

Smart Work Zone Safety Initiatives

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Implementation

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An aerial photograph of a road interchange with several buildings and parking lots. A semi-transparent white box is overlaid on the center of the image, containing text. The background shows a multi-lane road curving through a green, hilly landscape with scattered buildings and parking areas.

ABOUT
US

The Virginia Tech Transportation Institute (VTTI) conducts research to save lives, time, money, and protect the environment.

VTTI FACTS

ADVANCING TRANSPORTATION THROUGH INNOVATION



Infrastructure worth more than **\$150M**



5 VTTI faculty are among the top **10** sponsored research awardees at VT



Close to **500** faculty, staff, and students

- Top three transportation institute globally
- Largest group of driving safety researchers worldwide
- 300 active projects and collaborations, with more than 100 sponsors, private and public sectors
- Approaching \$50M in annual externally-sponsored awards
- Influenced public policies for driver, passenger, and pedestrian safety
- Advanced safety of infrastructure, vehicles and reduced environmental impacts



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What is Advanced Mobility?





Connected Vehicles

Equipment

- On-Board Unit (OBU)
- Roadside Unit (RSU)
- 4G/5G

Message Flows

- Vehicle-to-Vehicle (V2V)
- Vehicle-to-Infrastructure (V2I)
- Vehicle-to-Pedestrian (V2P)

Connectivity Technologies

- Dedicated Short Range Communications (DSRC)
- Cellular Vehicle-to-Everything (C-V2X)
- 4G/5G

Interfaces

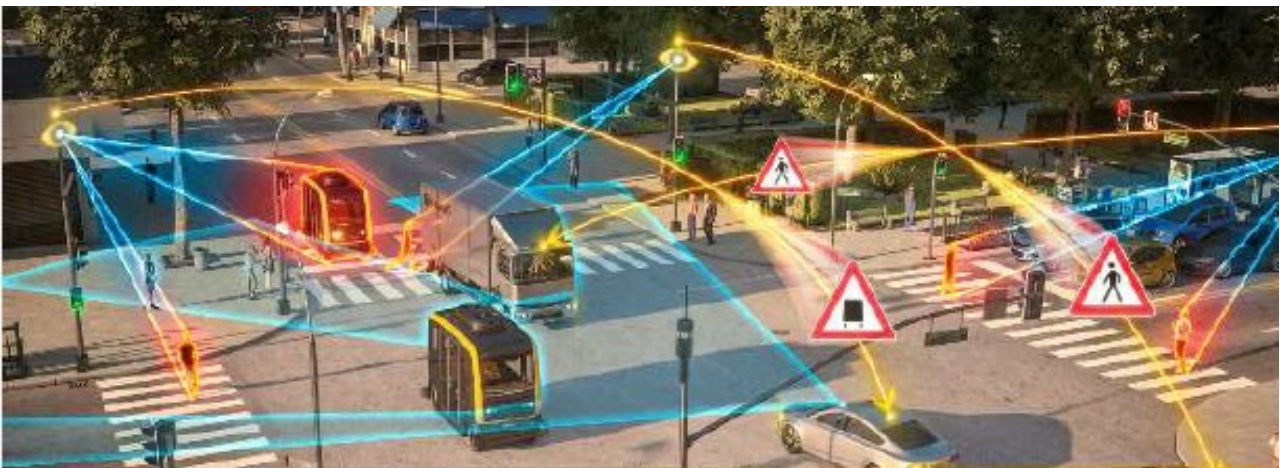
- Traffic Operations Centers
- Traffic Signal Controllers
- Data Exchanges





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Managing Connections - The virtual Twin

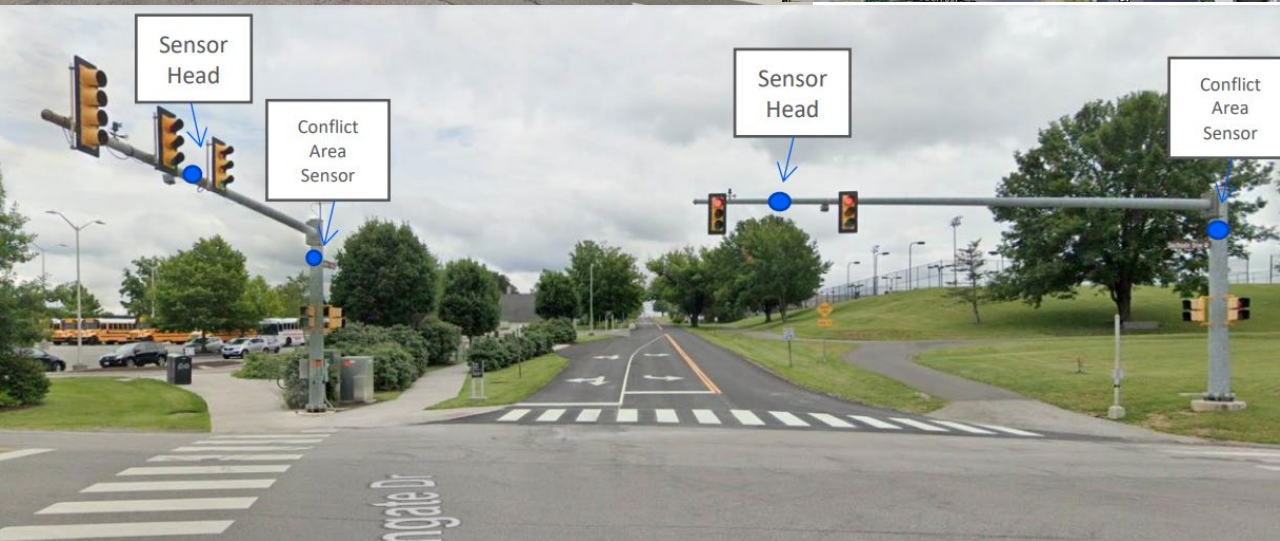
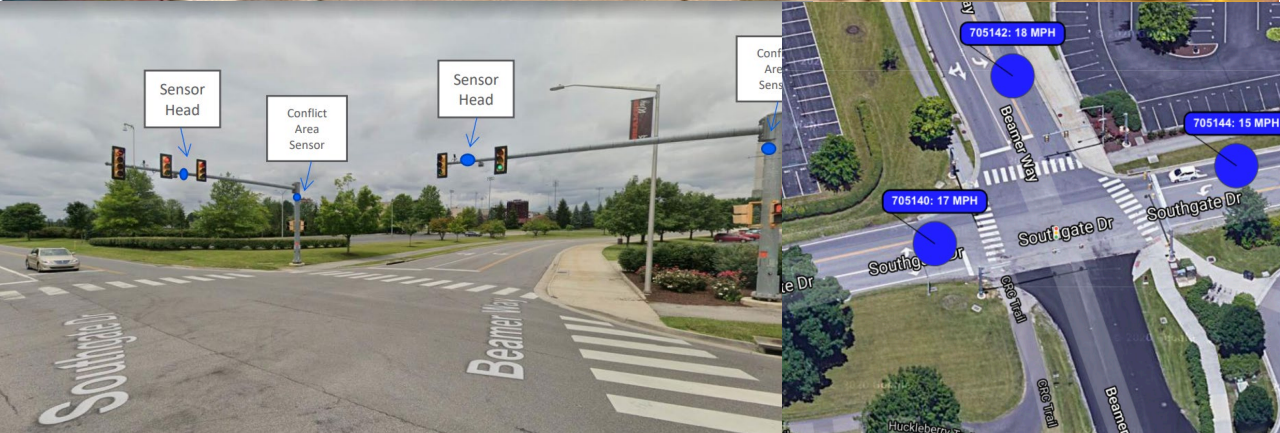


Smart Intersection Deployment

Sponsor: Virginia DOT

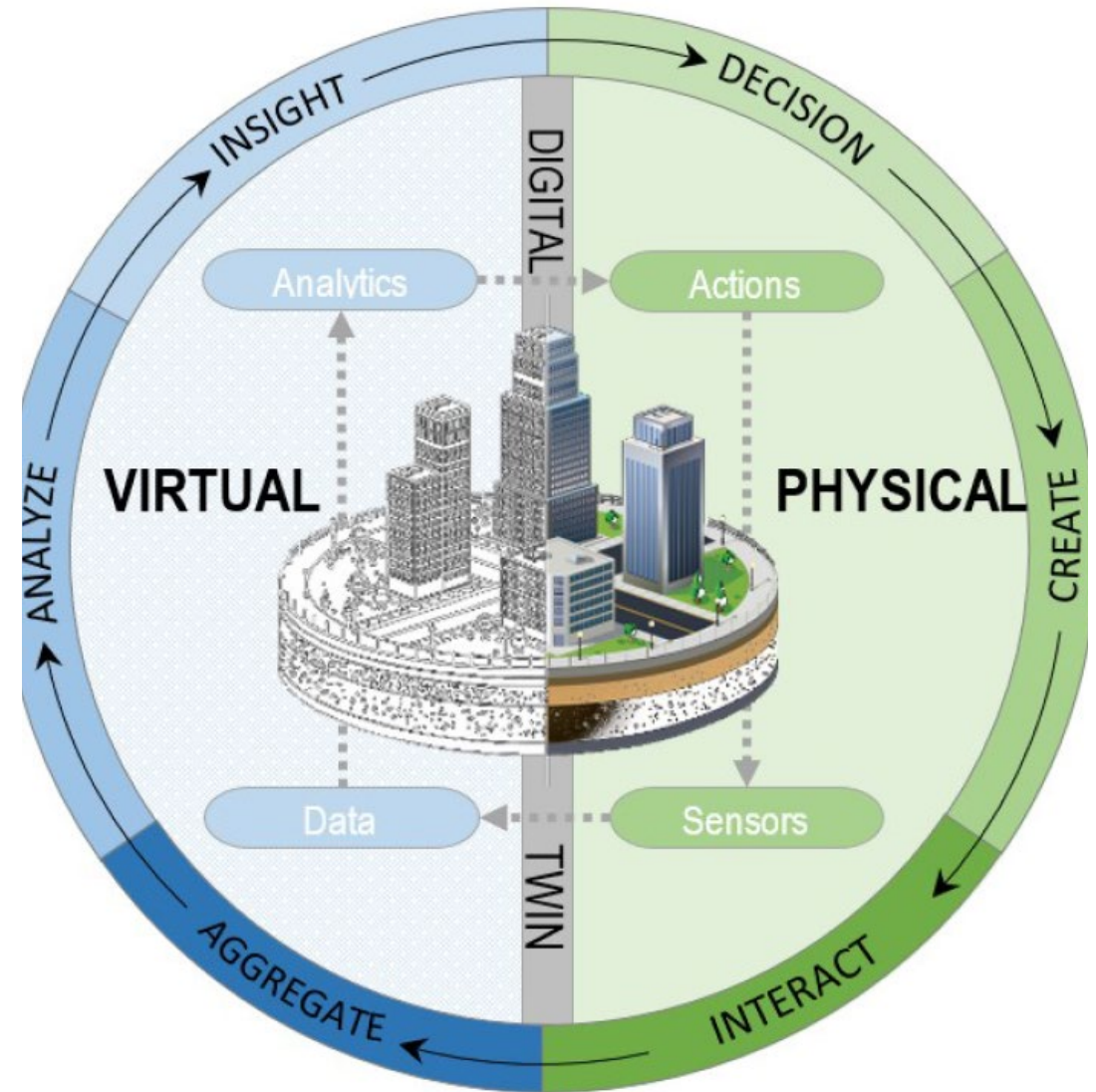
Focus:

- Deploy smart intersection technologies on test track and in live operations
- Camera and radar with edge processing for object detection, classification, and localization
- Evaluate data quality, reliability, accuracy, and latency
- Assess application requirements and align to available solutions
- Make recommendations to VDOT for future deployments
- Evaluate solutions with no cameras



FALLS CHURCH SMART CITY GRANT

- \$10M grant in awarded in 2021 to be administered by the Virginia Department of Transportation



Virtual Twin Applications

Adaptative Lighting

Smart Parking

Smart Intersections

Advance Mobility

Smart Work Zones



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Making the Workzone Smart

Smart Work Zone Development Motivations

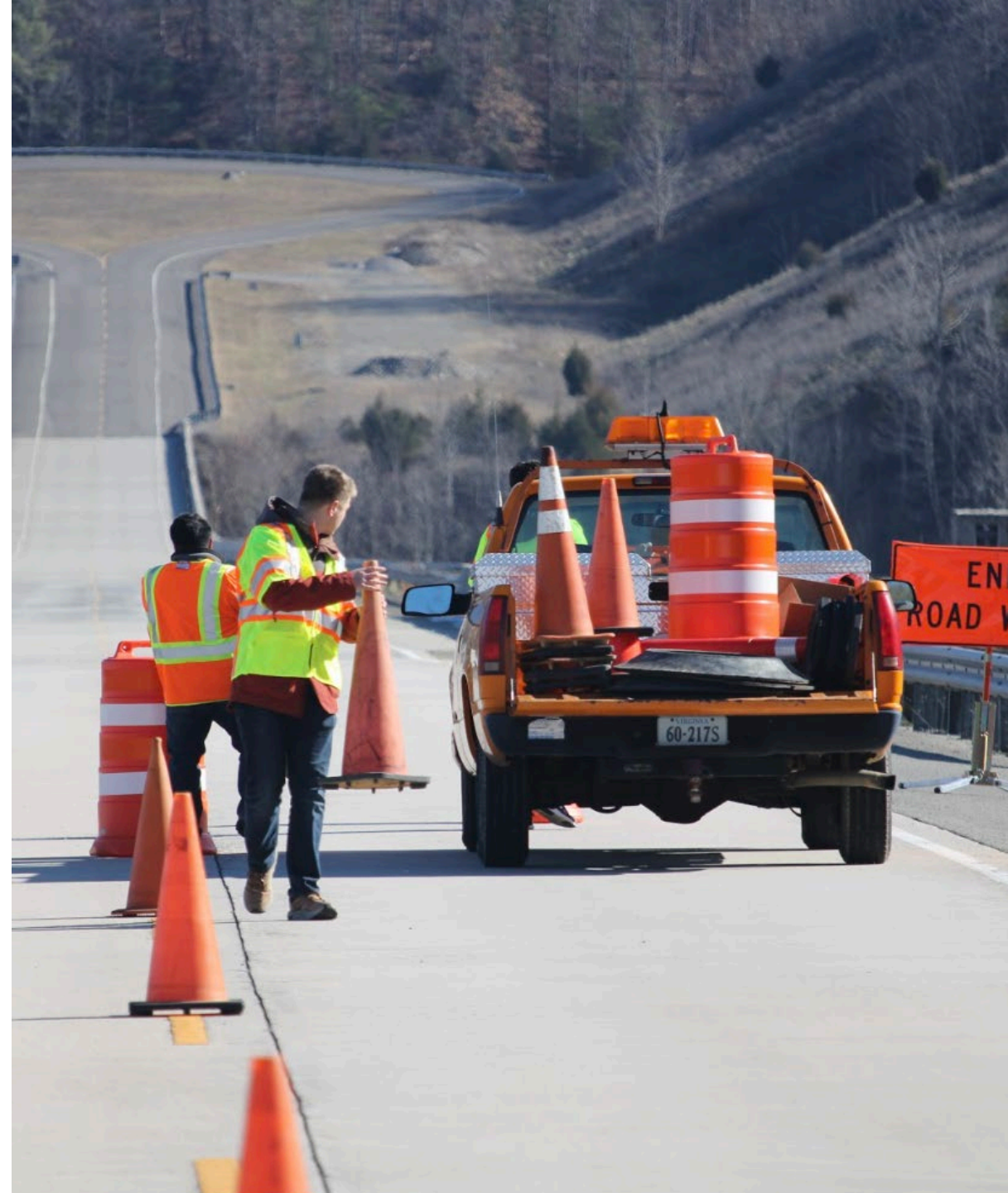
- Work zone safety remains a top priority for VDOT as crashes and injuries remain stubbornly high
- VTTI and VDOT have been working together to improve work zone safety for more than 15 years
- Recent advances in GPS localization and communications technologies create opportunities for new innovations
- Tools are needed to create accurate work zone data to distribute to 3rd parties
- New commercial products are often siloed and typically not part of an integrated system



SMART WORK ZONE

INTEGRATED COMPONENTS

- Smart Work Zone Field System
 - Smart Vest
 - Smart Helmet
 - Smart Cone
 - Equipment Unit
 - Base Station
- Move Over Law System
- Work Zone Builder Application
- Automated Truck Mounted Attenuator (ATMA)



Smart Vest

- Wearable ANSI Class 3 system to localize and communicate with roadside workers
- Wireless mesh network integrates to base station
- GPS+RTK module
- Inertial measurement unit
- Redundant modes of warning
 - Vibrating motors
 - Chirping buzzer
 - LED illumination
- 8 oz, 22 hours battery life



Video

Smart Helmet

(Under Development)

- Wearable system that integrates with Kask helmets
- Does not interfere with other accessories
- Wireless mesh network integrates to base station
- GPS+RTK module
- Inertial measurement unit
- Redundant modes of warning
 - Vibrating motors
 - Chirping buzzer
 - LED halo illumination over visor
- 6 oz, 16 hours battery life



Smart Cone

- Wireless mesh network integrates with base station, extends communications range
- GPS+RTK module
- Auto-defines boundaries of geo-fenced safe area
- Currently not MASH tested so used away from traffic
- A portable geo-plotter can also be used to define the “safe zone” for the system



Equipment Unit

- Magnetic base attaches quickly to equipment
- Wireless mesh network integrates with base station
- GPS+RTK module
- Inertial measurement unit
- Provides warnings to workers when they are close and equipment starts moving



Base Station

- Communications management and edge processing
- Wireless mesh network integrates with other devices
- 4G module for communications to cloud
- GPS+RTK module
- Can be mounted on vehicle, infrastructure, or temporary trailer
- C-V2X roadside unit functionality broadcasts worker presence and collision warnings to passing vehicles



Smart Work Zone Configuration

Base Station

- Manages wireless mesh network comms with vests and helmets
- Manages 4G cellular comms with VCC Cloud
- Receives and applies RTK corrections for GPS
- Processes and aggregates worker location and movement data
- Receives vehicle BSM data and runs collision warning algorithm
- Receives geofence data from Work Zone Builder and/or geo-plotter and runs geofence warning algorithm
- Sends vests and helmets vehicle proximity and collision warnings

Smart Cones

- Auto-define geofence boundary
- Expands range and reliability of mesh network



VCC Cloud

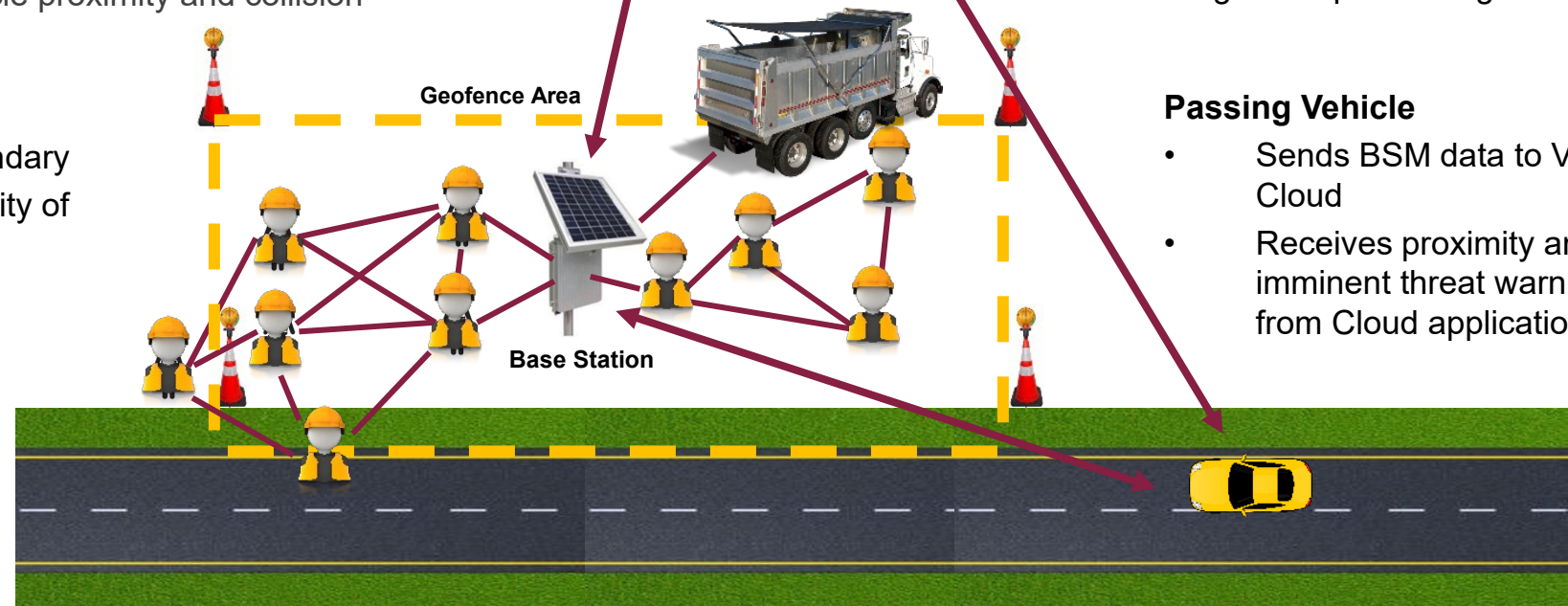
- Manages flow of data from vehicles to work zone system
- Forwards data to Work Zone Data Exchange

Construction Equipment

- Magnetic mount unit sends data to base station for collision algorithm processing

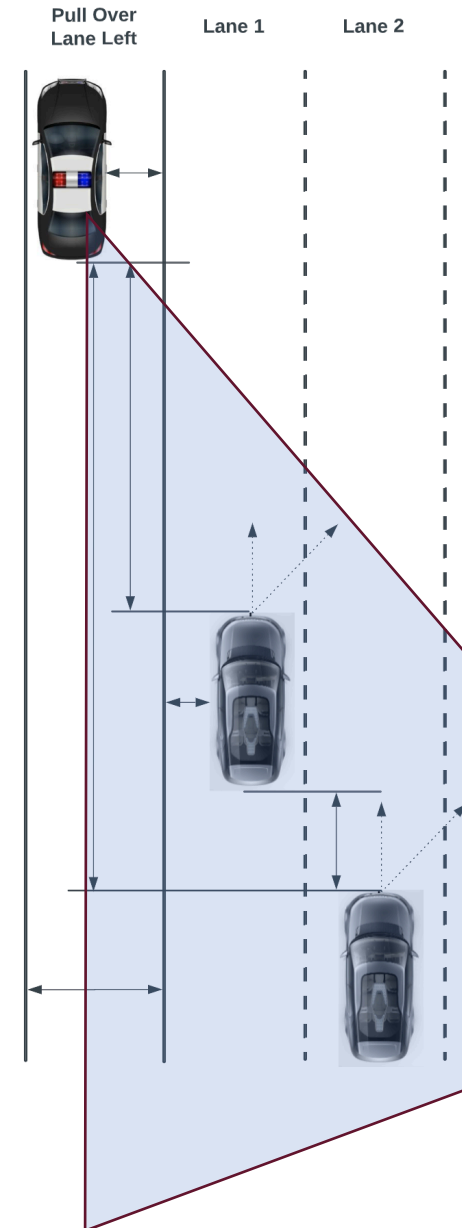
Passing Vehicle

- Sends BSM data to VCC Cloud
- Receives proximity and imminent threat warnings from Cloud application

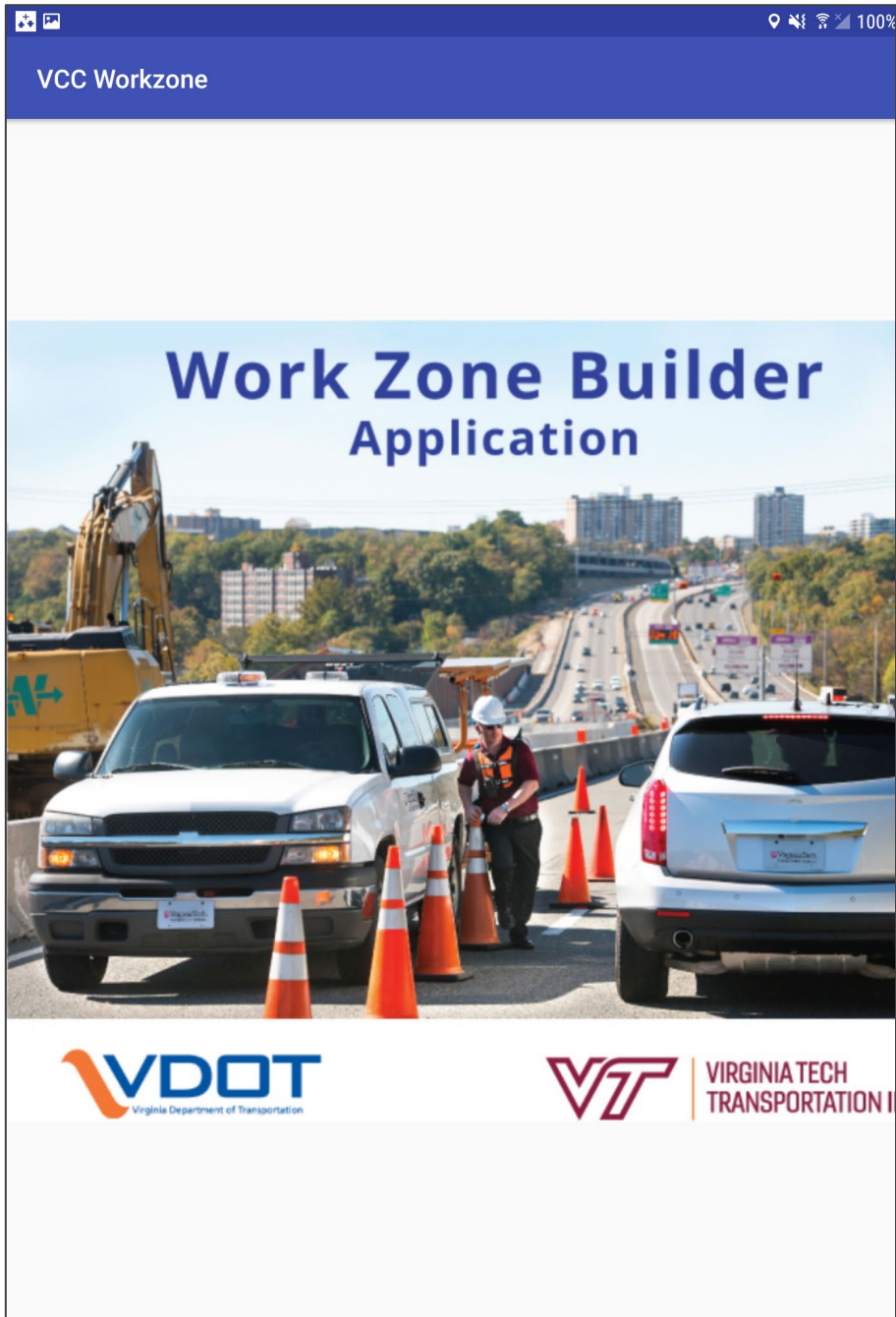


Move Over Law System

- Develop a system that can be mounted on roadside vehicles to evaluate compliance with VA's Move Over Law requirements
- Evaluate system under varying traffic and environmental conditions
- Develop potential warning solution for roadside workers based on trajectory of approaching vehicles
- Integration into fixed work zone warning systems and scenarios





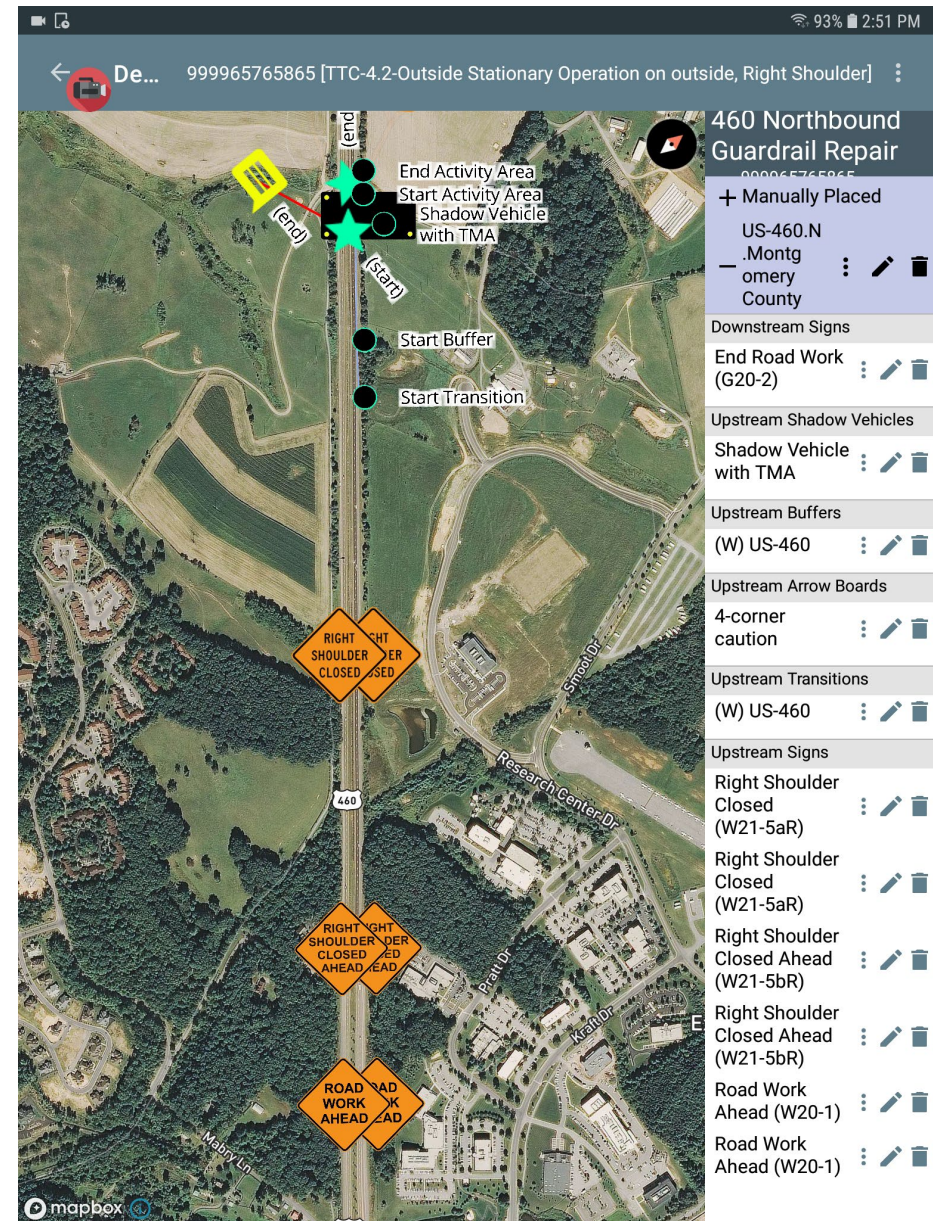


Work Zone Builder Application

- Tablet-based application to create and manage work zone plans
- Produce data that connected and automated vehicles will need to safely navigate work zones
- Streamline submission, review, and approval processes
- Provide a means to source work zone data for **maintenance** activities
- Create an app that work zone managers want to use
- Provide a means to source data for Work Zone Data Exchange and 3rd party applications

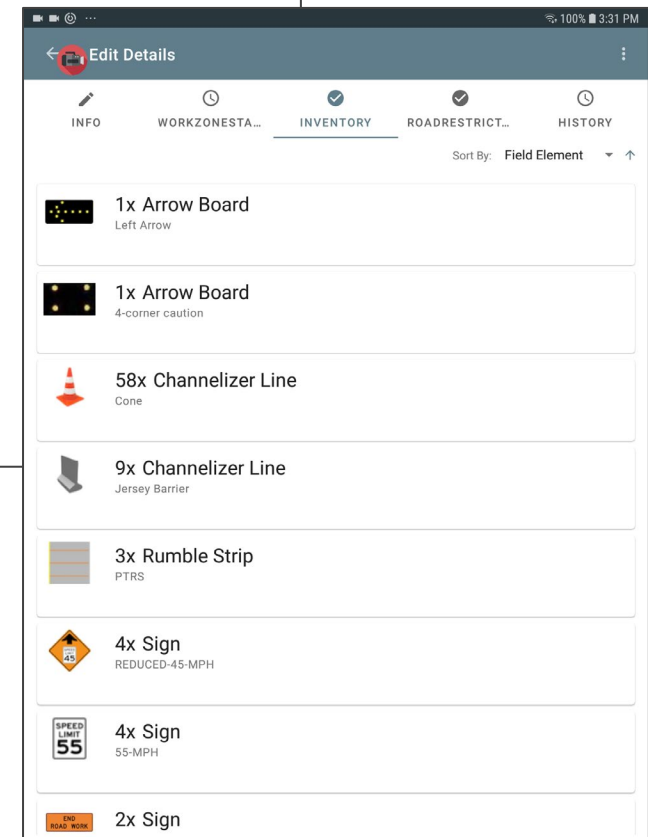
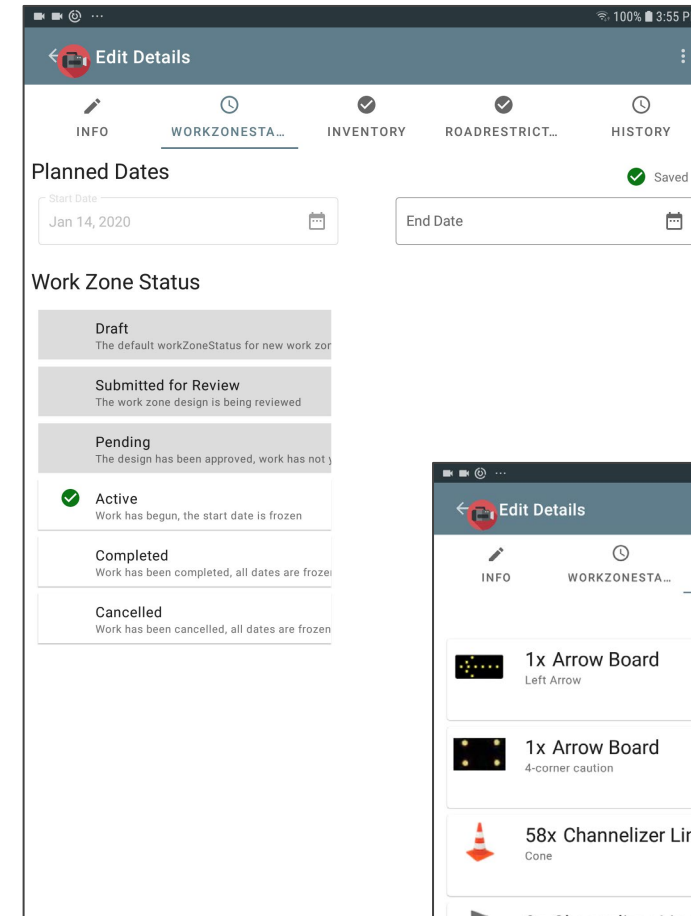
Design Mode

- Select activity area and apply TTC template
- Adjust positions of existing features
- Add new features from palette
- Mirror inside / outside templates
- Clone bi-directional templates
- Add notes to features
- Automatically add geofenced areas that will integrate with Smart Vest system



Management Mode

- View / set status of work zone
 - **Draft**
 - **Submitted for Review** – makes available for VDOT inspector to review
 - **Pending** - automatically sends data to a WZDX and VDOT's lane management systems (minimal integration)
 - **Active** - automatically generates connected vehicle messages for first sign, any lane changes, and activity area. User toggles **Worker's Present** field as appropriate
 - **Completed** – sends notification of complete
 - **Cancelled**
- View work zone inventory
- Set roadway restrictions
- View edit history and audit history
- Update worker presence status





Field Mode

- Use GPS to navigate to, position, and validate work zone features
- Update plans to reflect field adjustments made to address site conditions
- Communicate status electronically to TOC
- Capture imagery to further document the design

Field Trial – VA Rt 250/151 Roundabout

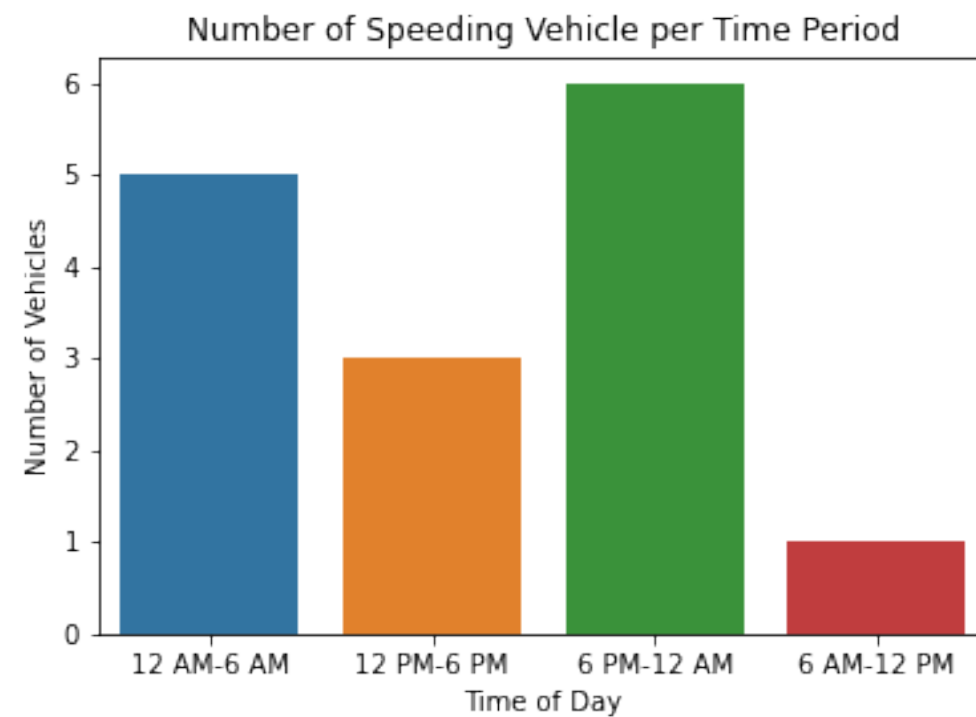
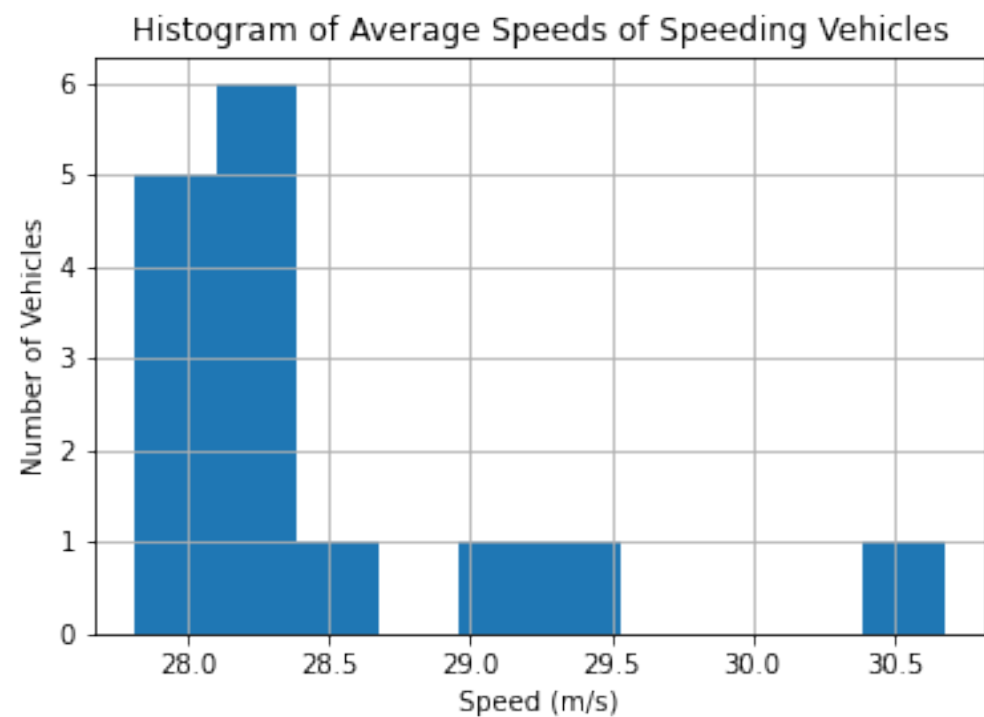
- Requested trial in dangerous intersection project
- 3 incursions in 2 months with equipment being hit
- Desired advanced warning of high-speed approaches
- System provides 8s warning when vehicles detected greater than 55 mph in 35 mph zone



Field Trial Setup



Sample Frequency Data



Vehicles greater than 60mph

Automated TMA Program

- Consortia formed to co-fund development of automated TMA prototype
- Freeway operations, HMI, robust safety features
- Multi-phase program
 - Phase 1: Design, build, and demo leader-follower ATMA System (complete)
 - Phase 2: GPS-Denied operations and reduced BOM (current)
 - Phase 3: Testing on public roadways in live work zone operations (spring 2023)
- Targeted Outcome
 - IP package suitable for commercialization



- Driven by the need to remove the driver from the most vulnerable position in mobile and dynamic work zones
 - TMAs are struck in Virginia at least once every 3-4 weeks, that rate is still increasing
 - Multiple fatalities reported in the last ten years
- Leader-Follower system for a “Driverless” TMA Truck
 - Universal lead vehicle package
 - Autonomous object detection and collision prevention
 - Commanded lateral and longitudinal offsets



Current Configuration



- Vehicle agnostic lead package
- Singular antenna rack on each vehicle
- Two forward camera
- Radar and Lidar on ATMA
- Footprint of computing hardware has been significantly reduced



Next Steps

- Develop field configuration and management software
- Plug-and-Play deployment capability
- Finalize integration with VA's WZDx system
- Complete commercialization partner negotiations





Questions?

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Advancing Transportation Through Innovation