Arizona
Work Zone and Incident Electronic Notification System

May 9, 2019
NOCoe Peer Exchange - WZ Demo
Project Goals and Objectives

• **Goals**
  1. Improve safety in work zones on freeway and freight corridors
  2. Improve traffic flow and reduce congestion on freeways and freight corridors due to work zones

• **Objectives**
  1. Develop and demonstrate a Work Zone warning and alert system using connected vehicle technologies (5.9 GZ DSRC communications) to provide in-vehicle information for commercial vehicle operators.
  2. Develop and demonstrate the use of connected vehicle systems, including variable speed limits, queue warning, lane closure warning, and vehicle-to-vehicle messages to augment the operation of core CVISN capabilities (e.g. electronic credentialing and enforcement).
Current Work Zone Systems

Equipment/Hardware

- Cones
- "End of Work Zone" Signage
- Speed Limit Sign
- Additional Signage
- Nighttime Lighting
- Protective Barriers
- Construction Equipment
- Aggregates/Raw Materials

Equipment/Hardware

- Cones
- Orange Barrels
- Other Channelizing Devices
- Arrow Boards
- Portable DMS
- Flashing/Oscillating/Strobe Lights

Equipment/Hardware

- Flashing/Oscillating/Strobe Lights
- Flags
- Portable DMS

# ITS/Smart Work Zones

<table>
<thead>
<tr>
<th>ITS Technology</th>
<th>Use and Benefit</th>
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<tr>
<td>Field Sensors and Video</td>
<td>Traffic Volumes, Traffic Flow</td>
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<tr>
<td>Vehicle and On-Board Sensors (via DSRC)</td>
<td>Traffic Speeds, Queue Locations, Hard Braking</td>
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<tr>
<td>Wired and Wireless Communications</td>
<td>Transmit/Receive Data for Processing, Dissemination, and Roadside Use</td>
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<tr>
<td>Field or TMC Software</td>
<td>Process, Analyze, and Visualize WZ Performance Data</td>
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<tr>
<td>Electronic Equipment (e.g., Dynamic Message Signs, DMS)</td>
<td>Disseminate Processed Data and Information for Traveling Public and Agencies</td>
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# Comparison of Work Zone Control Systems

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<tr>
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<th>Traveler Information</th>
<th>Queue Warning</th>
<th>Lane Merge</th>
<th>Incident Detection</th>
<th>Speed Limit</th>
<th>Automated Enforcement</th>
<th>Entering/Exiting Vehicle Notification</th>
<th>Performance Measurement</th>
<th>In-Vehicle Signage and Alerts</th>
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<tr>
<td><strong>Traditional Work Zone</strong></td>
<td>Static</td>
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<td>Signs</td>
<td>Traveler and Personnel Report</td>
<td>Fixed</td>
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<td>Recordsa</td>
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<td><strong>Smart Work Zone</strong></td>
<td>Real-Time</td>
<td>Fixed Points</td>
<td>Signs, Dynamic Fixed Points</td>
<td>Fast Detection</td>
<td>Variable, Fixed Point, CMS</td>
<td>Capture Images</td>
<td>CMS Warnings</td>
<td>Sensor based</td>
<td>511, WAZE, Google..</td>
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<td><strong>Connected Vehicle Work Zone</strong></td>
<td>Real-Time</td>
<td>Continuous</td>
<td>Dynamic, In-Vehicle Info, Continuous</td>
<td>Vehicle Based Detection</td>
<td>Variable, Vehicle Based</td>
<td>V2V Alerts</td>
<td>Vehicle Based</td>
<td>Direct: Visual, Auditory, Haptic Messages and Alerts</td>
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## CVWZ Stakeholders

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<th>Gov’t/Agency Stakeholder</th>
<th>Other Stakeholder</th>
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<td>Owner (DOT)</td>
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<td>Roadway Operator (TMC)</td>
<td>Highway Patrol (AZ DPS)</td>
<td>Freight (CMV) Operator</td>
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<td>WZ Traffic Management Plan (TMP) Lead</td>
<td>Firefighters</td>
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<td>Construction Worker</td>
<td>EMS / EMT</td>
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<td>Bicyclists</td>
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<td>ADOT, MCDOT (RADS)</td>
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<td>Transit Provider(s)</td>
<td>Valley Metro</td>
<td>Utility Suppliers</td>
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ADOT
Concept for the Proposed System
INFORM

- Allows driver to find alternative routes to avoid work zones
- Uses data from
  - MCDOT Road Closure and Restriction System
  - ADOT AZ511
  - Common Source: RADS

- External to the CVWZ System of Interest
• Driver is notified of a work zone in the roadway
• Information about
  • Lane Closures
  • Real-Time Traffic Conditions
  • Speed Limit
• Connected Vehicle System Components
  • MAP
  • TIM – Traveler Information Message
  • RSA – Roadside Alert Message
ALERT

- Driver can be alerted to hazardous conditions
- Based on Traffic Data and Vehicle Decisions

Alert Conditions
- Merge Warning (late merge)
- Speed Warning (exceeding speed)
• **V2V Events**
  • Construction Vehicle Entering Roadway

• **Vehicle Based Warning**
  • A vehicle in the work zone has a heading that intersects the current lane and is in the Drive gear
Connected Work Zone Software Toolchain

Work Flow and Current Progress

Niraj Vasant Altekar

04/15/2019
Work Flow (2)
Data Collection on 03/28/2019
33.435425, -112.293444 to 33.437068, -112.225599

- MC85/S-107th Avenue to MC85/S-75th Avenue (4.0 Miles)
- One Round Trip (12:00PM – 01:00PM)
- Data Captured: (.csv)
  - GPS waypoints, lane closures, presence of workers, locations of RSUs
Data Collection on 03/28/2019
33.435425, -112.293444 to 33.437068, -112.225599

- Data collected in (.csv) format
- # of Data Points: 4641

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# Work Zone Configuration

## CAMP V2I-SA Work Zone Configuration v1.0

### Work Zone Configuration Files
- Select Config File
- Save Config File
- Select Vehicle Path Data File

### Work Zone Information
- **Work Zone Description**: MC89_0219
- **Lane Information**
  - Number of Lanes (1-9)
  - Vehicle Path Data Lane (1-9)
  - Lane Width (m)
  - Approach Lane Padding (m)
  - Work Zone Lane Padding (m): 0.0
- **Speed Limits (5.80 mph)**
  - At Start of WZ: 40
  - At Ref. Point (Start of WZ): 40
  - When Workers are Present: 30

### Work Zone Schedule
- **Start Date (YYYY-MM-DD)**: 2019-01-26
- **End Date (YYYY-MM-DD)**: 2019-01-26
- **Days of Week**
  - Sun, Mon, Tue, Wed, Thu, Fri, Sat
- **Start Time (HH:MM)**: 00:00
- **End Time (HH:MM)**: 23:59

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**ADOT**

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**Maricopa County**
Map Builder - Info

--- Processing Input File:
C:/Users/nvaltekar/Desktop/Unsorted/RSZW Mapping Tool Chain/RSZW Mapping Tool Chain/CAMP WZ Mapping Software
Total input lines: 4640

--- Start of Work Zone at Data Point: 11
Reference Point @ 33.435444999999994, -112.293603999999999, 301.6

--- Mapped Approach Lanes: 18 meters
--- Mapped Workzone Lanes: 6404 meters

--- Start/End of lane closure offset from the reference point ---
Start of lane: 2 closure at data point: 2214 Offset: 2995 meters
End of lane: 2 closure at data point: 4621 Offset: 6338 meters

--- Start/End of workers present offset from the reference point ---
Start of workers present @ data point: 1097; Offset: 710 meters
End of workers present @ data point: 1110; Offset: 750 meters
Start of workers present @ data point: 3454; Offset: 4502 meters
End of workers present @ data point: 3575; Offset: 4627 meters
Start of workers present @ data point: 4052; Offset: 5397 meters
End of workers present @ data point: 4174; Offset: 5603 meters
Start of workers present @ data point: 4225; Offset: 5691 meters
End of workers present @ data point: 4235; Offset: 5707 meters

--- Total Nodes per Lane: 48
Total Nodes per Approach Lane: 2
Total Nodes per Work Zone: 46
Total message segment(s): 1
Nodes per Message Segment: 50

--- Message segment list: [[1, 50], [1, 1, 2], [1, 1, 46]]

--- Done Building WZ MAP and Visualizer...
Map Visualizer
Range Testing of RSU for Freeway Applications

Debashis Das
04/12/2019
• The RSU hardware used for Range testing was supplied by Savari, Inc. and is called the StreetWave unit.

• There are other manufacturers of RSUs – Cohda, Leer, etc.
Onboard Unit (OBU)

- Onboard Unit (OBU) is a hardware device that is deployed on the vehicle to exchange messages with the RSU based on the SAE J2735 standard using the Dedicated Short Range Communications (DSRC) standards.
- The OSU hardware used for Range testing was supplied by Savari, Inc. and is called Savari MobilWave units.
DSRC Radio

• The following figure demonstrates the V2V and V2I Communication via DSRC radio.

Source: https://www.researchgate.net/publication/287406124_Sensing_Traffic_Density_Combining_V2V_and_V2I_Wireless_Communications/figures
Basic Safety Message (BSM)

- The Basic Safety Message (BSM) is transmitted 10 times per second from an OBU. A BSM message has two parts:
  - BSM Part 1:
    - Contains the core data elements (vehicle size, position, speed, heading acceleration, brake system status)
  - BSM Part 2:
    - Contains a variable set of data elements drawn from many optional data elements.
- The BSM is transmitted over DSRC has a minimum range of 300 meters. Experience has shown that this range can be as much as 1,000 meters.
Range Testing Objective

• Locate an RSU at a candidate installation location in the field
• Drive a vehicle with an OBU that is broadcasting BSMs along the roadway segment
• Received the BSMs on the RSU at the candidate location when the vehicle is in the range of the RSU
• Evaluate the range and roadway coverage of the RSU at the candidate location.
Test Procedure – Location 1

- RSU was mounted near the DMS of freeway of west I-10 at Location-1.
Test Procedure - Location 1

- RSU was mounted near the DMS of freeway of west I-10 at Location-1.
Test Procedure – Location 2

- RSU was mounted near junction of 67 Ave and west I-10 at location-2.
Test Procedure – Location 2

- RSU was mounted near junction of 67 Ave and west I-10 at location-2.
Data Collection

- After mounting the RSU, a python script was run to collect and store all the received BSMs in the external computer (Computer-1).
- More than three thousand BSMs were received by the RSU at each location.

![Figure: Received BSMs](image-url)
All the collected BSMs were decoded by using the MMITSS J2735 library to obtain the GPS points from each BSM.

<table>
<thead>
<tr>
<th>Vehicle ID</th>
<th>Latitude</th>
<th>Longitude</th>
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<th>Speed(kmh)</th>
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Google Earth Plot

- The KML file is viewed in Google Earth Pro.
- Point A denotes the location of the RSU at location-1 and all yellow marks indicates the vehicle location.
Google Earth Plot

- The KML file is viewed in Google Earth Pro.
- Point A denotes the location of the RSU at location-2 and all yellow marks indicates the vehicle location.
Analysis: Location-1

- For the westbound approach, the RSU can receive the BSMs from a distance approximately 480 meter to the east and 930 meter to the west.
- For the eastbound approach, the RSU can receive the BSMs from a distance approximately 600 meter to the east and 450 meter to the west.
Analysis: Location-2

- For the westbound approach, the RSU can receive BSMs from a distance approximately 850 meter to the east and 500 meter to the west.
- For the eastbound approach, the RSU can receive BSMs from a distance approximately 1100 meter to the east and 400 meter to the west.
Concept for the Proposed System

Inform | Aware | Alert | Warn

RSU Message

Event or Incident Location

In-Vehicle Systems
- In-Vehicle Display
- Vehicle Processor

OBU

Infrastructure Transportation Management System

CVISN Enforcement Systems

Fleet Management System Routing/Dispatching

ADOT

Maricopa County
SAMPLE HEADER

• Questions and Discussion
  • Demonstration