Behavioral Substrates of Traffic Safety
Stop and Work Zone Crashes – A Human Factors Analysis

Thomas J. Smith, Ph.D.
Research Associate, Human Factors
School of Kinesiology
College of Education & Human Development
University of Minnesota

Michael G. Wade, Ph.D.
Professor
School of Kinesiology
College of Education & Human Development
University of Minnesota
Presentation Outline

• Statement of Problem
• Recent Experience with Traffic Safety Stop Crashes in Minnesota and Nationally
• Recent Experience with Work Zone Crashes in Minnesota and Nationally
• Factors That May Contribute to the Risk of TSS Crashes
• Behavioral Substrates of Traffic Safety Stop and Work Zone Crashes – A Speculative Human Factors Analysis
• Conclusions
• Future Research Needs
Statement of Problem

• Traffic safety stop (TSS) and work zone crashes are a persistent problem in Minnesota.

• These incidents are distinctive and significant for two reasons:
  – victims of such incidents typically are public service workers
  – these workers typically cannot effectively insulate themselves from such crashes

• There is no consensus agreement among the traffic community as to why these incidents occur.

• Environmental, enforcement, and management design factors, and/or driver behavioral factors, typically are invoked.
Recent Experience with Traffic Safety
Stop Crashes in Minnesota
Since Nov. 1, 22 trooper vehicles have been hit, compared with 10 during the same period a year ago.

By RANDY FURST; STAFF WRITER

The State Patrol, citing a rise in the number of trooper vehicles struck by motorists, on Tuesday urged drivers to obey a state law requiring them to move over one full lane when passing stopped emergency vehicles whose lights are flashing.

The 10-year-old law applies to drivers on roads with two or more lanes in the same direction. Motorists must move over for ambulances and vehicles used for firefighting, law enforcement, maintenance or construction. If they are unable to move over, drivers must reduce speed under the law.

Lt. Eric Roeske said the patrol decided to hold a news conference after Lt. Chris Edstrom suffered minor injuries Monday when his patrol car was struck while parked on the shoulder of northbound Interstate 35W southwest of Forest Lake. He was helping a disabled motorist and was in his car when it was hit.

Roeske showed a video of a Dec. 4 incident in which a skidding vehicle struck Trooper Richard Kitzmiller's patrol car on the shoulder of eastbound 1-94 near St. Cloud. Kitzmiller, who was in his car, suffered minor injuries.

The patrol said that since Nov. 1, 22 trooper vehicles have been hit, injuring five troopers, compared with 10 over the same period the previous year, injuring four.

From 2005 through 2009, at least 100 trooper vehicles were struck and 31 troopers were injured, the patrol said. Citations were issued to 9,173 motorists for "move over" violations during that period.

The "Ted Foss Move Over law" was enacted after Foss, a trooper, was killed in 2000 when a semitrailer truck hit his parked patrol car during a traffic stop along I-90 near Lewiston, Minn.

Roeske said such accidents are more common this winter because drivers are going too fast on snow and ice and not paying attention.

"By the time they recognize there is a hazard or crash ahead ... it's too late to slow down," he said.
Summary of Recent Experience with TSS Crashes in Minnesota and Nationally

• Recent Experience with TSS Crashes in Minnesota (Furst, 2011):
  – between November 1, 2010 and January 19, 2011, 22 Minnesota State Trooper vehicles were involved in TSS crashes, with five troopers injured
  – for the comparable 2009-2010 period, there were 10 trooper traffic stop crashes, with four trooper injuries
  – from 2005 through 2009, there were at least 100 trooper TSS crashes, with 31 troopers injured, and 9,173 motorist citations issued for ‘move over’ work zone violations
  – in the year 2000, a trooper was killed as a result of a TSS crash

• Recent Experience with TSS Crashes Nationally
  – nationally, 44.1 percent of a total of 681 accidental law enforcement officer fatalities between 1993 and 2002 were caused by TSS crashes (Ashton, 2011)
Recent Experience with Work Zone Crashes in Minnesota
MINNESOTA’S ROADS

1,915
Work zone crashes in 2010

80
MNDOT projects in the metro area in 2011

State law: Motorists must move one lane away from emergency vehicles and construction workers on a roadside.
Out-of-control car kills 2 road workers

With a raft of work zone crashes last year, the state is desperate to increase safety.
Crashes in I-94 work zone prompt warning

WisDOT tells drivers to watch road

By Andy Rathbun
aratbun@pioneerpress.com

The Wisconsin Department of Transportation is asking drivers to pay attention to the roadway after accidents two days in a row on Interstate 94 east of Hudson.

The accidents, which happened Thursday, April 26, and Friday, involved rear-end collisions in a construction zone at Wisconsin 65, said Chris Ouellette, a spokeswoman for WisDOT.

Neither accident involved serious injuries, she added.

The accident Friday caused delays during the morning rush hour, and the accident Thursday — which involved four vehicles — closed all westbound lanes for a period during the afternoon, Ouellette said.

WisDOT is examining the scene and may add additional signage to give motorists more notice of the construction zone.

Ouellette said traffic-safety engineers would inspect the site Friday “to see if there are any work-zone changes we can make.” She added that WisDOT also may change the lane-closure schedule.

“With that being said, construction season has started, and people have to keep their eyes on the road,” she said. “They need to put the distractions aside and allow extra time.”

She said construction workers have seen many drivers texting and talking on their cellphones while going through the work zone.

Traffic is reduced to one lane in each direction through the construction zone. The $44.8 million project affects two miles of the interstate and is expected to be completed in November 2013.

Crews are resurfacing the roadway, moving dirt to lower a hill and building a new bridge and exit ramps at Wisconsin 65.

Andy Rathbun can be reached at 651-226-2121. Follow him at twitter.com/andyrathbun.
Danger always lurks
National Concerns About Work Zone Crashes
A Guide for Reducing Work Zone Crashes
NCHRP Report 506-17

One of a Series of Guides to Help States Improve Highway Safety

In Work Zones: Nearly 1,100 Die and 50,000 Are Injured Each Year

The Problem

Much of the nation’s highway infrastructure is aging and work zones are expected to remain a familiar sight, given the emphasis on the reconstruction of existing roadways. About 26 percent of the National Highway System is under construction each year during the peak summer work season.

With a steady increase in vehicle miles traveled and growing congestion on the nation’s roads, there has been a trend of increasing deaths and injuries in highway work zones. In 2004, work zone crashes killed 1,028 people and injured another 50,000. The preponderance of crashes occur in longer term construction zones, with more than half of them during the day and most (60%) on non-interstate roads posted for 55 mph or higher. Alcohol is involved in 40 percent of work zone crashes. More than half involve a single vehicle, and one in five involves a heavy truck. Data show that roadway construction workers are killed at a rate nearly three times higher than construction workers in other areas and eight times higher than general industry workers.

The main goal of this Guide is the reduction of fatal work zone traffic crashes and the overall improvement of work zone traffic safety for workers, motorists and other highway users. Most of the recommended strategies are relatively low-cost, short-term treatments.

Objectives and Representative Strategies

✓ Reduce the number, duration and impact of work zones:
   - Improve maintenance and construction practices.
   - Utilize full-time roadway closure, time-related contracts, and/or nighttime road work.

✓ Improve work zone traffic control devices:
   - Improve visibility of work zone signs and markings, and work zone personnel and vehicles.
   - Reduce flaggers’ exposure to traffic.

✓ Improve work zone design practices:
   - Impersonate measures to reduce work zone intrusions and limit consequences.
   - Improve work zone safety for pedestrians, bicyclists, motorcyclists, and heavy trucks.

✓ Improve driver compliance with work zone traffic controls:
   - Enhance enforcement of traffic safety laws in work zones.
   - Improve credibility of signs.

✓ Increase knowledge and awareness of work zones:
   - Disseminate work zone safety information to road users.
Creating Safer Work Zones: Improving Operations on Both Sides of the Barrel

**Facts**
- During the past 5 years in work zone crashes more than 4,400 persons died (85 percent of which was the driver or passenger).
- 280,000 persons were injured.
- Drivers are the most frequent fatality in work zone crashes.
- Most work zone fatalities involve working-age adults.
- Rear-end crashes (running into the rear of a slowing or stopping vehicle) are the most common type of work zone crash.
- Fatal work zone crashes occur most often in summer and fall.
- The majority of fatal work zone crashes occurred on roads with speed limits greater than 50 mph.
- Stopping distance for motor vehicles at 50 mph:
  - Dry roadway—300 ft
  - Wet roadway—400 ft
  - icy pavement—1250 ft
- A loaded 80,000 lb. tractor-trailer requires almost 50% more stopping distance.
- It takes only 0.05 seconds to cover 1 mile at 45 mph compared to 65 mph.

**Safety Tips for the Driver**

**Stay Alert and Minimize Distractions**
- Dedicate your full attention to the roadway.
- Avoid changing the radio station, using a mobile phone, eating, or other distractions that can remove your concentration from the road.

**Keep Your Headlights On**

**Pay Attention to the Road**
- "Listen to the signs!"
- Watch brake lights on vehicles ahead.
- Watch traffic around you and be prepared to react.

**Merge into the Proper Lane**
- Merge well before you reach the lane closure.
- Be aware that traffic patterns can change daily.

**Don't Tailgate**
- Follow other vehicles at a safe distance.

**Obey the Posted Speed Limit**
- Workers may be present just feet away.
- Fines may be doubled for moving traffic violations.
- Be prepared to slow down further if conditions indicate the need.

**Change Lanes Safely**
- Change lanes only where pavement markings indicate, and only when traffic conditions permit.

**Follow Instructions from Flaggers**

**Expect the Unexpected**
- Workers, work vehicles, or equipment may enter your lane without warning.
- Other vehicles may slow, stop, or change lanes unexpectedly.

**Be Patient**

**Listen to the signs.**

Traffic is travelling in both directions on a roadway that is normally one way. Be alert for oncoming traffic.

Road work is just ahead. Be prepared for unusual driving conditions.

Traffic needs to follow this vehicle to get safely through the work zone.

A flagger is ahead—be prepared to stop and/or follow instructions.

You will need to take an alternate route soon.

You have reached the end of the work zone. Resume normal, safe driving.

A lane is about to end, requiring you to merge into the adjacent lane. The "bare" lane shows which lane is ending.
Summary of Recent Experience with Work Zone Crashes in Minnesota and Nationally

• Recent Experience with Work Zone Crashes in Minnesota (Humphrey and Walsh, 2011):
  – two work zone workers were killed on 10/13/11, in a work zone crash alongside I-35W in Burnsville
  – there were 1,915 work zone crashes in 2010, with 11 workers and motorists killed
  – there were 1,788 work zone crashes in 2009

• Recent Experience with Work Zone Crashes Nationally (NCHRP, 2004):
  – Nationally, in 2004, work zone crashes killed 1,028 people and injured another 50,000
  – work zone construction workers are killed at a rate nearly three times higher than construction workers in other areas, and eight times higher than general industry workers
Factors That May Contribute to the Risk of TSS Crashes

- Environmental Design
- Incident Management Design
- Enforcement Factors
- Traffic Stop Procedures
- Road Conditions/Weather
- Driver Behavior Factors
Factors That May Contribute to the Risk of TSS Crashes (Ashton, 2011)

- **Environmental Design factors:**
  - Highway engineering design factors (roadway design; existence and width of shoulders and lanes; exceptions to design standards; median barriers)
  - Officer visibility
  - Vehicle conspicuity

- **Incident management system design**
  - Officer training and supervision
  - Collision reporting and pullout investigation sites

- **Enforcement Factors**
  - Lack of compliance with ‘Move Over’ laws
Factors That May Contribute to the Risk of TSS Crashes (continued)

• **Traffic stop procedures**
  - Selection of a safe stop location (influenced by numerous conditions, such as terrain, traffic volume and congestion, visibility and sight distance, available protection, weather conditions, violation severity, and violator behavior).
  - Police vehicle placement and orientation during stop (distance between vehicles, setting the parking brake, wheel alignment (front wheels turned left or right), vehicle offset).
  - Officer remaining in police vehicle during stop, or exiting police vehicle to approach violator vehicle (driver or passenger side?).

• **Road conditions / weather**
Factors That May Contribute to the Risk of TSS Crashes - Driver Behavior

- **Driver distraction**
  - Conceivably, many different factors can contribute to driver distraction (inattention; inappropriate use of technology; inappropriate driving conduct; time of day; different modes of physiological or psychological impairment, other diverse design issues.
  - Arguably, attributing work zone and TSS crashes to driver distraction lacks explanatory specificity and rigor.

- **Excessive speed**
- **Substance abuse**
- **Malicious intent**
Behavioral Substrates of Traffic Safety
Stop and Work Zone Crashes – A Speculative Human Factors Analysis
Speculative Human Factors Assumptions About Driver Behavioral Substrates of TSS and Work Zone Crashes

- Most if not all such crashes involve an interaction between driver behavior and a series of design factors prevailing at the scene.

- **Context specificity** refers to the idea that variability in driver behavior that may contribute to these incidents is prominently influenced by such design factors.

- There are a number of well-documented sources of behavioral variability that conceivably can contribute, individually or together, to such crashes.
Speculative Human Factors Assumptions About Driver Behavioral Substrates of TSS and Work Zone Crashes (continued)

• Each traffic stop or work zone features a distinctive and unique combination of design factors.

• Consequently, the pattern of variability in the behavior of a given driver during interaction with a given stop or zone cannot necessarily be predicted in advance (a basic premise of human factors science).
Speculative Human Factors Assumptions About Driver Behavioral Substrates of TSS and Work Zone Crashes (continued)

• ‘One size fits all’ thus may not apply to understanding / modeling driver behavior during such incidents.

• Rather, education and training of officers/engineers/managers should emphasize "when" and "what if" cognitive decision-making skills, so that basic procedures may be safely adapted to varying design circumstances and conditions (Ashton, 2011).
Behavioral Factors That May Contribute to Distracted Driving in TSS and Work Zone Crashes

**Identified by Traffic Professionals**
- Disregard of ‘Move Over’ Law
- Speed
- Substance Abuse
- Over-steering
- Loss of Control Due to Adverse Weather

**Not Typically Identified by Traffic Professionals**
- Increased Reaction Time
- Attention-Arousal Interaction
- Inattentional Blindness
- Steering Bias Linked to Visual Fixation

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University of Minnesota Center for Transportation Studies 23rd Annual Transportation Research Conference
Distracted Driving Behavioral Factors Typically Identified by Traffic Professionals

- Burnsville TSS crash as example --- speed and alcohol not involved, but over-steering implicated.

### Speed not a factor in work-zone crash

As State Patrol investigated, the deaths of two men along I-35W brought a plea for caution.

By KATIE HUMPHREY
katie.humphrey@startribune.com

A driver wasn’t going too fast when he lost control of his car and veered off Interstate 35W in Burnsville on Thursday, killing two construction workers, the State Patrol said Friday. “We don’t believe excess speed was a factor,” said Lt. Eric Roeske of the Minnesota State Patrol. But many questions remain about

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Jodi Rajkowski, of St. Joseph, said Friday she hopes drivers will learn from the accident that killed her husband, Ron. “This instance should make people stop and think.”
Distracted Driving Behavioral Factors Not Typically Identified by Traffic Professionals

Increased Reaction Time

- Hick’s Law predicts that reaction time increases with the number of reaction time choices.

- The additional sources of visual stimulation with a traffic stop or work zone may increase driver reaction time.
Hick’s Law

Figure 4-5. Choice reaction time as a function of the number of stimulus-response alternatives. (Data from Merkel, 1885, as cited by Woodworth, 1938.)
Distracted Driving Behavioral Factors Not Typically Identified by Traffic Professionals

Attention-Arousal Interaction

• Definition --- A drop in the ability of subjects to maintain focused attention under conditions of high arousal (Schmidt, 1988).

• Traffic safety stops or work zones may tend to encourage higher levels of arousal on the part of approaching motorists, accompanied by a reduced ability to sustain focused attention on critical features in the visual field, such as a work zone worker or a law enforcement or traffic assist vehicle stopped on the roadway shoulder.
Distracted Driving Behavioral Factors Not Typically Identified by Traffic Professionals

Inattentional Blindness

• Definition --- Detection of an unexpected object drops with increasing distance of that object from the spatial focus of attention (Most, et al., 2000).

• Example: Gorilla suit experiment of Simons and Chabris (1999).

• With a TSS or a work zone, an approaching motorist may focus attention on warnings, resulting in inattentional blindness for the TSS vehicle of officer, or for a work zone worker.
Distracted Driving Behavioral Factors Not Typically Identified by Traffic Professionals

Steering in the Direction of Gaze

- Gaze direction appears to bias steering direction.

  - Principal aim of study was to examine impact of gaze fixation on steering around a bend.
  - Steering behavior reflected gaze behavior, in that oversteer was most prominent when gaze was directed most toward the inside of the bend.
  - This suggests a direct link between the direction of gaze and the direction of steering.
Figure 11. The proportion of time spent in each region of the road when fixating each road location. There are 10 zones across the 3-m road and 18 zones across the road. The four center zones, two either side of the (invisible) centerline are 0.1875 m wide; all other zones are 0.375 m wide. As the task was to steer as close to the centerline of the road as possible, small zones (particularly around the centerline) provide a sensitive measure of accuracy. The “fixation” labels of bars representing tangent point fixation are highlighted in red.
Conclusions

• The foregoing analysis delineates a series of behavioral substrates of distracted driving that may contribute to TSS and work zone crashes.

• Each particular TSS or work zone embodies somewhat different design features and conditions.

• The idea of context specificity assumes that different modes and patterns of variability in driver behavior therefore will be associated with different TSS or work zone crashes.

• Experience with TSS and work zone crashes supports this assumption --- the pattern of variability in the behavior of a given driver during interaction with a given stop or zone cannot necessarily be predicted in advance.
Conclusions (continued)

• Developing a unified explanatory framework for understanding TSS and work zone crashes probably represents an unrealistic expectation.

• Delineating the nature and extent of factors contributing to such crashes likely can benefit from broad, multi-factorial human factors perspective.

• “Concrete information about specific roadside locations; vehicle, highway, and officer characteristics; and the precise circumstances of reported deaths, injuries, near misses, and property damage will be required before definitive solutions can be recommended.” (Ashton, 2011)
Future Research Needs

• Emphasize a systematic, data-driven strategy for investigation of how and why TSS and work zone crashes occur.

• Develop a TSS and Work Zone Crash checklist in support of this strategy.
## Proposed Outline for a TSS and/or Work Zone Crash Checklist

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<th>Category of Factors Contributing to Crash</th>
<th>Factor Involved in Crash?</th>
<th>Comments</th>
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Questions?