UN SIGNALIZED INTERSECTION COLLISIONS

NCHRP Report 500, Vol. 5

Description of Problem

EXHIBIT 1-1  Fatal Crashes by Location

EXHIBIT 1-2  Severity of Accidents at Unsignalized Intersections

Source: GES 1999
Percentages do not total to 100 because "other" is not included.
Type of Accident

EXHIBIT III-3
Manner of Collision for Fatal Crashes at Unsignalized Intersections

- Non-Collision, 86%
- Motor Vehicle Collision, 1%
- Fixed Object Collision, 8%
- Other Non-Fixed Collision, 5%

Source: GES 1999

Unsignalized Intersection Accidents First Harmful Event

Non-Collision, 86%

Source: GES 1999
Objective I

• Improve access management near unsignalized intersection
  – Driveway access near intersection confuses drivers and creates conflicts
  – Driveways near intersection should be
    • Closed, relocated or restricted
Strategy A
Close or Relocate Driveways

• At unsignalized intersections with high crash frequency
• Close or relocate driveways on major street 250 ft. upstream or downstream of intersection

Major Street Functional Area at Unsignalized Intersection

May use stopping sight distance to define upstream and downstream major street functional area
Strategy B
Implement Driveway Turn Restrictions

- Depends on accident experience
- Highly site dependent
- Varies with volumes and conflicts present
Objective II

- Reduce frequency and severity of intersection conflicts with geometrics
  - Separate through and turning movements
  - Restrict or eliminate turns
  - Provide acceleration lanes
  - Close or relocate intersections

Strategy C
Provide Left-Turn Lanes at Intersection

- 70-75% crashes at intersections are left-turn related
- Added left-turn lanes on a major road at unsignalized intersections reduce total accidents;

<table>
<thead>
<tr>
<th>Accident Reductions</th>
<th>3-Legged Intersection</th>
<th>4-Legged Intersection*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>44%</td>
<td>28%</td>
</tr>
<tr>
<td>Urban</td>
<td>33%</td>
<td>27%</td>
</tr>
</tbody>
</table>

*Installation of left-turn lanes on both major approaches would nearly double the effectiveness
Strategy D - Provide Longer Left-Turn Lanes at Intersection

- Length of left lane includes
  - Entering taper
  - Deceleration length
  - Storage
- Rear-end collisions result from conflict between left-turning vehicles and through vehicles
- Problem would most likely occur when inadequate storage is provided
Strategy E
Provide Offset Left-Turns at Intersection

- Left-turn lanes without offset may not provide adequate sight distance to approaching vehicles
- New design standard in 1994, now Case F in 2004 Green Book
Strategy F - Provide By-Pass Lanes on Shoulders at T-Intersections

• Minnesota study did not find increased safety (1999)
• Nebraska study showed marked decrease in rear-end collisions
• Other states report few accidents at shoulder by-pass locations

Strategy G - Provide Left-Turn Acceleration Lanes at Divided Highway Intersections

• Left-turn acceleration lanes increase safety
• Even short acceleration lanes help
• Sufficient length to permit speed adjustment of through and entering vehicle is desirable
Strategy H
Provide Right-Turn Lanes at Intersections

- Vehicles decelerate in the lane to 10-15 mph to turn right
- Right-turn lanes reduced crashes;
  - 5% on one major road approach for 3- and 4-legged intersections
  - 10% on both approaches

Right-Turn Lanes Added at Unsignalized Intersections

Crash Reductions

<table>
<thead>
<tr>
<th></th>
<th>Total Accidents</th>
<th>Fatal &amp; Injury Accidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rural</td>
<td>-14%</td>
<td>-23%</td>
</tr>
<tr>
<td>Urban</td>
<td>-40%</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Note: Rural intersection approach accidents reduced 27%
Strategy I - Provide Longer Right-Turn Lanes at Intersections

• To reduce rear collisions
• No quantitative estimate of effectiveness
Strategy J - Provide Offset Right-Turn Lanes at Intersections

- Vehicles in right-turn lane block stopped vehicles view of on-coming traffic
- No research on safety effectiveness
Strategy K
Provide Right-Turn Acceleration Lanes

- Allows vehicles to accelerate to speed outside through lanes
- Research has shown right-turn acceleration lanes are effective
Strategy L
Provide Full-Width Paved Shoulders

• Provides space to avoid potential accidents
  – Improve lateral placement of vehicles
  – Space for pedestrians and bicycles
  – Space to park disabled vehicles
• Reduction in ROR and opposite direction accidents of 6-12%
• FHWA study indicates 2.8% per foot reduction in crashes
Strategy M - Restrict or Eliminate Turning Movements by Signing

- Restrict or eliminate some turns during peak period, or totally
- Turn restrictions should reduce crashes for those turns by nearly 100%
Strategy N - Restrict or Eliminate Turning Movements by Channelization or Controlling Median Openings

- Islands or medians can be placed to block certain movements
- Median opening can be directional to permit certain turns
- Should reduce turning crashes by nearly 100% for blocked or controlled turns
Strategy O
Close or Relocate High Risk Intersections

• Accomplished by;
  – Realignment of minor road approaches
  – Close or dead-end streets
• Should eliminate crashes
• Guard against driver expectancy that street continues through
Strategy P - Convert 4-Legged Intersection to Two T-Intersections

- Used on very low volume local street intersection
- Offset intersection has accident rate reduction of 57% (1976 study)
- With high cross-street volume, 4-legged intersection is safer
Strategy Q - Convert Offset T-Intersections to 4-Legged Intersections

- With high cross street volume, 4-legged intersection is safer
- Eliminate queue back-up interference from one intersection on the other
Strategy R - Realign Intersection
Approaches to Reduce or Eliminate
Intersection Skew

• Problems corrected
  – Longer crossing distance for intersection
  – Older drivers have difficulty with flexibility loss for adequate sighting
  – Sighting for stopped vehicles obstructed by sighting back through vehicle
  – Gap analysis and selection impaired
  – Larger intersection area for impact and judging other vehicle paths
Safety Effectiveness or Realignment of SKEW

- Accident modification factor;
  - AMF = exp (0.0040 skew) for 3-legged intersection
  - AMF = exp (0.0054 skew) for 4-legged intersection

where
- Skew = intersection skew angle (degrees), i.e., difference between 90° and intersection angle
Strategy S
Indirect Left-Turn Treatments to Minimize Conflicts at Divided Highway Intersections

- Reduce rear collisions
- Reduce right-angle between left-turning and on-coming through vehicles

Strategy T - Improve Pedestrian and Bicycle Facilities to Reduce Conflicts between Vehicles and Non-Motorists

- 32.2% pedestrian-related crashes occur within 50 ft. of intersection
  - 30% involve turning vehicle
  - 22% involve pedestrian running across intersection or darting out
  - 16% involve driver violation
Pedestrian Improvements

- Continuous sidewalks
- Signed and marked crosswalks
- Pedestrian signs, signals and markings
- Sidewalk setback
- Lighting
- FHWA pedestrian crash countermeasures
Bicyclist Improvements

- Widen outside lane or add bike lane
- Provide median refuges at key crossings
- Provide independent bicycle/pedestrian structures where necessary
- Replace drain grates with bicycle-safe models
- Provide smooth paved shoulders

Objective III

Improve sight distance at unsignalized intersections
Strategy U
Provide Clear Sight Triangles on Stop- or Yield-Controlled Approaches

- Intersection sight distance standards in 2001/2004 Green Book are shorter than previously
- AASHTO 2001/2004 Green Book height of object is 3.5 ft. (was 4.25 ft.)
- 2001/2004 Green Book intersection sight distances are based on gap acceptance
Intersection Sight Distance Effectiveness

- If available sight distance in any quadrant is less than for 12 mph (20 km/hr), design sight distance;
  - increases crashes by 5%
  - if all quadrant sight obstructed, increases crashes by 20%

Strategy V
Clear Sight Triangles in Divided Highway Median near Intersection

- Sight obstructions in median should be eliminated
- Obstructions include;
  - Vegetation, roadside appurtenances, other natural objects
- Criteria stated previously;
  - Design sight distance based on Case F (AASHTO)
  - Available sight distance (for 20 km/h less), increase accidents/quadrant by 5%
Strategy W
Change Horizontal and/or Vertical Alignment

- Eliminate horizontal and/or vertical alignment restrictions in all quadrants to reduce accidents by 20%
Strategy X
Eliminate Parking that Restricts Sight Distance

• Remove parking or control parking to periods when accidents are experienced

Objective IV
Improve gap availability in traffic and assist drivers in judging gaps
Strategy Y - Provide Automated Real-Time System to Judge and Inform Drivers of Available Gaps for Turning/Crossing

• Available systems include;
  – Simple pavement loop detectors and flashing lights
  – “Collision Countermeasure System”
    • Approaching major road, vehicles are warned with a flashing car symbol that vehicle is entering from cross street
    • Major street drivers also warned

Strategy Z
Roadside Marker or Pavement Markings Assist Driver Judging Available Gaps

• Passive markings at a fixed distance (or fixed travel time) from an intersection to show an acceptable gap
• Markings could be roadside markers or pavement markings
• Drivers must be informed not to enter intersection if approaching vehicle is closer than marker
• Elderly drivers judge gaps based on distance, not time separation
Strategy AA
Re-Time Adjacent Signals to Create Gaps at Stop Controlled Intersections

• Change signal timing or phasing

Objective V
Improve driver awareness of intersections on the intersection approach
Strategy BB
Improve Visibility of Intersection by Providing Enhanced Signing and Delineation

- Advance warning and guide signs can warn drivers
- Advance street signs provide early awareness and eliminate searching by drivers in intersections
- Elderly drivers benefit from advance guide signs and larger letter height
- Breaks in centerlines, edge-lines, and lane lines show presence of intersection
Strategy CC
Improve Visibility of Intersection by Providing Lighting

- Increase awareness
- Intersection lighting reduced accidents 25-50% (Minnesota)
- Benefit cost ratio of 15:1
Strategy DD
Install Splitter Islands on Minor Road Approaches

• Unsignalized intersections that are not visible can be improved with splitter islands
• Splitter island are particularly useful at skewed intersections
• May reduce approach speeds and accidents
Strategy EE
Provide Stop Bar (or Wider Stop Bar) on Minor Road Approaches

- Stop bar provides driver awareness
- No indication of safety effectiveness

Strategy FF
Install Larger Regulatory and Warning Signs at Intersections

- Signs will be more readily seen
- Human factors doesn’t suggest a major improvement with increased size
Strategy GG

Call Attention to Intersection by Installing Rumble Strips

- Appropriate where a pattern of crashes exist, where stop sign is not recognized
- May reduce accidents by 50% where susceptible to correction

Strategy HH - Provide Dashed Markings (Extended Left Edge Lines for Major Road Continuity Across Median Opening on Divided Highway Intersections)

- Separates median roadway from through major road
- Effectiveness unknown
Strategy II - Provide Supplementary Stop Signs Mounted over Roadway

- Stop signs may not be readily visible due to
  - Geometrics
  - Vegetation
  - Other objects
- Safety has not been quantified

Strategy JJ - Provide Pavement Markings with Supplementary Measures such as STOP AHEAD

- Helps reinforce stop sign
- Safety has not been quantified
Strategy KK
Improve Maintenance of Stop Signs

• Maintain
  – Proper position
  – Cleanliness
  – Legibility
• Replace damaged signs
• Establish schedule for
  – Inspection
  – Cleaning
  – Replacement
• Effectiveness had not been quantified

Strategy LL
Install Flashing Beacons at Stop-Controlled Intersections

• Change in condition attracts more attention than increased sized
• Two-way stop-controlled intersections
  – Flashing red beacon for stop-controlled approach; yellow for major street
• Four-way stop-controlled intersection
  – Flashing red beacon on all approaches
• Safety benefit is unproven
Objective VI

Choose appropriate intersection traffic control to minimize crash frequency and severity
Strategy MM
Avoid Signalization of Through Roads

• Signalization of unsignalized intersections leads to increased crashes on major roadways
• Alternatives
  – All-way stop-control
  – Roundabouts
  – Turn prohibitions
  – Indirect left-turn movements
  – Flyovers and other grade separations

Strategy NN
Provide All-Way Stop-Control at Appropriate Intersections

• All-way stop-control reduces right-angle and turning collisions
• Conversion from two-way to all-way stop-control could reduce crashes by 53%
Strategy OO
Provide Roundabouts at
Appropriate Locations

- Roundabouts can serve moderate traffic volumes
- Roundabouts can reduce crashes by 38%
  - Injury crashes by 76%
  - Fatal crashes by 90%