DelDOT's Artificial Intelligence Enhanced Integrated Transportation Management System (AI-ITMS)

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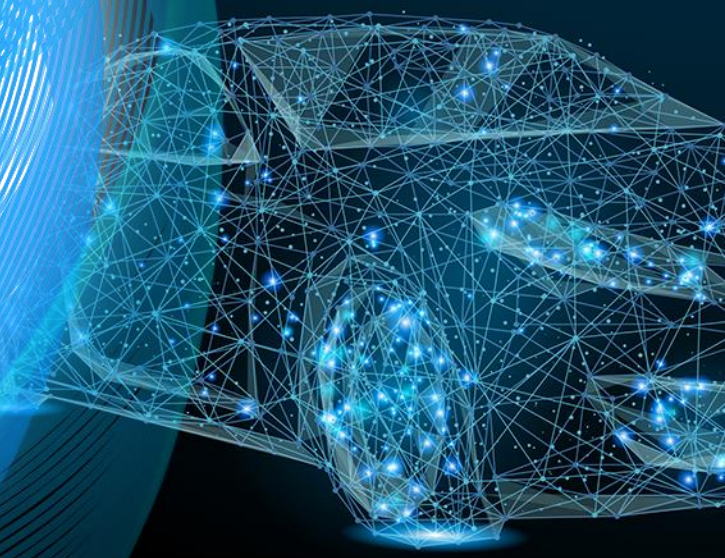
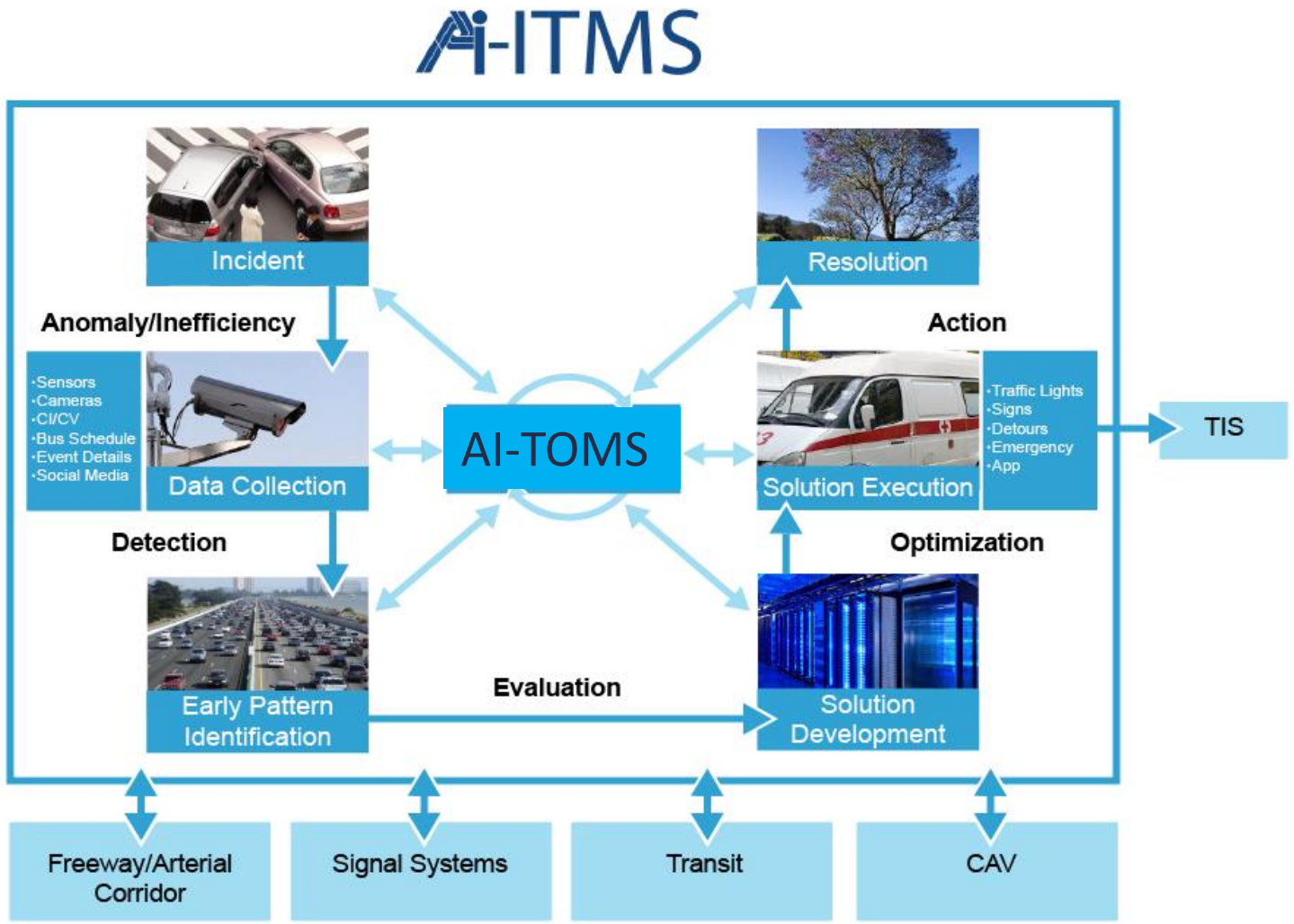
Outline

- DelDOT's AI-ITMS Program
- AI-TOMS Software Capabilities
  - Data Fusion
  - Short Term Traffic Flow Prediction
  - Proactive Incident Management and Decision Support
  - Machine Vision for Traffic Management
  - Traffic Signal Optimization and Operation
  - Connected Automated Vehicle (CAV) Integration
- Follow-up Efforts
  - Flood prediction and Vulnerable Road User safety for traffic management (ATTAIN grant)
  - Cloud based V2X and intersection safety (SMART grant)
  - Statewide Deployment of AI-ITMS



AI Enhanced Integrated Transportation Management System (AI-ITMS)



- 3 Year, $10M USDOT/DelDOT grant fund project “Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD)”
- The Vision of AI-ITMS:
  - Automate and optimize transportation systems monitoring and operations
  - Early and accurate detection and identification of transportation systems anomalies and inefficiencies,
  - Reason the cause and impact of these anomaly/inefficiencies,
  - Develop corresponding solutions and provide early responses

AI Transportation Operations and Management Software (AI-TOMS)

- A web-based AI/ML systems for comprehensive transportation management and operations
- Detect traffic disturbance and predict traffic demand
- Generate and evaluate response solutions for prevailing or impending traffic anomalies and inefficiencies


Road Weather Data


Traffic Flow Data


Travel Time Data

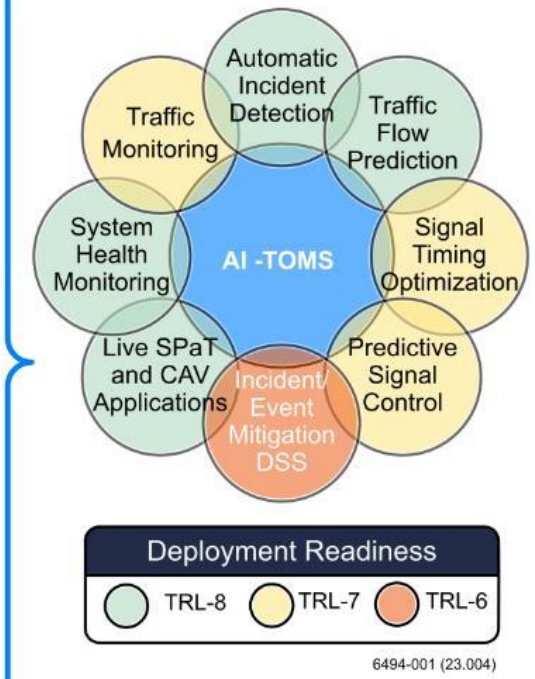

ATSPM and SPaT Data

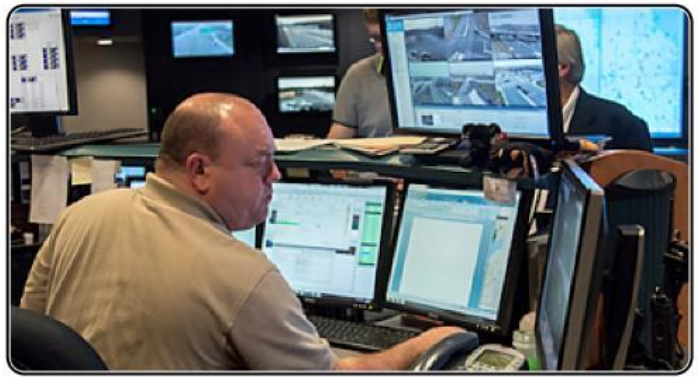

Traffic Camera Videos


Travel Restrictions Data

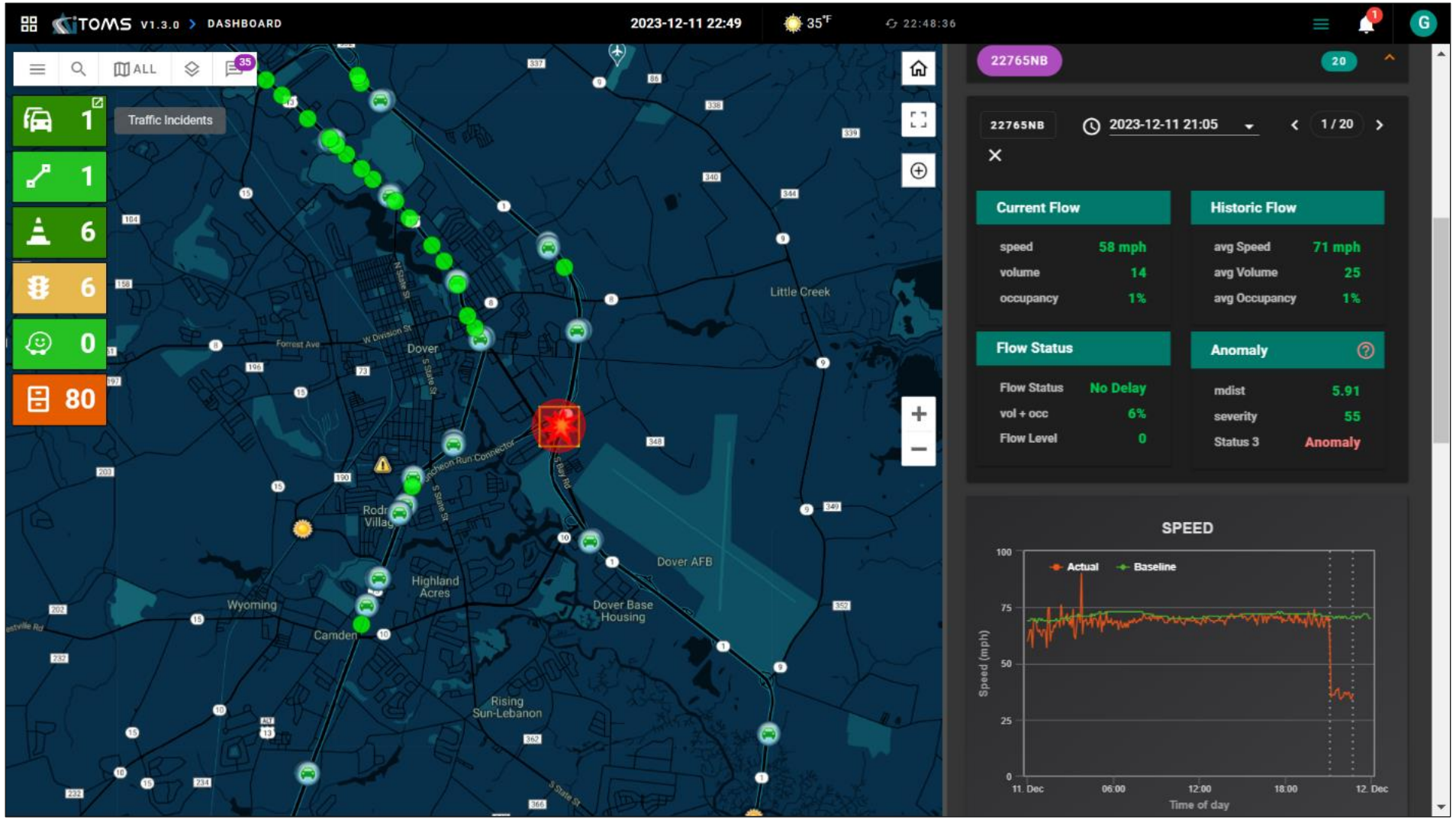
CAV Data


Social Media Data



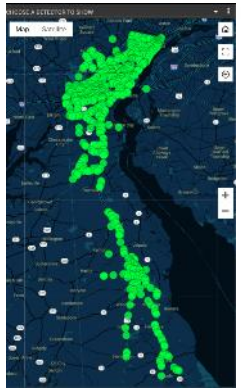


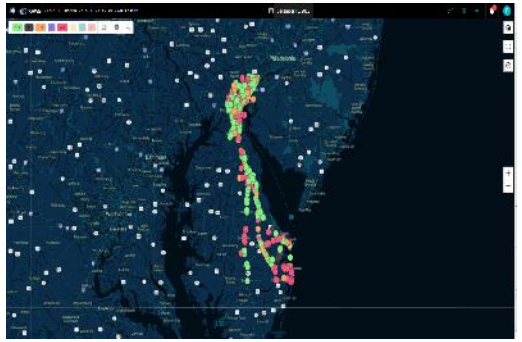
AI-TOMS Dashboard



Traffic Data

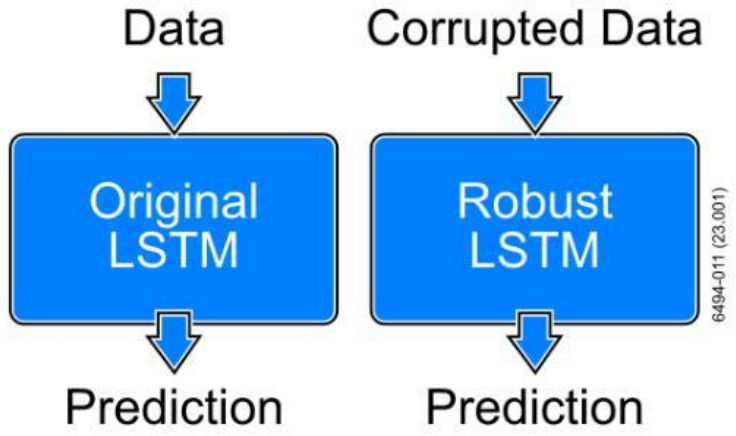
- A Cutting-edge AI Tool Streamlining Traffic Management Through Multi-source Data Collection And Visualization Capabilities.
- Empower Decision-making with Tailored Traffic Data, Environmental Insights, and Quality Metrics For Efficient Transportation Oversight.
- Modules:
  - Traffic Data Viewer
  - Traffic Anomaly Map
  - Travel Time Map
  - Detector Quality Map
  - Traffic Flow Prediction
- Features in each module
  - Date/Time Selection
  - Region Selections
  - Detector/Device Selection
  - Single or Multiple Device Selection
  - Data-refresh Time Interval Selection



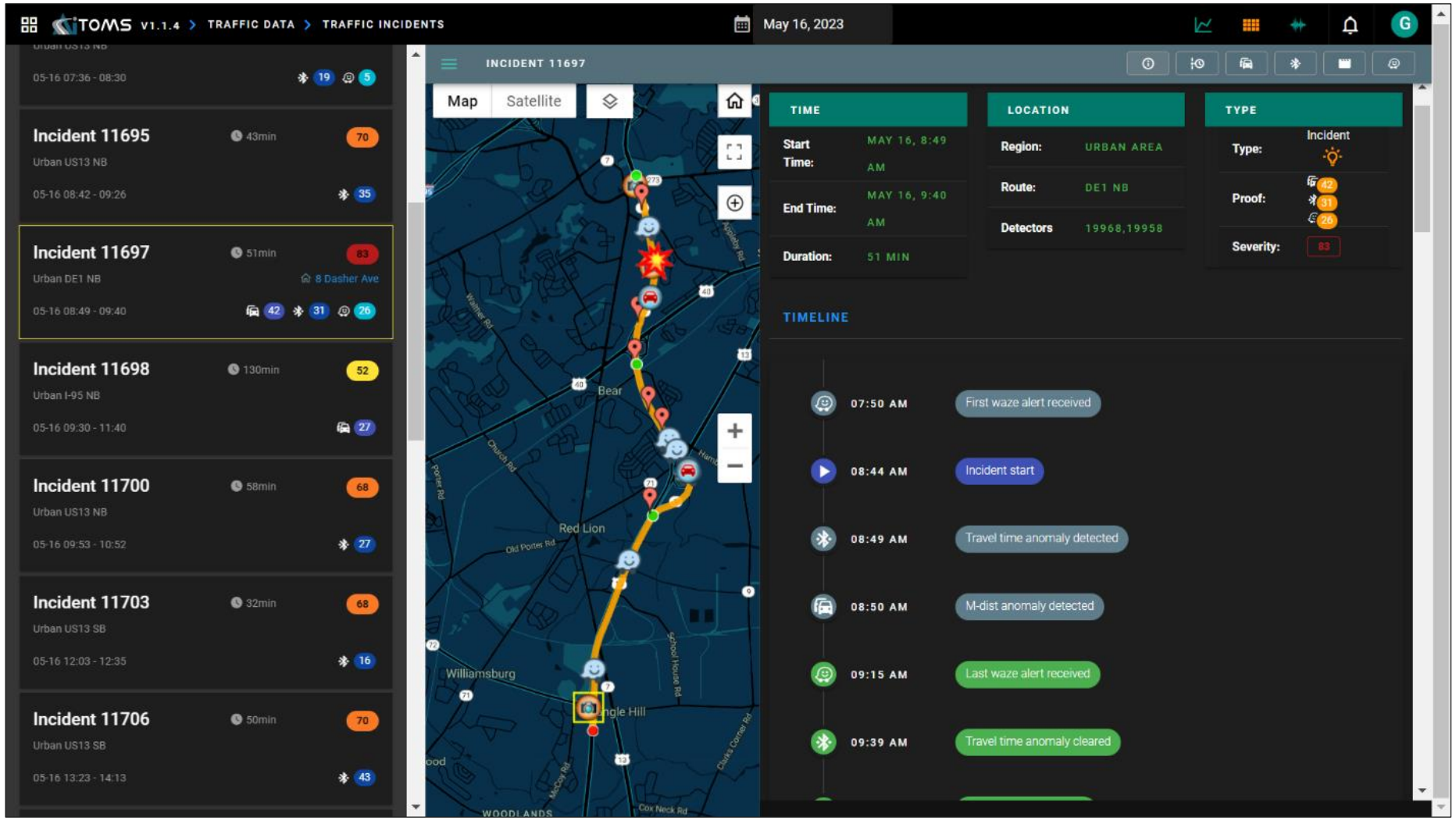




Traffic Flow Prediction

- Using Robust LSTM (Long Short-Term Memory) and GTS (Graph Structure Learning) models for prediction purposes
- Using different time frames of historical data input to capture immediate and seasonal variations
- Meta data input include time of day, day of week, month, weather, holiday
- Total trainable parameters ~750,000
- Predict Volume, Speed, Occupancy for the next 5, 10, 15, 30, and 60 minutes
- “Solution Development”:
  - Signal Optimization and Adjustment
    - ✓ Congestion Reduction
    - ✓ Improved Safety
  - Incident Mitigation Solution Recommendation and Implementation



Traffic Incident Detection and Management



Incident Detection Accuracy

- DelDOT incident alerts in urban area retrieved from 2021
- Date range: 2021-01-01 to 2021-08-02
- Total 93 incidents are recorded in the urban study area
- Distribution of urban incidents based on MUTCD classification:

Route	Minor	Intermediate/Medium	Major	Total
I-95	16	38	4	57
DE-1	2	25	6	33
Total	18	62	10	90

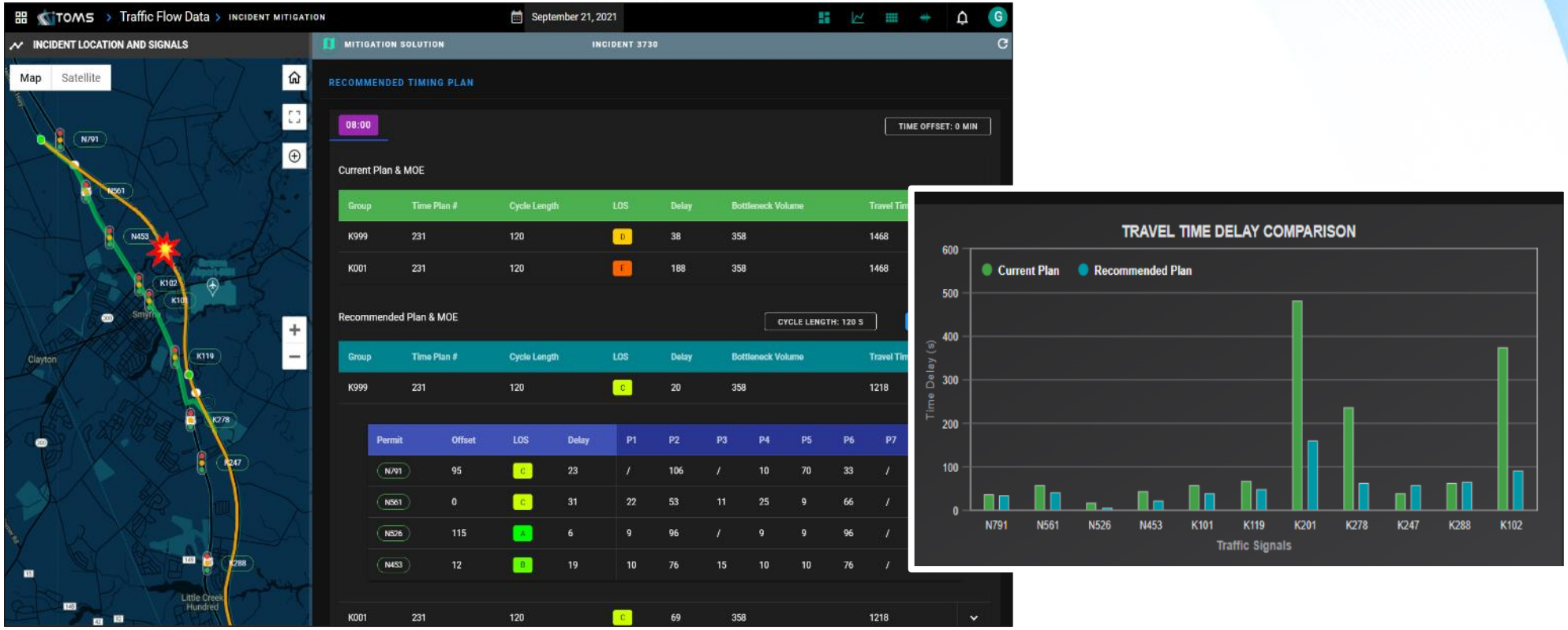
- Detection accuracy:

Major	Intermediate/Medium	Minor
100%	90.47%	88.88%

- Undetected incidents were either late night/early morning incidents or marginally outside of the study area (incident location is upstream of the study area).

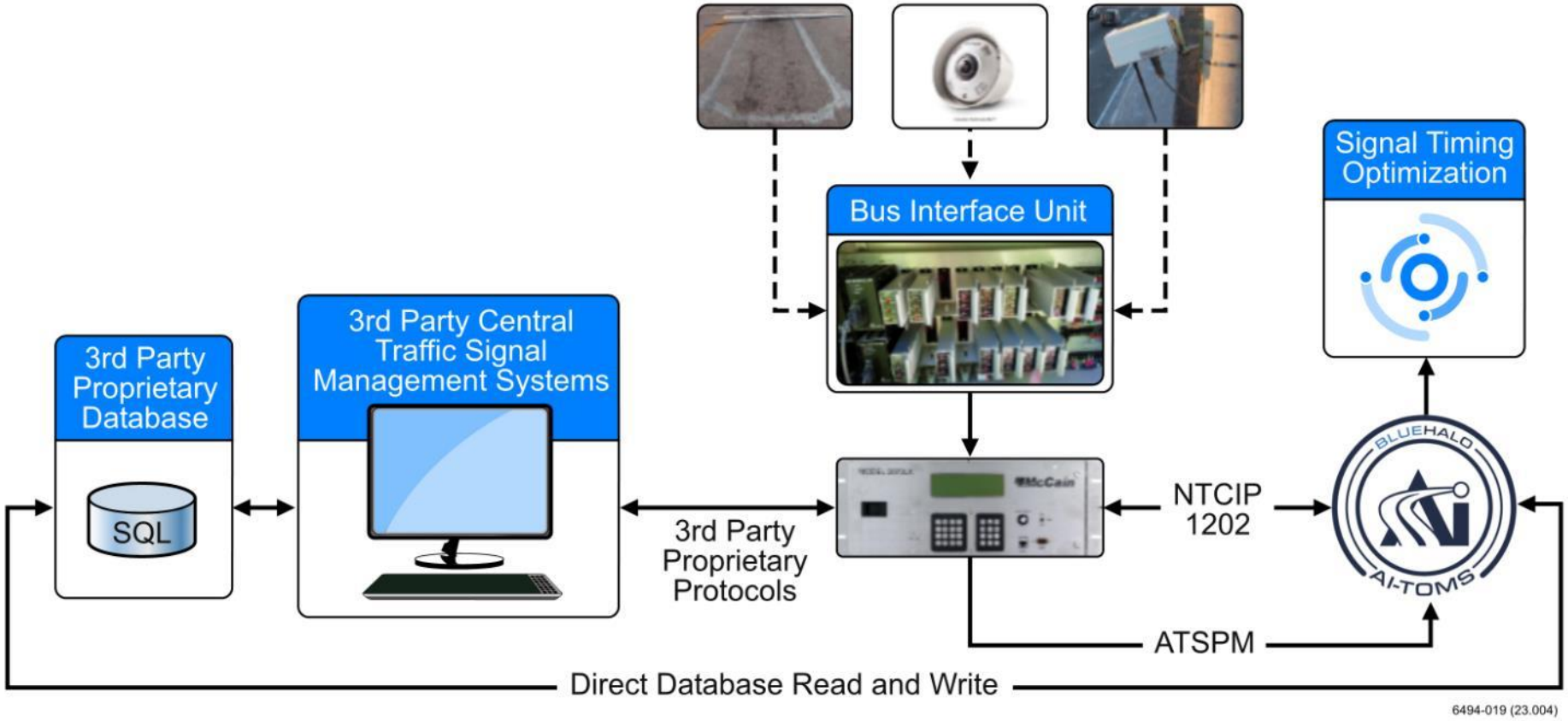
Response Plan Recommendation and Implementation

- Recommended signal timing is better than the current plan with reduced delay and travel time
- The detailed split and offset are optimized and ready for deployment



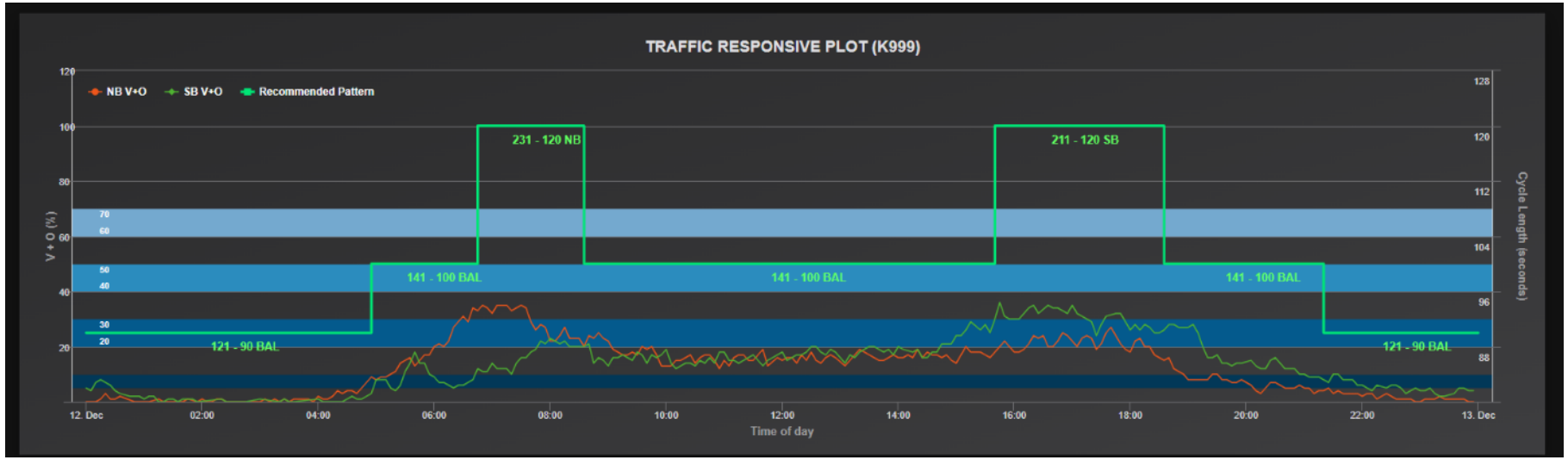
Traffic Signal Management

- Manage Key Intersection Data
  - Intersection info: Permit ID, Group ID, Location, IP Address
  - Signal timing data: Pattern ID, Cycle Length, Split, Coordinated Phase, Offset

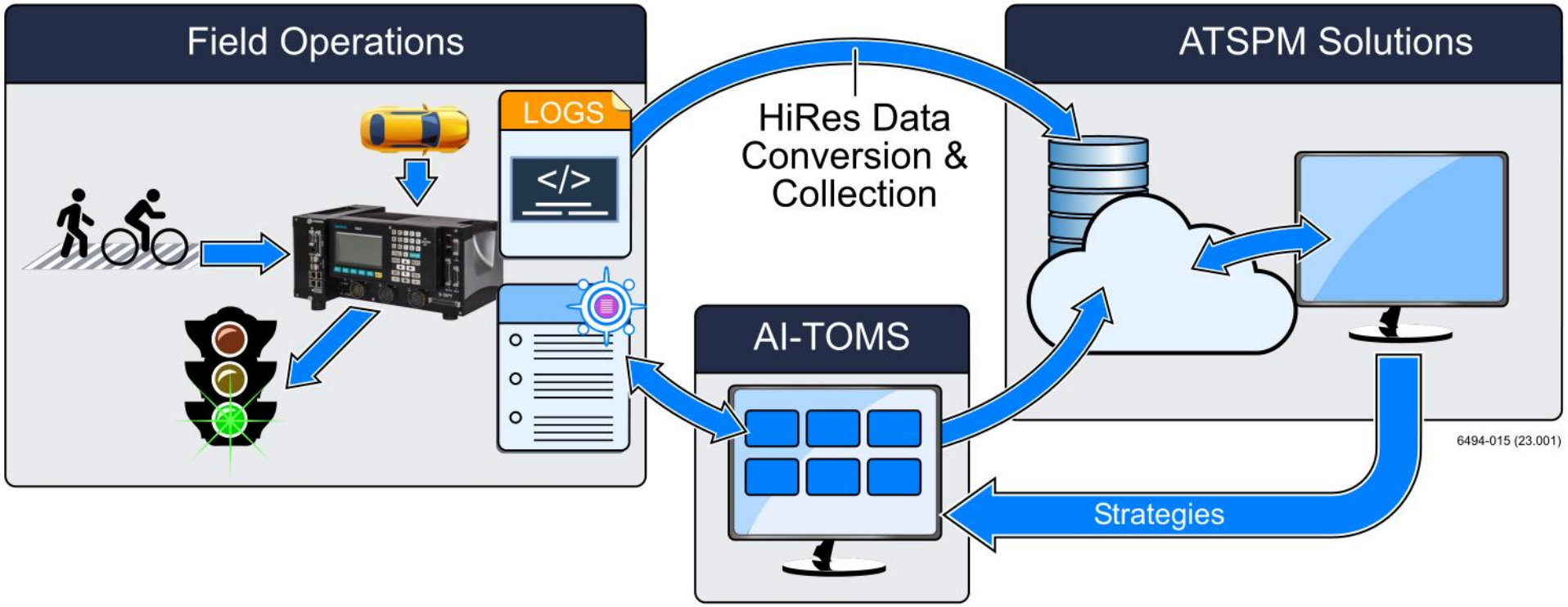


Adaptive/Predictive Signal Timing

- Three control modes:
  - AI-TOMS: Recommends signal patterns based on real-time demand
  - Time-of-Day: Issues signal patterns based on a pre-determined schedule
  - Manual: Allows technicians to issue manual signal pattern changes
- Allow group-based or individual intersection level control
- Leverage NTCIP 1202 to communicate with signal controllers

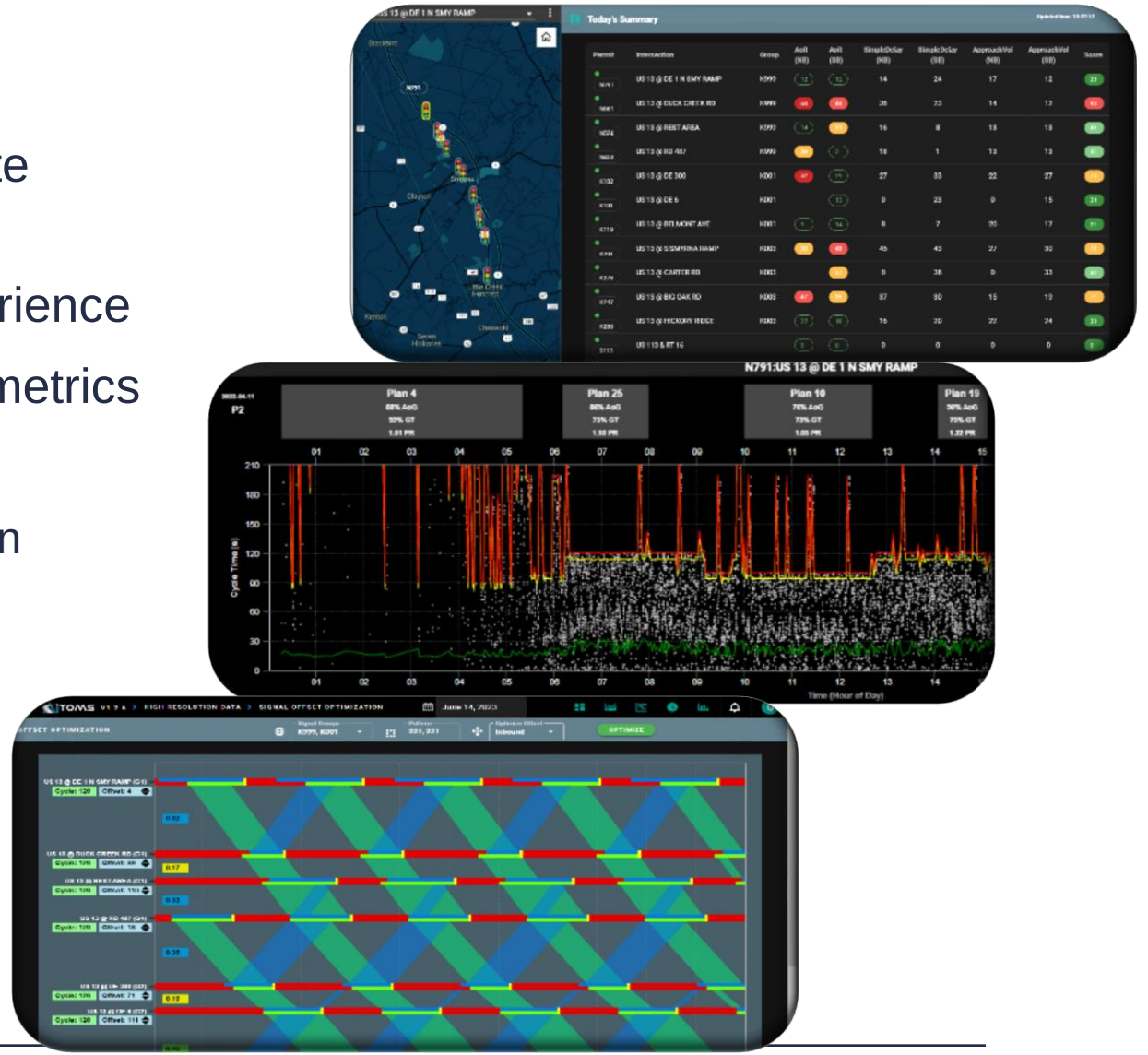


Automated Traffic Signal Performance Measures (ATSPM)

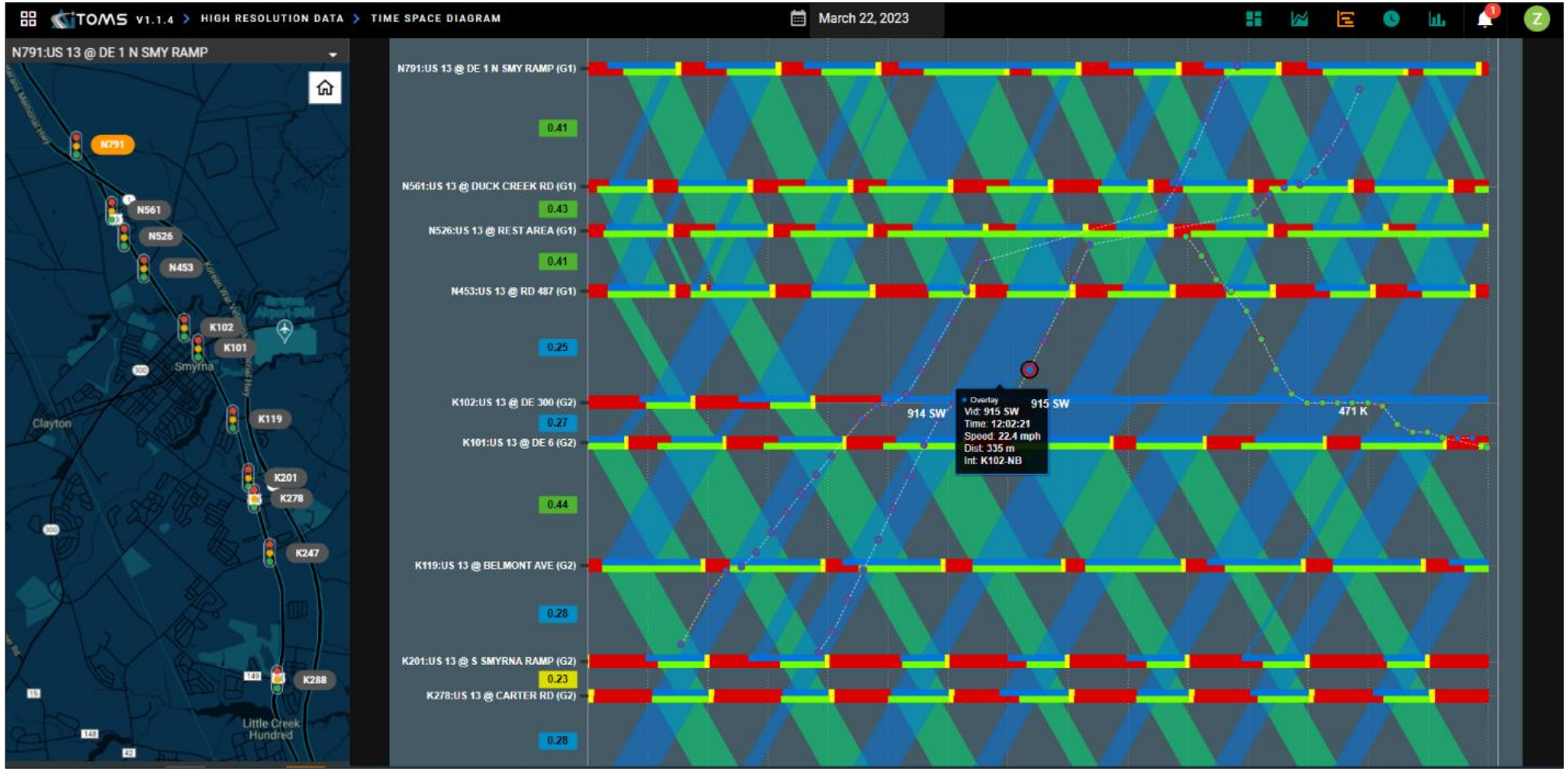


AI-TOMS Features Related to ATSPM

- Established pipeline for handling HR data
- Interacts with existing ATMS system to facilitate programming detection (ongoing)
- Pre-processes HR data to enhance user experience
- Allows creation of traditional and customized metrics
- Utilizes collected HR data to:
  - Increase situational awareness at the intersection
  - Support creation of new signal timing plans
  - Enhance turning movement counts' estimate
  - Support calibration & validation processes

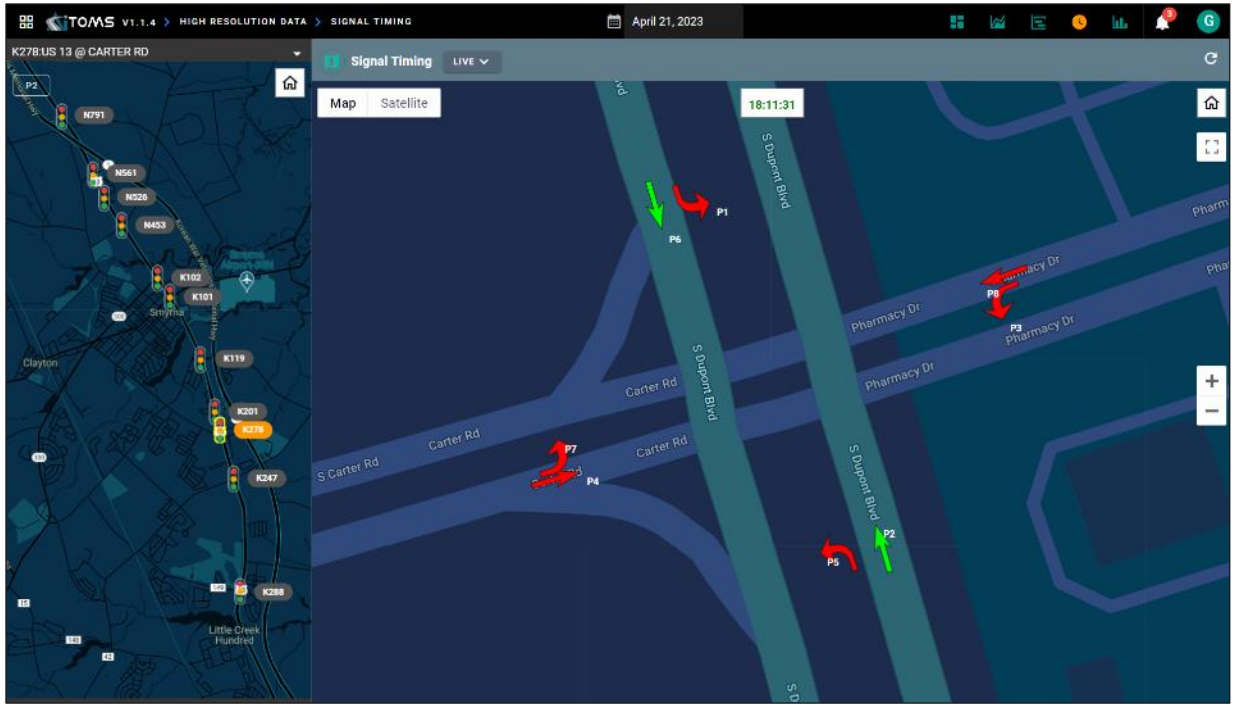


ATSPM and CAV Trajectories for Signal Performance



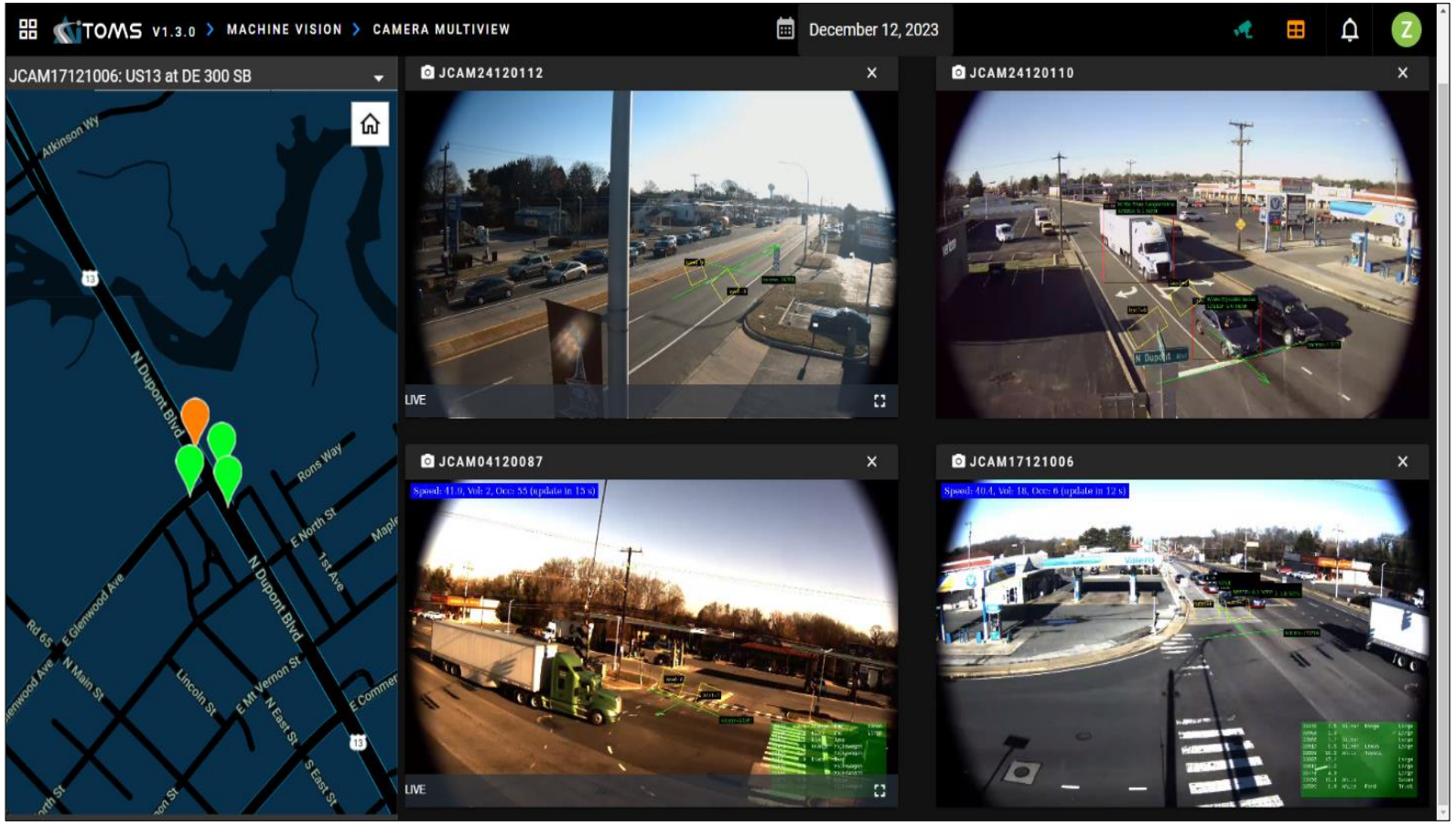
Live Signal Phase and Timing (SPaT) Broadcasting

- Live Signal timing data from the intersections
- Low latency (<100ms)
- Support Connected and Automated Vehicles
- Intersection safety applications



Machine Vision for Traffic Monitoring

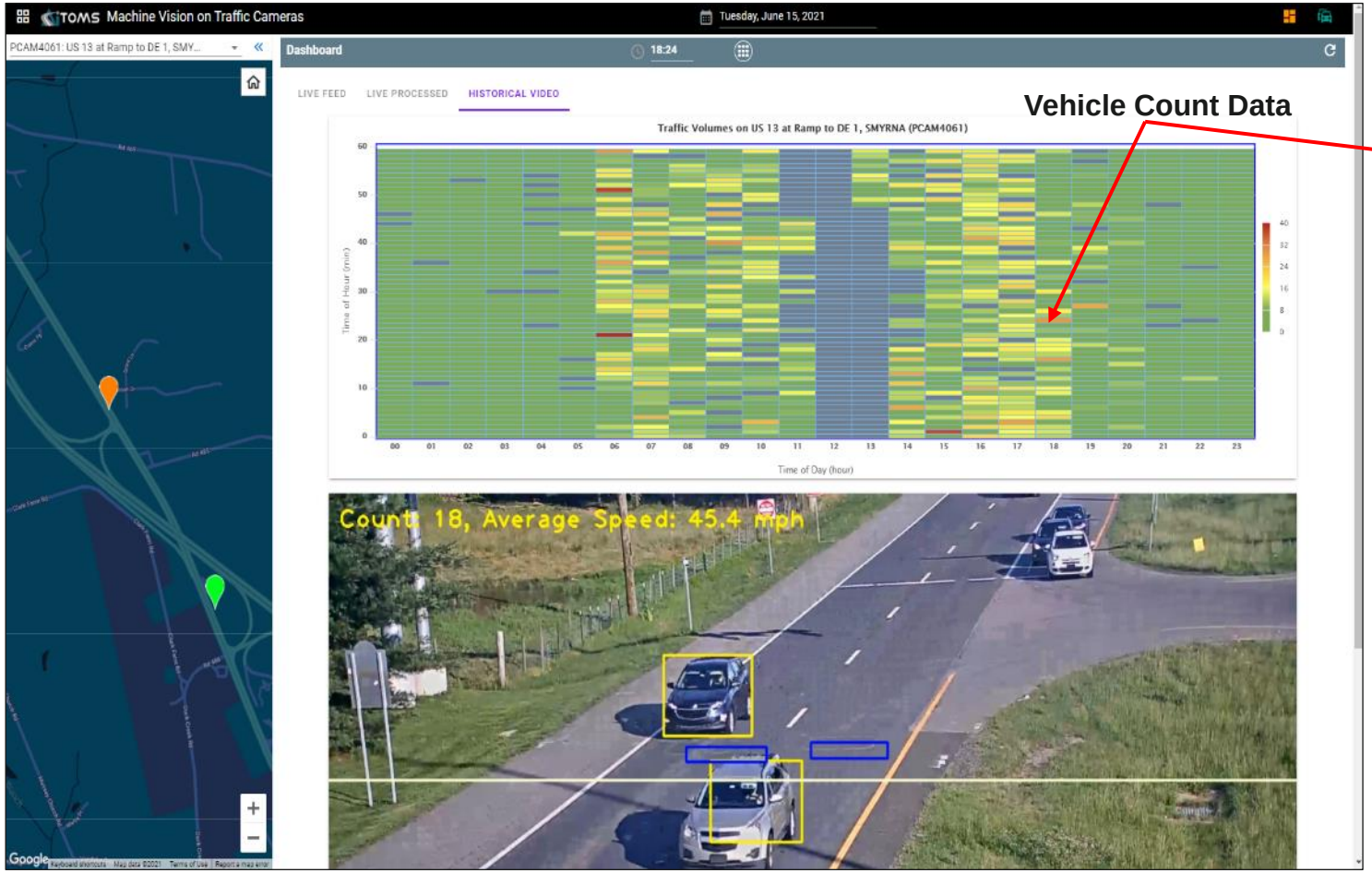
US-13 @ DE-300



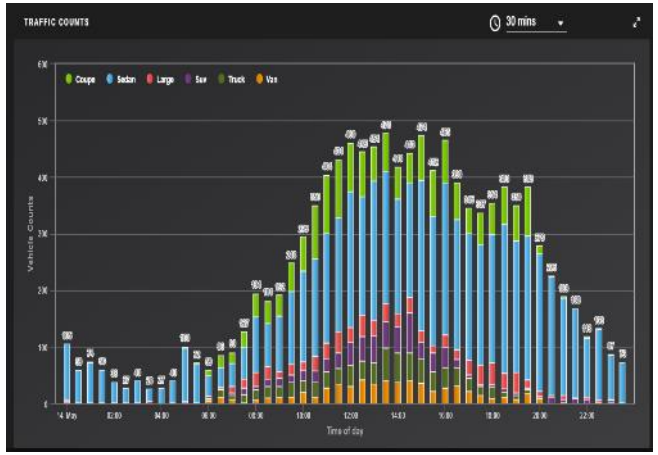
AI-TOMS Interface for Machine Vision Cameras and Data Analysis

Machine Vision for Traffic Monitoring

Count, Speed and Occupancy

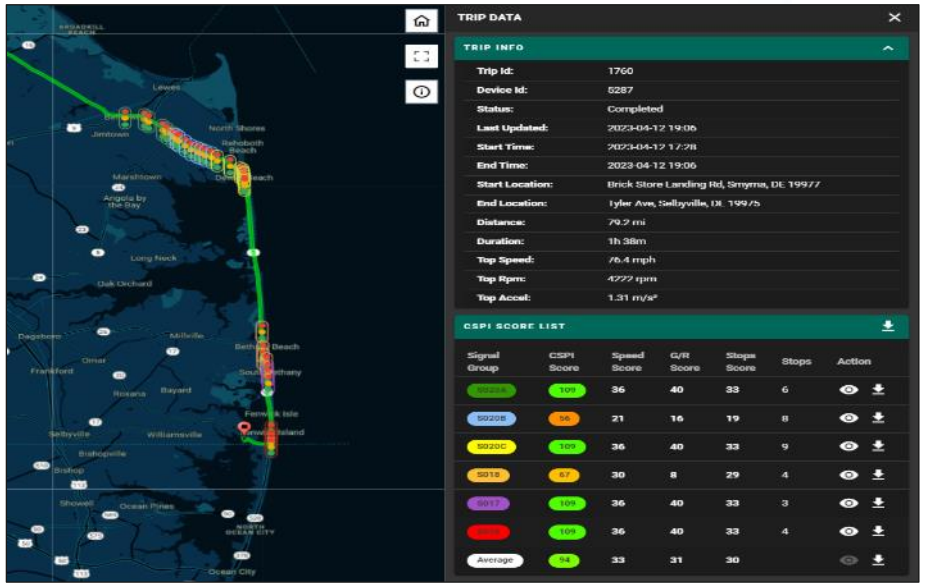


Vehicle Count Data

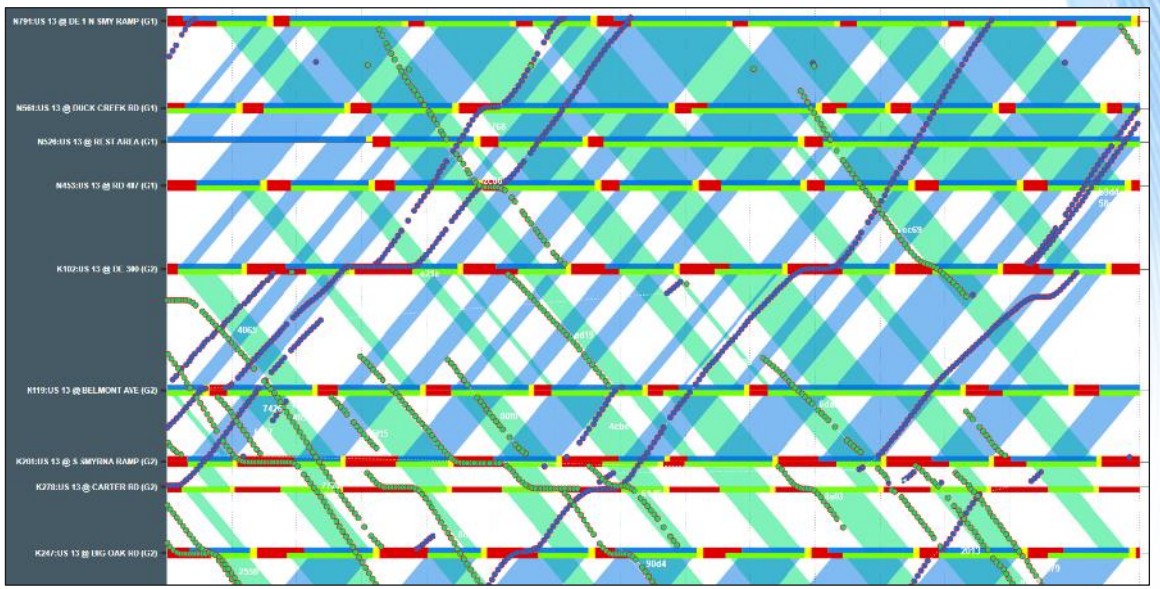


Connected Vehicle Data

- Corridor Synchronization Performance Index provide quantitative evaluation of the signal timing performance
- Feedback to signal optimization digital twin for model adjustment (for example, instead of using posted speed limit, use the actual traffic speed for improved accuracy)
- Digital twin achieves close coupling of physical network to the digital network and makes live optimization and evaluation possible

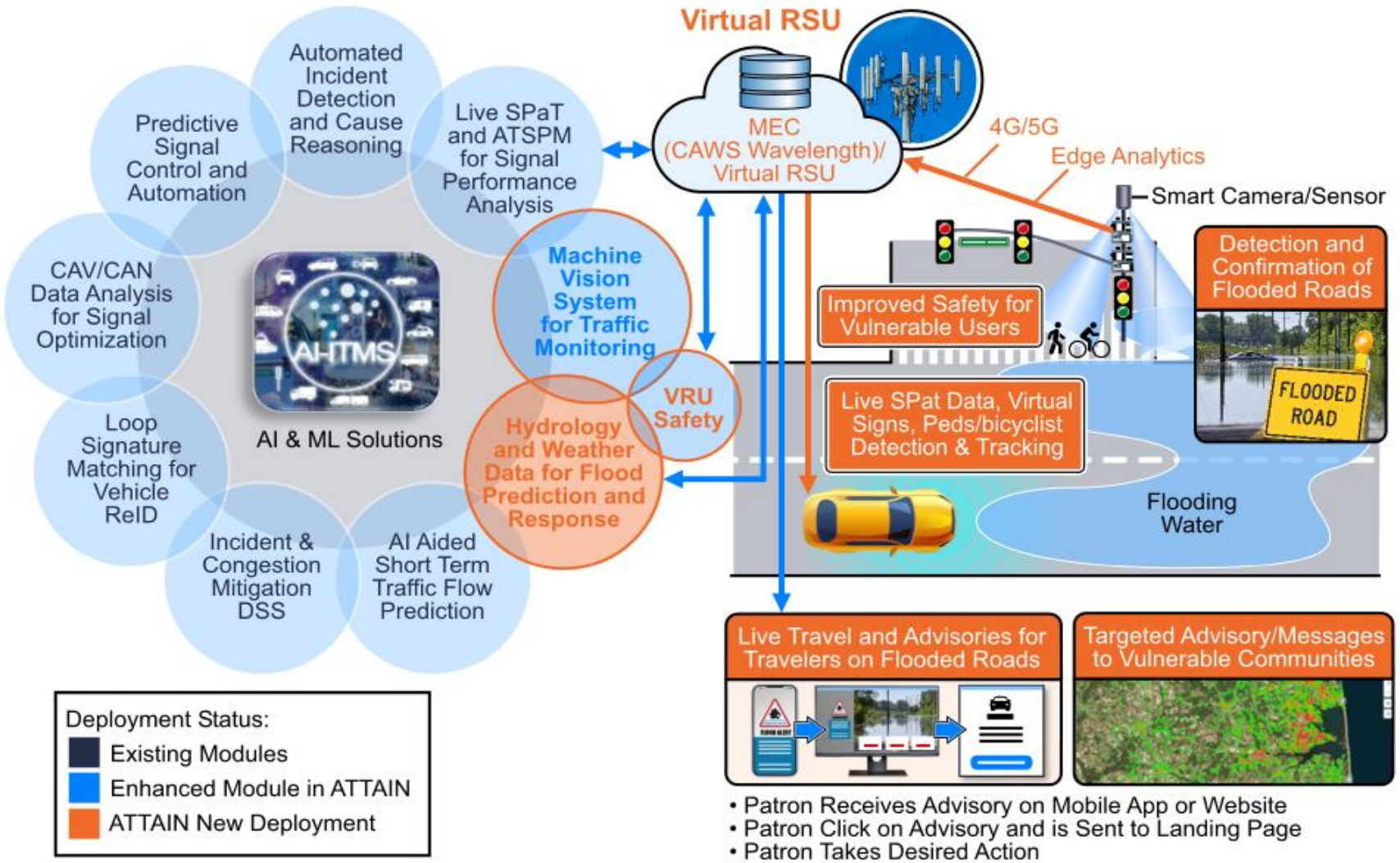


CAV/Probe Vehicle Data for Signal Performance Evaluation



Time-Space Diagram with CV Trajectories

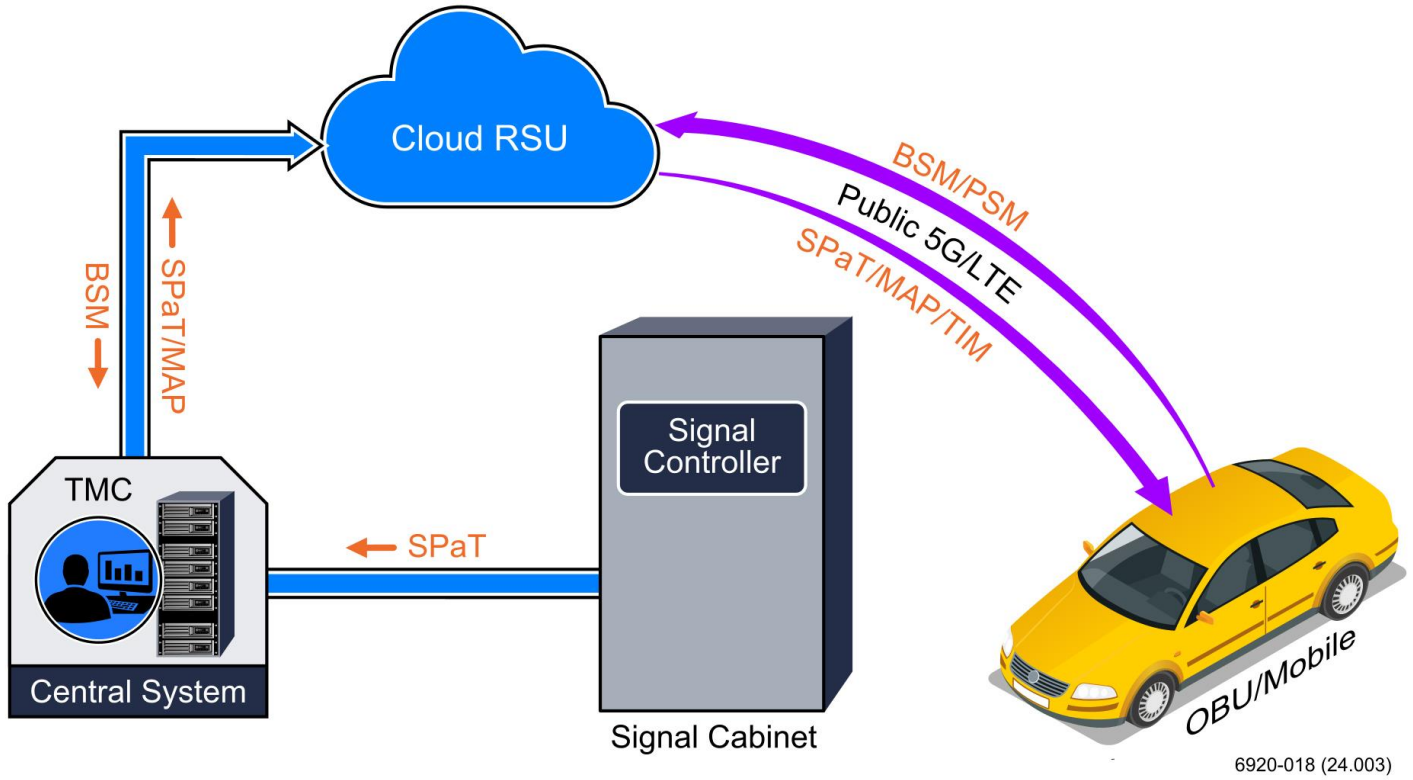
Follow on Efforts – ATTAIN Grant



- Flood Prediction
- Targeted warning and assistance
- Virtual RSU and road signs
- Machine vision for VRU detection and conflict warning

Follow on Efforts – SMART Grant

- Cloud-based vehicle-to-everything technology (CbV2X)
- Dilemma Zone (DZ) application



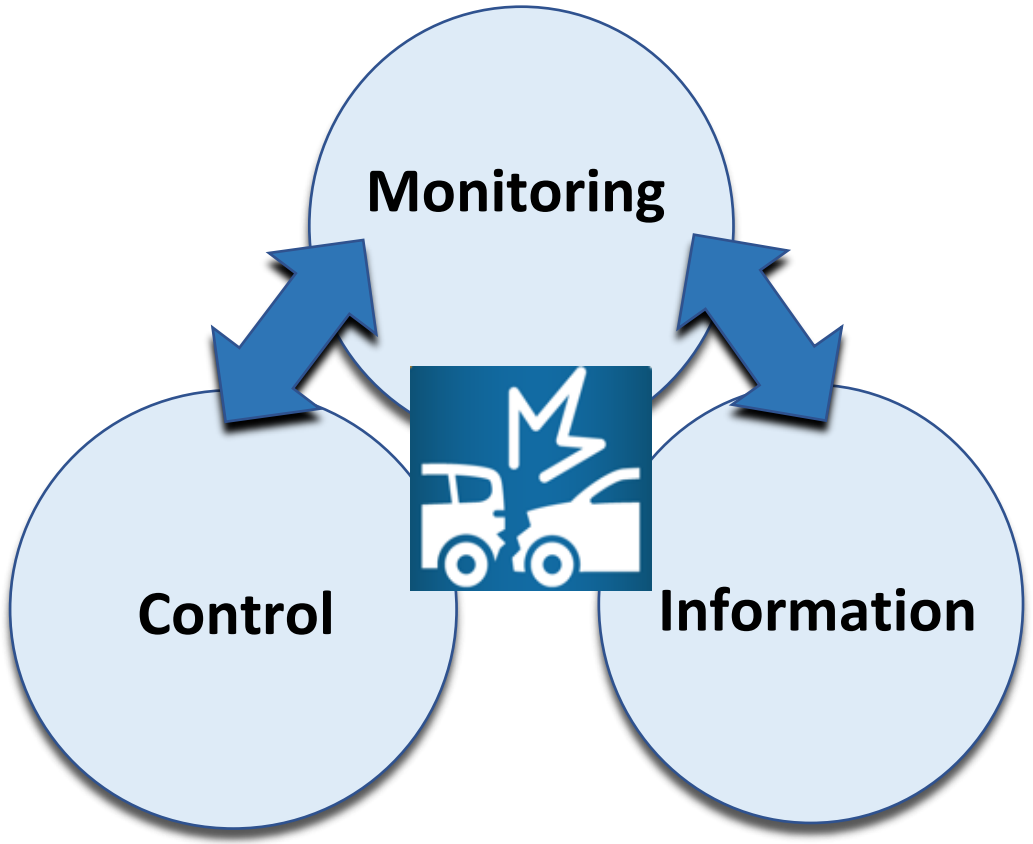
Architecture of CbV2X Technology

- Cloud and MQ Telemetry Transport (MQTT) technology
- 50 millisecond roundtrip delay times for SPaT data
- SPaT-enabled signal status information
- DZ warning advisories with both visual and audible prompts

DelDOT

Statewide Deployment of AI-ITMS

- Expand AI-TOMS all the freeways and key corridors
- Continuous enhancement – system will continuously learn, as a traffic engineer would, and automate operations
- Understanding what it takes to support this advanced system – need support of staff/team with the required knowledge, skills and abilities
- Detection system of today – enhancements with ML and AI
- Enhance mobility not only in Delaware, but for transportation systems everywhere
- **A truly predictive and adaptive self-monitoring statewide transportation management system that gets smarter over time**



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Thank You!

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