“Improving the Design and Operations of Intersections”

- Stopping Crashes Or Preventing Crashes

Definition

- Two Objects trying to occupy the same space at the same time
- Can be Vehicle, Pole, Tree, Bicyclist, or Pedestrian.
- Generally BAD

Car Crash

Real Crash


EB SCHUYLKILL EXP
SCHUYLKILL EXP RMP C
SCHUYLKILL EXP RMP C
SOUTH ST
SCHUYLKILL EXP RMP D
SOUTH ST
SCHUYLKILL EXP RMP D
WB SCHUYLKILL EXP

Causes

- One or more mistakes cause a Crash
- Bad Driving or Walking
- Not Following the Rules of the Road
- Malfunction Vehicle or Traffic Control
- Bad Design
- Old Design
- Poor Roadway

Actions

- Add All RED Phase done in 70s & 80s
- Add Mast Arms with Overhead Signals
- Add Second Overhead Signal
- Install All Way Stop
- Install Signal
- Remove Signal
- Install Corner Clearances
- Add Ped Countdown Signals
- Add Left Turn Signals
- Improve Signage

Pedestrian Countdown Signal

DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION

Systematic Approach to Intersection Safety

Feb 2, 2010

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U.S. Department of Transportation Federal Highway Administration

Federal Highway Administration RESOURCE CENTER

Safe Roads for a Safer Future
Investment in roadway safety saves lives

Why Intersection Safety?

- A small part of overall highway system, but -
- In 2008 – 7,772 fatalities related to intersections

  (21% of Total Highway Fatalities)
- Each year more than 3.17 million intersection crashes occur (over 55% of all reported crashes)

2008 US National Total Crash Characteristics

Crash Type	Total Crashes		Fatal/Injury Crashes	
	Number	**%**	**Number**	**%**
Non Intersection	**2,638,000**	**45%**	**722,680**	**43%**
Stop/No control Intersection	**984,000**	**17%**	**321,520**	**19%**
Signalized Intersection	**1,182,000**	**20%**	**380,511**	**23%**
Unclassified	**1,005,000**	**17%**	**240,306**	**14%**
Total	**5,801,228**	**100%**	**1,637,476**	**100%**

55% **57%**

Source: US DOT: Traffic Safety Facts 2008 Early Edition, A Compilation of motor vehicle crash data from FARS and GES, Table 29, Page 52

2008 Traffic Fatalities (FARS)

	US	Pennsylvania	New Jersey
Total Fatalities	37,261	1,468	590
Roadway Departure	19,794 (53%)	901 (61%)	216 (37%)
Intersections	7,772 (21%)	260 (18%)	206 (35%)

Systematic Approach to Intersection Safety

- **Rather than focusing on only a few intersections with the highest number of crashes – "Top Down" (typical HSIP program)**
- **Systematic Approach focuses on the intersections with the majority of the crashes – "Bottom Up"**

Developing and Implementing Intersection Safety Plans

- **Implementing the "Systematic Approach to Intersection Safety"**

- **South Carolina**
- **Louisiana**
- **Missouri**
- **Florida**
- **Indiana**
- **Mississippi**
- **Georgia**

Systematic Approach to Intersection Safety by the States: Implementation Plans

- ❑ **Identify those intersections that make up 40 to 60% of state total crashes**
- ❑ **Improve with low cost signing and marking and signal improvements: warning signs, double up, oversize, markings, Signal head per lane with backplates, etc.**
- ❑ **Break down the improvements into a series of annual elements over 5 years**

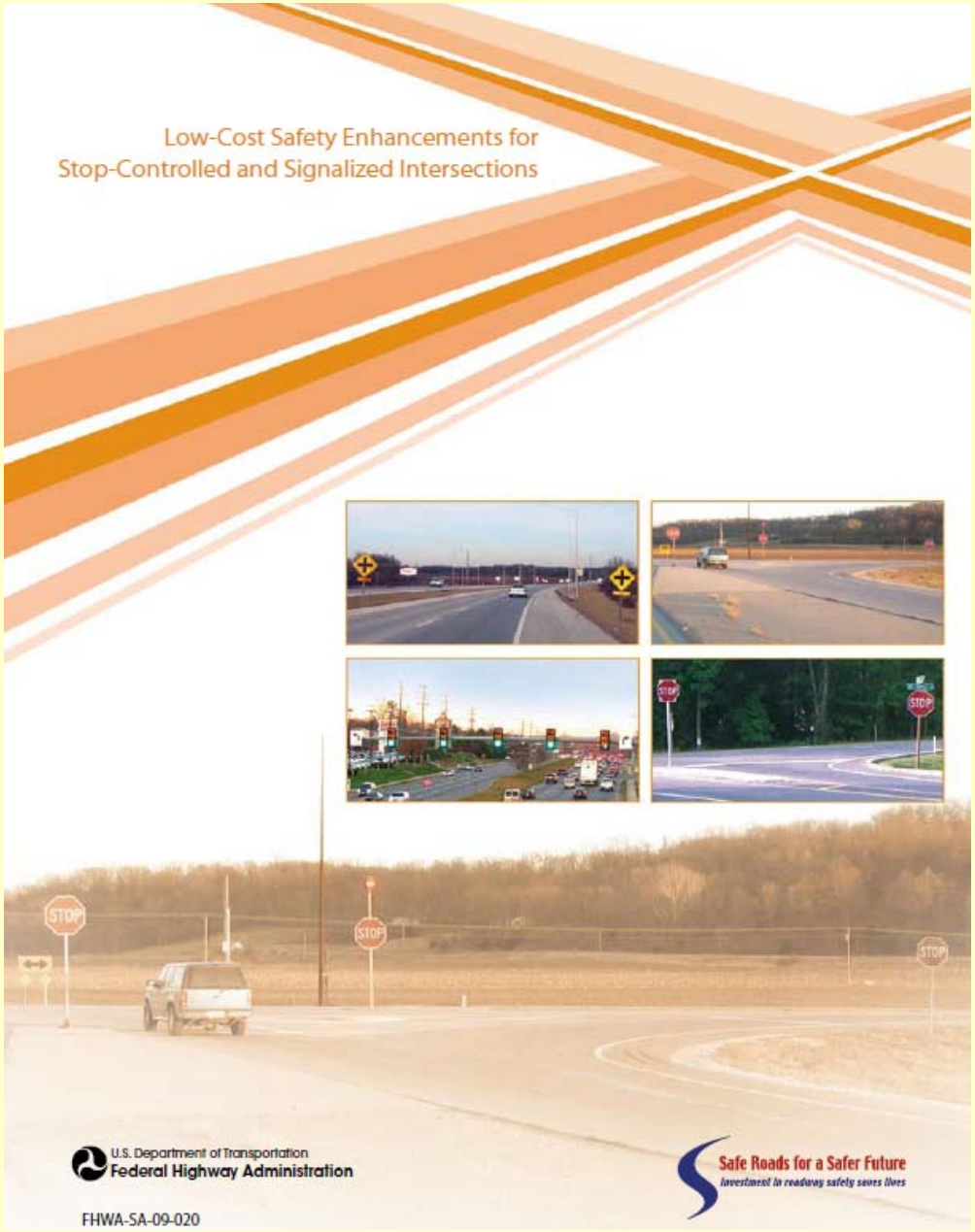
Systematic Approach to Intersection Safety

Application of low cost counter measures:

- ❑ **Signing and**
- ❑ **Marking and**
- ❑ **Minor Signal Visibility measures**

- Rather than high cost geometric reconstruction of intersections

Intersection Safety Counter-measures



UNSIGNALIZED INTERSECTION SAFETY STRATEGIES

CATEGORY A: IMPROVE MANAGEMENT OF ACCESS

A1 – Implement driveway closures/relocations

WHERE TO USE – Unsignalized intersections with high crash frequencies related to driveways adjacent to the intersection. Generally, driveways within 250 feet of the intersection are the greatest concern.

TIME – ●●● $

A2 – Implement driveway turn restrictions

WHERE TO USE – Driveways located near unsignalized intersections that experience high crash frequencies but that cannot practically be closed or relocated.

TIME – ●●● $

CATEGORY B: REDUCE CONFLICTS THROUGH GEOMETRIC DESIGN IMPROVEMENTS

B1 – Provide left-turn lanes at intersections

WHERE TO USE – Unsignalized intersections with a high frequency of crashes resulting from the conflict between (1) vehicles turning left and following vehicles and (2) vehicles turning left and opposing through vehicles.

TIME – ●●● $

B2 – Provide longer left-turn lanes at intersections

WHERE TO USE – Unsignalized intersections with existing left-turn lanes that are not long enough to store all left-turning vehicles and have a high frequency of rear-end crashes resulting from the conflict between vehicles waiting to turn left and following vehicles.

TIME – ●●● $

B3 – Provide offset left-turn lanes at intersections

WHERE TO USE – Unsignalized intersections with a high frequency of crashes between vehicles turning left and opposing through vehicles, as well as rear-end crashes between through vehicles on the opposing approach. Also at intersections on divided highways with medians wide enough to provide the appropriate offset but can be implemented on approaches without medians if sufficient width exists.

TIME – ●●● $

B4 – Provide bypass lanes on shoulders at T-intersections

WHERE TO USE – At free-flowing unsignalized intersections on two-lane highways with moderate through and turning volumes, especially intersections that have a pattern of rear-end collisions involving vehicles waiting to turn left from the highway.

TIME – ●●○ $

B5 – Provide left-turn acceleration lanes at divided highway intersections

WHERE TO USE – Unsignalized intersections on divided highways that experience a high proportion of rear-end crashes related to the speed differential caused by vehicles turning left onto the highway. Also where intersection sight distance is inadequate or where there are high volumes of trucks or recreational vehicles entering the divided highway.

TIME – ●●● $

B6 – Provide right-turn lanes at intersections

WHERE TO USE – Unsignalized intersections with a high frequency of rear-end crashes resulting from conflicts between (1) vehicles turning right and following vehicles and (2) vehicles turning right and through vehicles coming from the left on the cross street.

TIME – ●●● $

B7 – Provide longer right-turn lanes at intersections

WHERE TO USE – Unsignalized intersections with an existing

COST

SAFETY CONCERN	Low	Moderate	Moderate-High	High
High frequency of right-angle crashes attributed to:				
nearby driveways	A2,B12,C1,C2,C4	A1	B8	
traffic from minor street	B12,C1,C2,C4,D2	D1	B8	B13,F3
skewed intersection				B16,C3,F3
poor sight distance	C1,C2,C4,H3	D1		C3, F3
drivers misjudging gaps	D2,H3	D1		F3
not enough gaps for drivers	D2			B14, F3
driver unaware of intersection	E1,E5-E9,E10,E11	E3		
nighttime conditions	E10		E2	
failure to yield at stop or yield sign	E1,E-E4-E9,E11	G1		F3
possible signal location				F1,F2
heavy but balanced traffic flow	F2			F3
speed differentials of vehicles	H3	H1,H2		F3
High frequency of rear-end crashes attributed to:				
left turning vehicles hit from behind	B4	B1,B2		F3
left opposing vehicles hit from behind			B3	F3
trucks and RVs entering divided highway		B5		
speed differential of entering vehicles		B5,B9		F3
right turning vehicles hit from behind		B6,B7		B16,F3
approaching vehicles hit from behind		B10		
no left turn lane and high opposing traffic	B11,B12			B13
driver unaware of intersection	E1,E5-E9,E10,E11	E3		
nighttime conditions	E8,E10		E2	
speed differentials of vehicles	H3	H1,H2		F3
High frequency of left-turn crashes attributed to:				
left turn vehicles hit by opposing traffic	C2	B1,B17	B3	B15,F3
trucks and/or RVs entering divided highway		B5		
no left turn lane and high opposing traffic	B11,B12	B17		B13
nighttime conditions	E10		E2	
heavy but balanced traffic flow	F2			F3
Poor sight distance	C2, B11, B12	B17		B13
High frequency of sideswipe crashes attributed to:				
speed differential of entering vehicles		B9		F3
vehicles within intersection	I1,I2			
vehicles approaching intersection	I3			
High frequency of run off road crashes:				
approaching intersection		B10		
High frequency of pedestrian/bicycle crashes:				
			B19,H2	
Address overall safety issues:				
violation of traffic laws	G2			

Counter measures indicated on the table are *possible* treatments for individual crash problems. Implementation should be based on individual circumstances and studies.

B17 – Use indirect left-turn treatments to minimize

B8 – Provide pavement markings with supplementary messages, such as STOP AHEAD

WHERE TO USE – Unsignalized intersections with patterns of rear-end, right-angle, or turning crashes related to lack of driver awareness of the presence of the intersection.

TIME – ●●○ $

B10 – Provide improved maintenance of stop signs

WHERE TO USE – All unsignalized intersections.

TIME – ●○○ $

B11 – Install flashing beacons at stop-controlled intersections

WHERE TO USE – Unsignalized intersections with patterns of right-angle crashes related to lack of driver awareness of the intersection on an uncontrolled approach and lack of driver awareness of the stop sign on a stop-controlled approach.

TIME – ●○○ $

CATEGORY F: CHOOSE APPROPRIATE INTERSECTION TRAFFIC CONTROL

F1 – Avoid signalizing through roads

WHERE TO USE – Medium- to high-volume unsignalized intersections where installation of signals is being considered. Before a decision to install a signal is made, adequate consideration should be given to less restrictive forms of traffic control.

TIME – ●●● $

F2 – Provide all-way stop-control at appropriate intersections

WHERE TO USE – Unsignalized intersections with patterns of right-angle and turning crashes and moderate and relatively balanced volumes on the intersection approaches.

TIME – ●○○ $

F3 – Provide roundabouts at appropriate locations

WHERE TO USE – Unsignalized intersections that are experiencing right-angle, rear-end, and turning crashes. Roundabouts are appropriate at most intersections, and at intersections with large traffic delays roundabouts are oftentimes a superior alternative to signalization. Roundabouts can also be very effective at intersections with complex geometry (e.g., more than four approach roads) and intersections with frequent left-turn movements.

TIME – ●●● $

CATEGORY G: IMPROVE COMPLIANCE WITH TRAFFIC CONTROL DEVICES AND TRAFFIC LAWS

G1 – Provide targeted enforcement to reduce stop sign violations

WHERE TO USE – Unsignalized intersections where stop sign violations and patterns of crashes related to stop sign violations have been observed. Crash types potentially related to stop sign violations include right-angle and turning collisions.

TIME – ●○○ $

G2 – Provide targeted public information and education on safety problems at specific intersections

WHERE TO USE – Jurisdictions that have experienced a large number of safety problems at unsignalized intersections.

TIME – ●○○ $

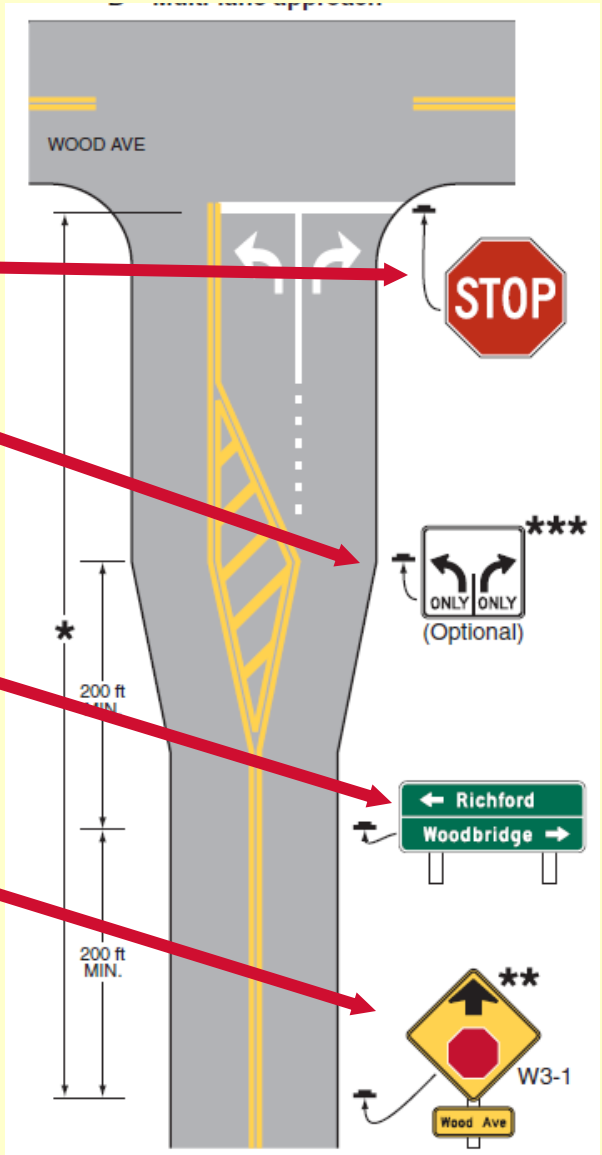
CATEGORY H: REDUCE OPERATING SPEEDS

Systematic Approach to Improving Intersection Safety

Regulatory
Right-of-Way

Guide

Warning



❑ **The BASIC Elements of Applying the two guiding principles of BEST Intersection Safety: Clarify and Simplify**

Systematic Approach to Improving Intersection Safety

- **The BASIC Elements of Applying the two guiding principles of BEST Intersection Safety: Clarify and Simplify**

Clarify and Simplify Example:

- Signal Control of 2 rural State Highways

Clarify and Simplify Example:

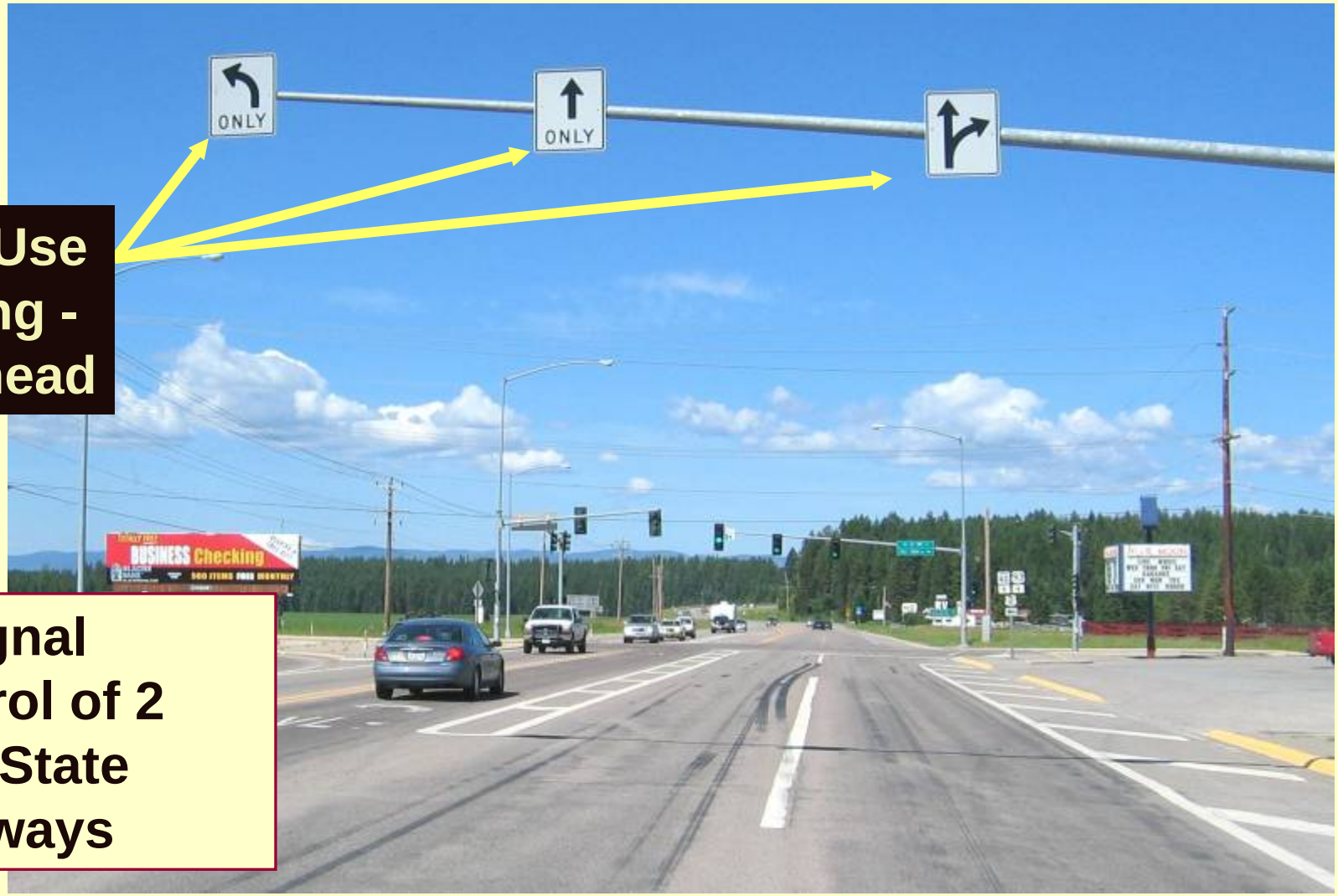
Guide

- **Signal Control of 2 rural State Highways**

Clarify and Simplify Example:

- **Signal Control of 2 rural State Highways**

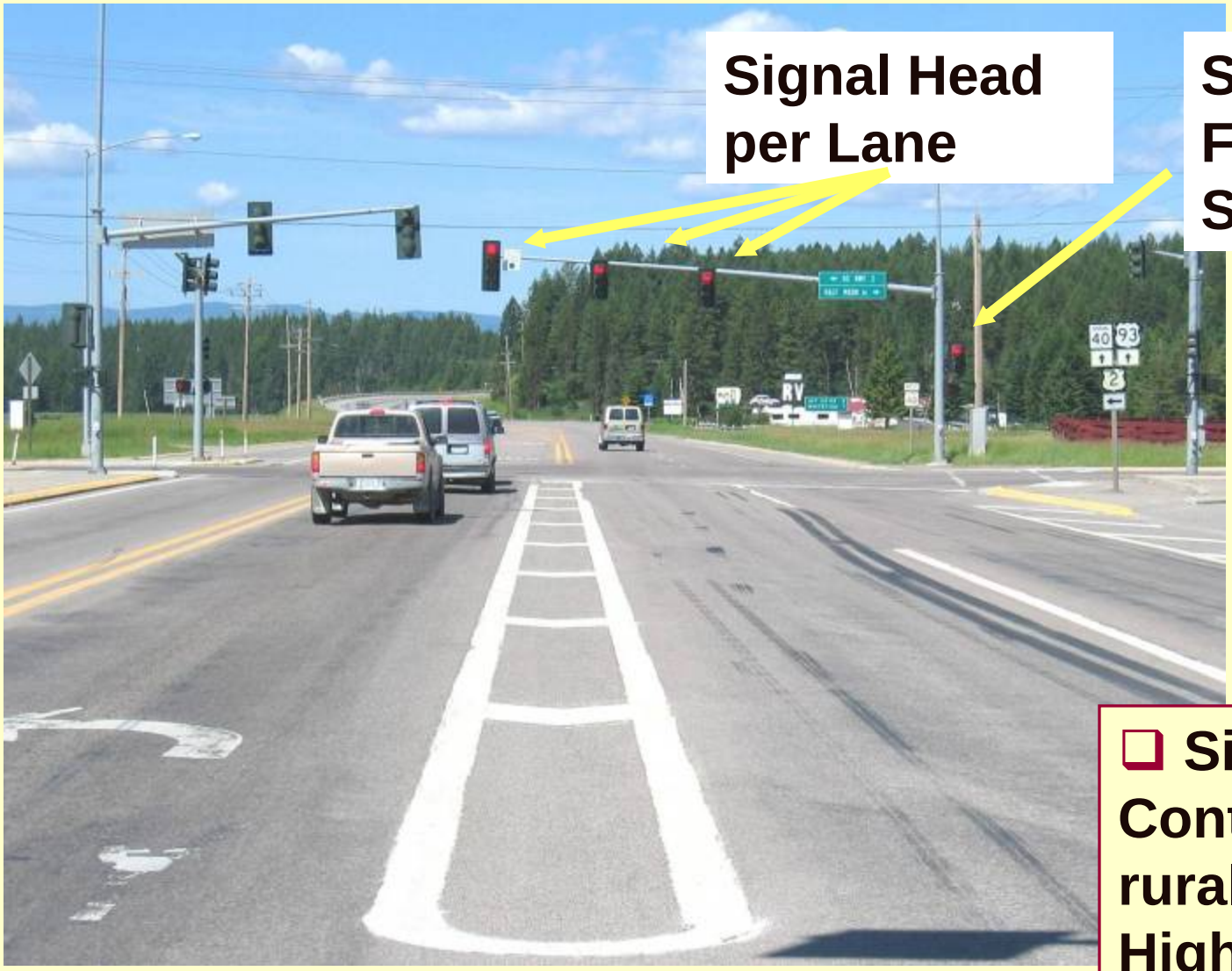
Clarify and Simplify Example:



Lane Use Signing - Overhead

- **Signal Control of 2 rural State Highways**

Clarify and Simplify Example:



- **Signal Control of 2 rural State Highways**

Pennsylvania Intersection Crashes 2004-2008	Intersection Crashes		Fatalities	
	Total	Percentage	Total	Percentage
State Rural	**29,543**	**11.61%**	**508**	**29.57%**
Signalized	4,018	1.58%	44	2.56%
Stop-Controlled	13,919	5.47%	309	17.99%
Unknown/Other	11,606	4.56%	155	9.02%
State Urban	**147,100**	**57.83%**	**938**	**54.60%**
Signalized	72,793	28.62%	419	24.39%
Stop-Controlled	35,104	13.80%	285	16.59%
Unknown/Other	39,203	15.41%	234	13.62%
Local Rural	**7,579**	**2.98%**	**32**	**1.86%**
Signalized	551	0.22%	2	0.12%
Stop-Controlled	3,925	1.54%	8	0.47%
Unknown/Other	3,103	1.22%	22	1.28%
Local Urban	**70,162**	**27.58%**	**240**	**13.97%**
Signalized	19,986	7.86%	72	4.19%
Stop-Controlled	31,181	12.26%	94	5.47%
Unknown/Other	18,995	7.47%	74	4.31%
Grand Total	**254,384**	**100.00%**	**1,718**	**100.00%**

PA Signalized 38%

Nationally 20%

Systematic Approach to Intersection Safety – 1. Signal Visibility:

CRF = 28% total crashes

CRF = 35% right angle crashes

*NCHRP 500, Strategy 17.2 D2: Improve Visibility of Signals

Systematic Approach to Intersection Safety – 1. Signal Visibility:

2 head for 2 Lt lanes

2 heads for 2 lanes

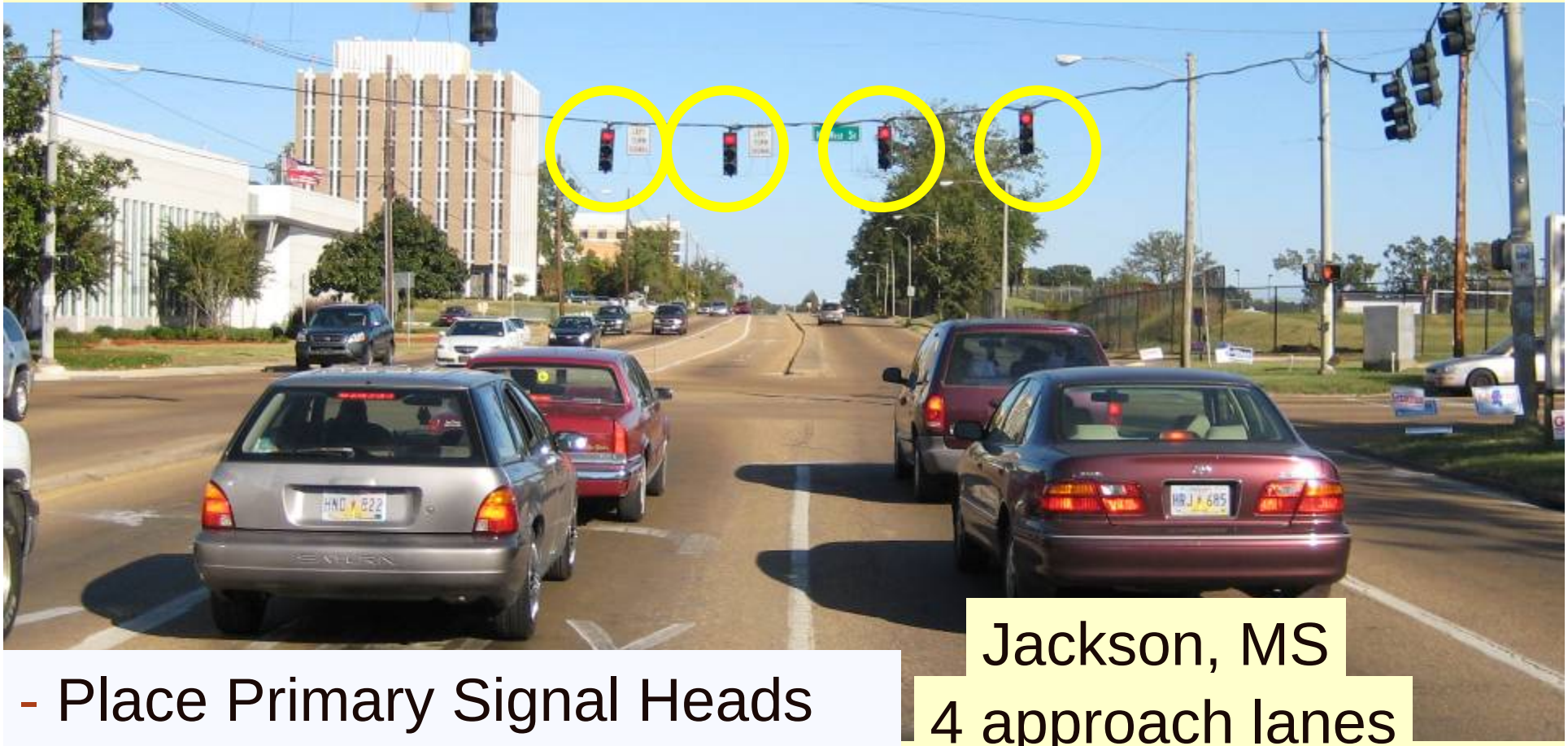
1 head for 1 Rt lane

CRF = 28% total crashes

CRF = 35% right angle crashes

*NCHRP 500, Strategy 17.2
D2: Improve Visibility of Signals

Systematic Approach to Intersection Safety – 1. Signal Visibility:



Jackson, MS
4 approach lanes
4 signal heads

- Place Primary Signal Heads over each Through lane

Systematic Approach to Intersection Safety – 1. Signal Visibility:

- Place Primary Signal Heads over each Through lane

Columbia, SC

CRF = 28% total crashes

Systematic Approach to Intersection Safety – 1. Signal Visibility:

Systematic Approach to Intersection Safety – 1. Signal Visibility:

Systematic Approach to Intersection Safety – 2. Signal Visibility:

Add Supplemental Signal Head(s)

- Right Hand Curve
- Supplemental Signal on span wire

Systematic Approach to Intersection Safety – 3. Signal Visibility:

Add Back Plates

No Back Plates

Back Plates

CRF = 13% total crashes

CRF = 50% right angle crashes

Systematic Approach to Intersection Safety –4. Signal Clearance Intervals:

1. Update Yellow Clearance Interval

Yellow Time

All-Red Time

NY study: 9% decrease in multi-vehicle crashes

*NCHRP 500, Objective 17.2 A2 – Optimize Clearance Intervals

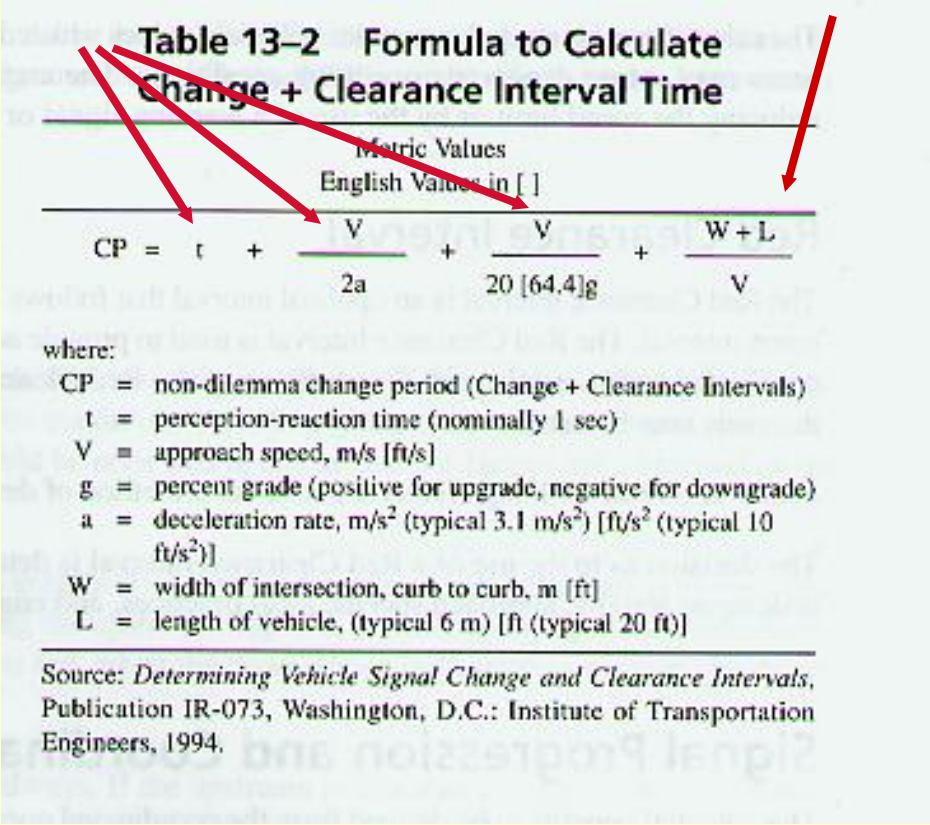


Table 13–2 Formula to Calculate Change + Clearance Interval Time

Metric Values
English Values in [ ]

$$CP = t + \frac{V}{2a} + \frac{V}{20\,[64.4]g} + \frac{W+L}{V}$$

where:

- CP = non-dilemma change period (Change + Clearance Intervals)
- t = perception-reaction time (nominally 1 sec)
- V = approach speed, m/s [ft/s]
- g = percent grade (positive for upgrade, negative for downgrade)
- a = deceleration rate, m/s^2 (typical 3.1 m/s^2) [ft/s^2 (typical 10 ft/s^2)]
- W = width of intersection, curb to curb, m [ft]
- L = length of vehicle, (typical 6 m) [ft (typical 20 ft)]

Source: *Determining Vehicle Signal Change and Clearance Intervals*, Publication IR-073, Washington, D.C.: Institute of Transportation Engineers, 1994.

NY study: CRF =8% total crashes CRF = 12% injury crashes CRF = 39% ped crashes

Systematic Approach to Intersection Safety –5. Signal Coordination:

CRF = 12% to 38% of total crashes – 3 studies

CRF = 32% right angle crashes

*NCHRP 500, Objective 17.2 A4 – Employ Signal Coordination

Systematic Approach to Intersection Safety –Signal Example:

- **Ohio – 90th Worst Intersection for State – 184 crashes in 3 years**

Systematic Approach to Intersection Safety

Signal Example:

Identify Underlying Crash Cause:

- **AIRS Crash Data identified 85% of Crashes were Red Light Running**

Apply two guiding principles for design and operation of an intersection:

- **Clarify**
- **Simplify**

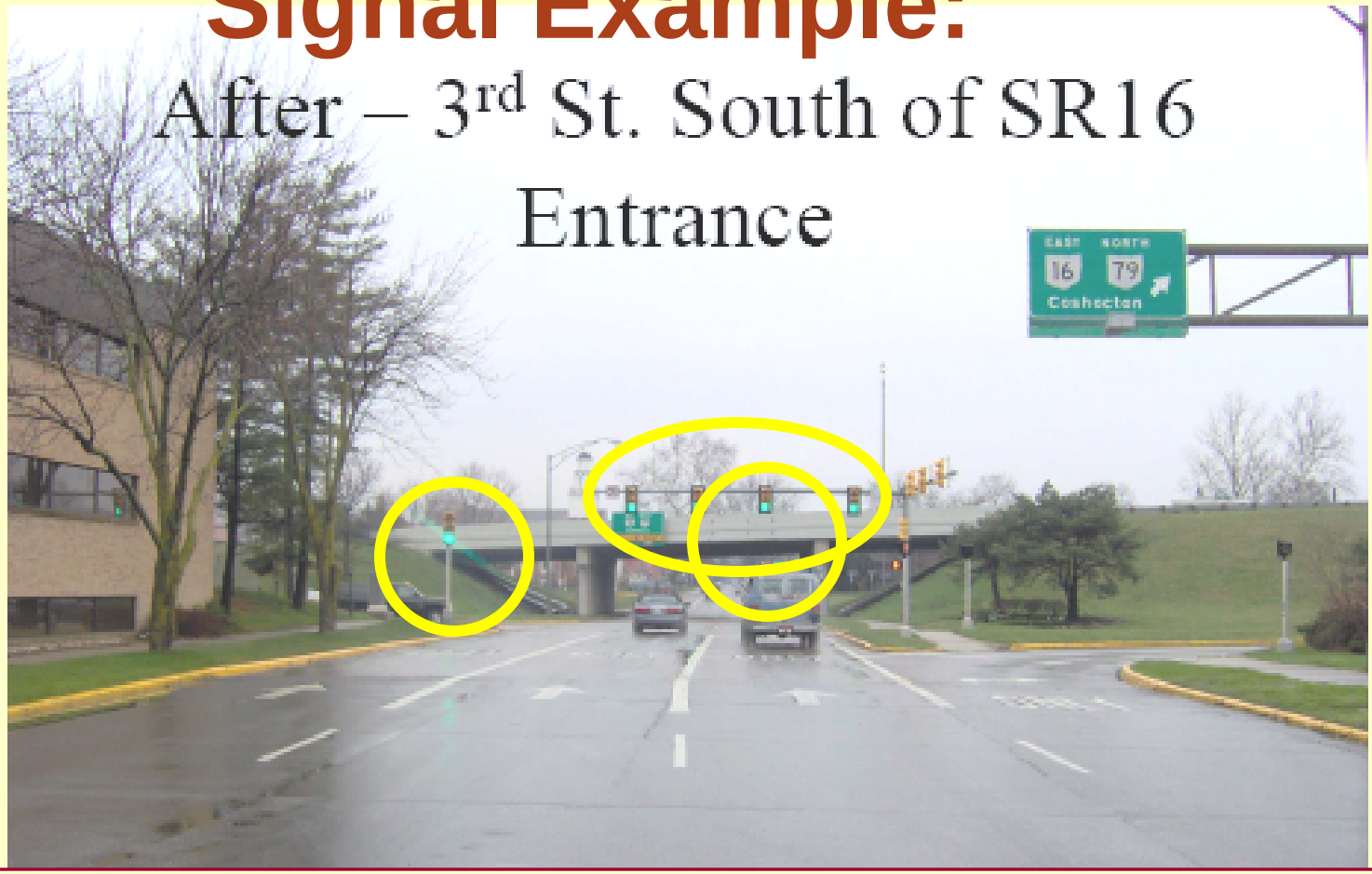
Systematic Approach to Intersection Safety

Signal Example:

- Removed 7 signs including 2 overhead guide signs from overpass
- Signal Heads Positioned over Lanes into Driver's Line of Sight
- Lowered signal heads on Mast Arms
- Added Supplemental Left Hand Signal
- Added Back Plates to Signal Heads
- Removed two street light poles

Systematic Approach to Intersection Safety

Signal Example:



- 4 month Period Before – 15 Crashes
- 12 month Period After - 7 Crashes

Systematic Approach to Intersection Safety by the States: Implementation Plans

- **12 states have developed Implementation Plans for Systematic Approach to Intersection Safety todate**
- **7 states are actively reviewing the identified intersections and conducting engineering field reviews.**
- **7 states have revised their engineering standards to provide for enhanced low cost signing and marking and for signal head per lane with back plates**
- **3 states have let contracts for the first year annual element for systematic improvement**

Systematic Approach to Intersection Safety – Results:

South Carolina:

- A Before (3 years of crash data) and After Study (3 years of crash data) was performed on the first 91 locations improved in 2003.
- Crash Rate Reduction of 54.7%
- Severity Index Reduction of 54.5%
- A Injury percentage reduction of 34.8%
- A Fatality percentage reduction of 75%
- Average Benefit/Cost ratio was 385.

Questions and Discussion:

NJDOT Comprehensive Strategic Highway Safety Plan: Highway Safety Emphasis Area 2 - Improving Design and Operation of Intersections

DVRPC Regional Safety Task Force

February 2, 2010

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Intersection Crashes: More Frequent Than You Think…

- Nearly half of all intersection crashes occur “strictly” at intersections, but potentially three quarters of them are intersection related and they are 20% more likely to result in injury as compared to mid-block crashes.
- In 2005, State and County roadways experienced 49% of their crashes at intersections, also referred to as “in the box”.
- Municipal roadways experienced 42% of their crashes at intersections.
- Signalized intersection crashes accounted for 10% of the crashes on Municipal roadways, 16% on the State system, and 18% on County roadways.

Goal:
Annually reduce intersection crash frequencies and severities across all roadway systems in New Jersey

- Intersection Crash Reduction Programs Currently Employed:

1) Intersection Improvement Program
2) Pedestrian
3) Left Turn
4) Right Angle (Incl. Red-Light Running)
5) Safe Corridors

Challenges:

1) MUTCD Guidelines for intersection design and operation are “minimal”
2) Wide range of signal designs and control methods employed throughout the State
3) Many locations with MUTCD warrant-satisfying crash experience frequently go unidentified until they are brought to the attention of the respective jurisdiction’s engineers by local police
4) NJ Access Code only applies to State roads
5) The significant volumes of traffic passing through intersection facilities require complex operations and control
6) Police resources are stretched thin enforcing other improper motor vehicle operator behaviors (e.g. speeding, drunk/aggressive/distracted driving, etc.)

Proposed Strategies:

1) *Develop and/or enhance methodologies for identifying and selecting intersections for safety improvements*

A. *Evaluate existing methodologies*

B. *Develop handbook for intersection crash location identification, project development and implementation, and evaluation process*

C. *Improve website version of crash records database for engineering and planning professionals*

2) *Develop and implement an NJ Best Practices Guidebook for design and operation of signalized and non-signalized intersections*

A. *Organize a forum to establish guidelines*

B. *Implement and promote guidelines*

Proposed Strategies (cont'd):

3) Educate the public on intersection safety issues

A. Promote utilization of existing resources to educate professionals

B. Expand intersection safety in NJ Driver's Manual and Driver Education programs

C. Educate decision-makers and the public about the benefits of investment in intersection safety

D. Develop a safety marketing plan

4) Enhance compliance and provide increased enforcement at intersections

A. Identify, evaluate and implement current technologies for enforcement

B. Educate law enforcement on the importance of the enforcement of traffic controls at intersections

Intersection Safety Program Methodologies

- High Priority (3-yr.Avg.>1 EPDO crash per month) and Top Priority (3-yr.Avg.>2 EPDO crashes per month) intersections in New Jersey
- Intersections averaging one moderate injury pedestrian crash per year
- Intersections experiencing four or more left turn crashes combined on opposing approaches
- Intersections experiencing five or more right angle crashes per year
- The three or four highest crash frequency and severity intersections or locations on NJ's State highway arterial corridors (representing 5% of the State system roadways)

Intersection Safety Project Prioritization

- Initial Safety Management Systems Ranking
- Obvious crash patterns
- Statistically significant crash types and frequencies
- Countermeasurability
- Ease of implementation (“Low-hanging fruit”)
- Minimal trade-offs
- Cost effectiveness / Return on investment

Project Justification/Evaluation

- Present Worth of Safety Elements of Capital Projects
- Benefit-to-Cost ratio of Low-Cost Projects exceed of 1.2
- Statistically significant reduction in crash frequencies and severities

New Jersey Best Practices Guidelines

- Driver considerations

1. CONTROL OF CHANNELIZED RIGHT TURN LANES AT SIGNALS (SDRE, PED)
2. LEFT TURN SIGNALS (SDRE, LT, CAP)
3. LEFT/RIGHT TURN OVERLAPPING SIGNAL OPERATION (SDRE, PED, CAP)
4. STOPLINE SETBACK FOR LEFTMOST LANE OF MULTIPLE LANE APPROACHES (ENC, PED, CAP)
5. LANE GUIDANCE TRACKING FOR ADJACENT PAIRS OF LEFT AND THROUGH MOVEMENTS (SDSS, CAP)
6. PHYSICAL AND OPERATIONAL CONTROL OF LEFT TURN MOVEMENTS (LT, SDRE, SDSS, PED)
7. CHOICE OF CYCLE LENGTH AND MANNER OF PHASING OF SIGNALS (SDRE, SDSS, CAP)
8. APPROPRIATE SETTING OF YELLOW AND ALL-RED TIMES (RA, SDRE)

Pedestrian considerations

1. LOCATION AND NUMBER OF PEDESTRIAN CROSSINGS PROVIDED/MARKED/SIGNALIZED
2. PEDESTRIAN SIGNAL TYPES
3. PPB SIGNS ACCOMPANYING PEDESTRIAN SYMBOL INDICATIONS
4. DURATION OF WALK AND FLASHING DON'T WALK INTERVALS
5. VEHICULAR (3-SECTION) HEADS CONTROLLING PEDESTRIANS
6. MOVEMENT OF PEDESTRIANS ADJACENT TO SPLIT PHASE-CONTROLLED SIDESTREETS (LEFT TURN ARROW USAGE ASSUMED)
7. PROVISION OF HIGH VISIBILITY CROSSWALKS
8. 2009 MUTCD


Pennington Rd
31

Engineering, Education, Enforcement, with Everyone personally accountable today…

...will keep the sights and sounds...
of the Emergency responders away!

Improving Intersection Safety in the Delaware Valley

DELAWARE VALLEY
dvrpc
REGIONAL
PLANNING COMMISSION

Regional Safety Task Force

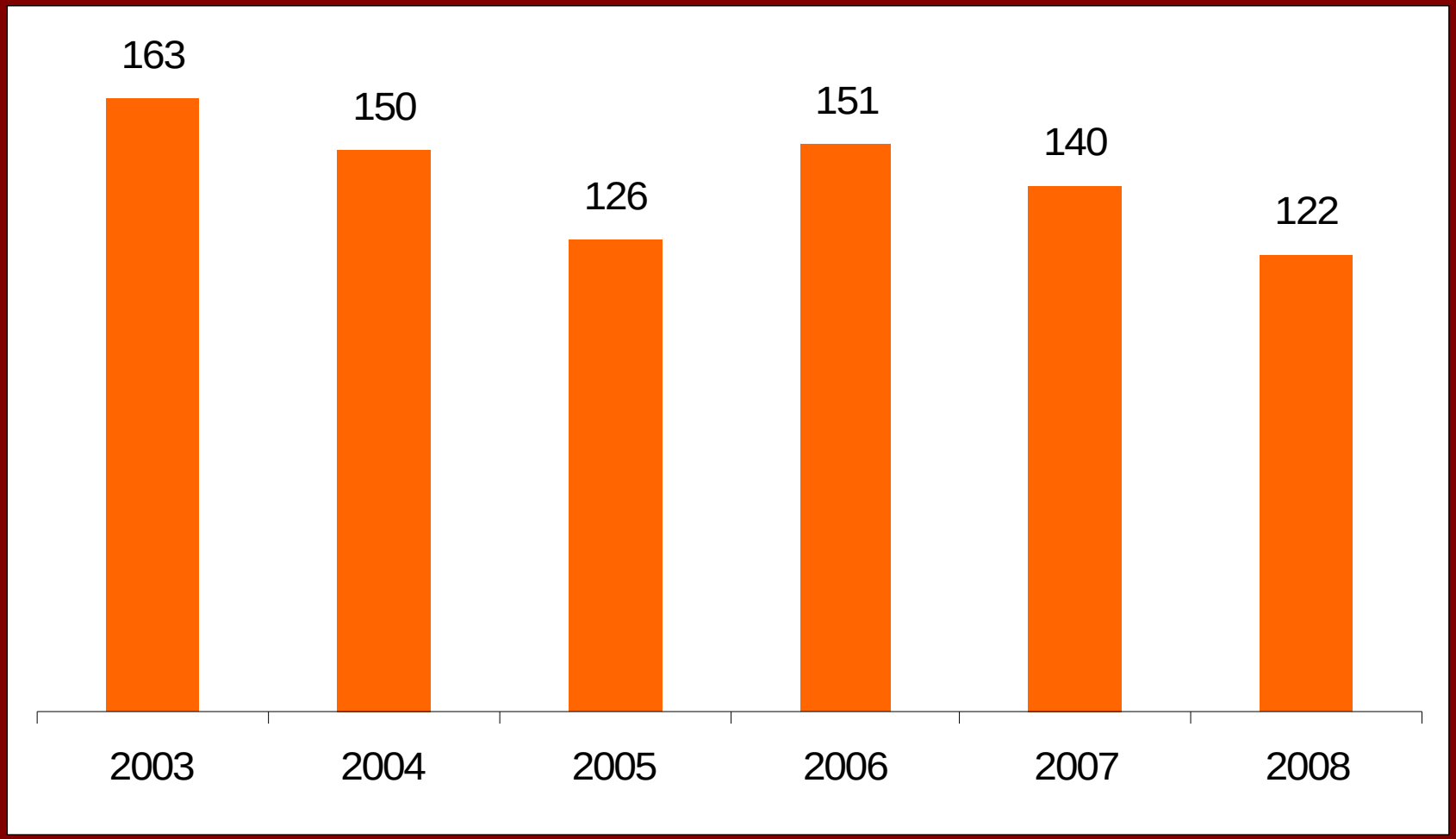
February 2, 2010

General Notes

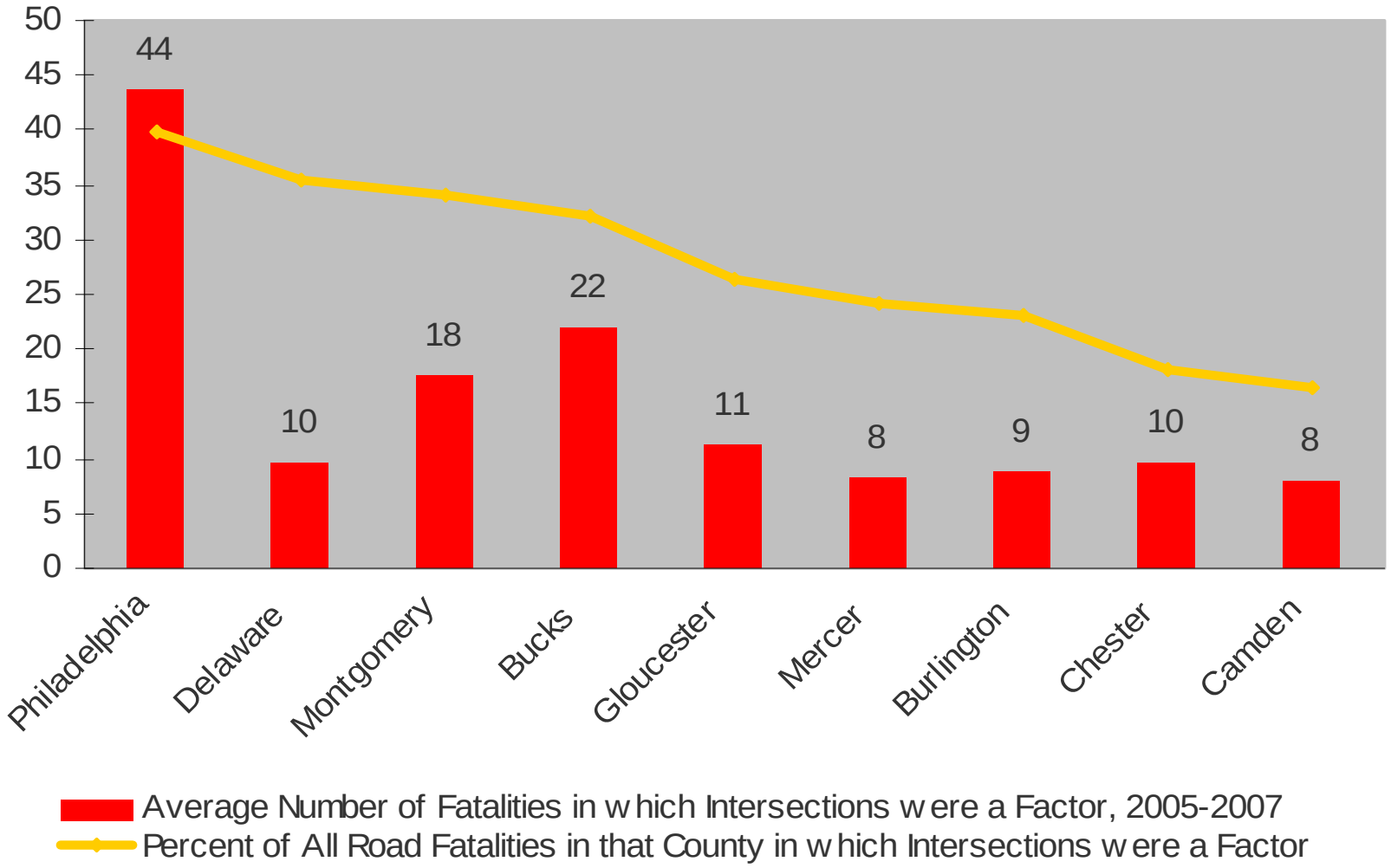
- Updated Safety Action Plan for the Delaware Valley completed in 2009
  - Data memo
  - Safety Action Plan
  - Summary cards
- RSTF focusing on one emphasis area per meeting for implementation

Why Link Safety & Intersections?

Crash Fatalities for Which Intersections Were a Factor in the Delaware Valley



Importance of Improving Intersection Safety



Priority Strategies

1. Enhance standardization for problem identification, prioritization, and funding
2. Implement engineering solutions
3. Continue to develop and implement specific intersection safety programs

Source: Safety Action Plan, p. 49

Resources

- All of you in the room
- Safety Action Plan and data memo
- DOT SHSPs
- NCHRP Reports available at safety.transportation.org/guides.aspx
  - 500-5: A Guide for Addressing Unsignalized Intersection Collisions
  - 500-12: A Guide for Reducing Collisions at Signalized Intersections

Starting Thoughts from…

- Fred Ranck, Safety Engineer, Resource Center Safety and Design Technical Services Team/MUTCD Team, FHWA
- Christopher Speece, Section Manager, Highway Safety Engineering, PennDOT– Bureau of Highway Safety & Traffic Engineering
- Charles Denny, Assistant Chief Traffic Engineer, Philadelphia Streets Department
- Kevin Conover, Section Chief, NJDOT – Bureau of Safety Programs: Crash Analysis & Safety Programs