New Technologies
Breakout Session #5

September 20, 2018
Adam Matteo, P.E. – Moderator
Assistant Division Administrator – VDOT Structure and Bridge Division
Today’s Agenda

- **Virginia Connected Corridors** – Virginia Lingham, P.E.

- **Corrosion Resistant Materials for Bridges** – Michael Sprinkel, P.E.

- **Laser Ablation Coating Removal on Steel Girders** – Stephen Sharp, Ph.D., P.E.
2018 Local Assistance Workshop:
Virginia Connected Corridors

- Virginia Lingham, P.E.
- Connected and Automated Vehicle Program Manager
- Office of Strategic Innovation
- Virginia Department of Transportation

September 20, 2018
Quiz Time!

- Connected Vehicle Environment
- Autonomous Vehicle (Self-Driving)
- Automated Vehicles
# Levels of Vehicle Autonomy

<table>
<thead>
<tr>
<th>Level 0</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Automation</td>
<td>Driver assistance</td>
<td>Partial automation</td>
<td>Limited self-driving</td>
<td>Full self-driving</td>
<td>Full self-driving</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>(conditional automation)</td>
<td>under certain conditions</td>
<td>under all conditions</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(high automation)</td>
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**Vehicle**
- No automation.
- Can assist driver in some situations.
- Can take control of speed and lane position in certain conditions.
- Can be in full control in certain conditions and will inform the driver to take control.
- Can be in full control for the entire trip in these conditions and can operate without a driver.
- Can operate without a human driver and need not have human occupants.

**Driver**
- In complete control at all times.
- Must monitor, engage controls, and be ready to take over control quickly at any moment.
- Must monitor and be ready to take over control quickly at any moment.
- Must be ready to take control quickly when informed.
- Not needed
- Not needed

Source: GHSA
Visit the CV PFS Website for a Connected and Automated Vehicle Glossary and Info on Ongoing and Completed Research Projects

Glossary is posted on the CV PFS Website
http://www.cts.virginia.edu/cvpfs_research

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Why Connect?
What Benefits Can We Expect?

National Timeline for Application Adoption and Associated Mobility Benefits

Cooperative Adaptive Cruise Control
Traffic Jam Assist
Traffic Jam Assist
Platooning
Fully Automated Vehicles

Forward Collision Avoidance
Adaptive Cruise Control

(Source: USDOT, FHWA-JPO-16-229)
Overview

What’s Happening Out There?

VDOT’s CAV Program

Virginia Connected Corridors

Testing, Demos, and Pilots
So, what's really happening out there?

Tesla Driver Gets Auto-Pilot Ticket Dismissed After ‘Driving’ With Feet Out Window

Published March 7, 2018 at 12:10 am PDT
By Jeff Mozee, Gary Toock, Ryan Noumaa, Mike Walters

A DJ who got busted for driving while on his cellphone, and with his FEET HANGING OUT THE WINDOW, just got off the hook because his car was self-driving and he was merely along for the ride.

In AIM, vehicles can often cross an intersection without stopping.
Soooo, what's really happening out there?

**Uber**

Self-driving Uber kills Arizona woman in first fatal crash involving pedestrian

Tempe police said car was in autonomous mode at the time of the crash and that the vehicle hit a woman who later died at a hospital.
Soooo, what's really happening out there?
… and the “What if Scenarios”
Overview

What’s Happening Out There?

VDOT’s CAV Program

Virginia Connected Corridors

Testing, Demos, and Pilots
VDOT envisions a future environment where Connected and Automated Vehicle applications provide connectivity between vehicles, roadside infrastructure and wireless devices.

This interconnected environment is expected to meet the following objectives:

- Increased Safety
- Improved Mobility
- Reduced Infrastructure Investments
- Enhanced Traveler Information
Virginia’s Unique Strengths

- Diverse highway system with a good state of repair
- An “Open-for-business” regulatory environment for innovative transportation solutions
- Data driven commitment to innovation
- Trusted world-class research and testing capabilities
- Capable knowledge based work force, including a strong military presence.
Connected and Automated Vehicle Program Development

• Full-Time Program Manager since Fall 2016

• Connected and Automated Vehicle Executive Steering Committee Established
  
  Sets strategic direction and priorities for VDOT’s CAV Program, including outreach & advocacy, implementation and more

• Connected and Automated Program Plan - Available Now at http://virginiadot.org/automated
Focus Areas of the Connected and Automated Vehicle Program

Outreach and Coordination  
Leadership  
Deployments  
Planning  
Policy
Contact us for more information!

• Please visit http://virginiadot.org/automated
Overview

What’s Happening Out There?

VDOT’s CAV Program

Virginia Connected Corridors

Testing, Demos, and Pilots
Virginia Connected Corridors Partnership

To facilitate the understanding of CV deployment, the Virginia Department of Transportation has partnered with the Virginia Tech Transportation Institute to create the Virginia Connected Corridors.
Virginia Connected Corridors

Mission: Provide an open connected vehicle environment where concepts can be developed, tested, deployed, and evaluated in real world operating environments.
Smart Roads at Virginia Tech Transportation Institute
Northern Virginia Challenges
The test beds include cellular communications to support cellular-based applications.
VCC Work Zone Components

VCC Cloud
Data and Processing Hub

VCC Monitor
Situation Awareness

VCC Worker
Dynamic Worker Location and Activity

VCC Vest

Work Zone Builder
Detailed Work Zone Definition

VCC Mobile
Driver Interface
Overview

What’s Happening Out There?

VDOT’s CAV Program

Virginia Connected Corridors

Testing, Demos, and Pilots
FHWA Truck Platooning Demonstration on I-66
September 13-15, 2017

More info at https://www.youtube.com/watch?v=iNTKqh7i5jQ
Testing, Demos, and Pilots are Active in Virginia

Virginia Tech Transportation Institute
Fall 2017

More info at
https://www.youtube.com/watch?v=EwujR1ARsog
Testing, Demos, and Pilots are Active in Virginia

FHWA Connected Vehicle Testing on I-95 Express Lanes
June 2018

Source: USDOT
National SPaT Challenge

What is the Challenge?
To challenge state and local public sector transportation IOOs to cooperate together to achieve deployment of DSRC infrastructure with SPaT broadcasts in at least one corridor or network (approximately 20 signalized intersections) in each state by January 2020.

What is SPaT?
A Signal Phase and Timing (SPaT) message defines the current intersection signal light phases. The current state of all lanes at intersection are provided, as well as any active pre-emption or priority. SPaT message defined by the SAE J2735 standard.
National SPaT Challenge Deployment Map

Source: NOCoE
Updated 9/10/18
Virginia Connected Corridor’s SPaT Challenge Architecture
One more thing!
SmarterRoads Hackathon Series
– Coming to Fredericksburg, VA
September 28-29!

https://nvite.com/SmarterRoadsVA

#SmarterRoadsVA
SmarterRoads Hackathon & Idea Jam

Objectives

- Accelerate Technology Development and Implementation
- Promote Existing Open Data Products
- Develop and Strengthen Relationships

GOAL: Create and share a model to follow for future events
Wrap Up

What's Happening Out There?

VDOT's CAV Program

Virginia Connected Corridors

Testing, Demos, and Pilots
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Corrosion Resistant Materials for Bridges

Michael Sprinkel PE
Associate Director

Local Programs Conference
September 20, 2018
INTRODUCTION

• The number one cause of bridge deterioration is corrosion of the reinforcement.
• In 2004 FHWA reported that a total of $10.5 billion was invested in bridge rehabilitation.
• Bridge repairs cause many traffic delays.
Corrosion of reinforcement

Bents

Piers

Beams

Decks

Prestress

PT Tendons
Innovative Corrosion Resistant Materials that extend bridge life and reduce future traffic delays for repairs

- low cracking concrete,
- fiber reinforced concrete,
- engineered cement concrete (bendable concrete),
- self consolidating concrete,
- corrosion resistant reinforcement
Low Cracking Concrete

- Cracking in decks and other structures has been a major problem since the 1990’s
- Cracks are caused by using too much cementitious materials to achieve high early strengths to allow accelerated construction and rapid opening to traffic.
- Cracks accelerate the corrosion of reinforcement and the deterioration of beam and substructure elements.
Cracking in Decks

Low cracking concrete: low cement, low shrinkage, few cracks

High cracking concrete: high cement, high shrinkage, many cracks
Cracking in Tunnel Segments

0.45-mm wide Crack in 3-ft thick Segment wall
Pressure Injection Repair
Normal weight concrete: total cementitious materials content shall be $\leq 600 \text{ lb/yd}^3$. The 28-day drying shrinkage shall be $\leq 0.035\%$. If needed, Shrinkage Reducing Admixture shall be used to reduce the shrinkage to acceptable level.

Light weight concrete: total cementitious materials content shall be $\leq 650 \text{ lb/yd}^3$ and the maximum fresh density shall be $\leq 120 \text{ lb/ft}^3$. 
Fiber Reinforced Concrete (FRC)

- Bridge overlays in 1974 and 1996.
- Pavement overlays in 1995.
- Bridge closure pours and engineered cement composite beginning in 2014.
- Recent use is the result of the development of new and improved fibers and admixtures to provide workable FRC.
- FRC has tight cracks that reduce or prevent water and chlorides from penetrating the concrete.
Fiber Reinforcement

- Polyvinyl alcohol
- Steel with hooked ends
- Polypropylene
FRC used for Joint Elimination

Eliminate joints: place closure pours
Engineered Cement Composite (ECC) Shear Keys, Route 645, 2013

Non-shrink grout

UHPC

ECC with PVA fibers

After 3 months, only ECC did not leak
ECC Culvert Repair

ECC: Bendable concrete with tight cracks
Metal Culverts are 10% of the bridge inventory

Spreading ECC over carbon fiber mesh
ECC Culvert Repair

ECC is Pumped into Culvert

5 weeks after repair
Self-consolidating Concrete (SCC)

- Consolidation of concrete is necessary to densify the concrete, remove entrapped voids and achieve good bond to reinforcement and to hardened concrete.
- Vibrators used to consolidate concrete prior to the development of admixtures that provide concrete that is self-consolidating.
Consolidation Problems

Core shows voids around reinforcement in slip formed parapet

Voids cause delamination of 3 inch thick overlay
Self-consolidating concrete

Conventional concrete
Slump test

SCC Slump Flow
Drilled Shaft US 28 with SCC, 2007

- Consolidation was not a problem
- Concrete placement and removal of casing were easy
SCC Substructure Repairs

Buttresses

Column

Pier Bent

Ref: Fawaz K. Saraf, VDOT
Corrosion Resistant Reinforcement

Carbon Fiber Reinforced Polymer (CFRP)

Nimmo Parkway, 18 piles: 2012, 2013

strands in form

prestressed piles

strands

Spiral

driven pile
CFRP Prestressed Beams
Route 49 over Aaron’s Creek, 8 beams, 2015

fabricating beam  transporting beam  setting beam

82-ft beams in place  completed bridge
Stainless Steel Prestressed Piles

Nimmo Parkway Bridge: four 24-inch piles
Rte 621 over Passenger Swamp: ten 16-inch piles
Rte 680 over Stallings Creek: twelve 16-in piles

strands in form

completed bridge
## Comparison of Properties of Strand

<table>
<thead>
<tr>
<th>Strand Properties</th>
<th>ASTM A416</th>
<th>CFRP</th>
<th>Stainless Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength (min), ksi</td>
<td>270</td>
<td>338</td>
<td>250</td>
</tr>
<tr>
<td>Elastic Modulus, ksi</td>
<td>28,600</td>
<td>22,500</td>
<td>24,500</td>
</tr>
<tr>
<td>Elongation at break, %</td>
<td>3.5 (min)</td>
<td>1.7</td>
<td>1.5</td>
</tr>
</tbody>
</table>
ACKNOWLEDGEMENTS

H. Celik Ozyildirim, Ph.D., P.E.
Stephen R. Sharp, Ph.D., P.E.
Many VDOT staff in Divisions and Districts
FHWA, concrete producers and contractors

September 20, 2018 – Roanoke, VA
Corrosion Resistant Materials for Bridges

Questions?
Laser Ablation Coating Removal on Steel Girders

Presented by,

Stephen R. Sharp, Ph.D., P.E.
Senior Research Scientist
Virginia Transportation Research Council

VDOT Local Programs Workshop, September 20th 2018
The Laser Ablation Coating Removal (LACR) Questions

• What if you could use a laser beam to clean a steel beam?
• Would it be safe?
• Would you be able to recoat the beam?
• What other challenges would you have?

(Video Courtesy of Jim Fitz-Gerald and Sean Agnew)
Addressing the LACR Questions

• The LACR Team
• Corrosion Damage and Coatings
• Introduction to LACR
• Beam End Laboratory Evaluation
• Beam End Field Evaluation
• Hot Work Evaluation
• Conclusions
LACR Project Team

- Adam Matteo, P.E., VDOT S&B
- Jeff Milton, VDOT S&B
- C. Wayne Fleming, VDOT Materials
- David Wilson, VDOT Environmental
- Raquel Rickard, VDOT Environmental
- Dr. Jim Fitz-Gerald, UVa Material Science
- Dr. Sean Agnew, UVa Material Science
- James Gillespie, VTRC
- Stephen Sharp, VTRC
- Contractors, Consultants, and Suppliers
Unfortunately, coating loss can lead to steel section loss and often it happens in certain spots.
Coating can be Restored

Fortunately coatings can be repaired and the steel protected from corrosion
Repairing Damaged Coatings

Containment

Worker Protection

Abrasive Media and Coating Disposal
Laser Ablation Coating Removal (LACR)

- Surface layer absorbs the pulsed laser energy and is converted into vapor (particles) from thermal energy.
- Fumes/particles from absorbing layer captured using an integrated 3-stage filtration unit.

Nd:YAG = Neodymium: Yttrium Aluminum Garnet
LACR Components
Laser Coating Removal Demonstration

Laser Head

9/17/2018

(Video Courtesy of Jim Fitz-Gerald and Sean Agnew)
Air Filtration

3-stage filtration system

- Primary stage large surface area particle filter cartridge
- 2nd stage activated carbon filter (13 lb),
- 3rd stage HEPA or Ultra Low Particulate Air (ULPA)
  - 99.97% w/HEPA,
  - 99.9995% w/ULPA.
VDOT’s LACR Evaluation: Lab

Lead rich coatings on older steel girders

• Laboratory LACR Work on Beam End
VDOT’s LACR Evaluation: Lab

• Removal of thicker debris by hand accelerates LACR from beams
LACR Laboratory Evaluation: Surface

(Images Courtesy of William Moffat)
LACR Laboratory Evaluation: Environmental/OHS Analysis

Monitored Personal and Area Concentrations

• Nine Metals using NIOSH Method 7300
  – Cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, and zinc
• 31 Volatile Organic Compounds with Assay 566 Badge

Toxicity characteristic leaching procedure (TCLP) analysis of waste and filters for eight metals

• Silver, arsenic, barium, cadmium, chromium, mercury, lead, and selenium
LACR Laboratory Evaluation: Environmental/OHS Results

- Airborne (area sample) concentrations of metals and VOCs were below the OSHA permissible exposure limits (PEL) and OSHA action levels (AL).
- Operator personal exposure to the nine metals were below the laboratory level of detection (LOD), with the exception of lead. Lead results were above the laboratory LOD, but below the OSHA PEL and OSHA AL.
- Operator personal exposure to the 31 VOCs were below laboratory detection limits.
- TCLP sampling of the filters found particle debris filter was hazardous for lead.
LACR Laboratory Evaluation: Recoating, Tensile, and Fatigue Tests

Coating Adhesion Test
- PATTI Test Used
- Two Coating Thicknesses Tested
- Results Based on 50 Pull Test/Thickness
- Average Values Good
  Thinner Coat 1721 psi
  Thicker Coat 2094 psi

Tensile Tests for Three Conditions
- Base, Grit-blasted, Laser cleaned
- Results showed agreement in YS and UTS

Fatigue Testing Ongoing

9/17/2018
VDOT’s LACR Evaluation: Field Equipment

• LACR Beam End Field Work
LACR Field Beam End Evaluation: Environmental/OHS Monitoring

• Again, nine metals and 31 VOCs were measured, with TCLP performed on the waste from each of the three filters

• Waste material generated was considered hazardous based on 2017 historical TCLP results. The HEPA filter exceeded the regulatory waste requirements for lead and the particle debris filter for lead and chromium.

• During the lab work special glasses could be used, but in the field a curtain was draped to protect the eyes of onlookers
LACR Field Beam End Evaluation: Accessing Beam Elements

Accessible vs. Not Accessible
LACR Field Beam End Evaluation: Coating Removal Observations

- Tight access areas contributed to a slow production rate
  - Changes in laser equipment design could improve production, such as a 90° adjustable head
- Weight of hand held laser could causes operator fatigue
  - Several operators needed during coating removal
VDOT’s LACR Evaluation: Coating Removal Before Hot Work

- Removing coating with LACR before hot work
  - Hot work includes spark generating tasks such as grinding, oxyacetylene torch and plasma torch cutting
VDOT’s LACR Evaluation: Coating Removal Before Hot Work Observation

- Maintaining contact between the roller and the steel during LACR provided the best air quality and most efficiency during coating removal.
VDOT’s LACR Evaluation: Hot Work
After LACR

Oxyacetylene Torch

Grinding

Plasma Torch
VDOT’s LACR Evaluation: Hot Work After LACR OHS Results

- LACR on the rolled I beam showed the greatest reduction in lead while doing hot work when compared to the welded C channel beam.
- The welded C channel beam had results high enough to cause exposure but were greatly reduced when compared to cutting through a fully coated beam.
- LACR will not remove coatings sandwiched between two steel surfaces.
Conclusions

• The new coating on a LACR cleaned steel surface exhibits good adhesion.
• Environmental/OHS results during beam end work are within acceptable limits. Main debris and filter wastes are hazardous waste.
• Tensile test results for LACR are similar to base metal and grit-blasted samples.
• Tight access is a challenge for LACR.
• It is important to maintain the proper distance during LACR to maximize coating removal efficiency.
• LACR can greatly reduce lead exposure if subsequent hot work is to be performed and coating is accessible for removal.
Acknowledgments

The presenter would like to acknowledge VDOT S&B, Materials, and Environmental Divisions, the VDOT Lynchburg, Culpeper, and Hampton Roads Districts, and the VTRC and FHWA for their support of this research. The University of Virginia Material Science and Engineering program is also recognized, particularly graduate students William Moffat and Md. Shamsujjohha for their contributions.
Questions?

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