University of Missouri

Driver behavior in Work Zones - Assessing Crash Risk using Naturalistic Driving Study Data

Alabama DOT Pre-Construction Conference, May 2021

Praveen Edara, Ph.D., P.E., PTOE
Department Chair and Professor
MU Civil and Environmental Engineering

Work Zone Safety

- Work zone crashes continue to be a concern
  - 842 fatalities and 135 worker fatalities (in 2019)
  - 123,000 total crashes and 45,000 injuries (in 2018)
    (Source: National WZ Safety Clearinghouse)

- Traditional work zone safety research
  - Reliance on crash reports to study effect of geometrics, traffic control
  - Driver behavior effects inferred indirectly from crash reports

- SHRP 2 Naturalistic Driving Study data provides a new avenue to understand work zone safety
  - Vehicle, driver, roadway, and environment variables

Study Objectives

FHWA SHRP2 BAA Project (2016-2020)

Phase 1

1. Develop new methods, algorithms, and visualization techniques to analyze SHRP 2 Safety data related to work zones
2. Conduct crash risk and severity analysis for work zone events
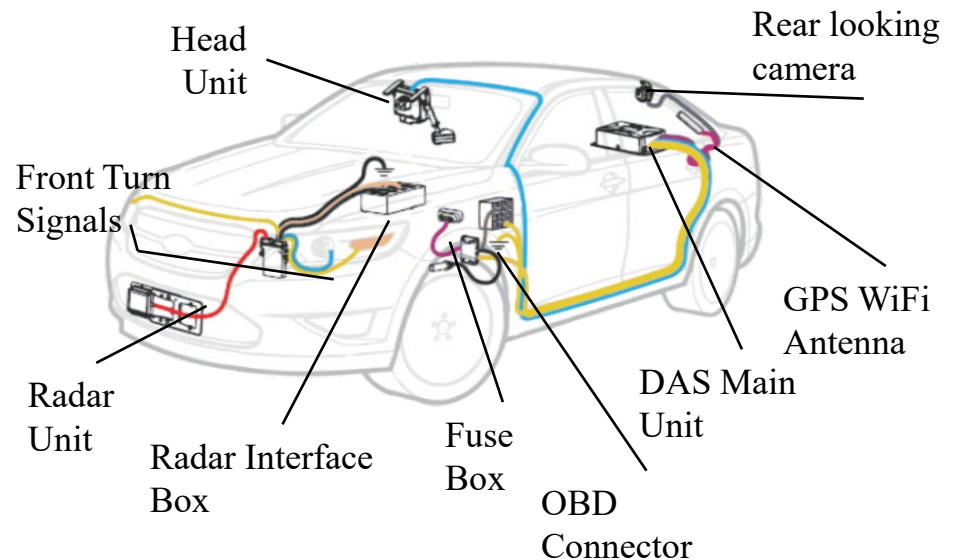3. 3D crash recreation in a virtual environment

Phase 2

1. Implement crash risk prediction models from Phase 1
2. Develop a user-friendly tool to estimate crash risk in work zones
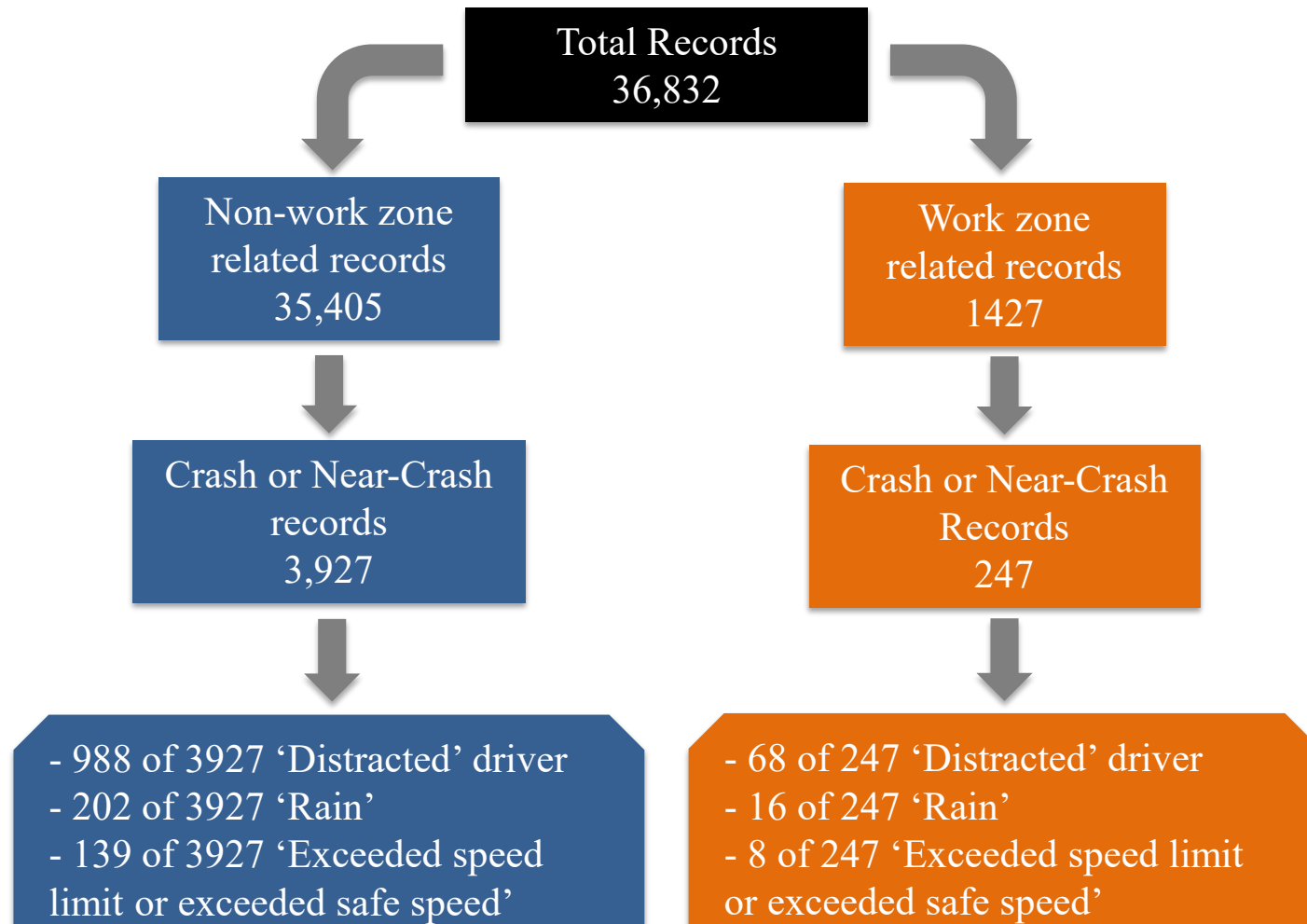
SHRP2 NDS Data

Naturalistic Driving Study (NDS)

- **3,542 instrumented vehicles**
- 32.5 million vehicle miles
- 1.5 Petabytes of data
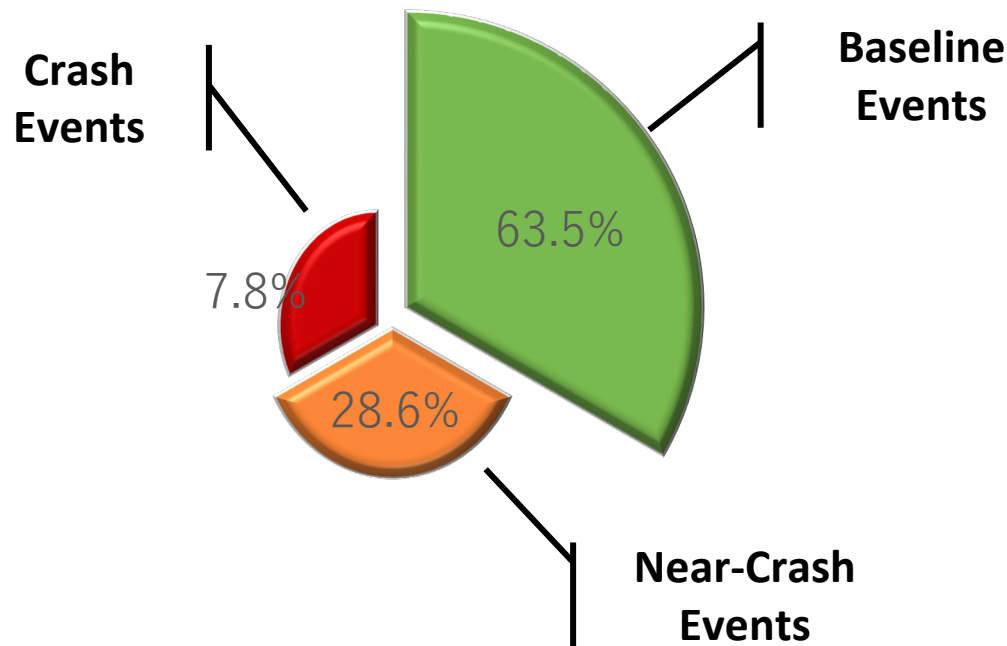- 6 states, 3 years data
- **~4,000 crashes and near-crashes**

Source: InSight database (VTTI)

Work Zone Data in NDS

Total Records
36,832

Non-work zone related records
35,405

Work zone related records
1427

Crash or Near-Crash records
3,927

Crash or Near-Crash Records
247

- 988 of 3927 'Distracted' driver
- 202 of 3927 'Rain'
- 139 of 3927 'Exceeded speed limit or exceeded safe speed'

- 68 of 247 'Distracted' driver
- 16 of 247 'Rain'
- 8 of 247 'Exceeded speed limit or exceeded safe speed'

5

Safety Critical Events in NDS

Crash Events — 7.8%

Baseline Events — 63.5%

Near-Crash Events — 28.6%

✓ *699 total observations*

Research Results

1. Crash causation in work zones – insights from analyzing NDS data

2. Predicting a crash using pre-crash driver and environment variables

3. Recreating 3D crash animations for public education, outreach and countermeasure development

4. Implications for countermeasure development

A better understanding of WZ crash causation

➢ **Logistic regression** to develop prediction model for safety critical events in work zone

➢ A dichotomous variable was created by combining crash and near crash (CNC) as one response and baseline as the other

➢ Explanatory variables

  o *Duration of secondary task*
  o *Driving behavior*
  o *Traffic density*
  o *Locality*
  o *Traffic control*
  o *Lighting conditions*

Odds of a crash happening in a work zone

Risk Factors	Categories	Odds Ratio (95% CI in parenthesis)
Duration of secondary task	>6 secs vs. 0-6 secs	5.46 (3.02-9.87)
Behavior	Violation vs. None	11.91 (4.09-26.45)
	Mistake vs. None	12.63 (2.39-54.30)
	Inattention vs. None	29.06 (11.05-75.64)
	Inexperience vs. None	17.39 *
Traffic density	LOS B vs. LOS A	1.75 (1.12-2.76)
	LOS C vs. LOS A	6.14 (2.939-12.84)
	LOS D vs. LOS A	7.43 (2.30-23.99)
	LOS E vs. LOS A	3.74 (0.61-22.74)
	LOS F vs. LOS A	2.95 (0.25-33.81)

Predicting event outcomes

- Two scenarios for classification algorithm

Scenario	Object	Input Variables
Case-I	Crash/Near-Crash, vs. Baseline events	22 driver characteristics + 35 pre-incident variables
Case-II	Crash, vs. Near-Crash events	22 driver characteristics + 64 pre-incident variables

- Selected pre-event variables for model development

Input Variables	Selected variables
Driver characteristics	sex, ageGroup, educ, wrkStat, income, milesLstYr, annualMiles, yrsDriving, numViol, violTypes, numCrash, crash1Sev, crash1Flt, crash2Sev, crash2Flt, crash3Sev, crash3Flt, crash4Sev, crash4Flt, crash5Sev, crash5Flt
35 pre-incident variables	eventStart, preIncidentManeuver, maneuverJudgment, driverBehavior1, driverBehavior2, driverBehavior3, driverImpairments, frontSeatPassengers, rearSeatPassengers, secondaryTask1, secondaryTask1StartTime, secondaryTask1EndTime, secondaryTask1Outcome, secondaryTask2, secondaryTask2StartTime, secondaryTask2EndTime, secondaryTask2Outcome, secondaryTask3, secondaryTask3StartTime, secondaryTask3EndTime, secondaryTask3Outcome, handsOnTheWheel, driverSeatbeltUse, lighting, weather, surfaceCondition, trafficFlow, trafficDensity, trafficControl, relationToJunction, intersectionInfluence, alignment, grade, locality
64 pre-incident variables	[35 pre-incident variables] + visual obstruction, vehicle contributing factors, precipitating event, evasive maneuver, subjectReactionStart, impactProximity, eventEnd, vehicle1SubjectConfig, vehicle2Config, vehicle3Config, eventNature1, incidentType1, vehicle1EvasiveManeuver1, vehicle1PostManeuver1, eventNature2, incidentType2, vehicle1EvasiveManeuver2, vehicle1PostManeuver2, infrastructure, numberOfOtherMotorists, numberOfObjectsAnimals, fault, motorist2Location, motorist2Type, motorist2Maneuver, motorist2Reaction, motorist3Location, motorist3Type, motorist3Maneuver

Prediction Accuracy

Case-I			Case-II		
Random Forest	t-SNE	Naïve	Random Forest	t-SNE	Naïve
92.6%	89.4%	62.3%	88.9%	62.5%	70.8%

Five most important variables for prediction

Case-I	Case-II
secondaryTask3Outcome	vehicle1EvasiveManeuver1
driverBehavior1	eventNature1
preIncidentManeuver	motorist2Reaction
yrsDriving	incidentType1
milesLstYr	subjectReactionStart

Prediction Tool Development
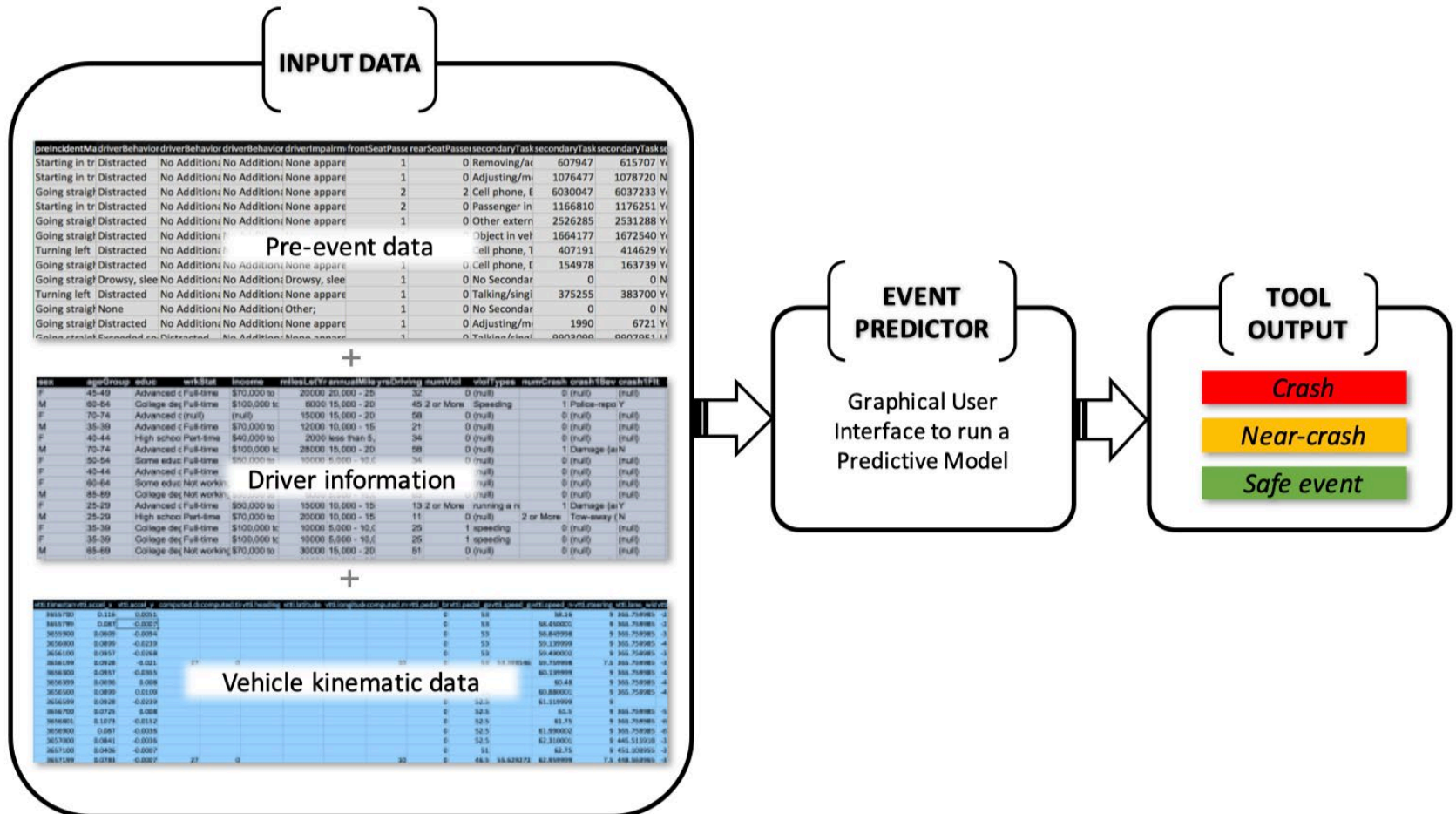
Figure 1. Framework of the PREMONITION Tool

PREMONITION Tool

PREMONITION : Prediction Model using Naturalistic Incident Information

This tool allows a user to proactively predict the occurrence of a safety critical event based on certain pre-event behavior and driver characteristics

1. MODEL SELECTION   2. PRE-EVENT DATA ▾   3.DRIVER INFORMATION ▾   4. PREDICTION OUTCOME

What kind of PREMONITION model do you want to try?

Plesae select a model from below:

⦿ WORK ZONE Model
○ NON-WORK ZONE Model
○ YOUNGER DRIVER Model

PREMONITION Interface

- **Interface under R plus Shiny library (open source)**

Interface features – input data

- **Interface under R plus Shiny library (open source)**

Tool, tutorial, and source code

- PREMONITION Tool – https://ycanns.shinyapps.io/app-1/

- Step by step tutorial –
  https://youtu.be/uC-uml-Mmr4

- Source Code -
  https://github.com/ycanns/SHRP2NDS/blob/master/Case_I_II_rf_prediction.r

3D Recreation of a Work Zone Crash

- Successfully tested 3-step workflow to capture crash videos into a simulation engine

- Developed interactive visualizations that provide a sanitized 3D visualization of the event

- 3D recreation allows training simulations and countermeasure development
  - Assessing in-vehicle warnings, messages via DMS using a driving simulator
  - Driver education and public safety announcements

Countermeasures

1. Driver behavior in work zones
   - Violations (e.g. speeding), inattention (e.g. distracted driving) found to significantly increase crash risk in work zones
   - Potential countermeasures: active/passive law enforcement presence, speed management, public education, and traffic laws against distracted driving, speeding
2. Traffic density in work zones
   - Level of service C/D threshold for spike in crash risk
   - Threshold to deploy smart work zone systems (e.g. queue warning)
3. Driver assistance systems and TMC applications
   - PREMONITION tool can be used for making real-time prediction of crash risk

Countermeasures

4. Crash animations/simulations can be used for public outreach and countermeasure evaluation

    - Use of Virtual Reality tools (headsets, simulators, etc)

    - e.g., Missouri and Texas are using virtual reality for work zone inspection training

5. Crash modification factors (CMFs) extremely lacking for work zones

    – Odds ratios derived in the study akin to CMFs

Q&A

Contact information

Praveen Edara, Ph.D., PE

edarap@missouri.edu

Ph: (573) 882-1900

Acknowledgments

FHWA staff
- Charles Fay (Project Manager)
- Yusuf Mohamedshah

Iowa State (RID)
- Shauna Hallmark
- Omar Smadi

Virginia Tech Transportation Institute (NDS)