Background

- Over 96,000 US work zones crashes (2015)
- 700 fatalities (2.0% of all roadway fatalities)
- 120 worker fatalities annually
  - 46% are struck by vehicle
- Most common type is rear end
- Common causes: following too closely, FTY, driver inattention, too fast for condition, improper lane change
Background

- Work zone crashes not well understood
- NDS data collected by SHRP2 Program offers a rare opportunity for a first-hand view of work-zone safety critical and base events

SHRP 2 Naturalistic Driving Study

- Largest naturalistic driving study ever undertaken
- 2,900 drivers, all age/gender groups
  - Most participants 1 to 2 years
- 3,900 data years; 5 M trip files; 32 M vehicle miles
- 2 years of data collection
- Vehicle Types: All light vehicles
- Six data collection sites
- Integration w/ detailed roadway information
Data Acquisition System

- Video cameras
  - Forward roadway
  - Rear
  - Driver face
  - Over shoulder
- Accelerometers
- GPS

Vehicle network information

Vehicle Kinematic Data

Represents vehicle position at 0.1 sec increments
Roadway Information Database

- 4 different data sources
  - ESRI: baseline data for entire country
  - State roadway inventory data: from 6 study states; data vary by state; about 200,000 miles
  - Mobile van data: very detailed, 12,542 centerline miles; 43,195 intersections, 518,570 signs; includes forward video
  - Supplemental data: from 6 study states, data vary by state

Objectives

- Project funded under FHWA Implementation Assistance Program in conjunction with the Minnesota DOT
- Develop relationship between speed and work zone and driver characteristics
  - Identify driver/work zone characteristics associate with safety critical events in work zone
  - Speed is used as a surrogate for crashes
    - Few crashes
    - Other surrogates such as lane position not reliable
- One of several analyses (also evaluating reaction point, merge behavior, and back of queue)
Identification of Work Zones

Identified potential WZ using 511 data (e.g., “construction”, “lane closure”) > 2 million records

* Linked 511 events to RID; select WZ > 3 days
* Requested # potential trips (9,290 work zones)

* Selected WZ ≥ 15 trips (1,680)
  * Reviewed forward video for (~ 700) to ensure active work zone was present

* Requested time series/forward video for subset (118 work zones)
  * Received ~ 4,800 time series traces (multi-lane, 4-lane, 2-lane)

* Identified additional 145 work zones (2 and 4-lane)
  * 2nd data request in progress
**Data Utilized**

- 4-lane divided roadways (speed limit 45 to 55 mph)
- 82 time series traces
- 14 unique work zones with lane closures
- 60 unique drivers
- Location (GPS) provided at 1 second interval
- Times series traces (0.1 second interval)
- Related vehicle position to work zone features

**Data Reduction**

- Environmental characteristics (forward video)
- Regular roadway characteristics (RID)
  - i.e. # lanes, median type, traffic control, speed limit, shoulder type
- Driver characteristics
  - Static from NDS database (i.e. age)
  - Reduced distraction and glance location
**Data Reduction**

- Work zone characteristics
- Reduced from NDS forward video
  - VMS
  - # lanes closed
  - WZ speed limit
  - type of lane shift
  - Shoulder/lane closures
  - lane shift
  - Start/end work zone
  - head to head traffic
  - work zone signs (static and dynamic)
  - Presence/location of workers/equipment
  - Location and type of barriers

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**Signs**

- Assumed legibility distance for signs
  - 600 ft. for VMS, DSFS
  - 450 ft. for work zone speed limit
  - 180 ft. for static
  - Based on expected sign size and letter height
  - Worked with human factors expert
- Still need to account for impact of multiple signs
Speed Prediction Model

- Linear mixed effects model (LME)
- Used lme4 in R
- Used time series intervals as observations
- Accounted for multiple observations
  - Driver
  - Work zone
- Accounted for distance in relationship to work zone
- Goodness of fit evaluated using AIC and BIC
- Model included variables significant at 95%
- Modeled speed as a function of
  - Location within work zone
  - Driver characteristics
  - Work zone characteristics

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</table>
Summary of Findings

- **Signing**
  - No impact of first work zone sign
  - -2.0 mph for VMS
  - Decrease at static lane merge (-3.5 mph)

- **Driver Characteristics**
  - Speed negatively correlated with age
  - -0.6 mph lower when driver glance is on roadway task
  - 0.7 m/s higher when interacting with cell phone
  - Lower for other types of distraction (interacting with in-vehicle controls, eating/smoking, interacting with passenger)

- **Work zone configuration (compared to shoulder closure)**
  - Head to head: -10.2 mph slower
  - Right lane/shoulder closer: -12.5 mph slower
  - Left lane/shoulder closer: -0.2 mph slower
Summary of Findings

- Channelizing device (compared to cones)
  - Concrete + cones: -3.0 mph
  - Barrels: -0.7 mph
  - Vertical panels: -1.8 mph
  - Concrete barrier + barrels: -2.0 mph
- Location
  - Begins to decrease ~500 m upstream
  - Levels out ~500 m downstream

Limitations/Challenges

- Significant data reduction
- Difficult to read work zone signs from video
- Work zones are complex environments
- Need to account for impact of multiple work zone devices
- Sample size (results are from interim model)
- Develop machine visioning techniques to identify and extract work zone features
Next Steps

- Significant data reduction
- Need to account for impact of multiple work zone devices
- Sample size (results are from interim model)
- Develop models for additional work zone types
  - 2-lane
  - Multi-lane