	Enforcement, Education and EMS Costs (Annual $ Thousand)	Estimated Annual Fatalities Reduced	Millions Expended Per Annual Life Saved
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Corridor 3E Improvements on High-Speed Arterials with Very High Frequencies of Severe Intersection Crashes	Comprehensive	6 Corridors	6.00	0.60	2.08	2.88
Municipal-Wide 3E Improvements in Municipalities with High Frequencies of Severe Intersection Crashes	Comprehensive	4 Cities	5.00	0.50	3.75	1.33
Roundabouts	Traditional	5	4.00		0.45	8.88
Total		**4,237**	**83.49**	**1.35**	**43.98**	

Reality Check

- Review set of countermeasures and deployment characteristics, costs, and lives saved calculations from Day 1
  - Changes, additions, deletions
- Review selected high-crash intersections to determine if the application of the identified countermeasure makes sense
  - Adjustments needed?
- Reach consensus on a enhanced straw man set of countermeasures

Module III: Strategic Directions

Module III Activities

- Identify top overall issues, concerns, and barriers that may prevent full implementation of each key countermeasure in the final straw man and discuss how to address
- Identify resource and funding requirements and potential institutional and technical issues that need to be addressed
- Identify key decisions and opportunities that need to be made in order to successfully implement the countermeasure

Module III Outcomes

- Identification of issues, concerns, and barriers that are preventing widespread implementation of each of the key countermeasures
  - Institutional
  - Technical
  - Budget and Resource
- Actions to overcome these issues, concerns, and barriers and promote widespread implementation of the promising countermeasures

Potential Cross-Cutting Barriers

- Funding
- Improvements at local intersections with federal funds
- Education and enforcement initiatives beyond the conventional 402 funding
- Use of countermeasures new or rarely used in the State – process
- Additional barriers – list

Actions to Overcome Issues, Concern, or Barrier and Promote Widespread Implementation

- Barrier – Lack of adequate funding:

- Actions to break through barrier:

Actions to Overcome Issues, Concern, or Barrier and Promote Widespread Implementation

- Concern – Implementing countermeasures effectively on local roads:

- Actions to address concern:

Actions to Overcome Issues, Concern, or Barrier and Promote Widespread Implementation

- Concern – Timely and effective implementing of countermeasures rarely or never used such that risk of adverse consequences or failures are greatly minimized:

- Actions to address concern:

Actions to Overcome Issues, Concern, or Barrier and Promote Widespread Implementation

- Concern – Insufficient 402 funds to implement the education and enforcement countermeasures:

- Actions to address concern:

Actions to Overcome Issues, Concern, or Barrier and Promote Widespread Implementation

- Barrier – Other identified barrier:

- Actions to break through barrier:

Key Countermeasures – Limitations or Restrictions

Once consensus is reached on a final straw man:

- Select key countermeasures (4-8)
- For each key countermeasure identify any major issues, concerns, or barriers that could prevent full implementation
  - List the basis or concern and steps needed to satisfactorily remove
    - Technical issues
    - Potential controversial items associated with the countermeasure; effectiveness
    - Design issues
    - Non-familiarity concerns with the countermeasure
    - Others
  - Determine opportunities to resolve
    - Identify actions and steps to mitigate the concern

Key Countermeasures

- Which countermeasures are key to achieving the intersection safety goal?
  - Basic set of sign and marking improvements – stop-controlled intersections
  - J-turn modifications on high-speed divided arterials
  - Basic set of sign and sign improvements – signalized intersections
  - Change of permitted and protected left-turn phase to protected only
  - Advance detection control systems
  - Pedestrian countdown signals
  - Separate pedestrian phasing
  - Pedestrian ladder or cross-hatched crosswalk and advanced pedestrian warning signs
  - New or upgraded lighting – rural stop-controlled intersections
  - Skid resistance surface
  - Enforcement-assisted lights
  - Corridor 3E improvements on high-speed arterials with very high frequencies of severe intersection crashes
  - Municipal-wide 3E improvements in municipalities with high frequencies of severe intersection crashes
  - Roundabouts
  - Left-turn channelization

Actions to Overcome Issues, Concern, or Barrier and Promote Widespread Implementation of Countermeasure “X”

- Issue, concern, or barrier:

- Actions to break through barrier:

Module IV: Determine the Critical Steps Necessary for Effective Countermeasures Deployment

For each identified countermeasure:

What are the key steps to go from where we are right now to full implementation of the countermeasure?

The Road to Deployment: Key Countermeasure “X”

Critical Step	Who Responsible	Any Key Decision(s) Associated with Step	Decision-maker	Required Preparation	Estimated Timeframe to Complete Step

Example of Key Steps for Basic Set of Sign and Marking Improvements Enhancements on State Highways

- Finalize a package of sign/marking improvements, guidelines, and directions to apply at the intersections (who, when)
- Using photo logs and field reviews, verify that signing and marking improvements are legitimate or illegitimate at the identified intersections; if not legitimate explain why (who, when)
  - May want to develop criteria for placing improvements based upon existing sign and markings installations and other conditions at the site
- List the specific improvements recommended for each intersection (what, who will perform, when)
- Determine how the improvements are to be made (when, who, e.g., maintenance forces or contract)
  - If by maintenance, what information is needed by maintenance to install the improvements?
  - If by contract, what information is needed and what set of intersections will be included in the contract?

Example of Key Steps for Basic Set of Sign and Marking Improvements Enhancements on State Highways (continued)

- If by contract, prepare a contract package to implement these improvements on state roads as a pilot in a few counties or a District (who, when)
- If by maintenance forces, prepare the necessary information for maintenance to install and pilot in a few counties (who, when)
- Pilot state intersection package in one or two regions or several counties (who, when)
  - Optional, but probably necessary and beneficial for countermeasures never or rarely used
- After the pilot phase, make appropriate enhancements to the package and process and implement statewide (who, when)
  - Optional
- Set performance measures for implementing the improvements; monitor progress in accomplishing the above steps (who, when)
- Set performance measures for effectiveness; evaluate the actual effectiveness of the improvements to reduce crashes and compare to that estimated in the plan (who, when)

Module IV: Action Items to Implement the Plan

Implementation Planning Steps

1. Based on discussion, reach consensus on purpose of the plan and develop first cut action plan outline that fulfills purpose
2. Determine organizations and offices that need to approve implementation plan and provide funding, to implement countermeasures and achieve the goal
3. Develop draft implementation plan
4. Finalize draft implementation plan
5. Gain approval of the plan from designated organizations and offices
6. Modify the plan if necessary to incorporate input from designated organizations and offices
7. Implement the plan

Purpose of an Implementation Plan

- Document problem, countermeasures, deployment characteristics, and costs that can reduce fatalities and achieve intersection goal
- Gain upper management support
- Obtain funding levels needed to implement plan
- Establish who has to approve initiative including the funds and what is needed for a decision
- Document key steps and decisions needed to effectively implement plan and achieve goal
- Document process for expanding implementation of countermeasures that are considered limited or restricted
- Establish performance measures and tracking mechanisms to monitor implementation and fatality reductions
- Other

Module IV: Develop Implementation Plan Outline

Implementation Plan Outline – Draft

- Executive Summary
- Background
- The Intersection Safety Goal
  - The Approach
  - Distribution of the State Intersection Fatality Problem
  - Summary of Countermeasures
- Key First Steps
- Implementation
  - Countermeasure Descriptions
  - Key Implementation Steps
- Performance Measures
  - Production Performance Measures
  - Impact Performance Measures
- Performance Standards – Program Effectiveness in Reducing Targeted Crashes
- Summary

Module IV: Action Items to Implement the Plan Performance Measurement Systems

What Characterizes Good Performance Measurement?

- It is derived from agency goals and objectives
- It allows decision-makers to tell how well goals and objectives are being met
- It is simple, understandable, logical, and repeatable
- It is not derived solely from what data are available, but instead drives the type and means of data to be collected

Source: Balke, Kevin. "White Paper on Measuring the Effectiveness and Performance of Multi-Agency Traffic Incident Management Programs," September, 2005.

Types of Performance Measures

- Measurement of implementation progress
- Measurement of results in terms of achieving goal

Example Highway Improvements Performance Measures Template – Implementation Progress

Countermeasure "X" applications on State highways

Date	# Intersections to Apply Countermeasure	Targeted # Intersections where Countermeasure is to be Applied	Actual # Intersections where Countermeasure has been Applied

Example Highway Improvements Performance Measures Template – Results Performance

Countermeasure "X" crash reductions on State highways

Date	# Intersections where Countermeasure has been Applied	Type of Crashes to be Reduced	Estimated Annual Reduction in Targeted Crashes and Fatalities	Actual Annual Reduction in Targeted Crashes and Fatalities

Module V: Next Steps

Finalize Draft Implementation Plan

- What organizations need to review the initial draft plan?
- What are the key steps to finalize and gain acceptance of the plan?

Next Steps

- Develop draft implementation plan
- Finalize implementation plan
- Identify organizations and offices that must approve implementation plan
- Gain organization and office approvals of the plan
- Begin implementation

Is anything missing?

QUESTIONS

THANK YOU