WORK ZONES OF THE FUTURE

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Overview of Presentation

• 2012 Work Zone Fatalities
• Work Zone of Today
• Work Zone of the Future
2012 Work Zone Fatalities

- Texas ranked #1 in work zone fatalities
- Twice as many work zone fatalities as next highest state (California)

<table>
<thead>
<tr>
<th>Rank</th>
<th>State</th>
<th>Not in Work Zones</th>
<th>In Work Zones</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Texas</td>
<td>3,273</td>
<td>125</td>
<td>3,398</td>
</tr>
<tr>
<td>2</td>
<td>California</td>
<td>2,790</td>
<td>67</td>
<td>2,857</td>
</tr>
<tr>
<td>3</td>
<td>Florida</td>
<td>2,373</td>
<td>51</td>
<td>2,424</td>
</tr>
<tr>
<td>4</td>
<td>Pennsylvania</td>
<td>1,289</td>
<td>21</td>
<td>1,310</td>
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<tr>
<td>5</td>
<td>North Carolina</td>
<td>1,281</td>
<td>11</td>
<td>1,292</td>
</tr>
<tr>
<td></td>
<td>All States</td>
<td>32,952</td>
<td>609</td>
<td>33,561</td>
</tr>
</tbody>
</table>
Work Zones of Today

- Mobility coordination
- Work zone capacity and delay estimation
- Work zone safety / traffic control
- Smart work zones
- Human factors
- ITS
- Corridor operations / prediction
Temporary Rumble Strips

• 2012 TxDOT Standard
• Used on
  • One-lane, two-way flagging operation
  • Lane closures
  • 70 mph or less
End of Queue Warning System

- **LANE CLOSED AHEAD:**
  - 67 mph
  - 66 mph
  - 65 mph
  - 63 mph
  - Speed Sensors
  - 3 miles

- **TRAFFIC SLOWS 3 MILES**
  - 64 mph
  - 62 mph
  - 57 mph
  - 42 mph
  - Speed Sensors
  - 2 miles

- **STOPPED TRAFFIC 2 MILES**
  - 64 mph
  - 52 mph
  - 31 mph
  - 25 mph
  - Speed Sensors
Construction Delay Forecast System

- Provide predictive estimates of expected delay
- Based on expected arrival time in work zone
- Disseminate at key decision points
- Automated updates based on measured conditions
Work Zones of the Future

• Connected vehicles
  • More availability of traveler information
  • Personal warning devices individual workers
  • Improved alert and warning devices directly in-vehicle

• Automated/autonomous vehicles
  • Automated acceleration/deceleration
  • Automated platooning
Connected Vehicles

Vehicle-to-Vehicle (V2V)  Vehicle-to-Infrastructure (V2I)

CONNECTED VEHICLES GOALS
✓ Improve Safety
✓ Improve Mobility
✓ Improve Environment
V2V Safety Applications

- Approaching Emergency Vehicle Warning
- Blind Spot Warning
- Cooperative Adaptive Cruise Control
- Cooperative Collision Warning
- Cooperative Forward Collision Warning
- Cooperative Vehicle-Highway Automation System
- Emergency Electronic Brake Lights
- Highway Merge Assistant
- Lane Change Warning
- Post-Crash Warning
- Pre-Crash Sensing
- Vehicle-Based Road Condition Warning
- Vehicle-to-Vehicle Road Feature Notification
- Visibility Enhancer
- Wrong Way Driver Warning
- Do Not Pass Warning
- Intersection Movement Assist
- Control Loss Warning
V2I Safety Applications

- Blind Merge Warning
- Curve Speed Warning
- Emergency Vehicle Signal Preemption
- Highway/Rail Collision Warning
- Intersection Collision Warning
- In-Vehicle Amber Alert
- In-Vehicle Signage
- Just-In-Time Repair Notification
- Left Turn Assistant
- Low Bridge Warning
- Low Parking Structure Warning
- Pedestrian Crossing Information at Intersection
- Road Condition Warning
- Safety Recall Notice
- SOS Services
- Stop Sign Movement Assistance
- Stop Sign Violation Warning
- Traffic Signal Violation Warning
- **Work Zone Warning**
Intelligent Network Flow Optimization (INFLO)

**Speed Harmonization**

1. Vehicles slowing down at recurrent bottleneck broadcast speed, location, etc.
2. Traffic Management Center identifies impending congestion and initiates speed harmonization plan for upstream vehicles.
3. TMC relays appropriate speed recommendations to upstream vehicles.
4. Upstream vehicles implement (or alert drivers to) the recommended speed.

**Queue Warning**

1. Queue condition forms.
2. Vehicles broadcast their rapid changes in speed, acceleration, position, etc.
3. Host Vehicle receives data and provides driver with imminent queue warning.
4. Driver provided sufficient time to brake safely, change lanes, or even modify route.

**Cooperative Adaptive Cruise Control**

**Without CACC:**
- Irregular braking and acceleration
- Longer headways
- Lower throughput
- Risk of rear-end collisions

**CACC Enabled:**
- Coordinated speeds
- Minimized headways
- Higher throughput
- Reduced rear-end collisions

- TMC observes traffic flow and adjusts gap policy to manage road capacity.
- TMC relays traffic information to vehicles.
- CACC-enabled following vehicles automatically adjust speed, acceleration, and following distance.
- Lead Vehicle broadcasts location, heading, and speed.

Source: Concept Development and Needs Identification for INFLO: Functional and Performance Requirements, and High-Level Data and Communication Needs
Front of Queue @ MP 132.2
Back of Queue @ MP 135.5
Queue Length = 3.3 miles
Average Speed in Queue = 15 mph
Rate of Growth of Queue = 30 mph
Direction of Queue Growth = Increasing

I’m at MP 134.2
I’m Queued

I’m at MP 134.2
I’m Queued

I’m at MP 135.2
ESTIMATED TIME TO CLEAR QUEUE = 12 MINUTES

I’m at MP 135.5
I’m Queued

Lane Closure at MP 132.2

I’m at MP 140.7
EXPECT STOPPED TRAFFIC IN 3 MINUTES

I’m at MP 136.7
STOPPED TRAFFIC 1.2 MILES AHEAD
SLOW TO 30 MPH
Connected Vehicle Merge Assist for Work Zones

Scenario A: Construction Vehicle Exiting Traffic Stream into the Work Zone

- Roadside Alert Message: Reduce Speed
- Roadside Alert Message: Merge Left
- Roadside Alert Message: Slow-moving-maintenance-vehicle

Activate DMS for non-equipped vehicles

Construction Truck Exiting to Work Zone

RSE for communicating with roadside devices

Scenario B: Construction Vehicle Entering Primary Traffic Stream from the Work Zone

- Roadside Alert Message: Reduce Speed
- Roadside Alert Message: Merge Left

Activate DMS for non-equipped vehicles

Construction Truck Entering from Work Zone

Roadside Alert Message: Slow-moving-maintenance-vehicle

RSE for communicating with roadside devices
### Connected vs. Automated vs. Autonomous

<table>
<thead>
<tr>
<th>Level</th>
<th>NHTSA Classification</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No-Automation</td>
<td>Driver complete and sole control</td>
</tr>
<tr>
<td>1</td>
<td>Function-specific</td>
<td>One or more specific control function automated. E.g., electronic stability control</td>
</tr>
<tr>
<td>2</td>
<td>Combined Function</td>
<td>At least two control functions work in unison. E.g., adaptive cruise control with lane centering</td>
</tr>
<tr>
<td>3</td>
<td>Limited Self-Driving</td>
<td>Driver cedes full control of all safety-critical function under certain conditions. Driver not expected to constantly monitor vehicle. E.g., Google Car</td>
</tr>
<tr>
<td>4</td>
<td>Full Self-Driving</td>
<td>All safety-critical functions and monitoring of roadway conditions performed by vehicle for entire trip</td>
</tr>
</tbody>
</table>

Source: NHTSA's Preliminary Statement of Policy Concerning Automated Vehicles
Implementation Challenges

• Dynamic nature of work zones
  • Lane closure start and end times
  • Changing geometric conditions
  • Communication “MAP” to connected vehicle

• Coordination between DOT and contractor staff
  • Maintaining accurate up-to-minute information
  • Additional equipment needs

• Human Factors
  • Driver acceptance of automated/autonomous vehicle
  • Expectation/reasonable of drivers performance
Questions ?