WORK ZONE CRASH DATA COLLECTION, REPORTING, AND ANALYSIS
Wayne State University – Transportation Research Group
• Detroit, Michigan

University of Missouri - Columbia
• Columbia, Missouri
Based on following guidelines

**A Guide for Work Zone Crash Data Collection, Reporting, and Analysis**


**Development and Application of Work Zone Crash Modification Factors**


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Wayne State University

University of Missouri - Columbia
Overview / Problem Statement

Work Zone Crash Data Elements
  - Model Minimum Uniform Crash Criteria (MMUCC)

Agency Process

Analytical Tools and Strategies
  - Safety Performance Functions (SPFs)
  - Crash Modification Factors (CMFs)

Wrap-Up
  - Recommendations
- Importance of accurate work zone crash data
  - Identification and analysis of crash trends
  - Contributing factors of work zone crashes
  - Countermeasures
  - Strategies
  - Development of CMFs

- Inconsistent and limited
  - Variation in captured work zone data elements across states
  - Difficult to determine if crash was influenced by work zone
Involvement of many individuals and agencies

- Call to first responder
- Field data collection
- Crash report review and preparing digital data

Detailed crash data required for severe injuries and fatalities

- Location of skid marks
- Vehicle damage details
- Location of harmful event(s)
- Crash scene photographs
WORK ZONE CRASH DATA ELEMENTS - MMUCC GUIDELINE

- Document includes “minimum set” of standardized data elements
  - Voluntary implementation by state
  - Crash, vehicle, person, roadway data elements
    - Attribute subfields and values
- Uniformity in all areas of crash data
  - National, state, and local levels
- Work zone attribute subfields essential to include
  - “Was the crash in a construction, maintenance, or utility work zone or was it related to activity within a work zone?”
  - “Location of the crash”
  - “Type of Work Zone”
  - “Workers Present”
  - “Law Enforcement Present”
- Important to collect at scene

MMUCC Guideline definition of work zone related crash
- “A crash that occurs in or related to a construction, maintenance, or utility work zone, whether or not workers were actually present at the time of the crash. “Work zone-related” crashes may also include those involving motor vehicles slowed or stopped because of the work zone, even if the first harmful event occurred before the first warning sign.”

Work zone related crashes not always apparent
- Crash occurring upstream from first warning sign
- On-site personnel must understand how work zones influence traffic

LOCATION OF WORK ZONE CRASH

Source: Adapted from Manual on Uniform Traffic Control Devices (MUTCD) (Figure 6C-1)
Degree to which work zone modifies existing traffic

Four work zone types along with “Other” category

- Determination of taper based on work zone type
  - Merging taper
  - Shifting taper
  - Shoulder taper

Source:
Consideration of work zone related crash
- Workers do not need to be present at time of crash
- Anecdotal evidence suggests drivers react differently to work zones
  - Workers present vs. no workers present

Workers Present  Yes □  No □  Unknown □

Prevention of speeding or errant vehicles
Help direct traffic where traffic control is needed
Manual on Uniform Traffic Control Devices (MUTCD) promotes law enforcement in work zones
- Temporary road closure (TA-13)
- Mobile operations (TA-17)
- Closure at side of intersection (TA-27)
- Work in vicinity of grade crossing (TA-46)

(12-13) Contributing Circumstances, Roadway (Maximum - two per crash)

0 None (no unusual conditions)
1 Road Surface Condition
2 Debris
3 Rut, holes, bumps
4 Work zone (construction, maintenance, utility)


WORK ZONE CRASH DATA ELEMENT JUSTIFICATION

- **Identification of work zone crashes, injuries, and fatalities**
  - Development of programs and initiatives
  - Improvement of safety and mobility
  - Contributing factors

- **Countermeasures for same-cycle and future construction projects**
  - Provide/increase buffer space
  - Increase taper length to accommodate approach speed
  - Reduce cone spacing to increase visibility
Variances among states regarding work zone data collected


MMUCC Work Zone Crash Data Inclusion:
- **Location of Crash**: 23 States
- **Type of Work Zone**: 24 States
- **Workers Present**: 25 States
- **Law Enforcement Present**: 10 States
Some states include work zone attributes not listed in MMUCC

15 states identify work zone activity
- Construction, maintenance, utility
- Minnesota includes diagram defining the areas within a work zone
- Pennsylvania and West Virginia include work zone speed limit
- Pennsylvania includes entire lane closure information

Source:
Field data collection
- Police officer arriving at scene of crash
  - Collection of necessary data for crash report form

Reporting and recordkeeping
- Transferring crash reports from hardcopy to electronic media
  - Simplified data collection process
  - Reduced administrative responsibilities for officers
  - Appropriate tools and software required
CRASH REPORT REVIEW PROTOCOL

- Field crash report form reviewed for accuracy
  - Entered to digital database
- Digital database transferred to state-wide repository
  - Reviewed for accuracy and modifications (if applicable)
- Finalize unified state-wide database
- Provide fatal crash data to national database
  - Fatality Analysis Reporting System (FARS)
HARDCOPY CRASH DATA REPORTING ISSUES

- Time consuming
- Inconsistent notation between officers
- Inconsistent technique of crash diagrams
- Difficulty in quality assurance
- Manual input from hard copy to digital database
- Illegible handwriting
- Labor intensive
- Prone to error
ELECTRONIC CRASH DATA REPORTING BENEFITS

- Removal of “cheat sheet” to find code
- Drop down lists of plain-text responses
- Exact location with Global Positioning System (GPS)
- Easily exported to other databases for sharing
- Instantaneous data entry
- Simplified supervisor’s review
- Reduced chance for misspellings and errors

STATE-SPECIFIC ONLINE TOOLS

**eCite - Alabama**

**Georgia Electronic Accident Report System (GEARS) – Georgia**
- [https://gearsportal.com/Pages/Public/Home.aspx](https://gearsportal.com/Pages/Public/Home.aspx)

**Electronic Vehicle Crash Records – Indiana**
- [http://evcrs.software.informer.com](http://evcrs.software.informer.com)

**LACRASH – Louisiana**
- [http://lacrash.lsu.edu](http://lacrash.lsu.edu)
**WORK ZONE DATA ELEMENT CHALLENGES**

- Minimal when compared to entire crash form
- Encouraging change in agency policy
- Training officers on new forms
- Competing for data space against other elements
  - Engineering, driver related, enforcement related
- Limited space on standard form
  - Very cluttered

STRATEGIES IN OVERCOMING WORK ZONE DATA ELEMENT CHALLENGES

- Usage of MMUCC work zone crash data element
  - Encouragement to stakeholders / policy makers
- Benefits of work zone crash data
  - Site-specific treatments and development of targeted countermeasures
- Approval from Traffic Record Coordinating Committee (TRCC)
  - [https://www.transportation.gov/trcc](https://www.transportation.gov/trcc)
- Accompany other changes in crash report form
Availability of work zone crash data
- Limited to data collected on crash report form

Essential to have usable work zone data
- Location of crash, type of work zone, etc.

Allows agencies to review work zone crashes
- Area-wide evaluation of work zone treatments
- Effective work zone safety analysis
WORK ZONE CRASH DATA ANALYSIS

- Individual crashes
  - Modify intermediate and long-term work zone treatments
- Groups of similar work zone sites
  - Develop future temporary traffic control plans
- Crash and severity trends in work areas
  - Before first warning sign, advance warning, transition, activity, termination
- SPF and CMFs
  - Prediction of safety consequences in work zones
\[ N_{predicted} = N_{SPF} \times CMF_1 \times CMF_2 \ldots \times C \]

(AASHTO, 2014)

Where:

- \( N_{predicted} = \) predicted crash frequency
- \( N_{SPF} = \) predicted crashed frequency (base conditions)
- \( CMF_i = \) Crash Modification Factor (adjustment from base condition)
- \( C = \) Calibration Factor
HSM WORK ZONE CMFs

- **Work zone duration**
  \[ CMF_{d,all} = 1.0 + \frac{\% \text{ increase in duration} \times 1.11}{100} \]

- **Work zone length**
  \[ CMF_{l,all} = 1.0 + \frac{\% \text{ increase in length} \times 0.67}{100} \]
OTHER WORK ZONE CMFs

Active work (temporary lane closure)

Two-way two-lane work zone operations

Active work (no lane closure)

Left-hand merge and downstream lane shift

Increase inside or outside shoulder width

No active work with no lane closure

Source: http://www.cmfclearinghouse.org/
USING EXISTING CMFs

1. Identify countermeasures for analysis
2. Determine CMF availability
3. Determine countermeasure evaluation criteria
4. Data collection
5. Perform analysis
6. Select countermeasures for implementation
Step 1: Identify countermeasures for analysis
- Increase outside shoulder width by 1 ft

Step 2: Determine CMF availability
- CMF = 0.948 (CMF Clearinghouse)

Step 3: Determine countermeasure evaluation criteria
- Implement if B/C > 1.25

Step 4: Data collection
- Improvement cost = $3,000 / mile
- Project length = 2 miles
- Expected number of crashes = 8
- Crash cost = $20,000

Step 5: Perform analysis
- Estimated improvement costs = 2 miles * $3,000/mile = $6,000
- Estimated crash reduction = (1 – 0.948) * 8 = 0.416 crashes
- Estimated crash cost savings = 0.416 crashes * $20,000/crash = $8,320
- B/C = $8,320 / $6,000 = 1.39

Step 6: Select countermeasures for implementation
- B/C > 1.25  
  Implement!
DEVELOPING NEW CMFs

1. Select countermeasure for CMF development
2. Select method for CMF development
3. Assess data needs and availability
4. Select sites
5. Data collection
6. Calculate CMFs
7. Evaluate results
Common methods for CMF development

- Empirical Bayes Before-After Method
  - Based on expected crash frequency without treatment in after period
- Cross-Sectional Method
  - Compares treatment sites and control sites
Step 1: Select countermeasure for CMF development
- Work zone length
- Work zone duration

Step 2: Select method for CMF development
- Cross-sectional study (using negative binomial regression)

Step 3: Assess data needs and availability
- Missouri Department of Transportation (MoDOT) databases
  - Work zone database
  - Crash database
  - Road segment database

Source: Rahmani et al., 2016
Step 4: Select sites
- 1,571 freeway work zones in Missouri (2009-2014)
- Minimum work zone length = 0.1 mile
- Minimum work zone duration = 10 days

Step 5: Data collection
- Spatial and temporal matching of data
- Assignment of crashes to work zone locations

Step 6: Calculate CMFs

\[ CMF_{Length} = 1.0 + \frac{\% \text{ increase in } \text{Length} \times 0.62}{100} \]

\[ CMF_{Duration} = 1.0 + \frac{\% \text{ increase in } \text{Duration} \times 1.01}{100} \]
SYSTEMATIC ANALYSIS TO CREATE SAFER WORK ZONES

- **Location, time, and type of crash**
- **Relevant factors based on crash report**
  - Speeding, distracted driving, sight distance problems
- **Additional data needs**
  - Construction plans, citation reports, traffic volume data
- **Countermeasures to alleviate similar crash occurrences**
  - Arrow board, portable rumble strips, law enforcement
## WORK ZONE TRAFFIC CONTROL SAFETY COUNTERMEASURES

<table>
<thead>
<tr>
<th>CRASH TYPE</th>
<th>POTENTIAL ISSUE</th>
<th>OBJECTIVE</th>
<th>WORK ZONE MODIFICATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Vehicle</td>
<td>Improper Use of Channelizing Devices</td>
<td>Mitigate Errant Vehicles</td>
<td>Decrease Channelizing Device Spacing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Increase Buffer Zone</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Add Temporary Traffic Barriers and/or Crash Attenuators as Appropriate</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Add Barricades, Warning Lights, Signage and/or Delineators</td>
</tr>
<tr>
<td>Rear End</td>
<td>Sudden Queuing</td>
<td>Increase Braking Distance</td>
<td>Increase Distance of Advance Warning Signs (Consider Adding beyond Minimum Traffic Control Devices)</td>
</tr>
<tr>
<td></td>
<td>Speeding</td>
<td>Promote Alert Driving</td>
<td>Decrease Work Zone Speed Limit</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Add Law Enforcement</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Add Portable Rumble Strips</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Add Various Intelligent Transportation Systems Deployment</td>
</tr>
<tr>
<td>Angle</td>
<td>Sight Distance Issue at Access Points (e.g., Driveways)</td>
<td>Increase Line of Sight</td>
<td>Provide Flagger</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Provide Alternate Access and Temporarily Close Driveway</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Restrict Left-Turning Movements Out of Driveway</td>
</tr>
<tr>
<td>CRASH TYPE</td>
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<td>OBJECTIVE</td>
<td>WORK ZONE MODIFICATION</td>
</tr>
<tr>
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<td>--------------------------------------------------------</td>
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</tr>
<tr>
<td>Head-On Left-Turn</td>
<td>Improper Signal Timing</td>
<td>Create Greater Temporal Separation of Conflicting Traffic</td>
<td>Provide Protected Left-Turns (e.g., Split Phasing)</td>
</tr>
<tr>
<td>Head-on; Sideswipe-Opposite</td>
<td>Improper Lane Delineation (e.g., Lane Shift)</td>
<td>Improve Adherence to Lane Lines</td>
<td>Increase Lane Width</td>
</tr>
<tr>
<td></td>
<td>Improper One-Way Traffic Control</td>
<td></td>
<td>Add Temporary Raised Pavement Markers and/or Islands</td>
</tr>
<tr>
<td>Sideswipe-Same</td>
<td>Improper Merging Maneuvers</td>
<td>Restrict Lane Change Behavior</td>
<td>Modify Taper to Accommodate Approach Speed</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Provide Arrow Board</td>
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<tr>
<td></td>
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<td></td>
<td>Add Temporary Pavement Markings (i.e., Override Permanent Pavement Markings)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Add Temporary Lane Separators</td>
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<td></td>
<td></td>
<td>Provide Temporary Traffic Control Signal</td>
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<td></td>
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<td></td>
<td>Provide Flagger</td>
</tr>
</tbody>
</table>
Many states have online analysis tool
- "Excel-based" tool stores data elements from crash report
- Available to stakeholders and sometimes public
- Query of wide variety of filters
  - Limited to attributes on crash report form
### Sideswipe same direction work zone crashes in transition areas within State in 2013

#### MICHIGAN TRAFFIC CRASH FACTS DATA QUERY TOOL

**Inputs**

- **Analysis Level**: Crashes - (One Result per Crash)
- **Time Frame**: Entire State, 2013
- **Geographic Location**: Entire State

**Construction Type**

- Construction/maintenance
  - Utility

**Construction Lane Closed**

- Lane open
- Lane closed

**Crash Type**

- Sideswipe same direction

#### Output (Table)

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Sideswipe same direction</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction/maintenance</td>
<td>310</td>
<td>310</td>
</tr>
<tr>
<td>Utility</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><strong>Total Crash Count</strong></td>
<td><strong>318</strong></td>
<td><strong>318</strong></td>
</tr>
</tbody>
</table>

Nationwide fatal rear-end work zone crashes in 2013

http://www.nhtsa.gov/FARS
Does not include other MMUCC work zone attributes

- Location of crash, type of work zone, etc.

<table>
<thead>
<tr>
<th>Work Zone</th>
<th>Manner of Collision</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Front-to-Rear</td>
<td></td>
</tr>
<tr>
<td>Construction</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td>Maintenance</td>
<td>18</td>
<td>18</td>
</tr>
<tr>
<td>Work Zone, Type Unknown</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>107</strong></td>
<td><strong>107</strong></td>
</tr>
</tbody>
</table>

Nationwide fatal rear-end work zone crashes in 2013

http://www.nhtsa.gov/FARS
RECOMMENDATIONS TO ACHIEVE WORK ZONE DATA ELEMENT INCLUSION

1. Recognition of data elements in safety analysis
2. Review of existing practice
3. Building coalition interested in work zone data
4. Preparation of documentation for state policy makers
5. Preparation of cost estimate for change
6. Be a champion of work zone data
7. TRCC and stakeholder coordination
8. Consultation with others who have been successful
9. Development and adoption of improved policy
CONCLUSIONS FOR WORK ZONE DATA ELEMENT INCLUSION

- Essential for establishing how work zones influence crash patterns
- Update of police accident reports based on need
  - Coordination with existing efforts makes work zone inclusion easier
- TRCC members great source of information and guidance
- Safety benefits convince leaders to support work zone data
- Increased standardization of state police accident reports
  - Data sharing and development of national policies
  - Broad examination of work zone crash history
- End goal – Improve work zone safety
ADDITIONAL RESOURCES

Wayne State Work Zone Safety Homepage: http://workzone.eng.wayne.edu

National Work Zone Safety Information Clearinghouse: https://www.workzonesafety.org

FHWA Work Zone Management Program: https://ops.fhwa.dot.gov/Wz/index.asp


NHTSA Traffic Records: https://www.nhtsa.gov/research-data/traffic-records


QUESTIONS / COMMENTS
THANK YOU