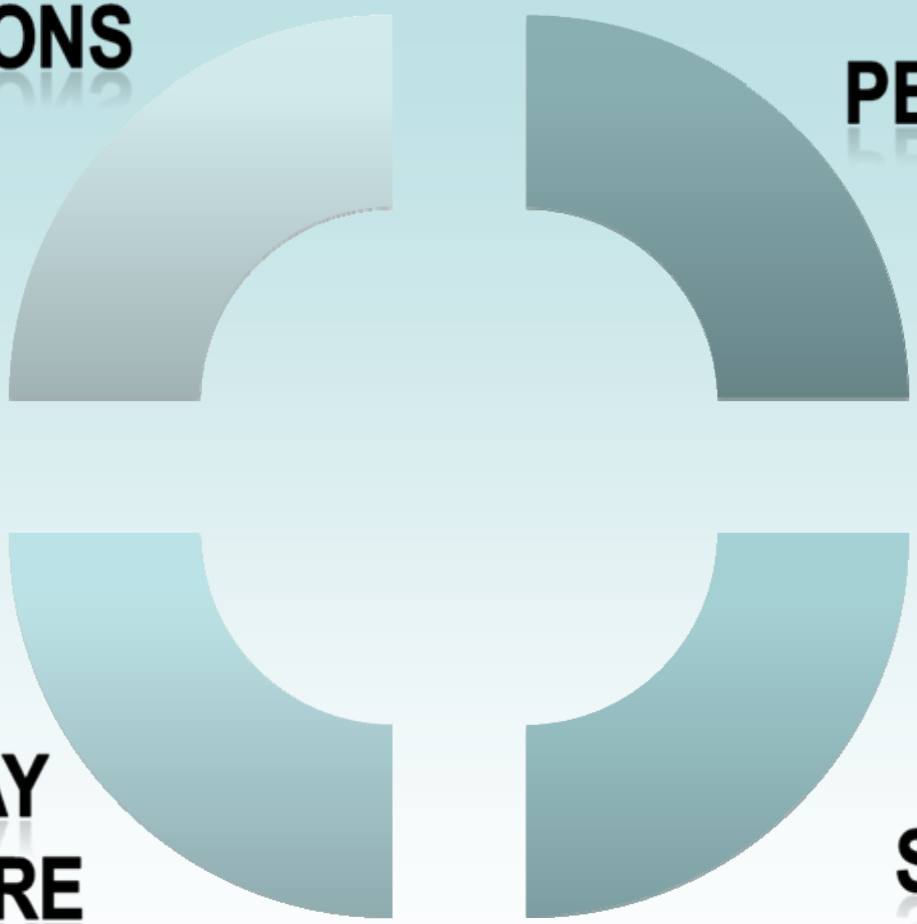
U.S.Department of Transportation
Federal Highway Administration

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

Safety at Signalized Intersections

Gary B. Thomas
Texas Transportation Institute
Traffic Gurus Annual Meeting
May 14, 2008

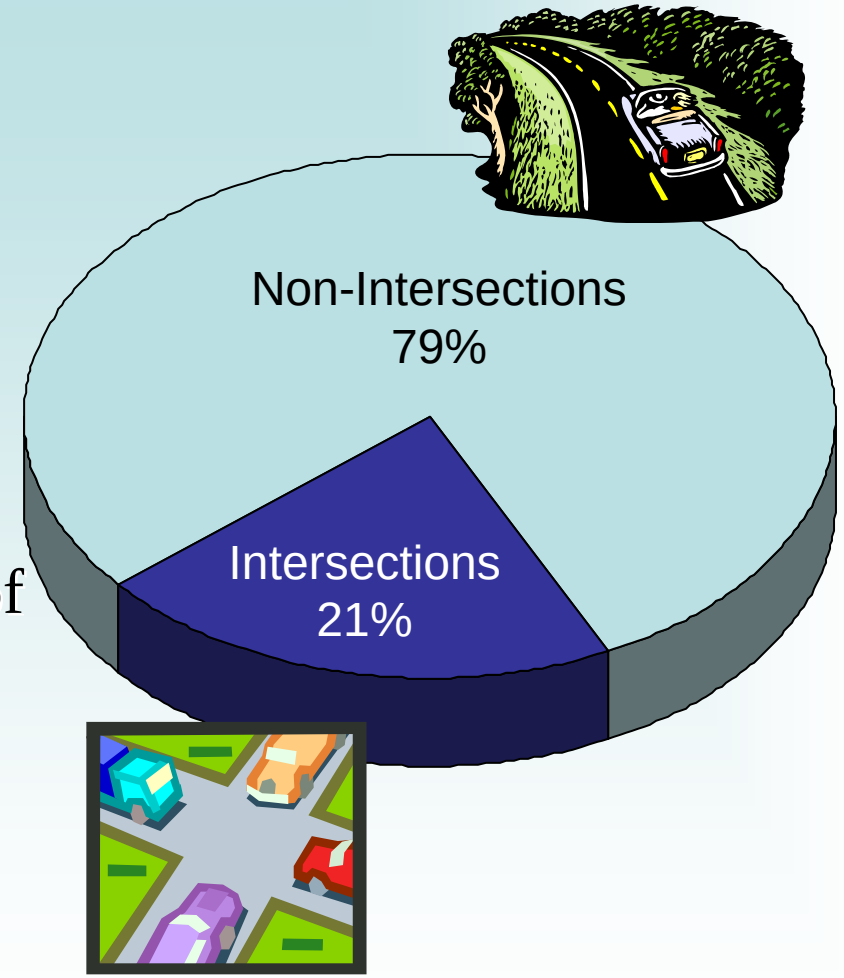
FHWA Safety Focus Areas



Nationwide Fatalities

There were 41,059 highway fatalities in 2007.

Where did they occur?

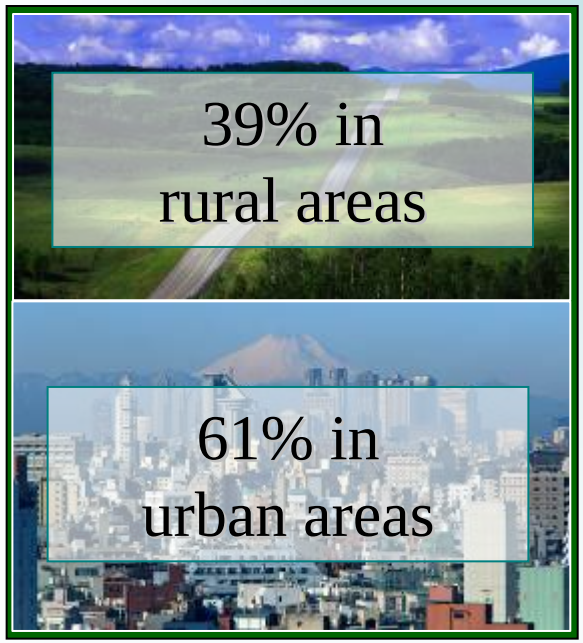


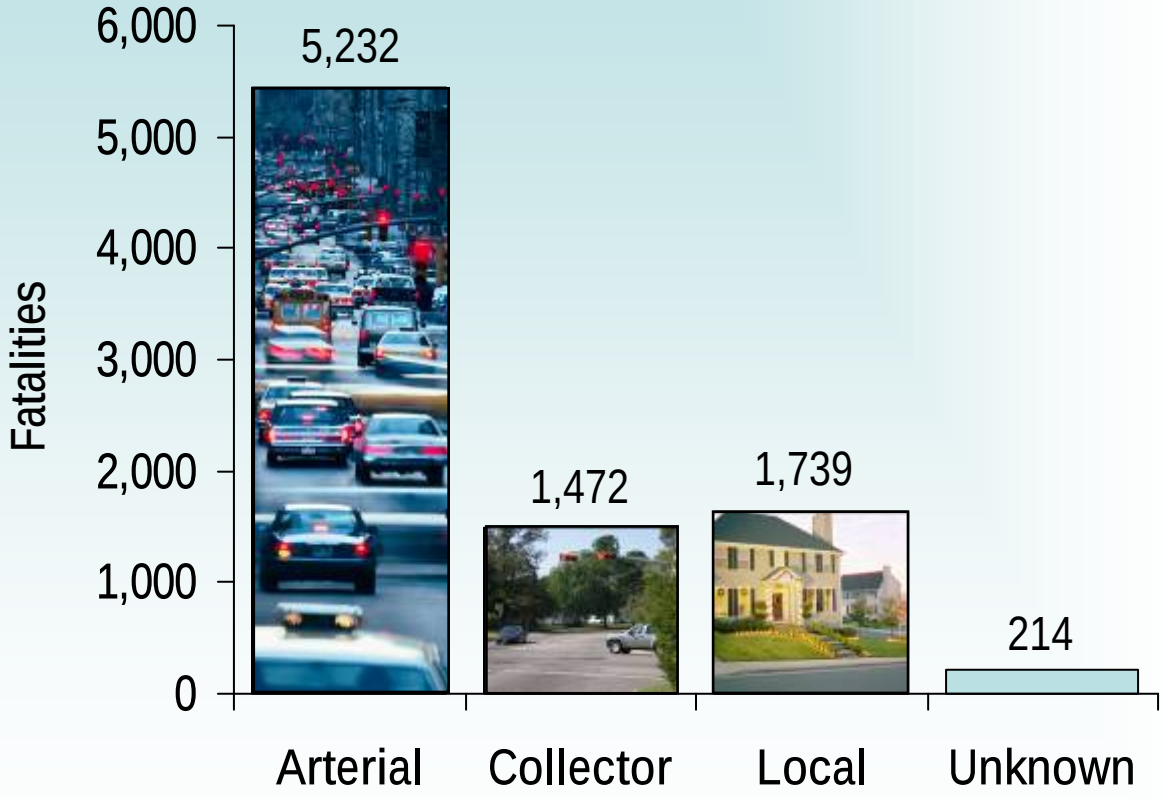
About half of <u>all</u> crashes and half of all injury crashes occur at intersections.

Intersection Fatalities

There were 8,657 intersection fatalities in 2007.

Where did they occur?



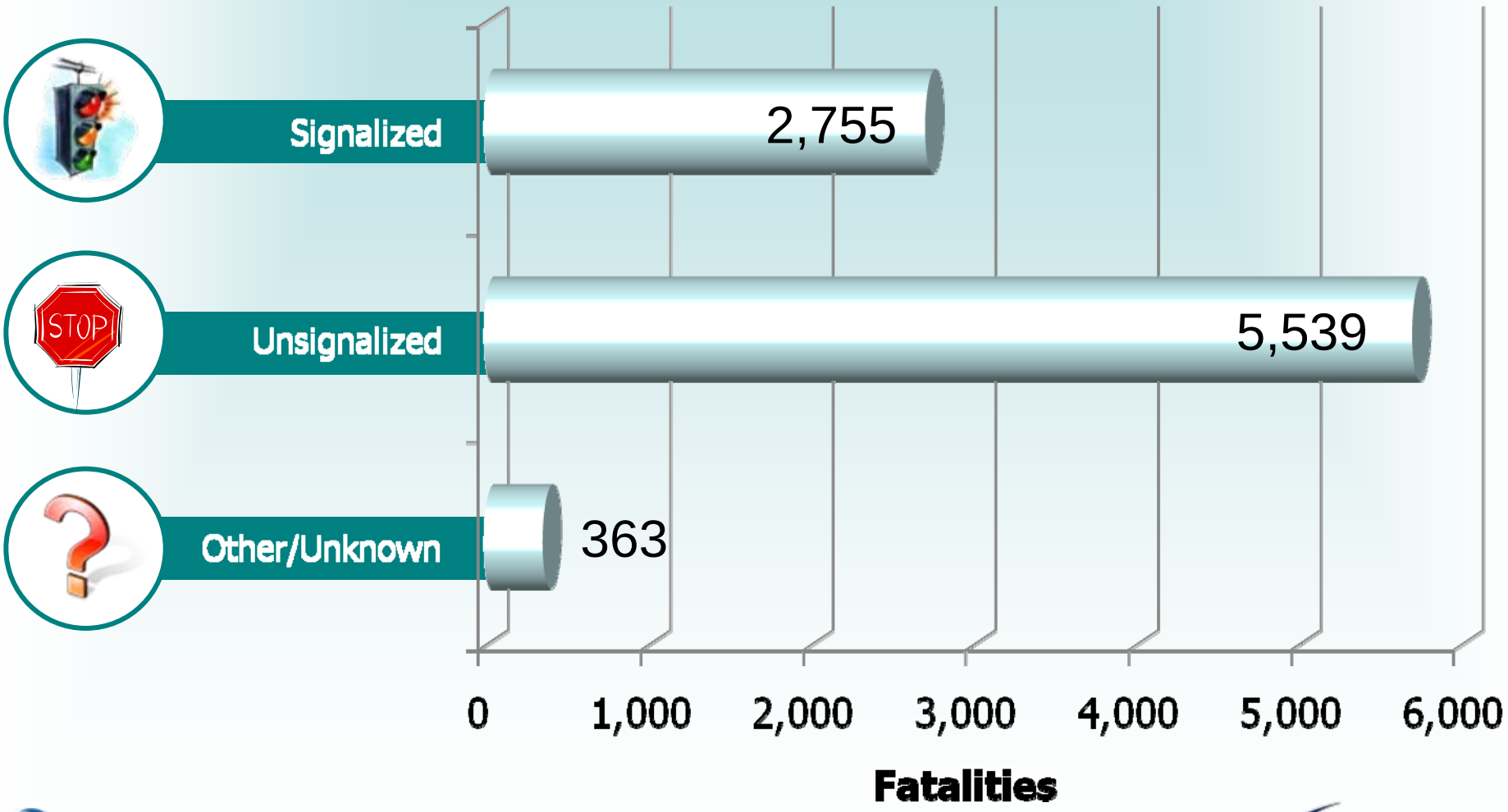


Traffic Signals

There are at least 3 million intersections in the United States.

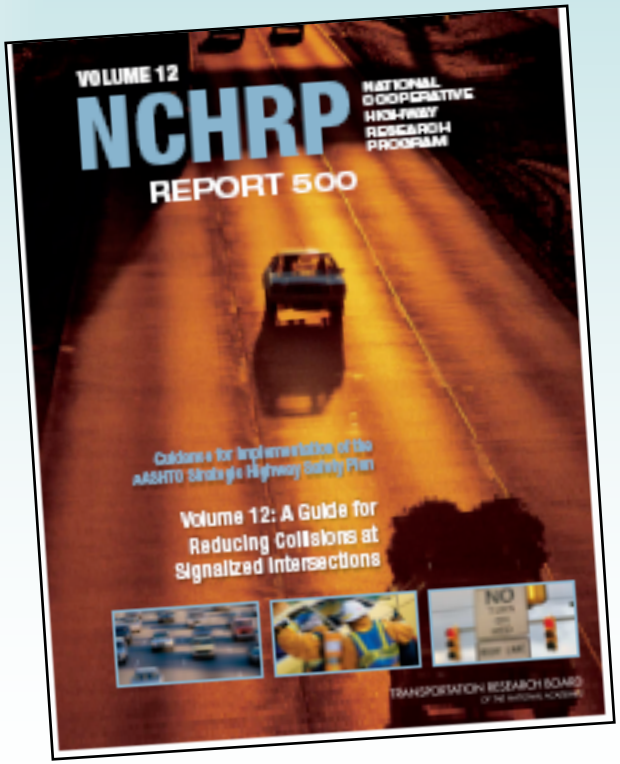
At least 300,000 are signalized.

Intersection Fatalities



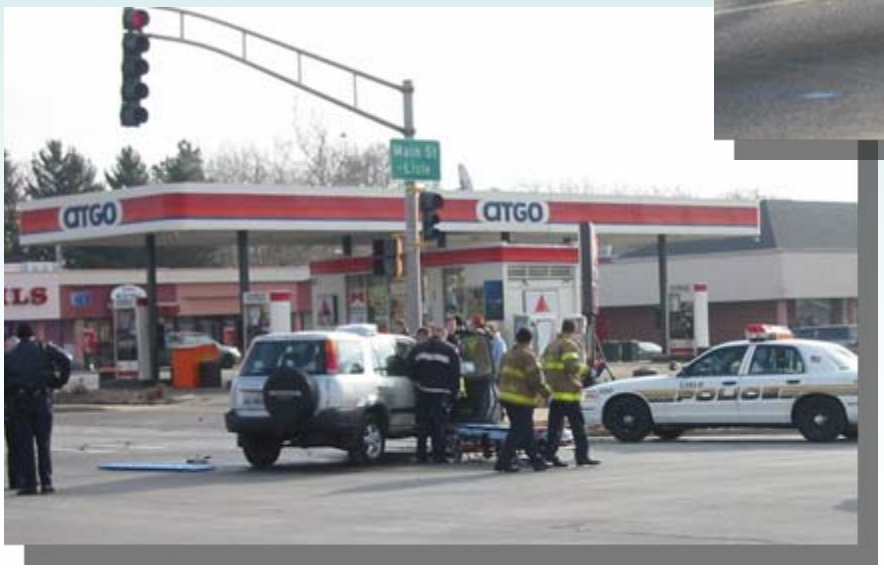
Intersection Safety Guidance

- NCHRP Report 500 Volume 12
- Guide sheets
- Safety Strategies brochure



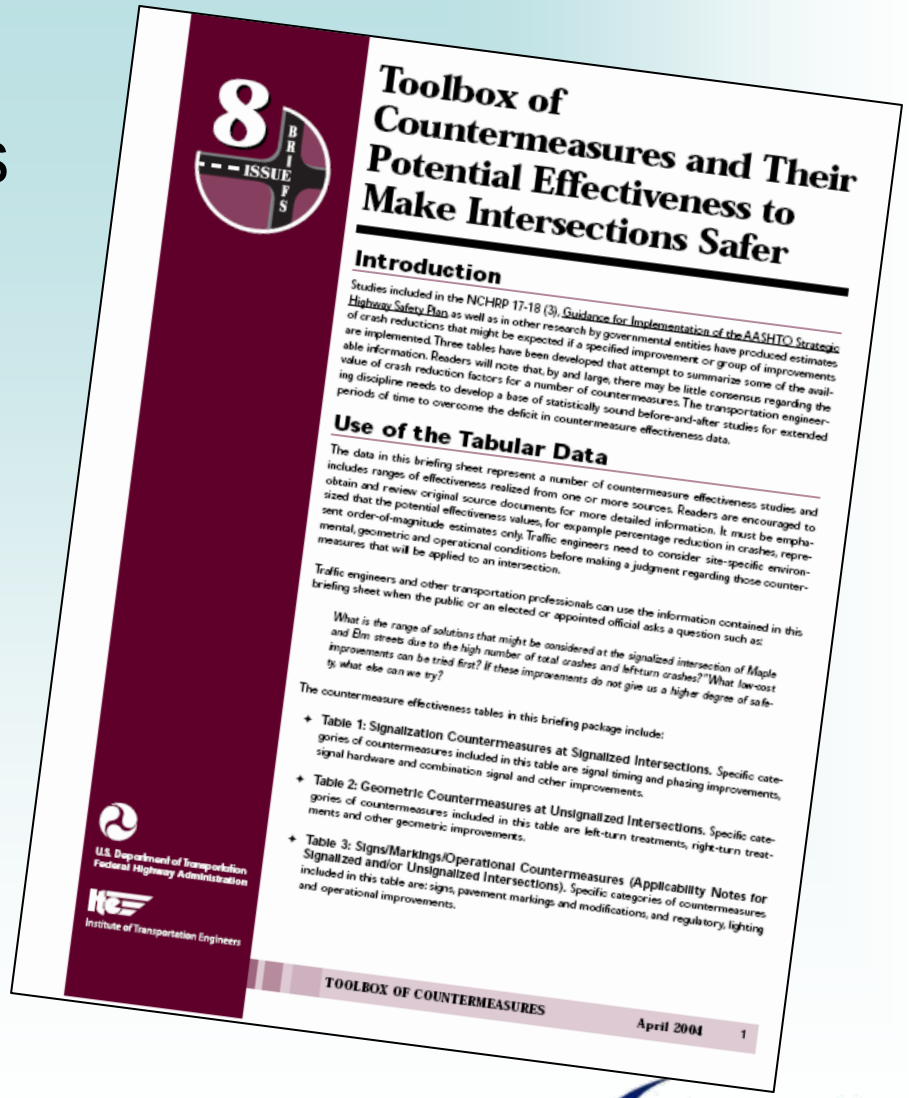
Typical Signalized Intersection Crash Types

- Right angle
- Rear end
- Left turn
- Sideswipe
- Pedestrian/bicycle



Crash Reduction Factors

- Quantitative results from research or other studies
- Expected reduction in crashes from implementation of a specific countermeasure



8 ISSUE BRIEFS

U.S. Department of Transportation
Federal Highway Administration

Institute of Transportation Engineers

Toolbox of Countermeasures and Their Potential Effectiveness to Make Intersections Safer

Introduction

Studies included in the NCHRP 17-18 (3), Guidance for Implementation of the AASHTO Strategic Highway Safety Plan as well as in other research by governmental entities have produced estimates of crash reductions that might be expected if a specified improvement or group of improvements are implemented. Three tables have been developed that attempt to summarize some of the available information. Readers will note that, by and large, there may be little consensus regarding the value of crash reduction factors for a number of countermeasures. The transportation engineering discipline needs to develop a base of statistically sound before-and-after studies for extended periods of time to overcome the deficit in countermeasure effectiveness data.

Use of the Tabular Data

The data in this briefing sheet represent a number of countermeasure effectiveness studies and includes ranges of effectiveness realized from one or more sources. Readers are encouraged to obtain and review original source documents for more detailed information. It must be emphasized that the potential effectiveness values, for example percentage reduction in crashes, represent order-of-magnitude estimates only. Traffic engineers need to consider site-specific environmental, geometric and operational conditions before making a judgment regarding those countermeasures that will be applied to an intersection.

Traffic engineers and other transportation professionals can use the information contained in this briefing sheet when the public or an elected or appointed official asks a question such as:

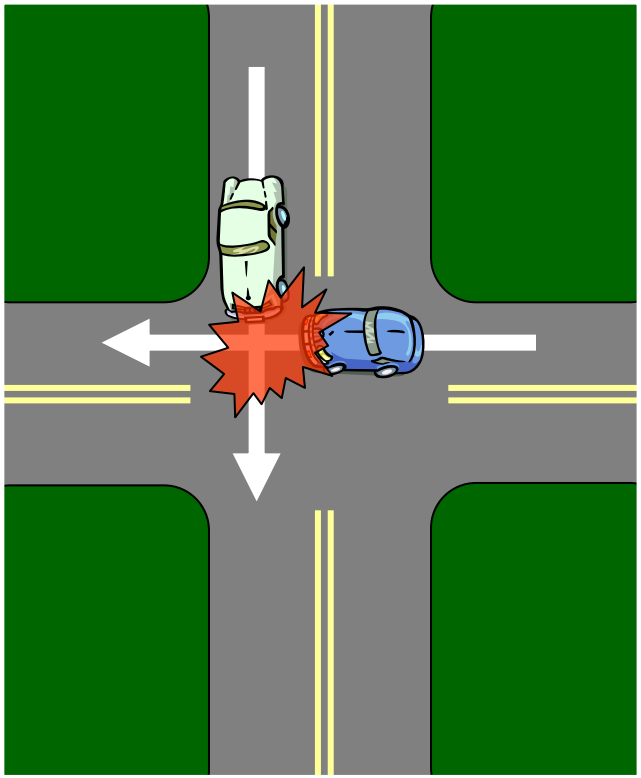
What is the range of solutions that might be considered at the signalized intersection of Maple and Elm streets due to the high number of total crashes and left-turn crashes? What low-cost improvements can be tried first? If these improvements do not give us a higher degree of safety, what else can we try?

The countermeasure effectiveness tables in this briefing package include:

- Table 1: Signalization Countermeasures at Signalized Intersections. Specific categories of countermeasures included in this table are signal timing and phasing improvements, signal hardware and combination signal and other improvements.
- Table 2: Geometric Countermeasures at Unsignalized Intersections. Specific categories of countermeasures included in this table are left-turn treatments, right-turn treatments and other geometric improvements.
- Table 3: Signs/Markings/Operational Countermeasures (Applicability Notes for Signalized and/or Unsignalized Intersections). Specific categories of countermeasures included in this table are: signs, pavement markings and modifications, and regulatory, lighting and operational improvements.

TOOLBOX OF COUNTERMEASURES April 2004 1

Angle Crashes



- Account for 42% of fatal crashes at signalized intersections
- Potential countermeasures:
  - Optimize change intervals
  - Improve sight distance
  - Restrict access
  - Provide targeted enforcement
  - Restrict parking
  - Construct roundabouts

Optimize Change Intervals

Intervals that are too long encourage disrespect and lead to red-light running.

Intervals that are too short violate driver expectancy and lead to abrupt stops.

AASHTO Report 500 Volume 12

LOW COST COUNTERMEASURE

Countermeasure	CRF
Change Intervals per ITE	Total = 8% Ped/Bike = 37% Multi-vehicle = 9%

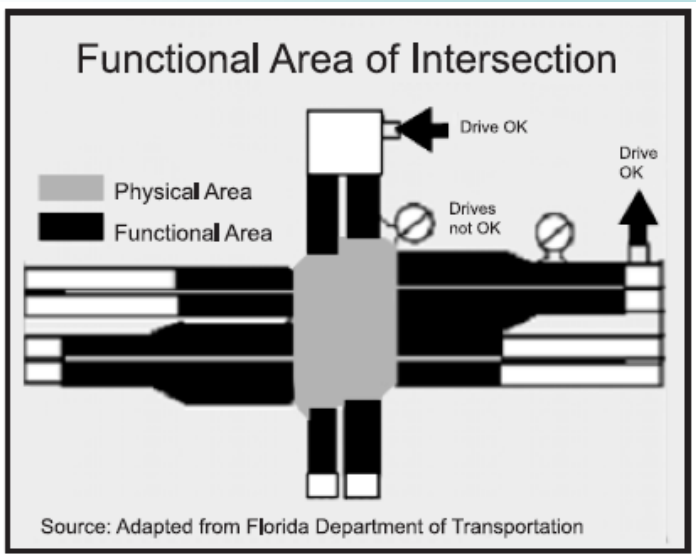
Improve Sight Distance

The driver of a vehicle approaching an intersection should have an unobstructed view of the entire intersection, including any traffic-control devices, and sufficient lengths along the intersecting highway to permit the driver to anticipate and avoid potential collisions.

AASHTO "Green Book"

LOW COST COUNTERMEASURE

Restrict Access



Driveways should not be located within the functional area of an intersection.

Intersection Safety Brief #13: Access Management

Provide Targeted Enforcement

Enforcement is a potential countermeasure to unsafe and illegal motorist behavior at intersections. Studies report the reduction of traffic law violations when enforcement is used.

AASHTO Report 500 Volume 12

Countermeasure	CRF
Automated Enforcement	Total = 12% Right Angle = 25% Left Turn = 45%

Restrict Parking

LOW COST COUNTERMEASURE

Parking maneuvers into or out of on-street parking stalls can affect the operation and safety of the through traffic lane adversely.

NCHRP Report 457:
Evaluating Intersection Improvements:
An Engineering Study Guide

Countermeasure	CRF
Restrict Parking	Total = 49% Pedestrian = 30%

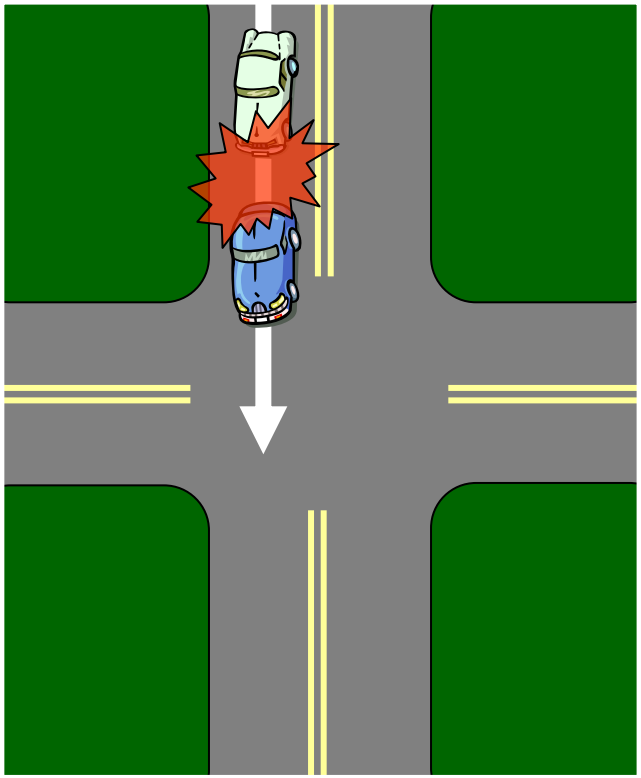
Convert to Roundabout

Many studies have found that one of the benefits of roundabout installation is the improvement in overall safety performance

Roundabouts: An Informational Guide

Countermeasure	CRF
Convert signalized intersection to roundabout	Total = 48-67% Injury = 60-78% Fatal/Incapacitating = 90%

Rear End Crashes



- Account for 8% of fatal crashes at signalized intersections
- Potential countermeasures:
  - Increase visibility of intersection and/or traffic signals
  - Increase awareness
  - Improve signal coordination
  - Install turn lanes
  - Control approach speeds
  - Optimize change intervals*

* Discussed previously

Increase Visibility of Signals

...12 inch signal indications shall be used for all signal sections in all new signal faces...

Proposed amendment to the MUTCD

LOW COST COUNTERMEASURE

Countermeasure	CRF
Convert to 12-inch Lenses	Total = 11-24% Injury = 16%
Add Supplemental Heads	Right angle = 35% Rear end = 28% Total = 28%

Increase Visibility of Signals

Countermeasure	CRF
One Primary Head Per Lane	Total = 28% Rear end = 28% Right-angle = 35%
Add Backplates	Total = 13% Right-angle = 50%

Increase Awareness of Intersection

[A signal ahead sign] shall be installed on an approach to a [signal] that is not visible for a sufficient distance to permit the road user to respond to the device.

Manual on Uniform Traffic Control Devices

Countermeasure	CRF
Advance Warning Signs	Total = 22% Right Angle = 35%
Dilemma Zone Protection	Fatal/injury = 39%

Improve Signal Coordination

Countermeasure	CRF
Signal Coordination	Right Angle = 32%

Apart from its operational benefits, signal coordination is known to reduce vehicle conflicts along corridors where traffic signals are coordinated.

Signalized Intersections: Informational Guide

Install Turn Lanes

Provision of an exclusive left-turn bay...generally improves the operations of all movements...

NCHRP Report 457: Evaluating Intersection Improvements: An Engineering Study Guide

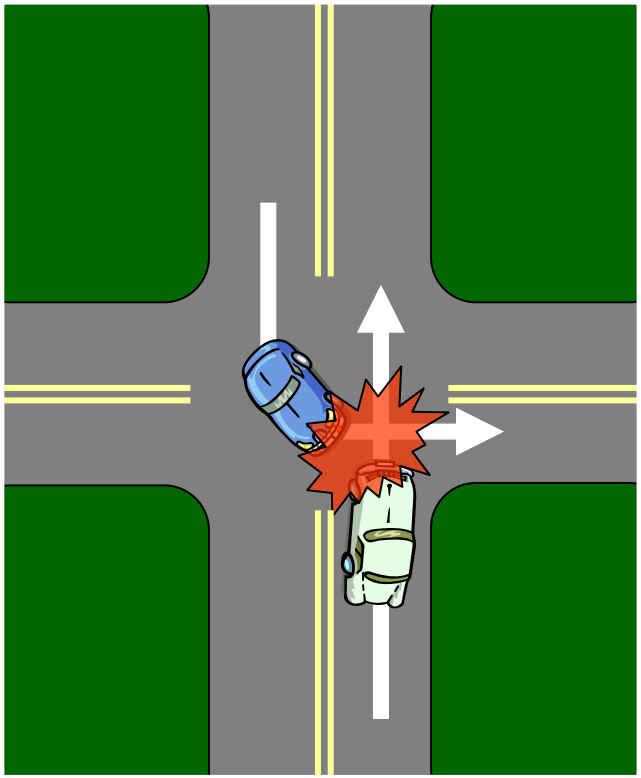
Countermeasure	CRF
Add Left Turn Lane	Total Urban = 7-19% Injury Urban = 9-17% Total Rural = 15-18%
Add Right Turn Lane	Total = 4% per approach

Control Approach Speeds

Since speed contributes to crash severity, lowering speeds on approaches to intersections can help reduce the severity of crashes. Slowing vehicle speeds...can improve safety for motorists, pedestrians, and bicyclists.

AASHTO Report 500 Volume 12

Left Turn Crashes



- Account for 21% of fatal crashes at signalized intersections
- Potential countermeasures:
  - Employ protected left turn phasing
  - Implement turn restrictions
  - Improve turning lane design
  - Reconstruct approaches
  - Improve sight distance*
  - Improve signal coordination*

* Discussed previously

Employ Protected Left Turn Phasing

The phasing and sequencing of a traffic control signal have the potential to affect both the safety and efficiency of vehicle and pedestrian traffic movement at the intersection.

Toolbox on Intersection Safety and Design

Countermeasure	CRF
Add Protected-Only Left Turn Phase	Total = 27% Left turn = 48% Right angle = 54-63% Rear end = 27-35%
Add Permissive/Protected Left Turn Phase	Left turn = 17% Right angle = 25%

Implement Turn Restrictions

Countermeasure	CRF
Prohibit Left Turns	Total = 45% Left turn = 90% Rear end = 30% Pedestrian = 10%
Prohibit RTOR	Rear end = 20% Right angle = 30% Sideswipe = 20%

When the right-of-way needed to provide [left-turn] storage is not available, left-turn restriction is a means of eliminating [safety and operational] problems.

NCHRP Report 457:
Evaluating Intersection Improvements: An Engineering Study Guide

Improve Turn Lane Design

[Offset left turn lanes help] improve safety and operations of the left-turn movement by improving driver acceptance of gaps...

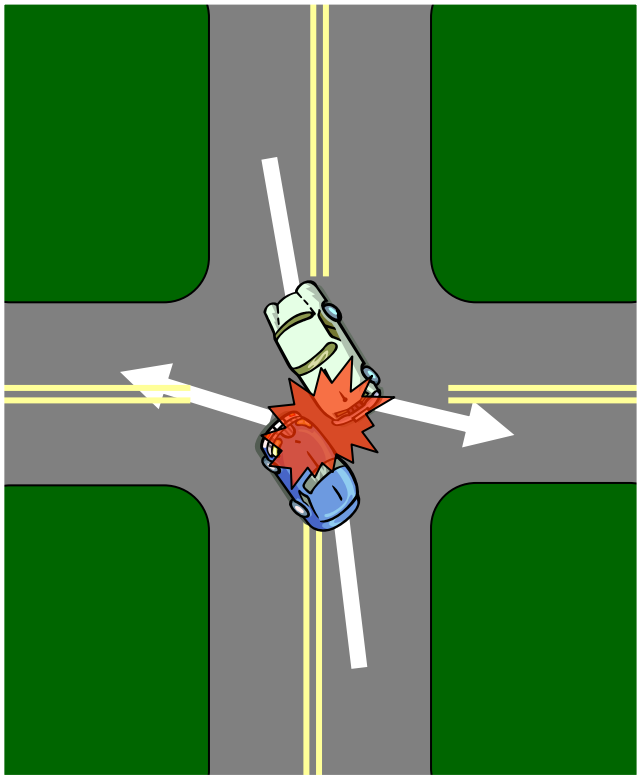
Signalized Intersections: Informational Guide

Reconstruct Approaches

If other less expensive methods cannot be used or are ineffective, horizontal or vertical (or both) realignment of approaches may be a solution.

AASHTO Report 500 Volume 12

Sideswipe Crashes



- Account for 13% of fatal crashes at signalized intersections
- Potential countermeasures:
  - Install pavement markings
  - Provide protected left turn phasing*

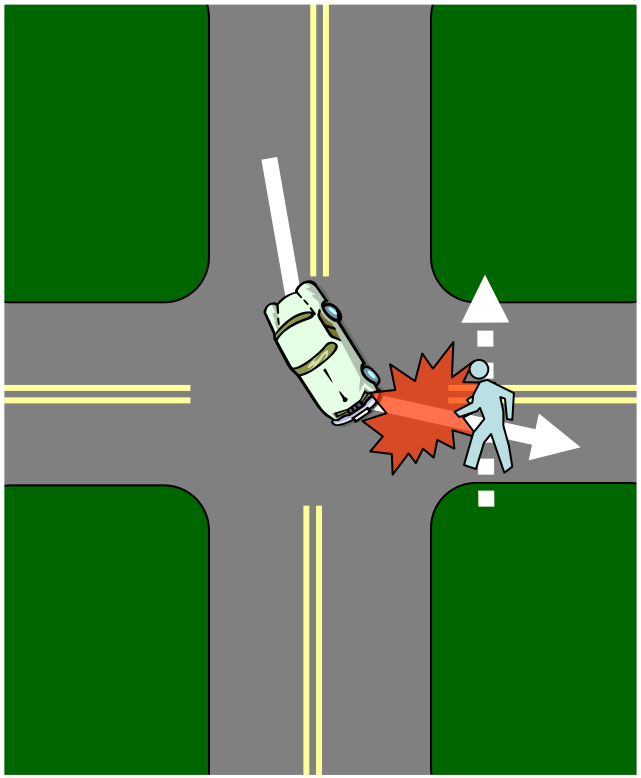
* Discussed previously

Install Pavement Markings

Providing positive guidance for the driver in the form of pavement markings can help eliminate driver confusion and eliminate vehicle conflict by channeling vehicles in their proper turn path.

Signalized Intersections: Informational Guide

Pedestrian/Bicycle Crashes



- Account for 25% of fatal crashes at signalized intersections
- Potential countermeasures:
  - Improve signal hardware
  - Improve pedestrian/bicycle facilities
  - Provide information and education

Improve Signal Hardware

Countermeasure	CRF
Countdown Signal Heads	Total = 20% Pedestrian injury = 25%

...all new pedestrian signal heads shall include a pedestrian change interval countdown display...

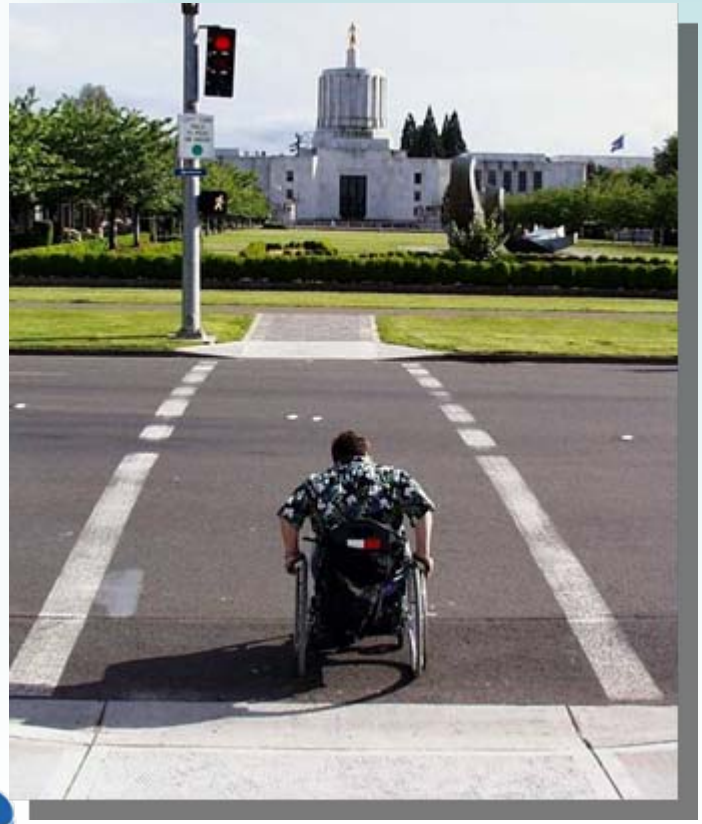
A pedestrian change interval countdown display shall be added to all existing pedestrian signal heads...

Proposed amendments to the MUTCD

Improve Pedestrian/Bicycle Facilities

Because pedestrians are the most vulnerable of all transportation facility users, particular attention to pedestrian safety is needed.

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



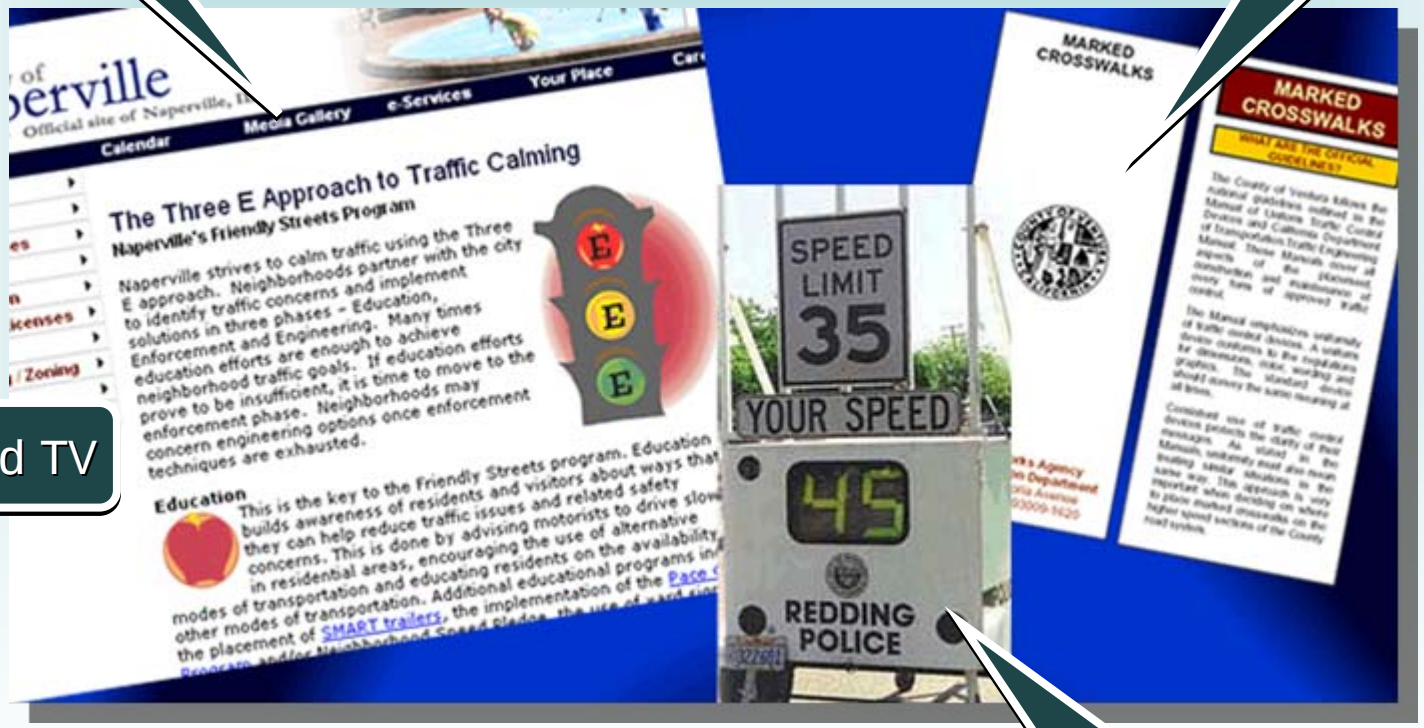
Countermeasure	CRF
Bicycle Lanes	Bicycle = 36%
Provide Sidewalks (both sides)	Pedestrian = 88%

Information and Education

Web sites

In school programs

Printed material



Radio and TV

Community outreach

Speed trailers

For More Information

- NCHRP Report 500 Series Volume 12
  - http://safety.transportation.org/
- Manual on Uniform Traffic Control Devices
  - http://mutcd.fhwa.dot.gov/
- Signalized Intersections: Informational Guide
  - http://www.tfhrc.gov/safety/pubs/04091/index.htm
- FHWA Office of Safety
  - http://safety.fhwa.dot.gov/