The Interstate 24 Transportation Technology Corridor

Highway Safety and Operations Conference
November 14, 2023

TN TDOT Department of Transportation

ARCADIS

Gresham Smith

VANDERBILT UNIVERSITY

Outline

I24motion.org

- I-24 SMART Corridor
  - Purpose and Need
  - ICM Elements; Project Phases
  - Measures of Success – Early Returns
- I-24 MOTION
  - Vision
  - System Components
  - First Experiment
  - World's Largest Time-Space Diagram
  - What is Possible?

I-24 SMART Corridor

I-24 SMART Corridor: Mission & Goals

TDOT Mission:

*To provide a **safe and reliable transportation system** that supports economic growth and quality of life.*

I-24 Smart Corridor Mission:

*To improve the **safety and reliability of all travel** along the corridor through the proactive management of intelligent and connected infrastructure, and the formation of strong operational partnerships between local and state agency stakeholders.*

I-24 Smart Corridor Goals:

Goal 1: Increase Travel Time Reliability

Goal 2: Increase Mobility of all Modes

Goal 3: Reduce the Concentration of Crashes

Goal 4: Develop Agency Coordination

I-24 SMART Corridor: Project Goals

- Mobility: Travel Time Reliability
- Safety: Reduce Secondary Crashes

Reliability

System Wide Peak Periods:

6:30 am - 8:30 am and **4:00 pm - 6:00 pm**

I-24	AM Peak Travel Time Index (TTI)	PM Peak Travel Time Index (TTI)
2018	1.3	1.32
2019	1.25	1.35
2020	1.04	1.13
2021	1.17	1.26
2022	1.57	1.49

SR-1 / US-41	AM Peak Travel Time Index (TTI)	PM Peak Travel Time Index (TTI)
2018	1.51	1.69
2019	1.47	1.65
2020	1.24	1.45
2021	1.32	1.56
2022	1.19	1.43

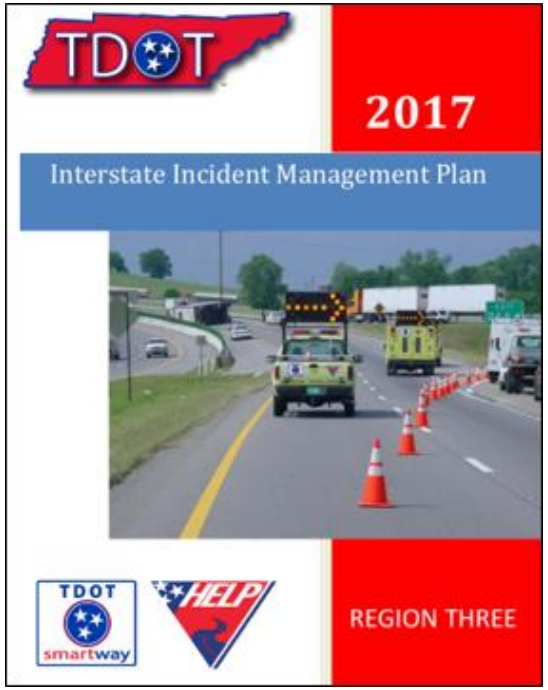
Based on weekday averages (M-F)

Safety

* Data as of June 30, 2023

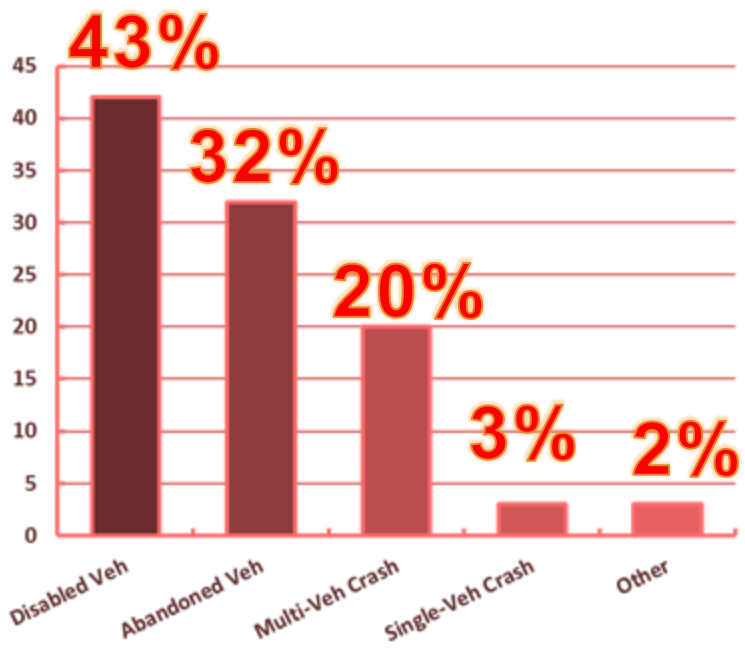
I-24	Fatal Crashes	Major Injury Crashes	Minor Injury Crashes	Prop Damage Crashes	Total
2018	12	39	623	1746	**2420**
2019	10	19	646	1969	**2644**
2020	9	41	468	1353	**1871**
2021	15	39	579	1597	**2230**
2022	9	40	613	1609	**2271**
2023*	3	11	266	682	**962**

SR-1 / US-41	Fatal Crashes	Major Injury Crashes	Minor Injury Crashes	Prop Damage Crashes	Total
2018	5	20	559	1429	**2013**
2019	12	40	600	1464	**2116**
2020	6	39	521	1268	**1834**
2021	10	55	599	1290	**1954**
2022	8	52	607	1199	**1866**
2023*	5	21	294	639	**959**

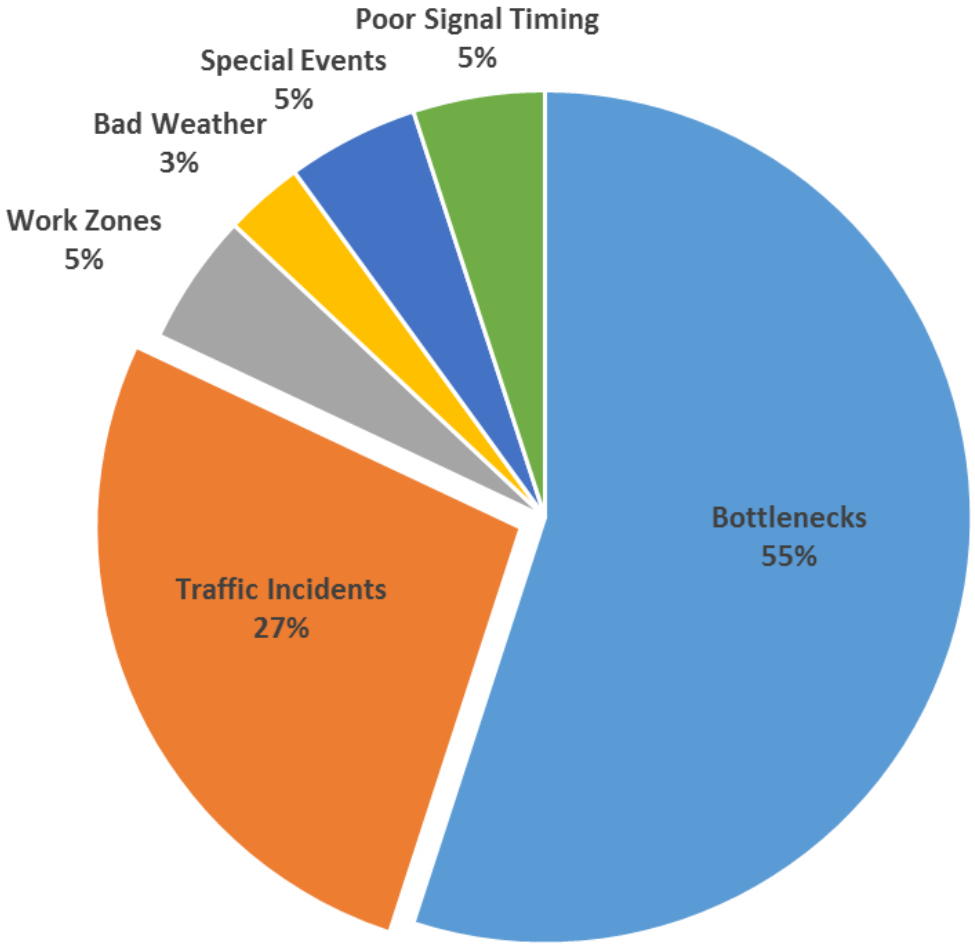


Purpose and Need

Traffic Incidents 27%



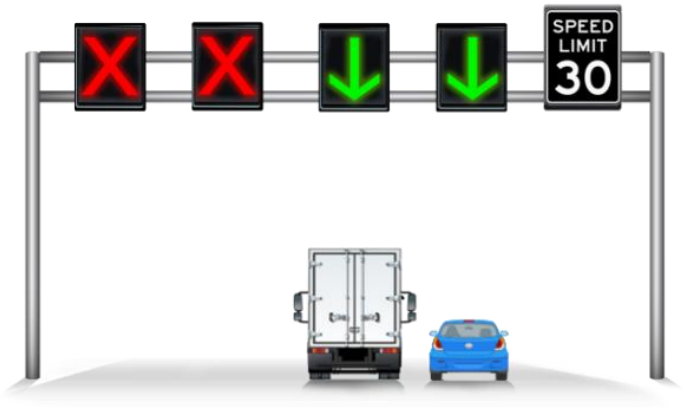
Incidents Breakdown 2015
(Total Crashes:1,661)

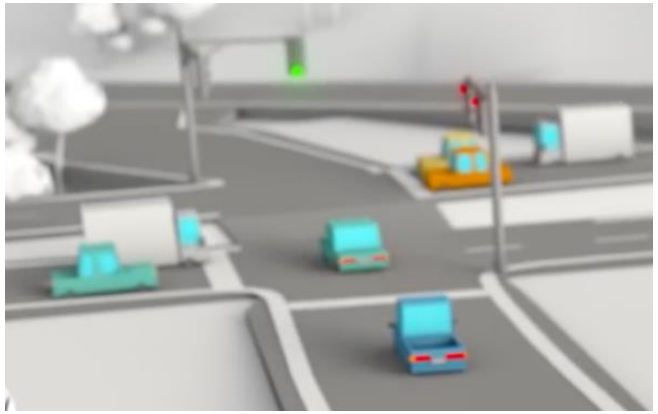


Contributors to Congestion

I-24 SMART Corridor: ICM Elements

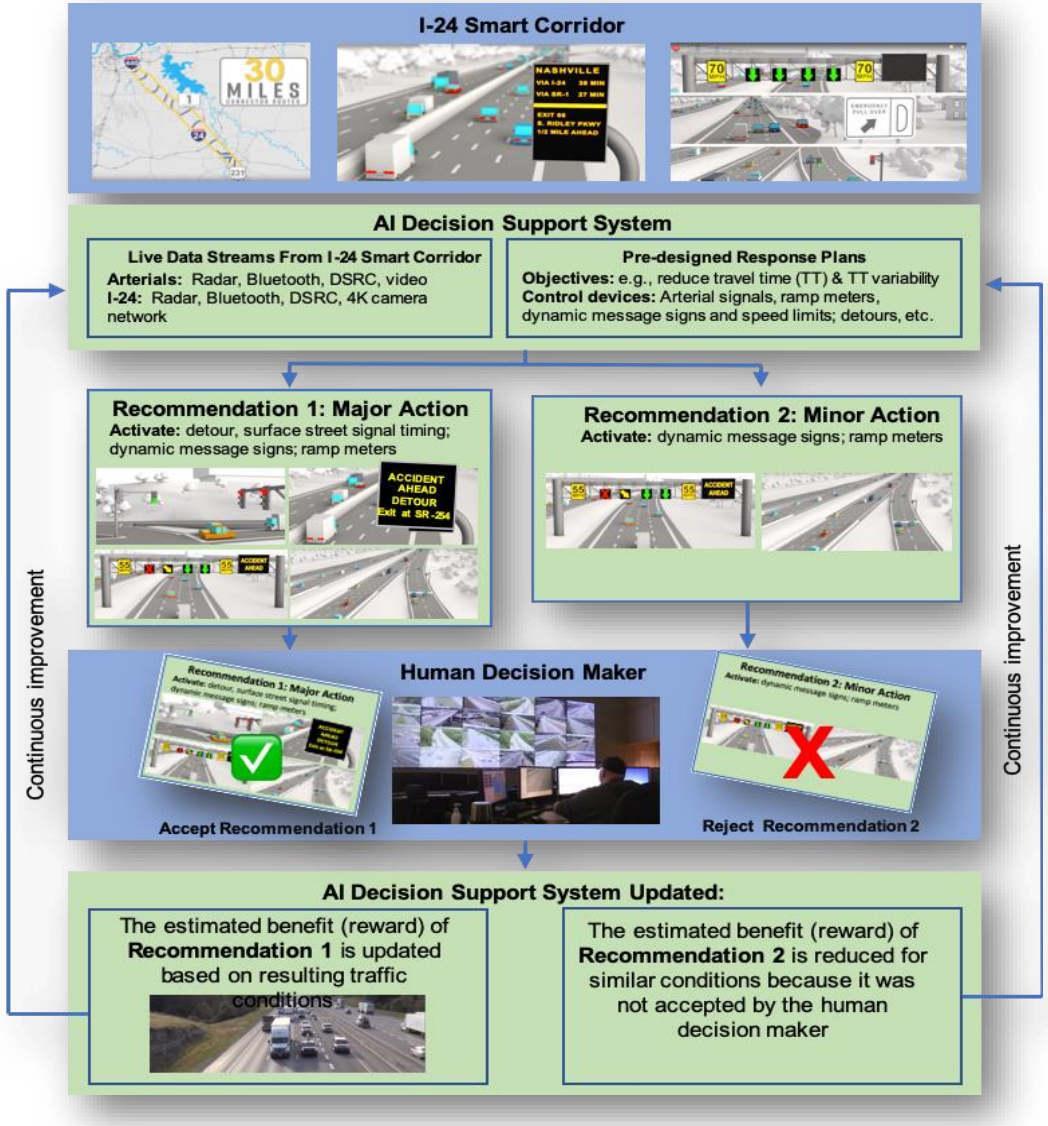
- **Integrated corridor management across 29 miles of I-24 and 29 miles of US 41, using 30 miles of connector routes.**
- **Physical improvements consisting of:**
  - Extended ramp lengths
  - Emergency pull-offs
  - Variable speed limits
  - Lane control system
  - Signal optimization and control
  - Diversion Traffic Signal Operations
  - Arterial digital messaging and camera coverage
  - Ramp meters
- **Coordination powered by an AI-based decision support system**





AI Decision Support System

- Hundreds of new devices increase management challenge for TMC operators.
- Need software that can scale with the growing complexity of the TMC.
- AI-DSS automatically suggests ICM plans to human operators for approval.
- Learns from edits or feedback from operators, as well as data, over time.



I-24 SMART Corridor: Stakeholders

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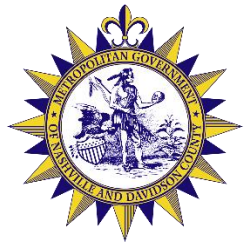
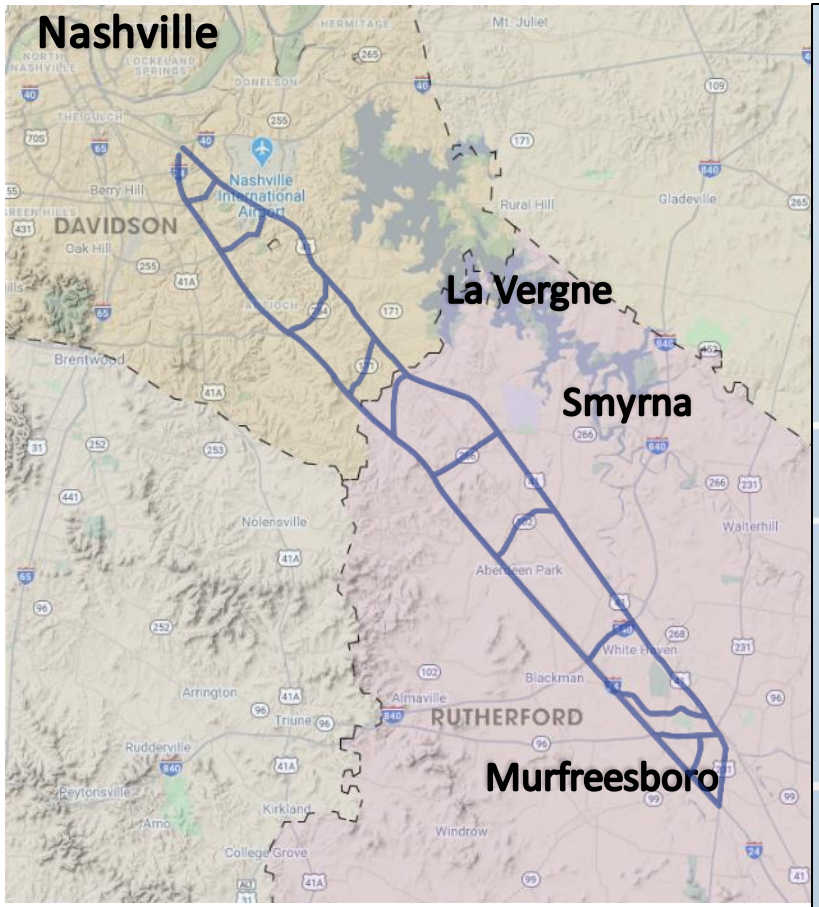


I-24 SMART Corridor Phase 1



Length: 94 Total Miles (29 Miles along I-24)

Termini:

- I-24 from I-440 to SR-231
- US 41 from I-24 to SR-231
- Various connector routes

Phase 1

- **Scope of Work:**
  - Interchange ramp improvements along I-24
  - Roadside Dynamic Message Signs (DMS) along I-24
  - Connected vehicle infrastructure – Dedicated Short Range Communication (DSRC) devices
  - Upgraded signal system and signal timing
  - Emergency pull-offs along I-24
- **Let to Contract:** October 2018
- **Contractor:** Stansell Electric
- **Completed:** December 2021

I-24 SMART Corridor Phase 2

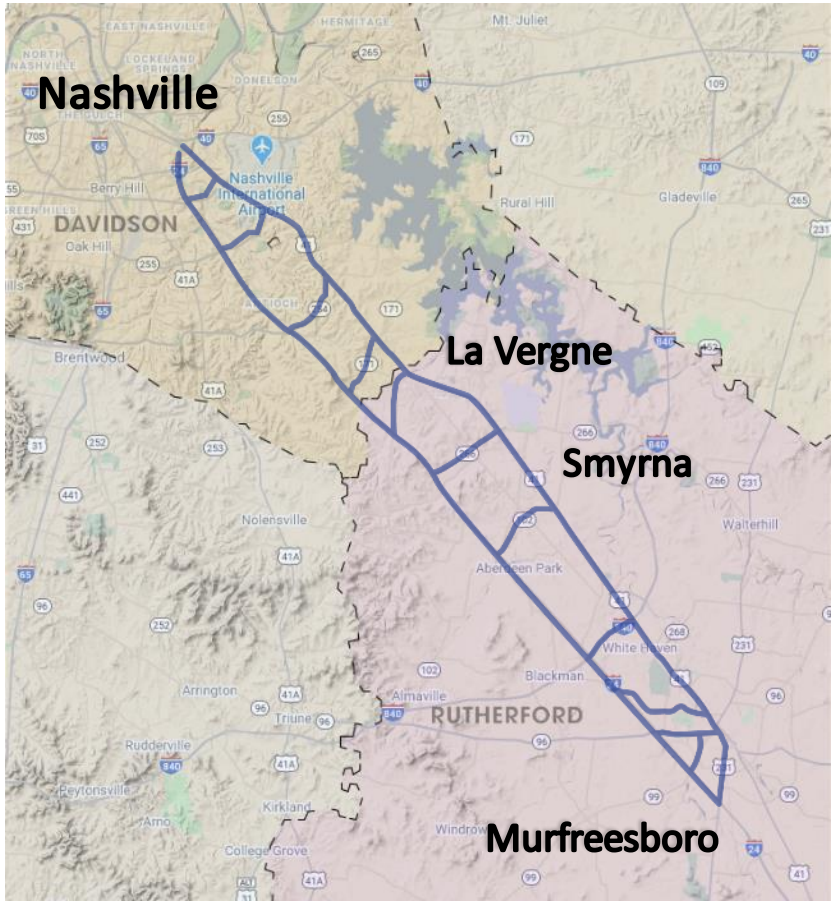
Length: 94 Total Miles (29 Miles along I-24)

Termini:

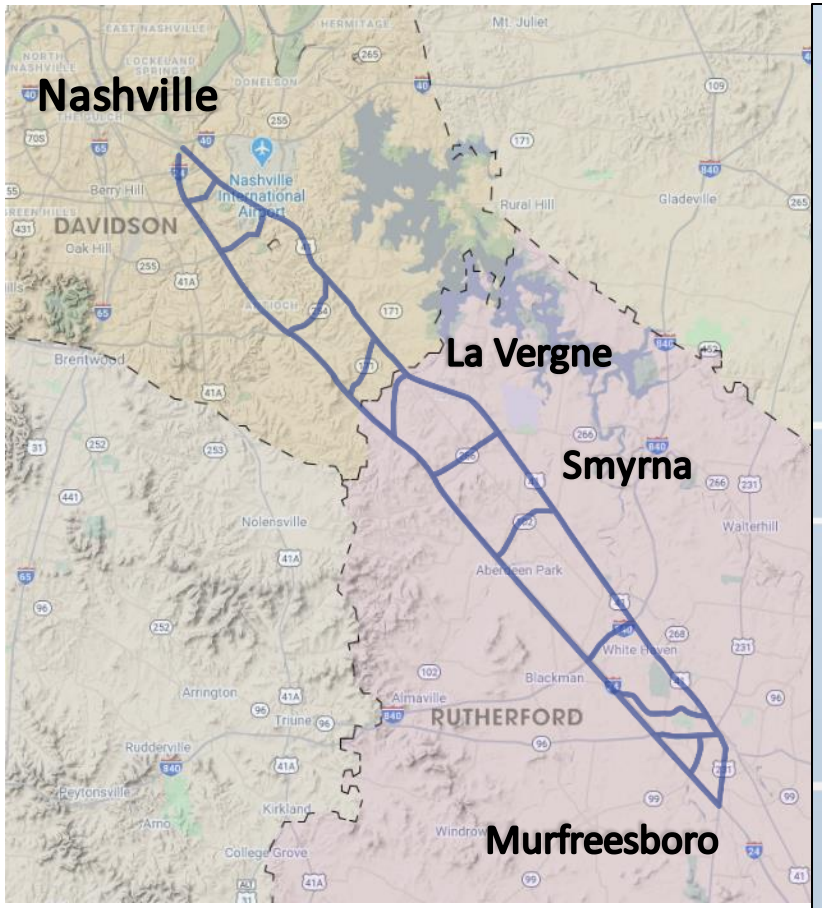
- I-24 from I-440 to SR-231
- US 41 from I-24 to SR-231
- Various connector routes

Phase 2

- **Scope of Work:**
  - Overhead DMS for Active Traffic Management (LCS and VSL) on I-24 between I-440 and SR-102
  - Upgraded Interstate Fiber Communications
  - Traffic Signal upgrades: radar and video detection
  - Implement Active Traffic Management (Arterial & Freeway)
- **Let to Contract:** October 2019
- **Contractor:** Stansell Electric
- **Estimated Completion:** December 2023



I-24 SMART Corridor Phase 3



Length: 94 Total Miles (29 Miles along I-24)

Termini:

- I-24 from I-440 to SR-231
- US 41 from I-24 to SR-231
- Various connector routes

Phase 3

- **Scope of Work:**
  - Ramp Metering along I-24
  - Install and upgrade Arterial Fiber Communications on Arterials
  - CCTV, DMS, and Travel Time Signs along Arterials
  - Artificial Intelligence Decision Support System for Active Traffic Management
- **Current Design Phase: ROW Plans due Oct 2024**

Lane Control System (LCS)

- Compliance with Red X and Yellow Arrow
- Lane Management
- Maintain Traffic Flow around traffic incident
- Reduce Driver Frustration
- Buffer Zone for First Responders
- Improved Incident Clearance Time
- Reduced Delay

Variable Speed Limits (VSL)

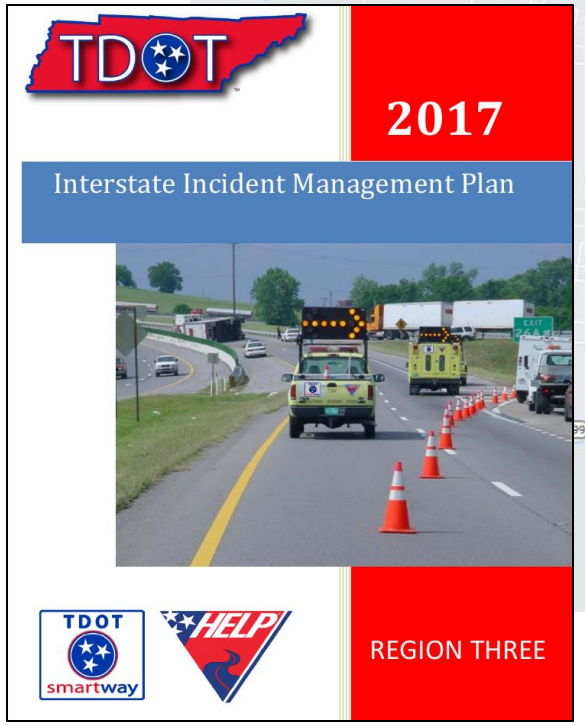
- Regulatory not Advisory Speed Limit
- Compliance
- Advance Warning of Recurring and Non-Recurring Congestion
- Speed Harmonization
- Slow is Smooth, Smooth is Fast
- WZ Safety

Emergency Pull Offs

- 14 Emergency Pull Offs
- Refuge area for disabled motorist and First Responder
- Video Detection

Incident Diversion Plans

- Predetermined Diversion Plans
- Shared with First Responder partners
- Traffic Signal Timing Plans for when traffic is diverted from I-24 to parallel arterial
- Developed with local agency collaboration
- Can be implemented from local agency TOC or TDOT TMC



I-24 SMART Corridor: Measuring Success

What Project KPIs and performance measures will be tracked?

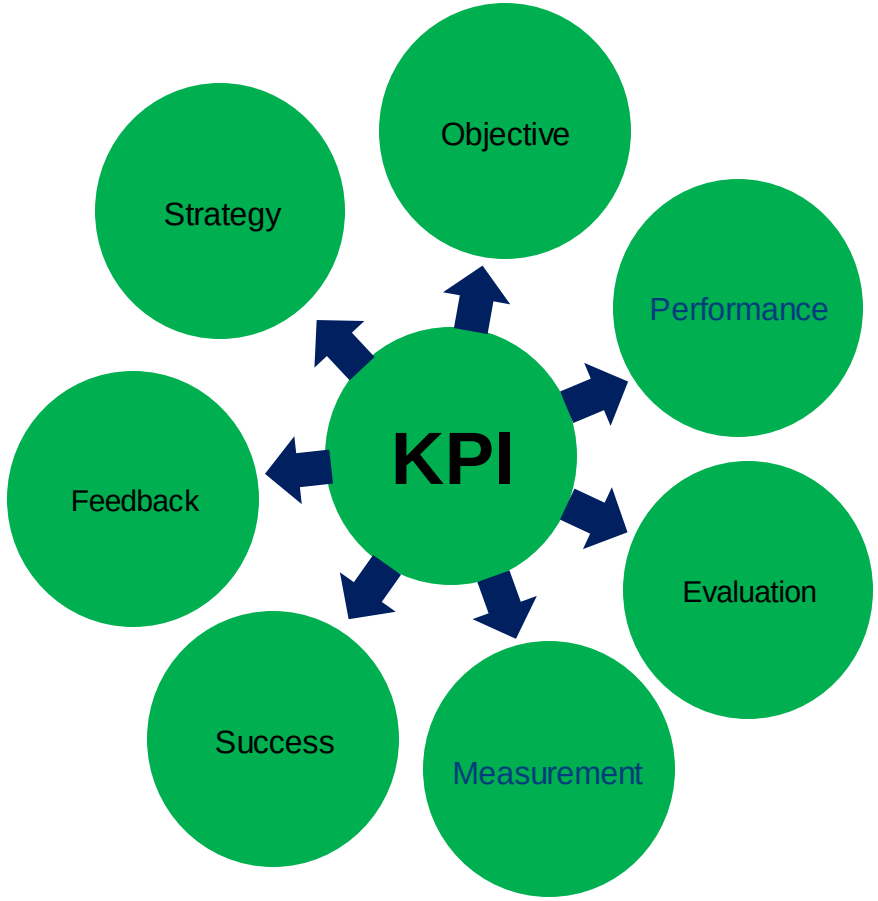
- KPIs tracked daily, monthly, quarterly & annually.

Operational KPIs:

Travel Time and Travel Time Reliability	**Delays & Economic Impacts**
Speed/Volume/Density	**Crash Data (Rates/Frequency)**
Causes of Congestion	**Automated Traffic Signal Performance Measures**

Maintenance KPIs:

Target Up-Time (Interstate/Arterial/Network)	**Site Reliability (tracking failures at sites)**
Preventative Maintenance Visits	**# of Work Orders/Call Tickets, Time to Respond & Resolve Issues**



I-24 SMART Corridor: Measuring Success

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What are the expected benefits for the I-24 SMART Corridor?

- Texas saw a 44% reduction in crashes with a queue warning system.
- Virginia observed that VSL provided a reduction in collisions in low visibility conditions by over 50%.
- A Texas study shows that VSL systems provide a 7:1 to 14:1 benefit-cost ratio.
- In San Diago, CA, Analysis has shown that ICM can save commuters more than 1,400 person-hours a day during peak commuting periods.

I-24 SMART Corridor: Measures of Success

I24motion.org

Crash Comparison

June 20 through August 20
Mile Marker 52 to 74

Change in Serious Crashes
2022 – **82**
2023 – **58**

- 29%

Change in Total Crashes
2022 – **272**
2023 – **204**

- 25%

Traffic Volume Comparison

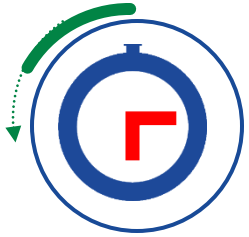
June 20 through August 20
Mile Marker 54 to 59

Change in Average Vehicles per Day
2022 – **161,000 vpd**
2023 – **186,000 vpd**

+ 15%

Traffic Delay Comparison

Before and After "Go-Live"
Mile Marker 52 to 74



Change in Daily Hours of Delay
May – **4826 hours**
July – **4065 hours**

- 16%

Note:
Delay is the time spent traveling below the maximum posted speed limit.


I-24 MOTION

Traffic jams on real roadways are complex

Video courtesy TDOT

Connected and Automated Vehicles are creating new needs for understanding traffic

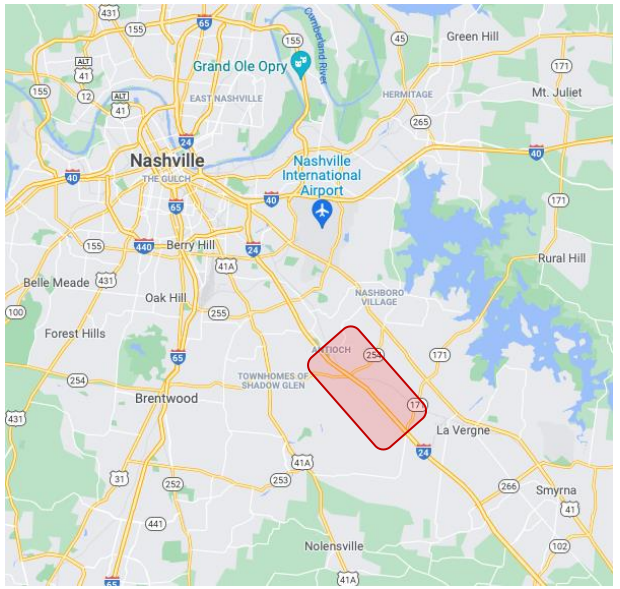
[https://www.youtube.com/watch?v=HjtiiGCe1pE]

Vision: Create the premier, globally-recognized on-road testbed for:

- Ultra-high-resolution traffic observation.
  - Driver behavior, safety studies, traffic waves.
- Integrated corridor management.
- Real world *connected and autonomous vehicle* (CAV) deployments.
  - Vehicle interactions, truck platooning, etc.

Innovation:

- Dense installation of 4K resolution video cameras and modern computer vision algorithms on I-24.
- Four miles of continuous camera coverage observing all vehicles.



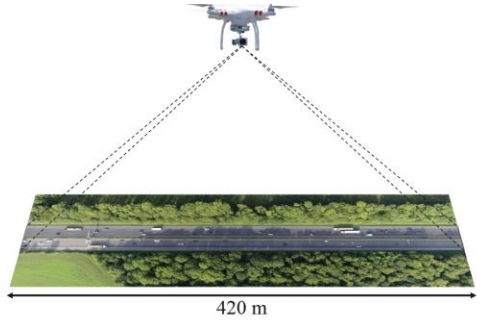
I-24 MOTION: Data Production

- 2006 N
  - 1,800
    datase
  - Backb
    comm
- 2018 High-D (Germany)
  - 25,000 vehicle miles traveled
- **2022+ I-24 MOTION**
  - 200,000,000 vehicle miles traveled/year.
  - Ongoing year after year.
  - Persistent sensing captures full spectrum of traffic, plus rare events.

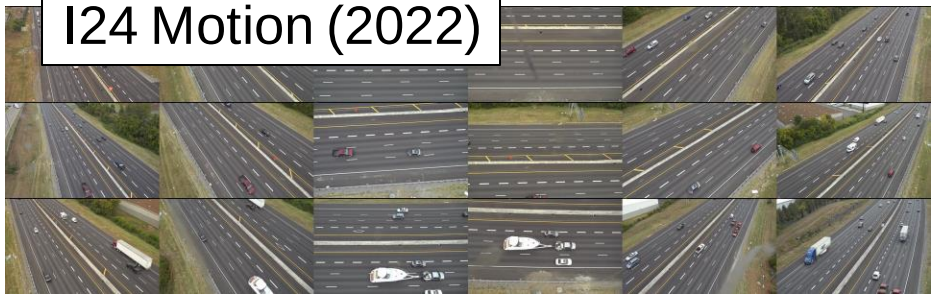
Estimated data:
- **31 PB/yr video processed (not stored)**
- **11 TB/yr trajectories shared**

NGSIM (2006)

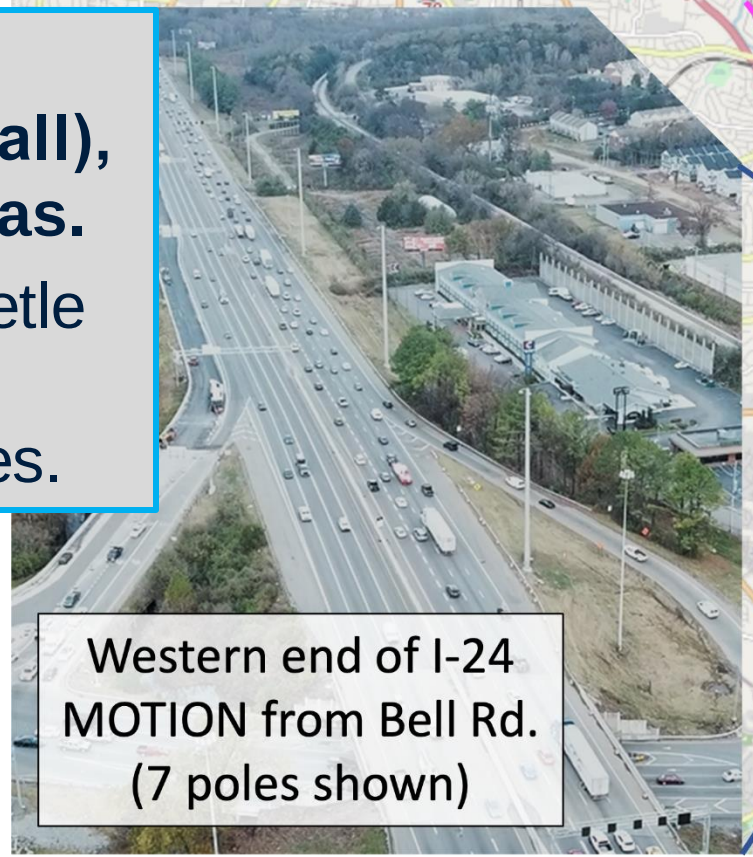
High-D (2018)



I24 Motion (2022)



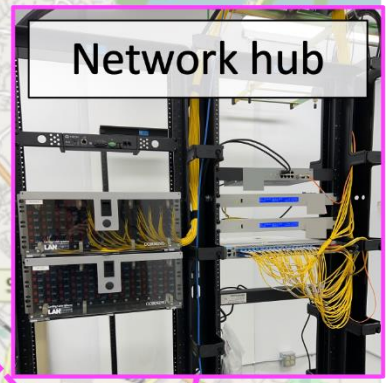
- **40 poles (110-135’ tall), 276 cameras.**
- 6x dual-Beetle poles at interchanges.



Western end of I-24 MOTION from Bell Rd. (7 poles shown)

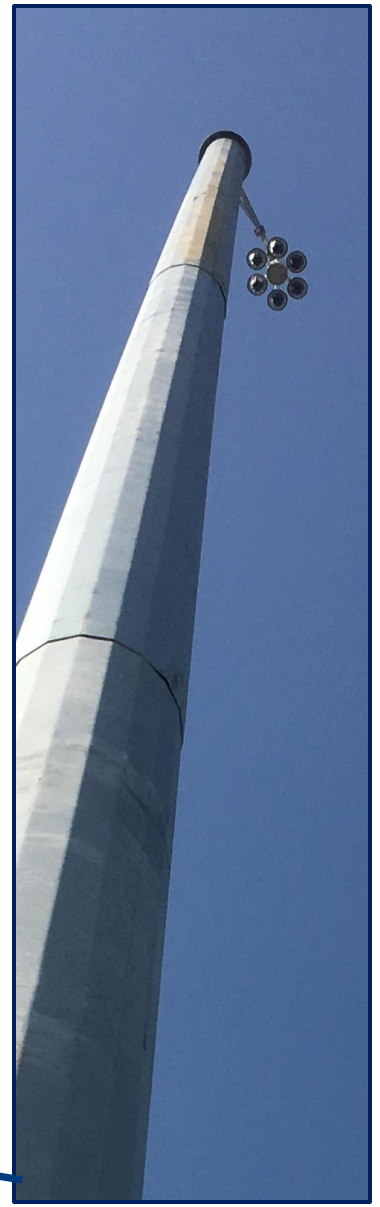
Vanderbilt datacenter

Network hub



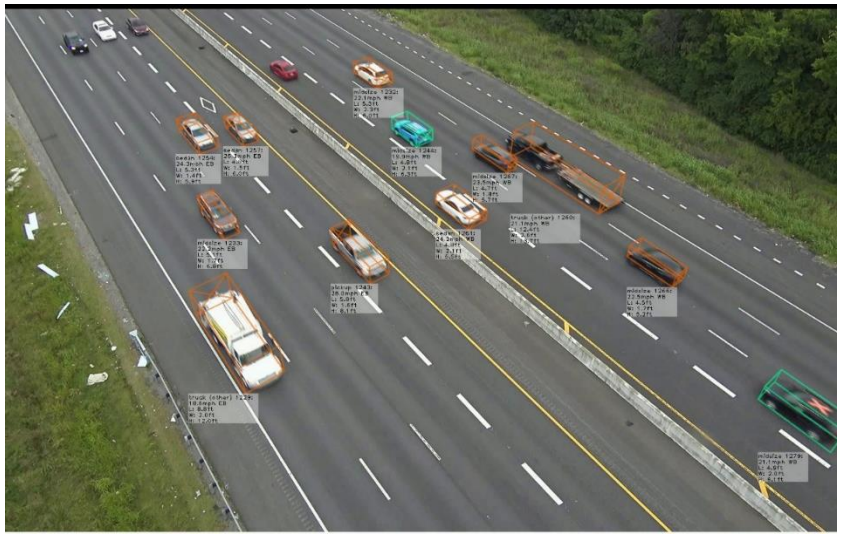
Network hub

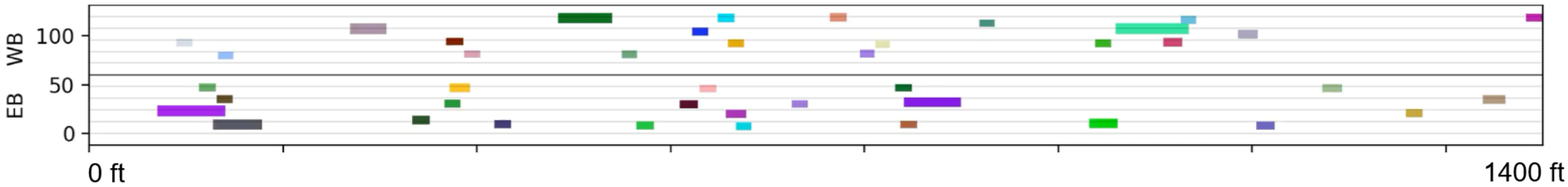
Fiber network



I-24 MOTION: Trajectory Algorithms

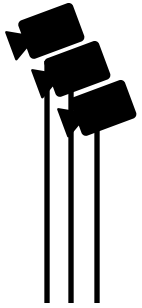
- Generate high-precision 3D bounding boxes for all vehicles within view on each video frame (30 fps)
- Trajectories generated across all cameras and stitched together to form 4-mile data source
- Coordinate and transform from image to roadway reference coordinates



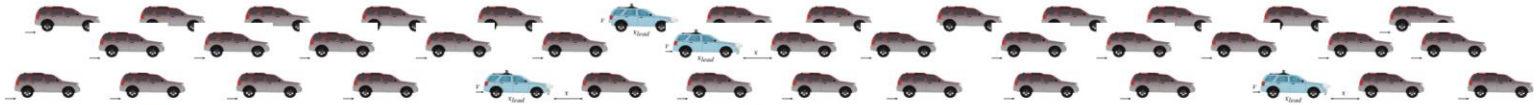


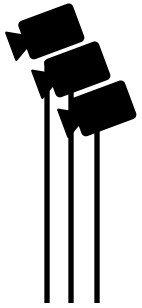
Use 100 CAVs to reduce stop-and-go waves in a real roadway setting, thereby improving safety and efficiency.

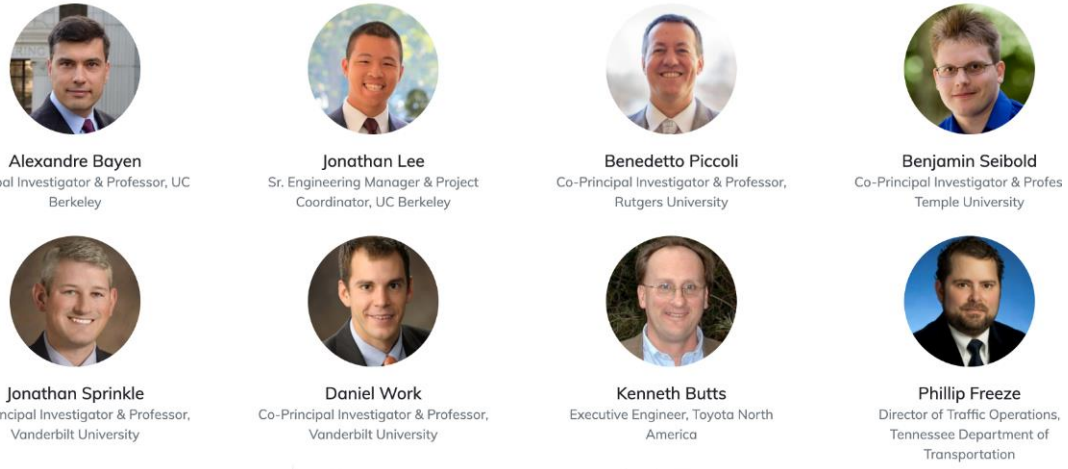
Without control: more stop-and-go, more fuel used. Some cars directly measured, all vehicles estimated



With control: more uniform flow, less fuel used. Only some cars controlled/measured, all vehicles estimated







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Co-Principal Investigator & Professor, Vanderbilt University

Kenneth Butts
Executive Engineer, Toyota North America

Phillip Freeze
Director of Traffic Operations, Tennessee Department of Transportation

45+ researchers

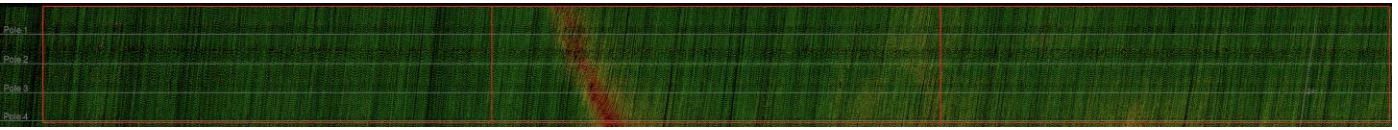
5 universities, TDOT and 3 OEMs

Use standard platforms with our solutions

Previously: Your Settings stay on while engaged

Today: Settings may change based on traffic conditions (the research)

Trajectory Data available from NGSIM (2006)



I-24 MOTION Trajectory Data from Partial Morning

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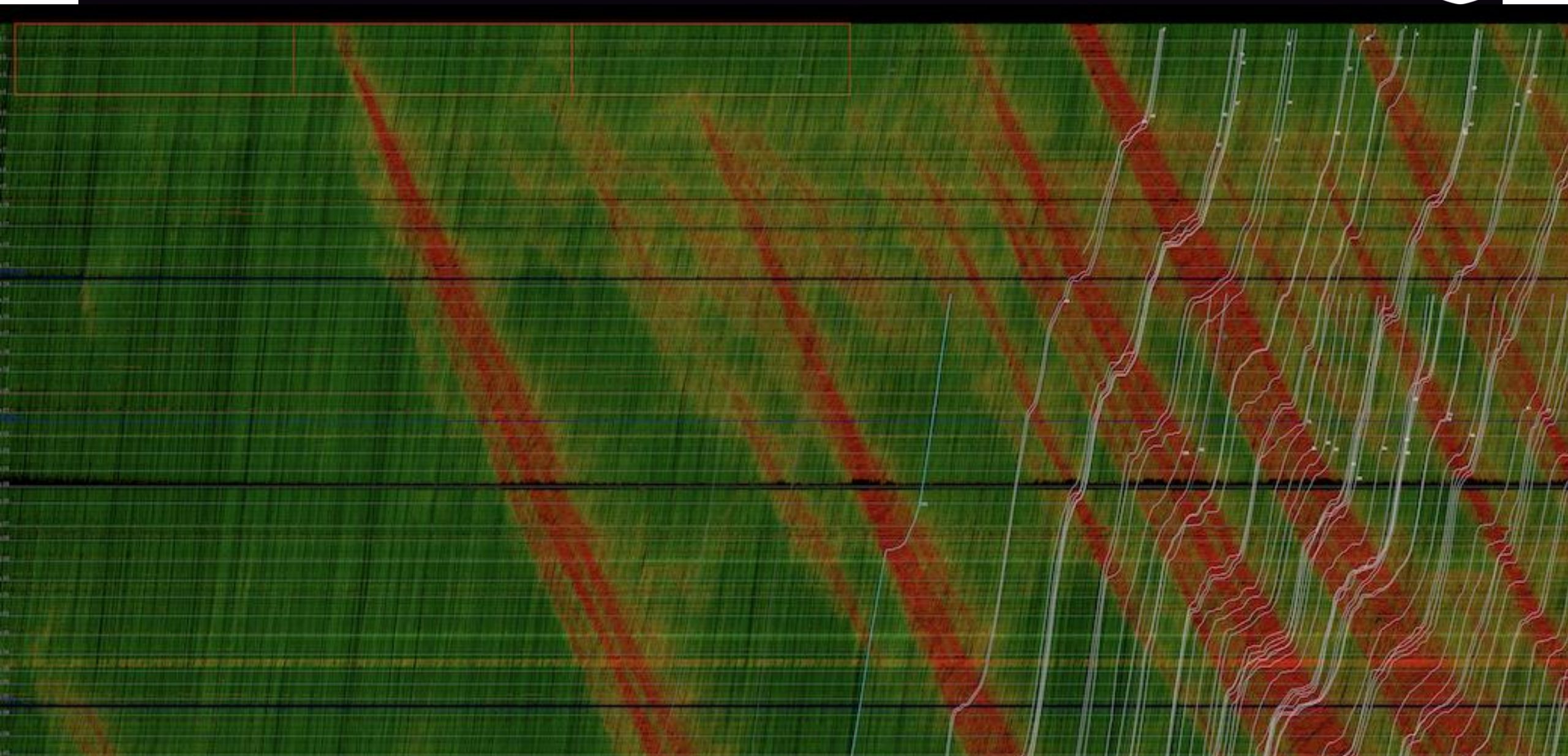
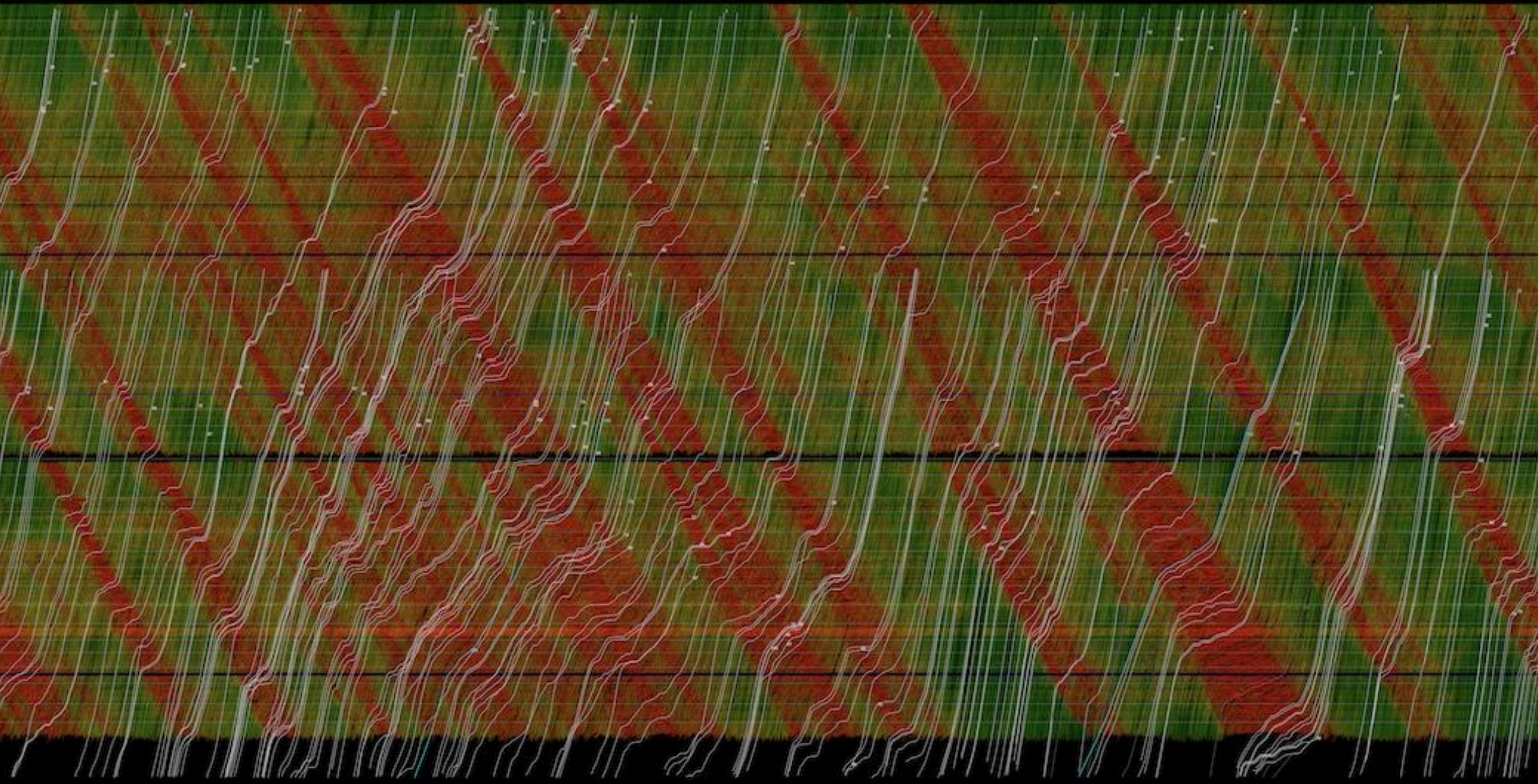


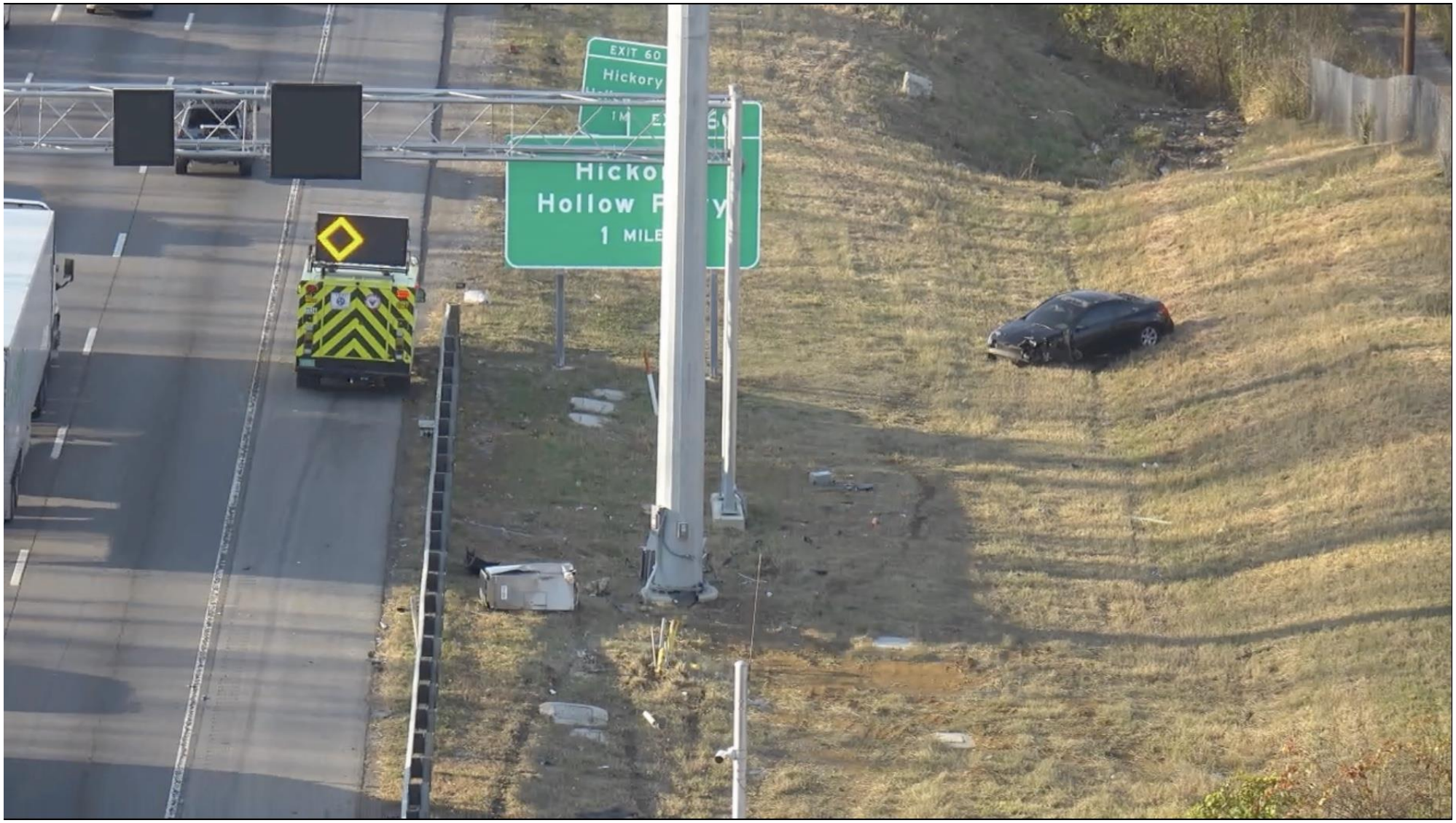


What's Possible for I-24?

TDOT: Active Traffic Management

- How do drivers respond to active traffic management?
  - Completed Studies
    - Variable Speed Limit Optimization
  - Potential Studies Include:
    - Variable Speed Limit Compliance
    - Responses to Lane Control Signals and Ramp Metering
    - Incident Diversion
    - New Operational Strategies
    - Use of Yellow Arrow for LCS
  - Choice Lane simulation models and experiments

Driver Compliance: Move Over Laws & 1st Responders

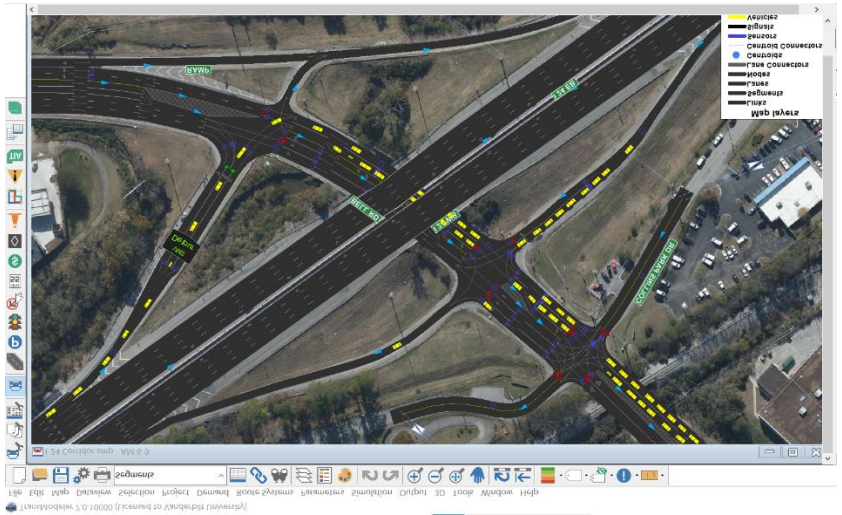


External Coordination & Collaboration

TDOT envisions opportunities to pursue mutually beneficial testing with industry:

- Automotive original equipment manufacturers and suppliers
- Researchers
- Traffic simulation software developers
- Freight and logistics operators
- Infrastructure owners
- USDOT
- Intelligent Transportation Systems (ITS) product manufacturers
- Enterprise networking and data solution providers

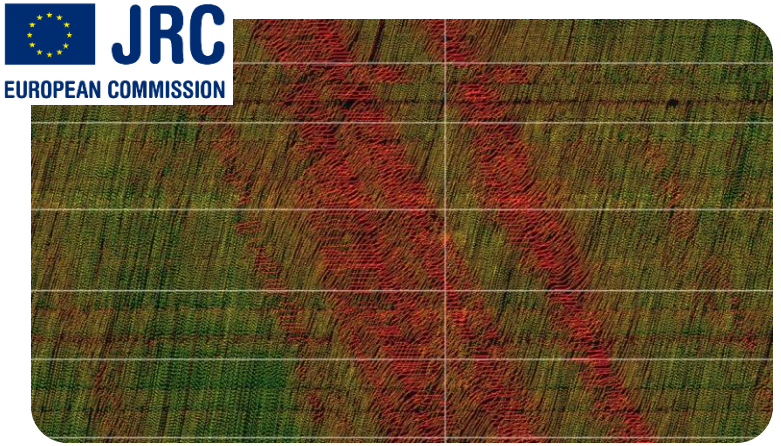
Source: FHWA



Future Testing Partners

Freight Electrification Insights

- Identify class 8 truck cab types (sleeper, regional).
- Experimenter/funder: Tennessee Valley Authority
- Timeframe: 2023-2025



Level 2 Automated Vehicles

- Quantify level 2 automated vehicle impacts on traffic stability
- Experimenter/funder: European Commission Joint Research Centre
- Timeframe: January 2024

And more…

Testing with TDOT – Ramp Meter Optimization

Testing with USDOT – "Jambusters": AVs driven at VSL speed, improving compliance and safety (proposed USDOT grant)

Testing with states – pooled fund studies: lane control signals, move over laws, incident scenes

Testing with industry – Nissan, GM/Cruise, express lane operators (Cavnue, Cintra, Transurban), start-ups (Armada IQ, roadsAI)

Data Distribution

- Intend to freely share I-24 trajectory data and other data feeds to registered users across the country and around the world.
  - Due to data size, users will need to record data from API feed.
- Can support data manipulation and basic analytics tools, in order to help with large data volumes and common tasks.
- Data distribution expected to begin with limited scope in summer 2023, reaching full maturity by the end of 2023.
- As of November 2023 – 50+ registered data users

Questions?

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