Worker Safety During Work Zone Setup and Removal

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Colorado DOT Research Objective(s)

• To obtain information about automated cone placement and retrieval technologies
• To make recommendations for best practices for automating the placement and retrieval of traffic cones.
Worker Hazards

• Being on foot in the path of an errant vehicle
  – If struck, likelihood of survival is low
• Lifting and lowering of TTC devices
  – Potential for injury to upper body
• Standing unrestrained on open platforms
  – Potential for falling
Research Questions

• Do the systems remove workers from the pavement?
• Do the systems require workers to manually lift and lower devices?
• Do the systems require workers to stand unrestrained on open platforms?
• How many workers are required to operate the system?
• How much do the systems cost?
Product Categories

• Fully-automated
• Partially-automated
• No automation (commercial trucks, trailers, & baskets)
• Pushing systems
• Transportation Agency fabricated
Fully-automated AutoCone 500
AutoCone 500 Features

• Increased capacity (holds 500 28-inch cones)
• Requires one worker (driver/operator)
• Place and retrieve cones from both sides
• Place and retrieve cones in forward or reverse
• Truck-mounted or trailer-mounted
• Recent mechanical improvements (gear box system, electric motor, etc.)
# Fully-Automated System(s)

<table>
<thead>
<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removes workers from pavement</td>
<td>Subject to mechanical breakdowns and cone jams</td>
</tr>
<tr>
<td>Reduces risk of upper body injuries to worker</td>
<td>May require workers to exit vehicle to troubleshoot problems</td>
</tr>
<tr>
<td>Eliminates need for workers to stand on platforms</td>
<td>Only accommodate one type of TTCD</td>
</tr>
<tr>
<td>Requires fewer workers to operate</td>
<td></td>
</tr>
</tbody>
</table>
Partially-Automated Systems

• J-Tech Dynamic Lift System (DLS)
• Epic Solutions Roadrunner System
J-Tech Dynamic Lift System (DLS)

• Designed for vertical panels
• Still requires worker to stand on platforms
• $40,000 to install (customer supplies chassis)
Epic Solutions Roadrunner System

• $35,000 to install (customer supplies truck)
• Sold through Royal Truck & Equipment
• System consists of cone setter and cone retriever
## Partially-Automated Systems

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<tr>
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<td>Subject to mechanical breakdowns</td>
</tr>
<tr>
<td></td>
<td>May require workers to exit vehicle to troubleshoot problems</td>
</tr>
<tr>
<td></td>
<td>Typically only accommodate one type of TTCD</td>
</tr>
</tbody>
</table>
Systems with No Automation

- Centreville Trailer Roadway Safety Trailer
- J-Tech Baskets
- Royal Truck Cone Safety Pattern Truck
- S.P.A. Safety System Cone Truck
Centreville Trailer Roadway Safety Trailer
J-Tech Baskets

• Large
  – 4 ft x 8 ft
  – $25,000 plus truck

• Small
  – 3 ft x 6.5 ft
  – $9,000
  – Mount on DOT pickup truck
Royal Truck Cone Safety Pattern Truck

$45,000 + chassis cab
S.P.A. Safety Systems Cone Truck

$60,000
# Systems with No Automation

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<tr>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removes workers from pavement</td>
<td>Requires workers to lower and lift TTCD manually</td>
</tr>
<tr>
<td>May accommodate several types of TTCD</td>
<td>Requires workers to stand on open platforms</td>
</tr>
</tbody>
</table>
Pushing Systems

- Artec Innovation Sidewinder ($100K)
- SCR Industries Barrel Picker Pro ($4K)
- Barrel Mover 5000 ($20K)
- Synergy Innovations Safety Shift ($8K)
# Pushing Systems

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<thead>
<tr>
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<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Removes workers from pavement</td>
<td>Requires setup and removal of TTCD by other means at beginning and end of project</td>
</tr>
<tr>
<td>Reduces risk of upper body injuries to worker</td>
<td></td>
</tr>
<tr>
<td>Eliminates need for workers to stand on platforms</td>
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<td>Requires fewer workers to operate</td>
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</table>
Transportation Agency Products

- Arizona DOT (ADOT) Cone Truck
- CalTrans Cone Truck
- Delaware DOT (DelDOT) Cone Trailer
- Minnesota DOT Cone Cart & Cage
- Missouri DOT Baskets
Transportation Agency Products

- North Texas Tollway Authority (NTTA) Traffic Control Trucks
- Ohio DOT Basket & MOT Truck
## Summary

<table>
<thead>
<tr>
<th>Automation Level</th>
<th>Addresses Workers on Pavement</th>
<th>Addresses Lifting</th>
<th>Addresses Workers Riding on Platforms</th>
<th>Number of Workers Required</th>
<th>Relative Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Full</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>1</td>
<td>High</td>
</tr>
<tr>
<td>Partial</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>2-3</td>
<td>Medium</td>
</tr>
<tr>
<td>None</td>
<td>✓</td>
<td></td>
<td></td>
<td>2-3</td>
<td>Low</td>
</tr>
<tr>
<td>Pushers</td>
<td>✓*</td>
<td>✓*</td>
<td>✓*</td>
<td>1</td>
<td>Varies</td>
</tr>
</tbody>
</table>

*may still be required at beginning and end of project.
Ohio DOT Research Objective

- Identify cost effective and safer alternatives to the current procedures used during single work shift maintenance operations.
Operations Observed

• 15 maintenance activities
  – 9 mobile
  – 6 stationary
• About ½ daytime and ½ nighttime
• Majority on high-speed freeways
• Majority single lane closures
Procedural Safety Enhancements

• Periodically pull over to allow traffic to pass convoy
• Do not park work vehicles in areas where drivers are merging
• Activate vehicle warning lights when located in travel lane or on the shoulder
• Make two passes to set dual advanced warning signs
• Ensure workers know how to space shadow vehicles
• Ensure workers know how to position advanced warning vehicles
Equipment Studied

• Modifying existing traffic control setup/removal equipment
  – Worker basket
  – Dedicated maintenance-of-traffic (MOT) truck
• Performance Class 3 apparel
• Personal task lighting
• Equipment-mounted task lighting
• Mobile barrier
Existing Equipment
Pickup with Lift Gate

- Worker in truck bed
  - Highest risk
  - Repetitive arm movement abduction
  - Outstretched arms
  - Bending
  - No fall protection

- Worker on lift gate
  - High to moderate risk
  - Trunk twisting
  - Side bending
  - Arm movement abduction
  - No fall protection

- Worker on pavement
Rack Truck with Lift Gate

- Similar risks as seen on pickup with lift gate
- Repeated shock from separating drums
- High to moderate risk stacking cones (75” high stack)
Pickup with Trailer
Addition of Worker Basket
Columbus MOT Truck
Cleveland MOT Truck
### Ergonomic Risk Comparison

<table>
<thead>
<tr>
<th>Worker Location</th>
<th>MOT Truck</th>
<th>Trucks with Lift Gates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Platform</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Lower Platform</td>
<td>Lower</td>
<td>Higher</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Worker Location</th>
<th>Truck with Basket</th>
<th>Trucks with Lift Gates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Platform</td>
<td>Equal (high)</td>
<td>Equal (high)</td>
</tr>
<tr>
<td>Lower Platform</td>
<td>Lower</td>
<td>Higher</td>
</tr>
</tbody>
</table>
Field Study

• Researchers measured the setup and removal rates for existing and proposed methods

• Findings
  – Pickup with lift gate slowest
  – Pickup with basket faster, but varied
  – Dedicated MOT trucks fastest
  – Overall no practical differences among methods
Summary

• Faster deployment reduces exposure time
• Consider automating the lifting process
• System designs may benefit from oversight by a qualified professional industrial engineer or ergonomic professional
• Be aware of the need to provide fall protection at all times
Reports

Automated Placement and Retrieval of Traffic Cones
https://www.codot.gov/programs/research/pdfs/2017-research-reports/cones/view

Evaluation of Safety Practices for Short Duration Work Zones
http://cdm16007.contentdm.oclc.org/cdm/ref/collection/p267401ccp2/id/15346
Questions?

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