Smart Work Zone Safety Initiatives

Mike Mollenhauer

Director, Division of Technology Implementation

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VIRGINIA TECH TRANSPORTATION INSTITUTE
VIRGINIA TECH

VTTI FACTS

ADVANCING TRANSPORTATION THROUGH INNOVATION

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

Infrastructure worth more than **$150M**

Historically, on average, employs 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 across the private and public sectors
- Approaching $50M in annual externally-sponsored awards
- Research has positively influenced public policies for driver, passenger, and pedestrian safety
- Advanced safety of infrastructure, vehicles and reduced environmental impacts

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

VDOT
Virginia Department of Transportation

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

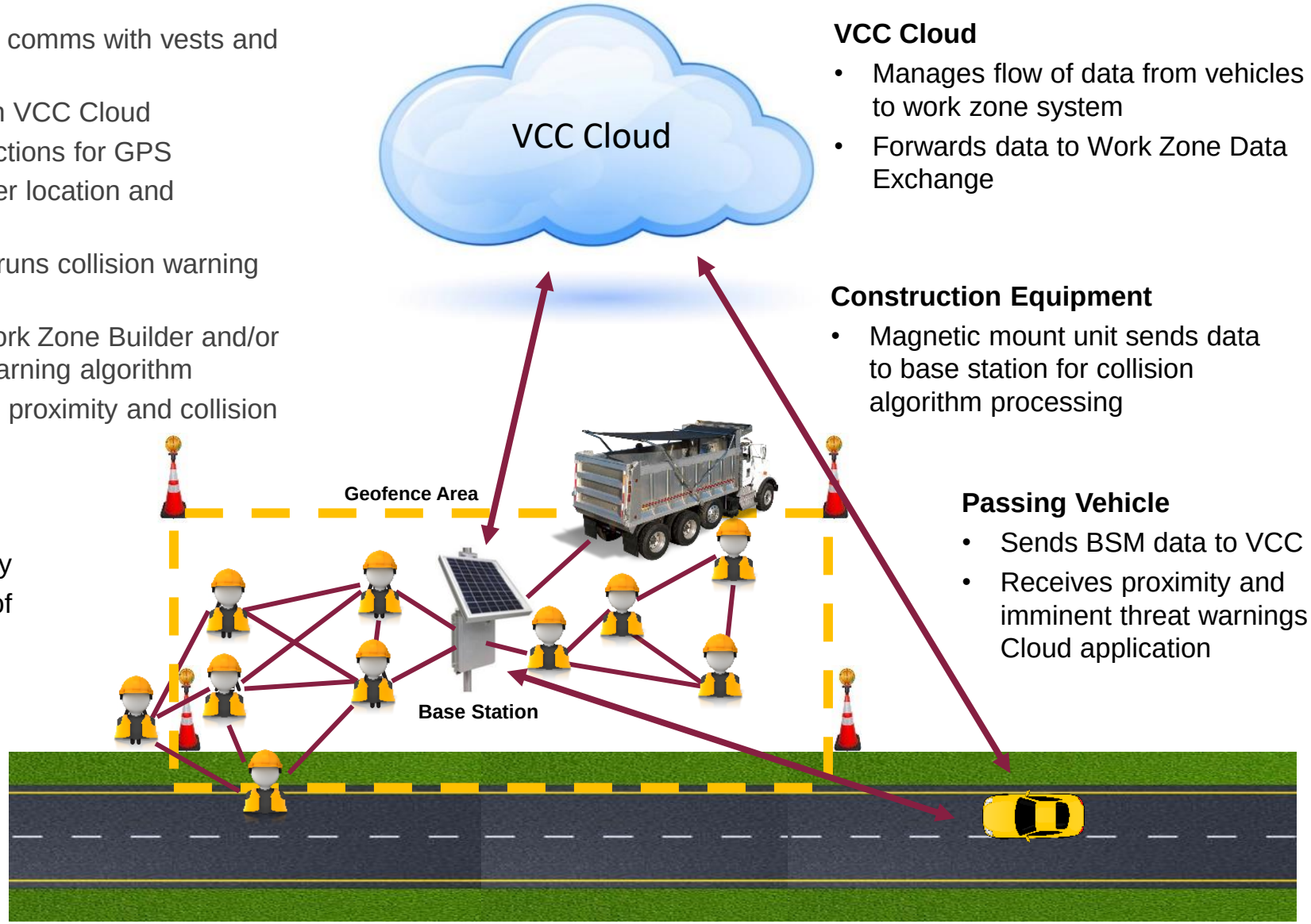
Smart Work Zone Configuration

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

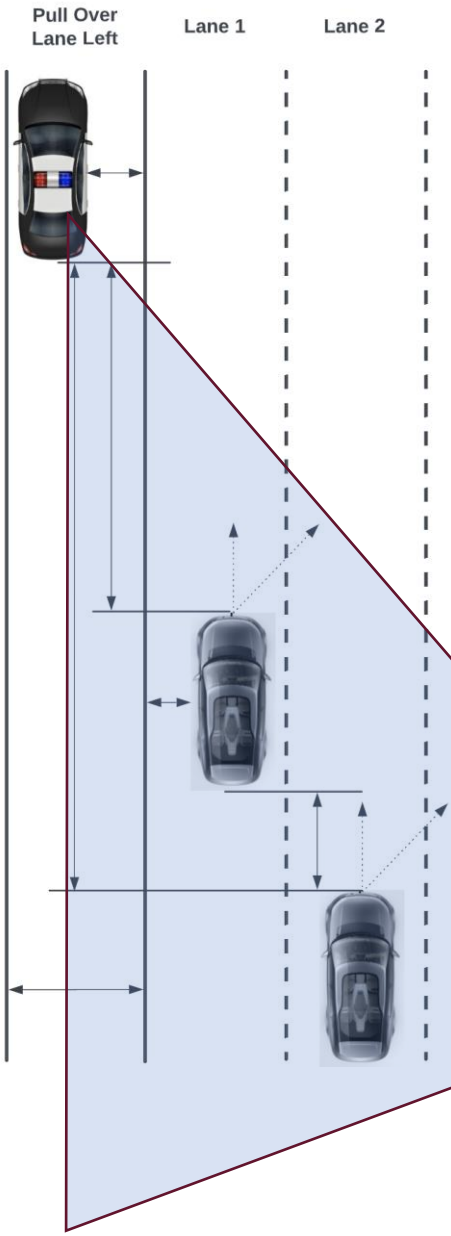
- Magnetic mount unit sends data to base station for collision algorithm processing

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



jpcalledo@CCIDev: ~/output_files

File Edit View Search Terminal Help

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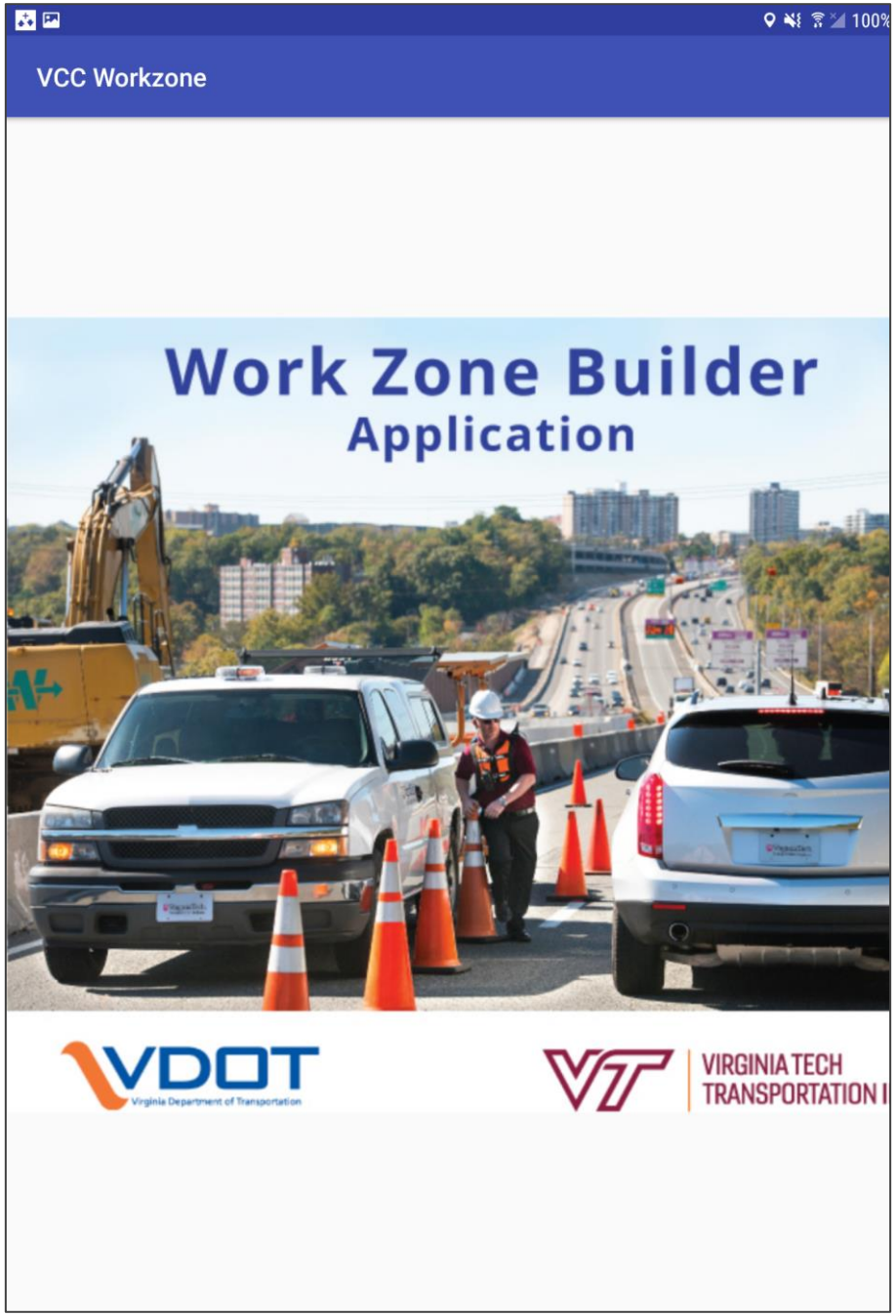
DriveNet Sample

US50_SmartRoad.PNG

morning

US50_.zip

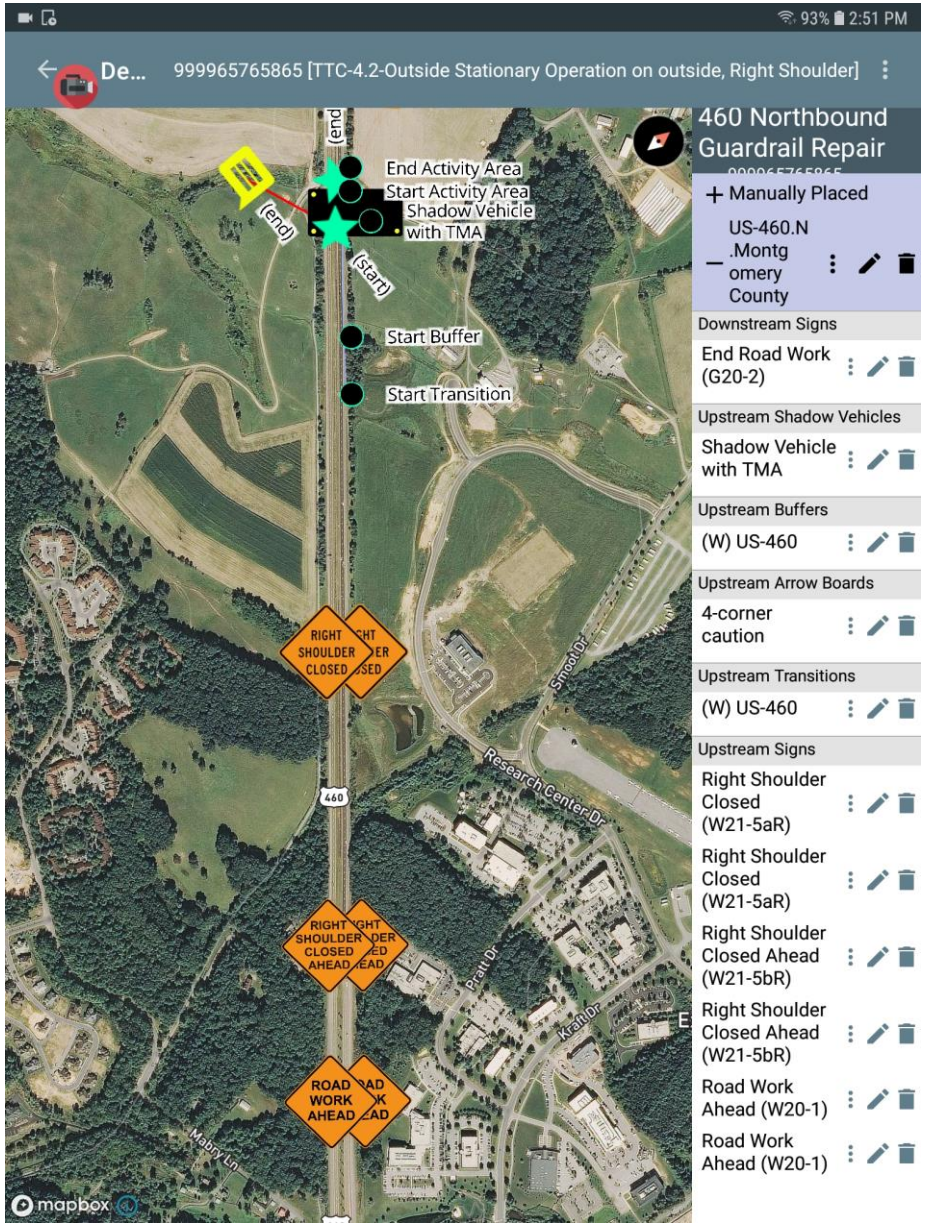


Work Zone Builder Application

- 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

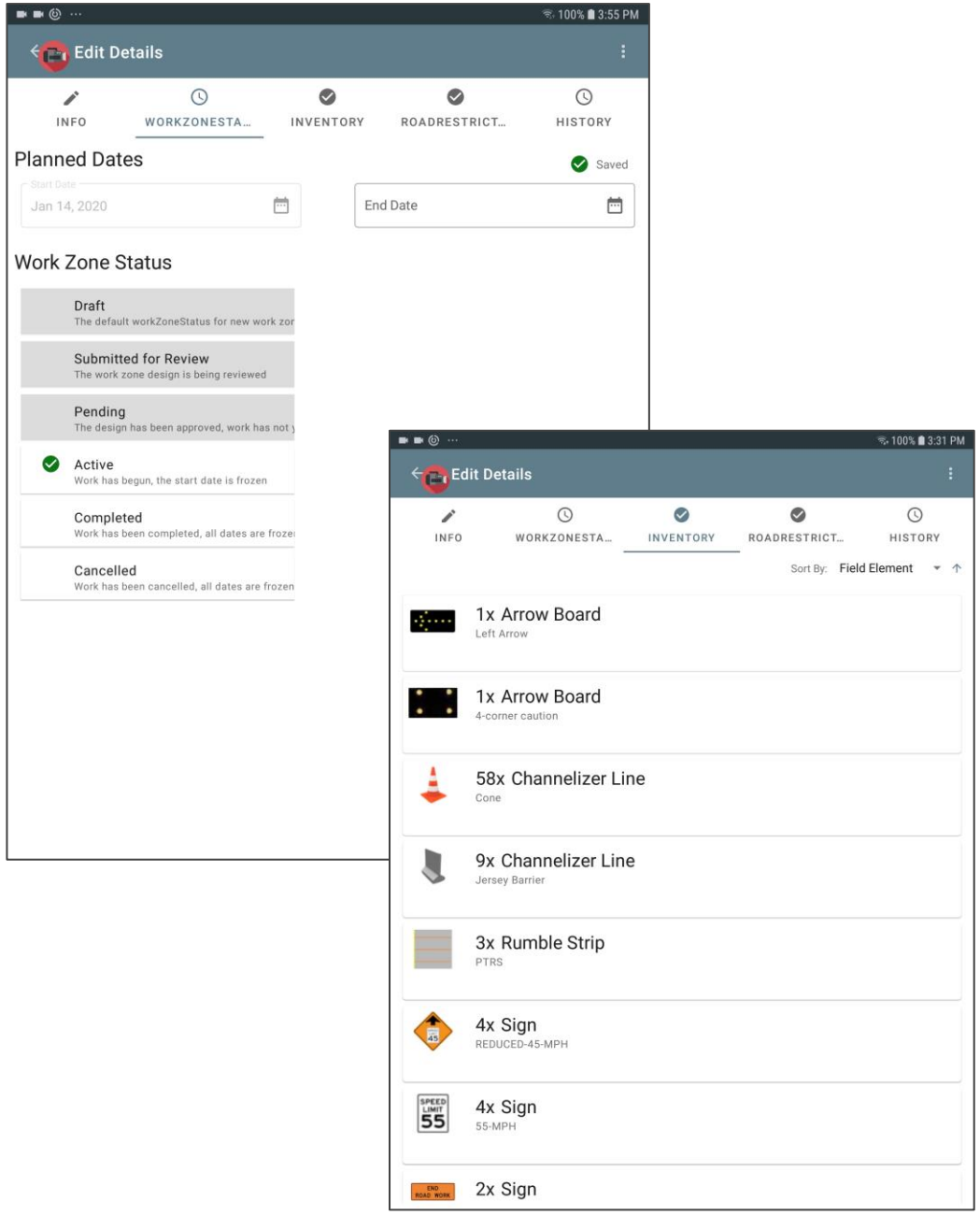
Design Mode

- 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

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

VDOT Virginia Department of Transportation

Transurban

DCS DeANGELO CONTRACTING SERVICES

SAFE-D SAFETY THROUGH DISRUPTION

FOLLOWING
CANCEL AUTOMATION
0 FT
25 FT MINIMUM
9 MPH
LEAD HOLD
SET 150 FT
153 FT
STOP
400 FT
9 MPH
FOLLOWING HOLD
0.1 FT
-12 FT
12 FT
SET 0.0 FT
LEFT
CENTER
RIGHT
Advancing Transportation Through Innovation

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

mol_2022-11-14-14-27-40.bag – Foxglove Studio

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Waiting for images on:
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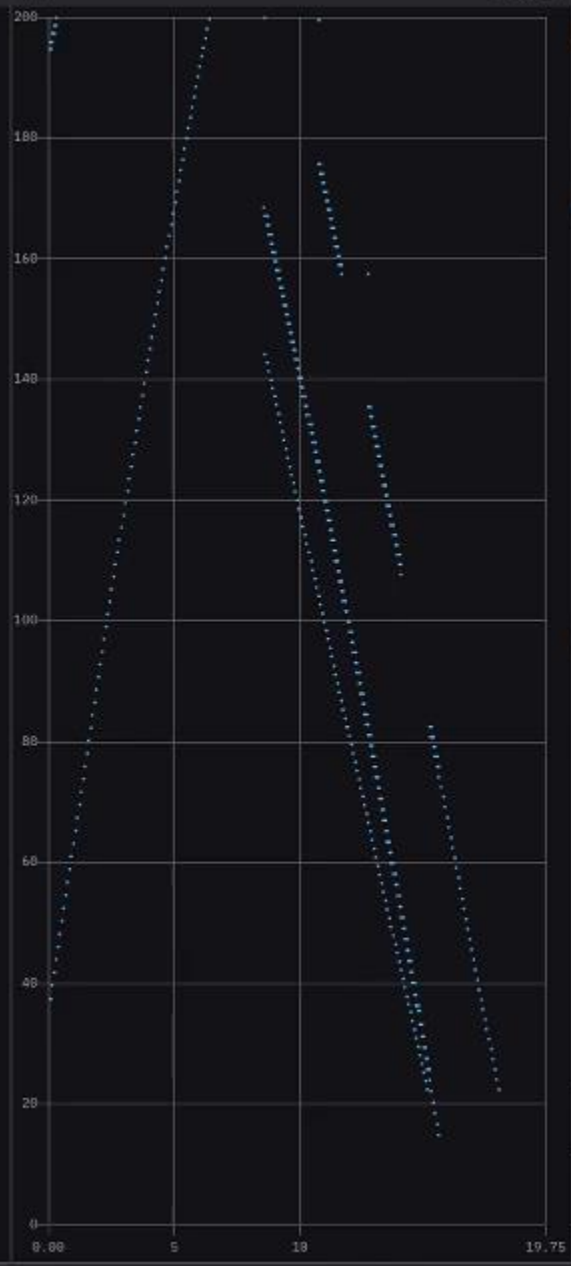
Plot



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  - seq 370817
  - stamp 2022-11-14 2:27:40.946 PM EST
    - sec 1668454060
    - nsec 946565137
  - frame_id "radar_objects"
- numObjects 2
- objects [] 2 items
  - 0 {} objectId: 118
    - point norm = 35.39
      - x 35.231998443603516
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      - x 28.100000381469727
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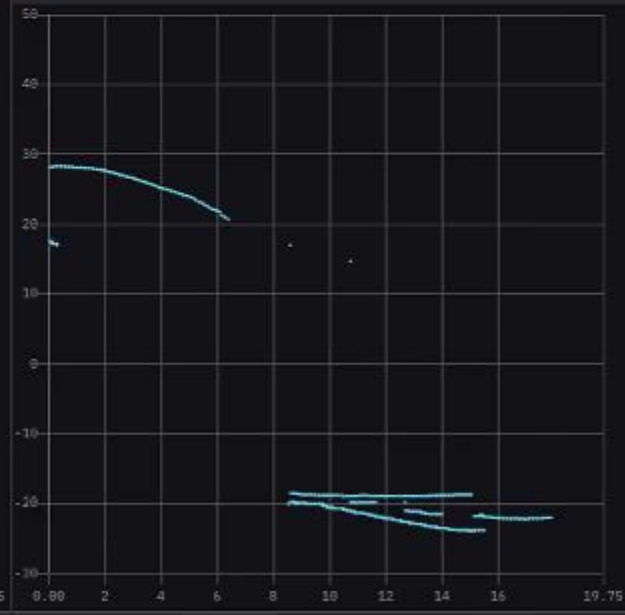
Plot



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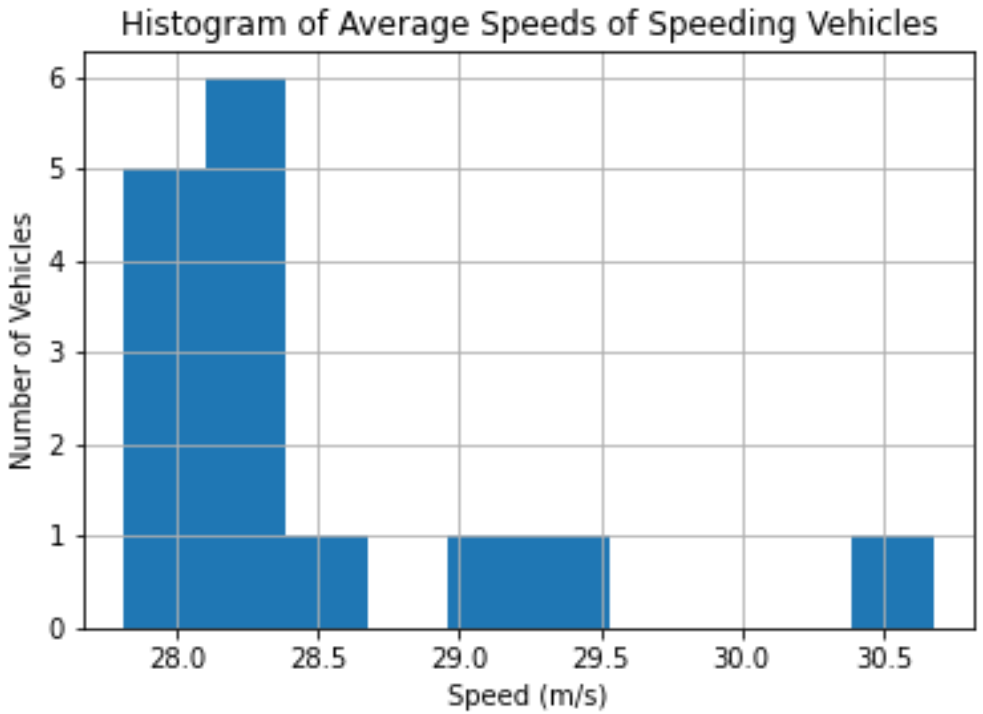
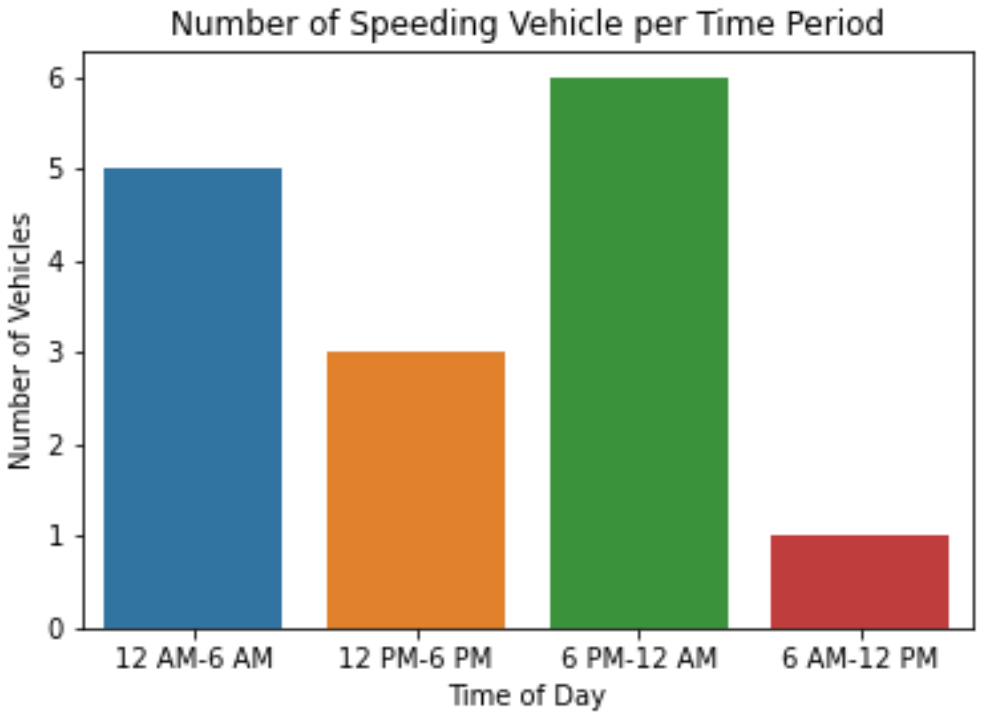
Sample Frequency Data





Vehicles greater than 60mph

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?

Mike Mollenhauer
mmollen@vt.edu
(970)227-3373

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