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**Smarter Work Zones: SHRP2 WISE Demonstration Work Shop**
**Hanover, Maryland**
**September 20, 2017**

# Smarter Work Zone Planning and Operations with WISE in Maryland


## Subrat Mahapatra[1], Tom Jacobs[2], Lei Zhang[3]

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MDOT State Highway Administration

**2. PI,** Director, Center for Advanced Transportation Technology
University of Maryland

**3. Co-PI and Technical lead,** Director, National Transportation Center
Herbert Rabin Distinguished Professor, University of Maryland

# Presentation Overview

- Transportation Systems Management & Operations Program in Maryland – Work Zone Performance & Planning in Context
- Original Maryland SHRP2 R11 WISE Project Scope
- Integration of WISE and MITAMS for Optimal Work Zone Planning, Scheduling, and Operations Decision Support
- WISE-MITAMS Use Case Applications and Model Demonstration
- Next Steps

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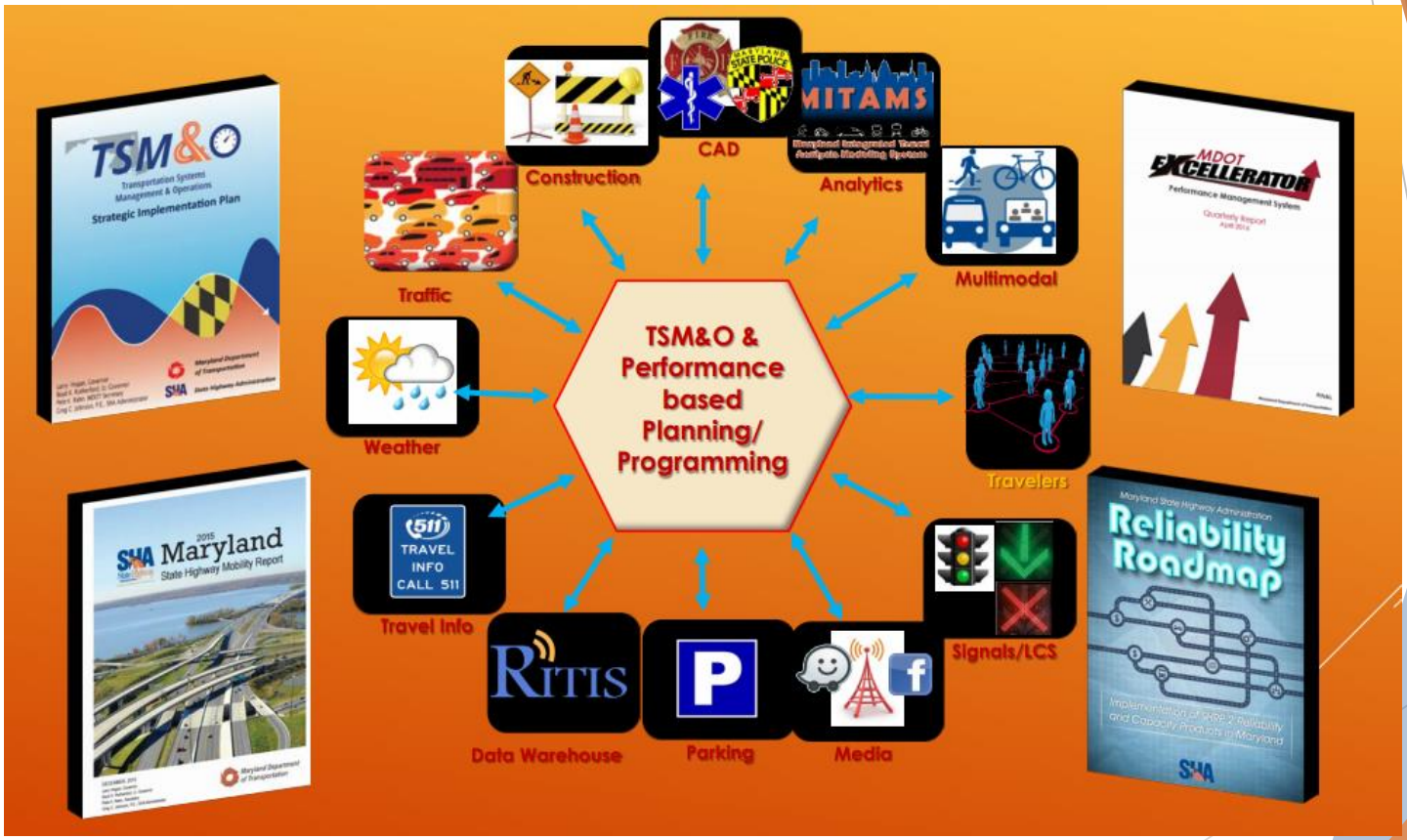
# TSM&O Program in MD – WZ Context

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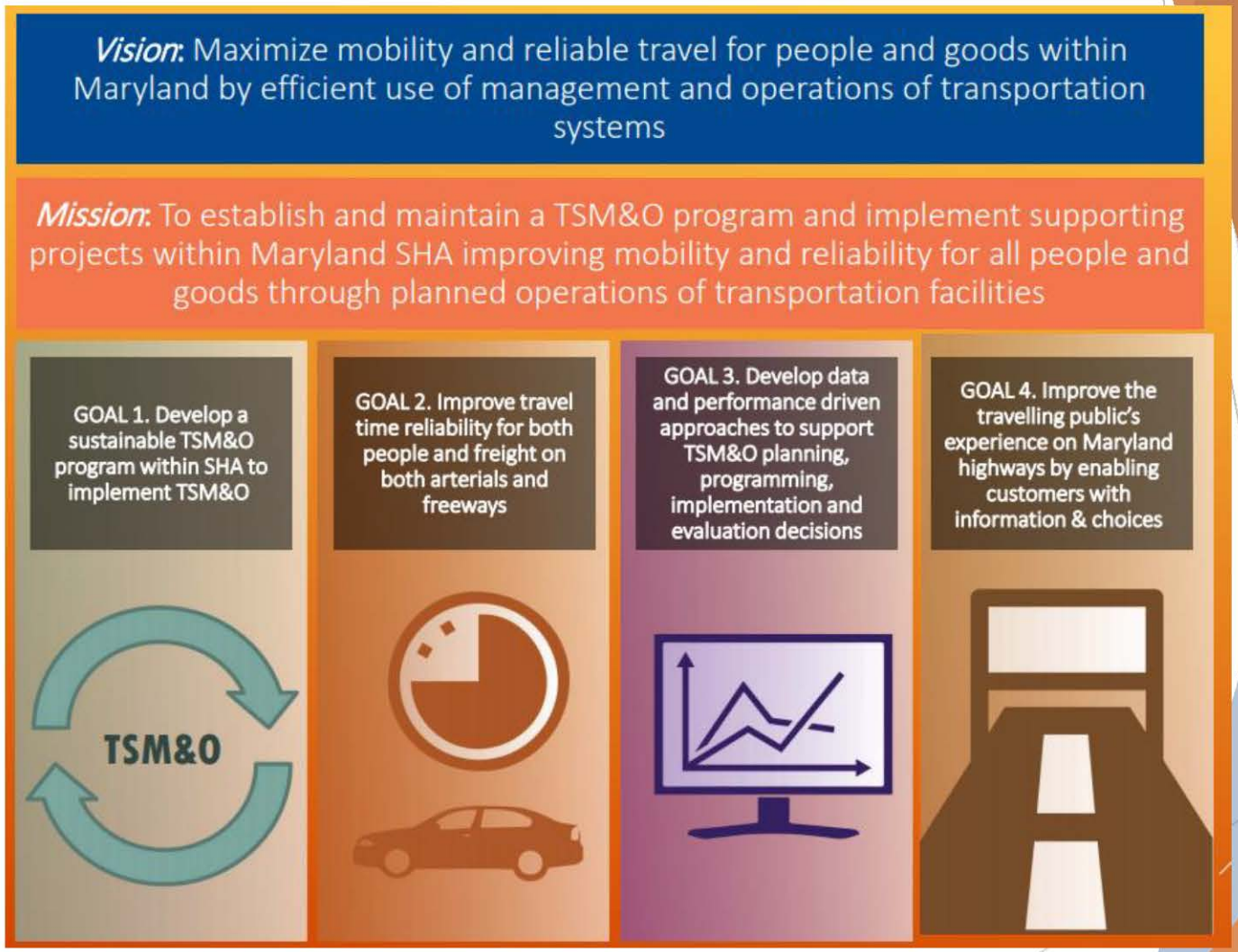


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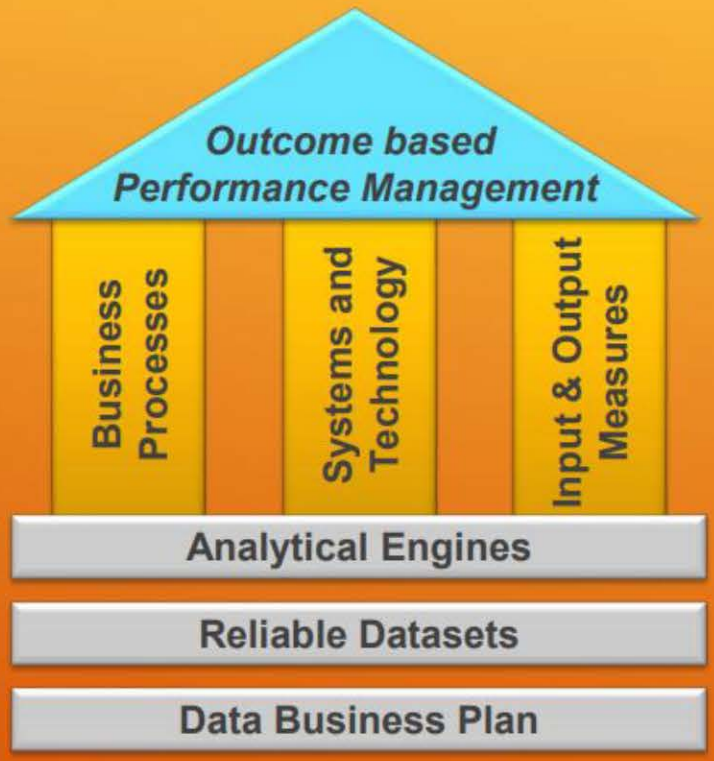


**An integrated approach to programmatic optimization of planning, operations, and maintenance**

***Implement new multi-modal systems, services, and projects to preserve capacity and improve the security, safety, and reliability of our transportation system***

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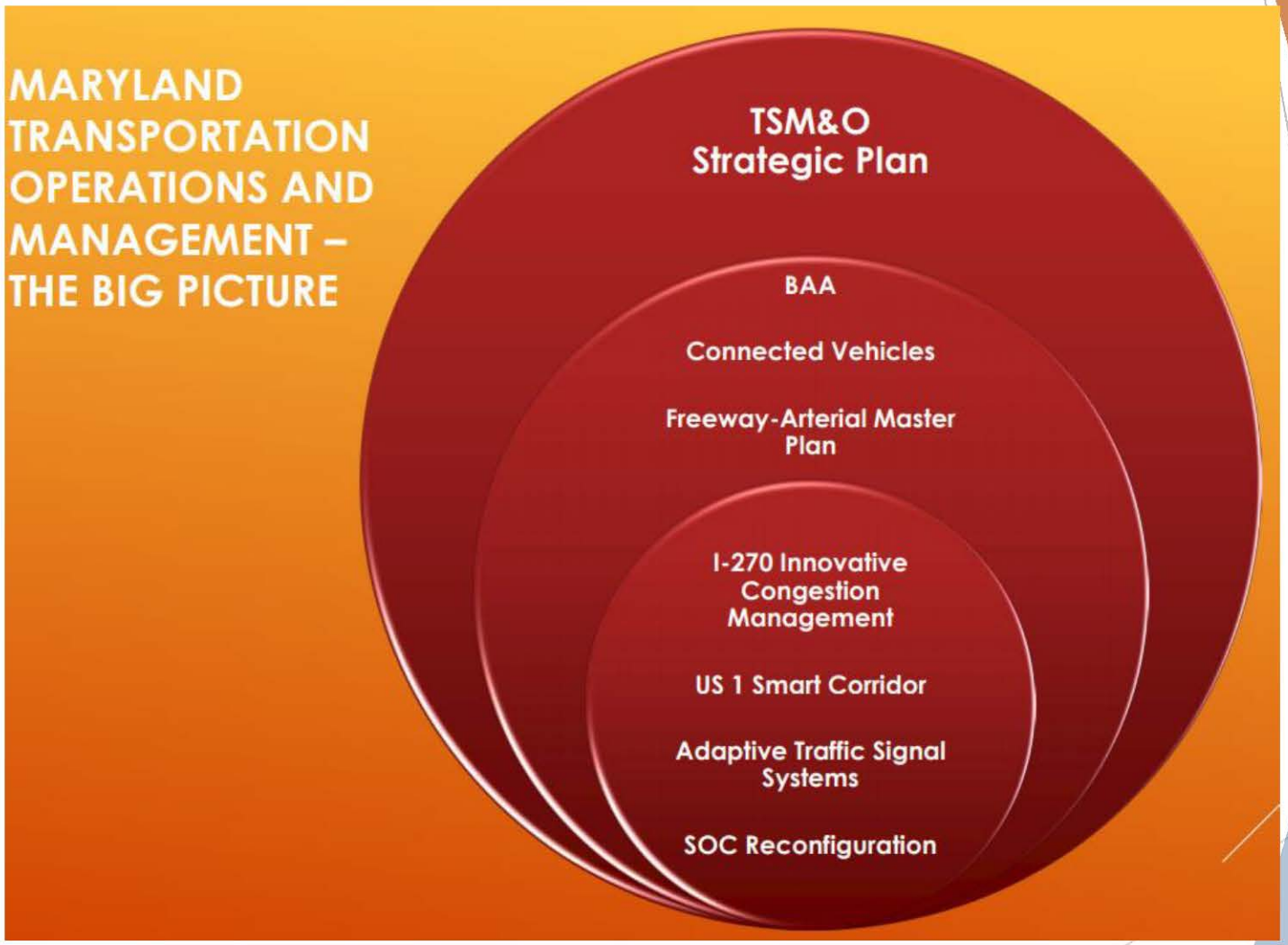


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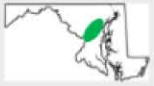
# TSM&O Program in MD – WZ Context

| | Title | Purpose | Scope | Dependence |
|---|---|---|---|---|
|  | TSM&O Strategic Plan | Overall TSM&O Direction [Signed August 2016] |  | |
|  | **Freeway / Arterial TSM&O Master Plan** | Identify Specific TSM&O Implementation Considerations |  |  |
|  | Communications Infrastructure Study | Concurrent Analysis of Network Needs to Support TSM&O |  |  |
|  | Connected and Automated Vehicle Strategic Action Plan | Focus on Strategic Direction for CAV Development |  |  |
|  | B/W Integrated Corridor Management (ICM) Plan | Assessment / Plan for Intermodal Coordination |  |  |
|  | US 1 Arterial / Connected and Automated Vehicle (CAV) Pilot | Develop a Test Bed for TSM&O and CAV Technologies |  |  |
|  | Advanced Transportation and Congestion Management Technologies Deployment | Funding Grant Application for the US 1 Corridor |  |  |
|  | I-270 Innovative Congestion Management Project | Specific Project Incorporating TSM&O Technologies on I-270 |  |  |
|  | I-95 Active Traffic Management Project | Specific Project Incorporating TSM&O Technologies on I-95 |  |  |

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# Current Work Zone Related Initiatives in MD

- Planning / Optimizing Construction Project Scheduling (Underway through SHRP 2 R11)
- Enhanced Reliability Based Measures for MOT (Underway through application of SHRP 2 L08)
- Real-time Work Zone Performance Monitoring (Existing Work Zone Dashboard Application)
- Historical Work Zone Performance Reporting (Future)

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# Work Zone Dashboard

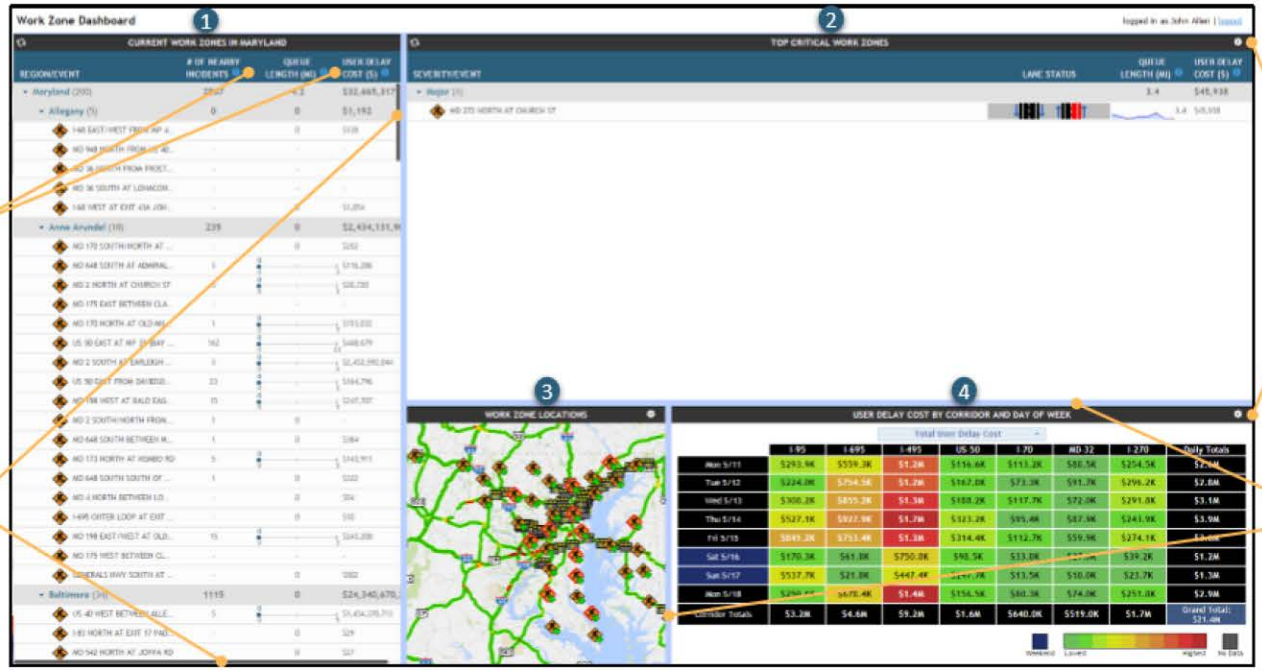
## The Work Zone Dashboard

- There are four interactive widgets that make up the Work Zone Dashboard...

Work Zone Performance Monitoring

**1 Current Work Zones (Overview List)**
Here's where you'll find a summary of all the currently active work zones in the state – grouped by county – with number of nearby incidents, indications of increasing or decreasing queue lengths and user delay cost for the lifetime of each work zone.

**2 Top Critical Work Zones**
Major and Critical events will appear here as they develop, with indications of lane status, associated queue lengths and user delay cost.




Click on a tool tip for explanations and definitions.

Use the scroll bars to move through the list.

Click on a gear icon to change a widget's settings.

Click and drag any of the blue frames to resize the widgets.

**3 Work Zone Locations (Map)**
Use this scalable map to locate and zoom in on work zones, DMS and probe data; clickable icons give you to access more information.

**4 User Delay Cost by Corridor and Day of Week**
See the last full week's worth of delay and cost summaries for a select number of corridors in the state.



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# Work Zone Dashboard

## The Individual Work Zone Profile

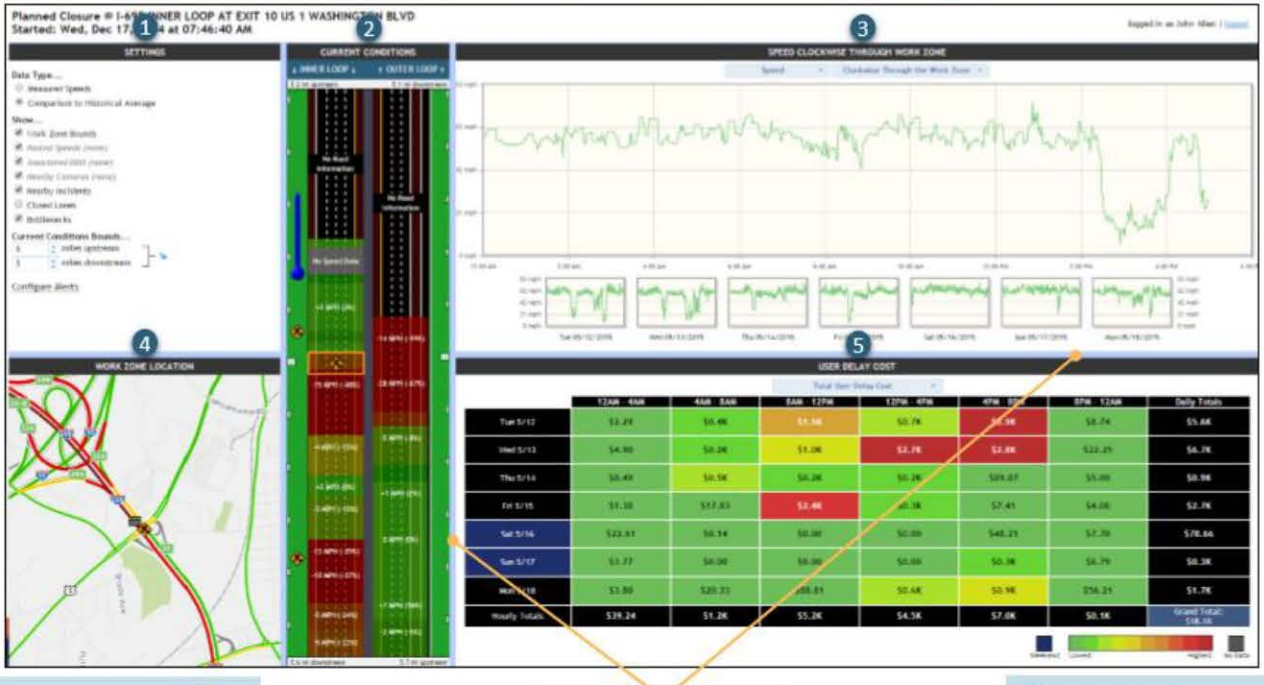
- There are five interactive widgets that make up the Individual Work Zone Profile…

Work Zone Performance Monitoring

**1 Settings**
Here's where you'll set the speed data type, choose associated data layers, set your current conditions boundaries and create an alert for the work zone.

**2 Current Conditions**
Graphically displays work zone speeds, either measured or historic average, along your pre-defined boundaries. Events, queuing and other data are also displayed as available.

**3 Traveling Through Work Zone**
Graphically display queue length, travel time or speed for the current day and the previous seven days for comparative purposes.




**4 Work Zone Location**
Use this scalable map to zoom in on your selected work zone. Clickable icons (such as work zone, DMS, roadway links) give you to access more information.

Click and drag any of the blue frames to resize the widgets.

**5 User Delay Cost**
See the last full week's worth of delay and cost summaries for your individual work zone, by day of week and grouped by 4 hour time bins



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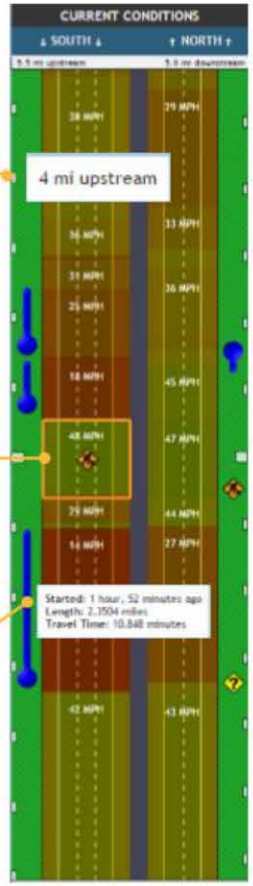
# Work Zone Dashboard

## 2 Current Conditions

- This widget shows graphical results from the parameters selected under Settings

Work Zone Performance Monitoring




**Mile Marker Indicators** – click to see the distance upstream and downstream from the work zone.

**Work Zone Bounds** – shows the selected work zone area, inside the orange box.

**Bottlenecks** – indicates bottleneck head, direction and approximate length. Click the icon for more information.

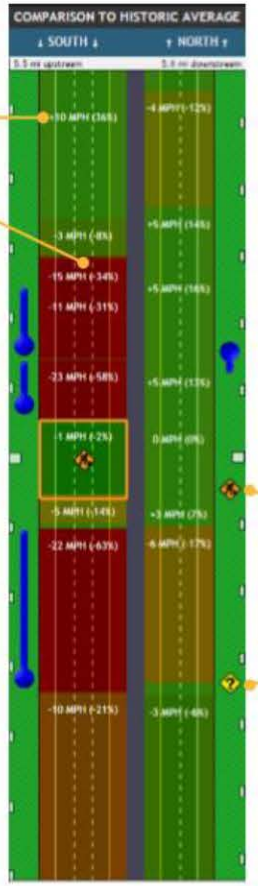

**Posted Speeds** – speed limit sign locations are shown, when available.

**Nearby Cameras** – CCTV camera locations are shown, when available. Clicking on an icon brings up the camera feed.

**Measured Speed/Historic Average** – posted for every TMC segment within your Current Conditions Bounds.

***

Colors vary with speed, ranging from green (higher speeds) to red (lower speeds)




**Nearby Incidents** – other incidents will be shown as available. Click the icon for more information.



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# Maryland SHRP2 R11 WISE Project Scope

- Task 1 – Develop a calibration/re-calibration module for WISE (complete)
- Task 2 – Prepare list of long term planned work zone projects in the NCR (complete)
- Task 3 – Enhance the user demand and behavior inputs (complete)
- Task 4 – Validation / Pilot Application (ongoing)
- Task 5 – Final Report (anticipated Nov 2017)

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# Maryland SHRP2 R11 WISE Project Scope

- Partnership of MDOT, VDOT, DDOT, WMATA
- Began in 2009
- Comprised of:
  - Steering Committee
  - Information Systems Committee
  - Operations Subcommittee
  - Severe Weather WG
  - **Regional Construction Coordination WG**

MATOC
Metropolitan Area Transportation Operations Coordination


www.matoc.org

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# Integration of WISE and MITAMS for Optimal Work Zone Planning, Scheduling, and Operations Decision Support in Maryland

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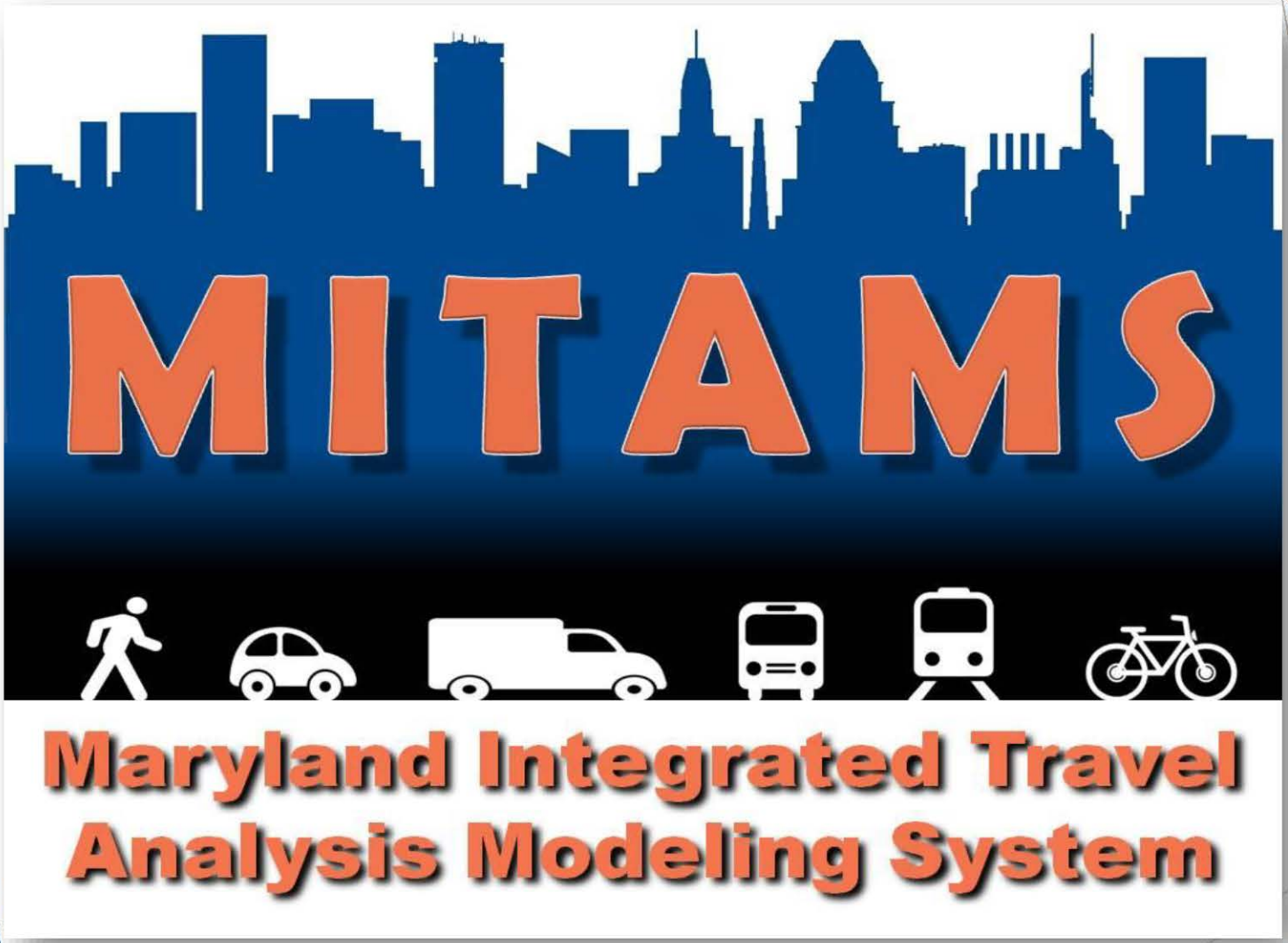
# Background: MITAMS

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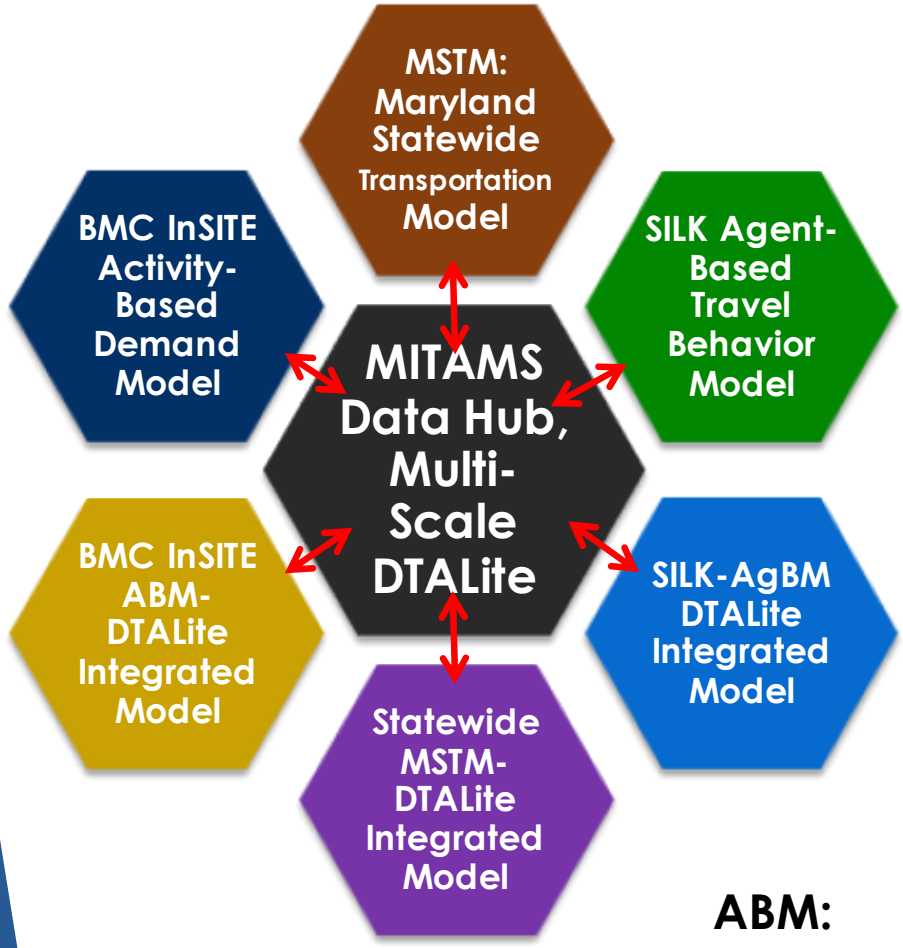
# MITAMS Overview




1. Statewide MSTM-DTALite
2. BMC MPO InSITE ABM-DTALite
3. Subarea/Corridor SILK AgBM-DTALite

ABM: Activity-Based Model
AgBM: Agent-Based model

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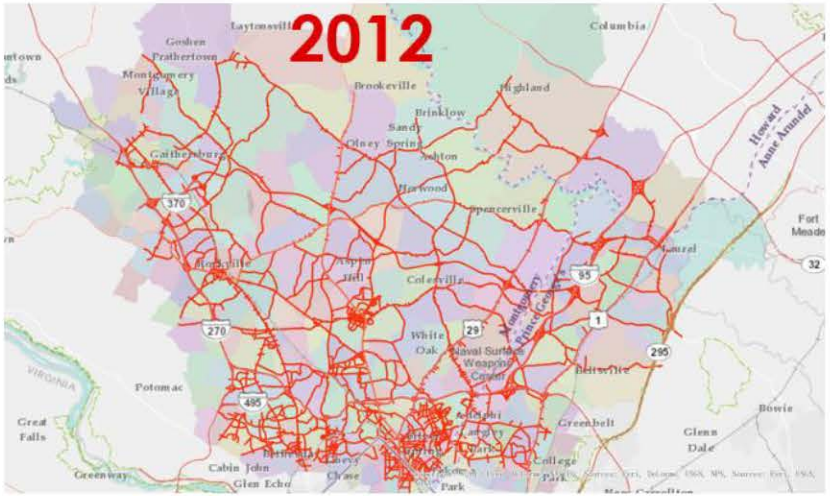
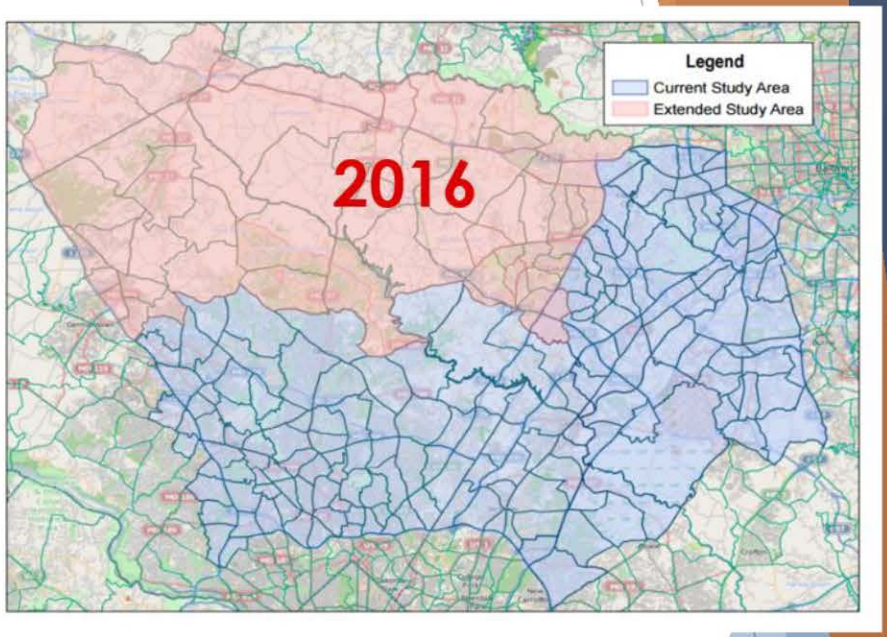
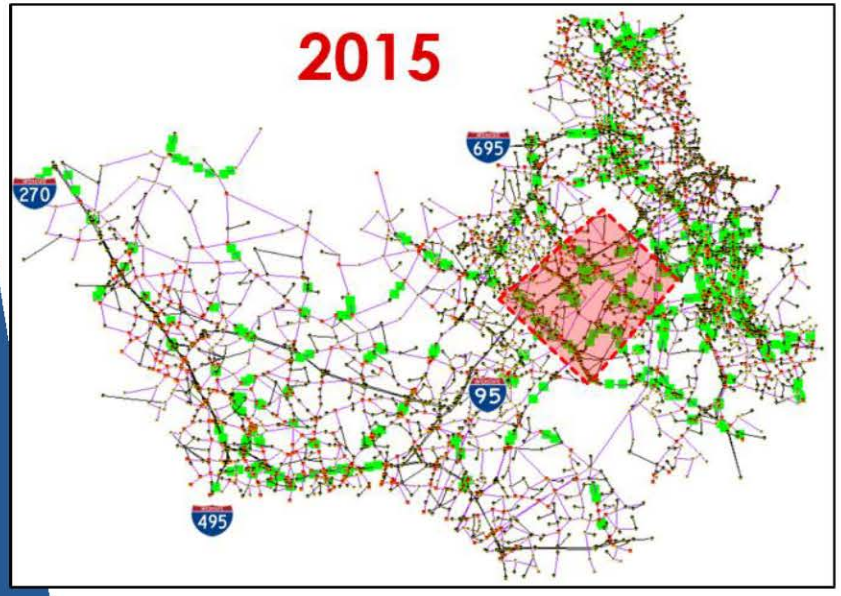
# MITAMS TSM&O Model Coverage




## 2017

**A parallel effort, funded by U.S. DOE, is to extend model coverage to the entire D.C.-Baltimore region.**

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# MITAMS: A Focus on Applications

DTALite Dynamic Traffic Assignment

Integrated SILK Agent-Based Demand & DTALite

Integrated InSITE Activity Based Model & DTALite

InSITE Activity-Based Model

## MITMAS Applications

**Short-term**

- Dynamic Ramp Metering
- Managed Lane Analysis (Hard Shoulder, Reversible HOV, Dynamic Toll Lanes)
- Work Zone Operations

**Mid-term**

- Cumulative Impact Development
- Peak Spreading Analysis.
- Multi-dimensional Travel Behavior Impact of TSM&O, ICM, ATM.
- BRT and Transit Improvement
- Work Zone Planning and Scheduling

**Long-term**

- Land-use change analysis in brownfield, Baltimore, MD.
- Time of day and pricing analysis.
- Aging population in the BMC area.

Short-term to Long-term

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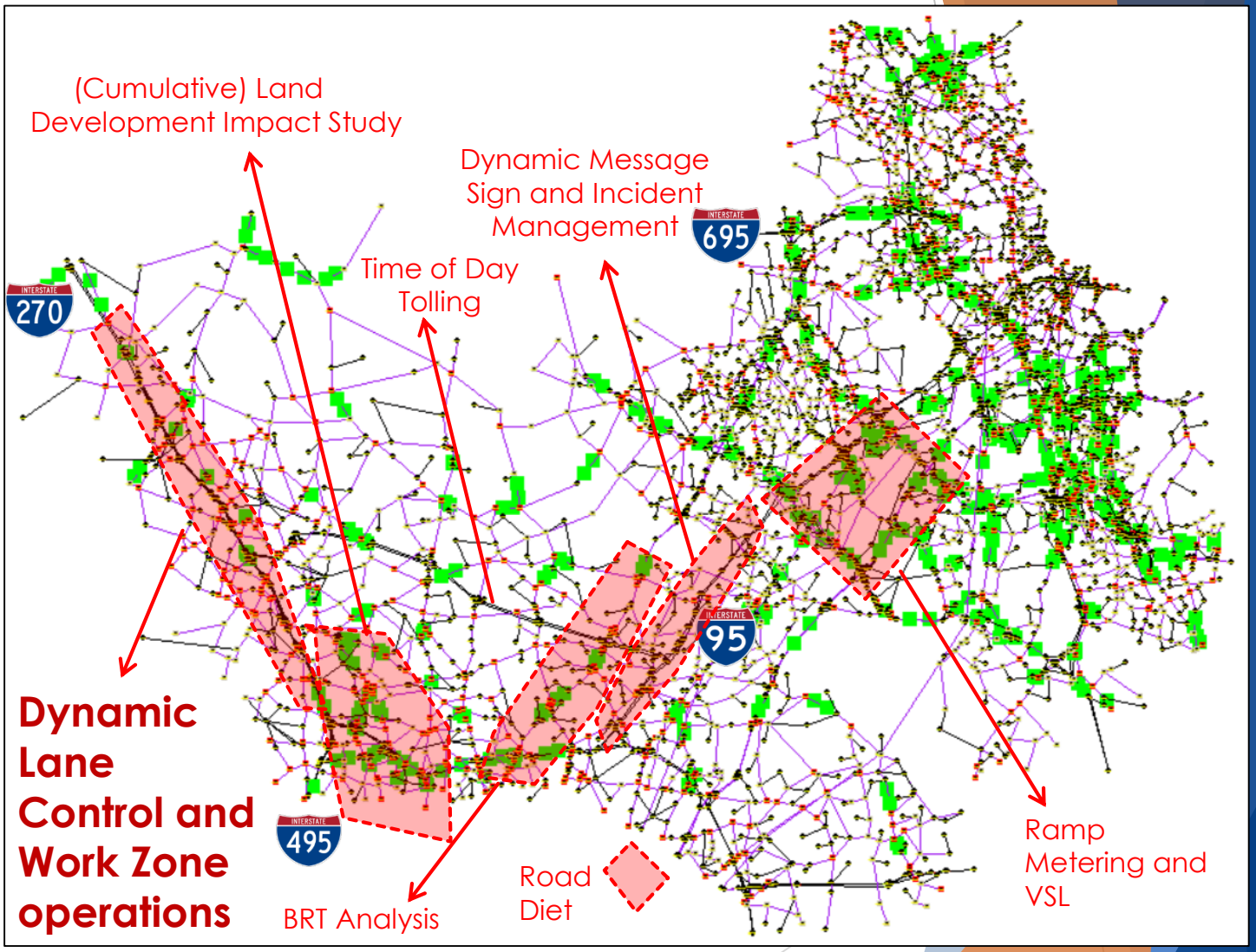
# MITAMS TSM&O Model Applications

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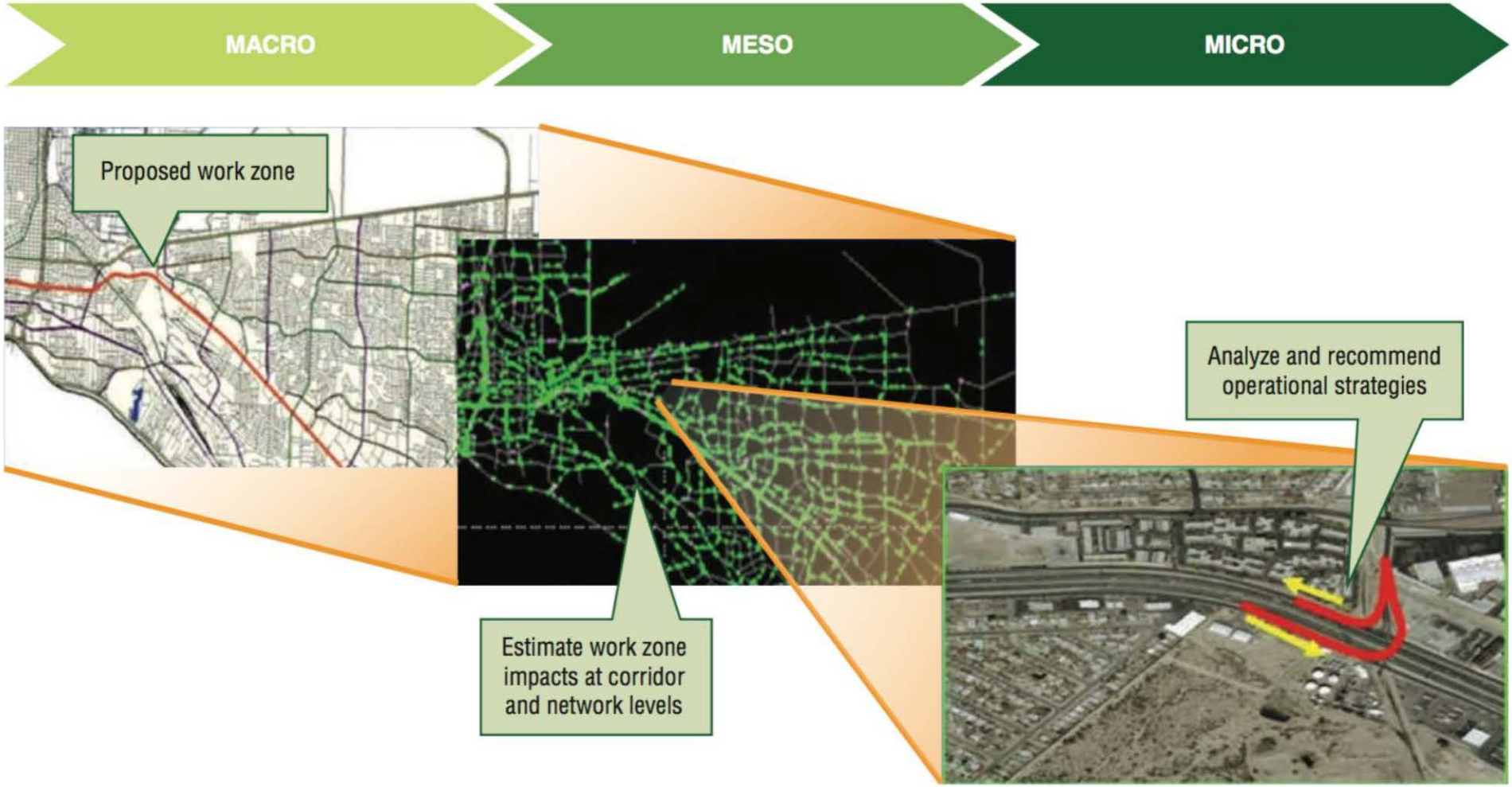
# Work Zone Planning/Operations

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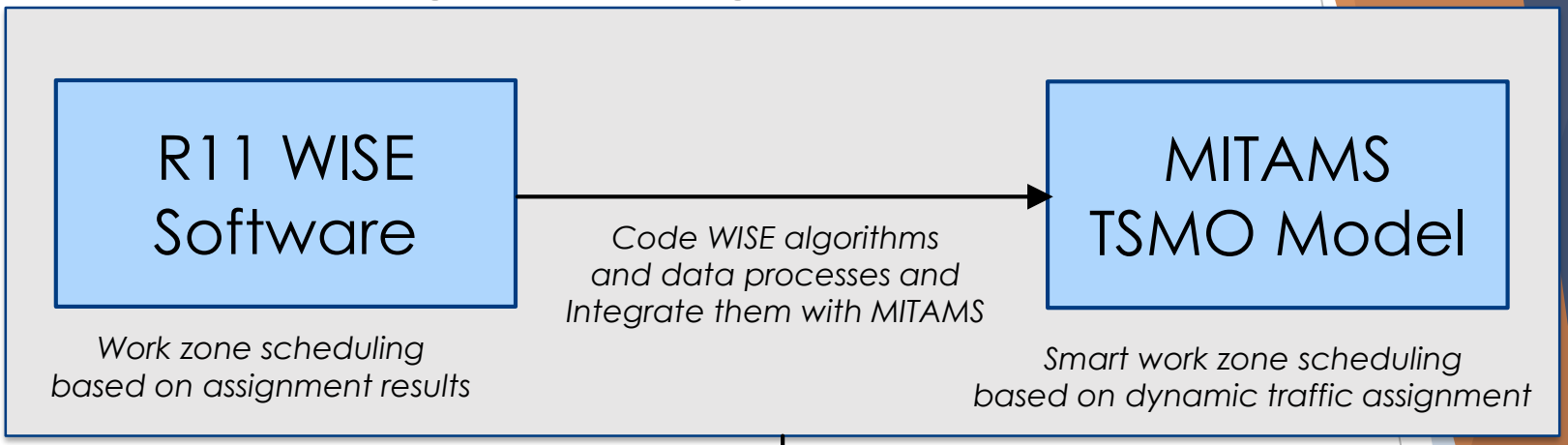
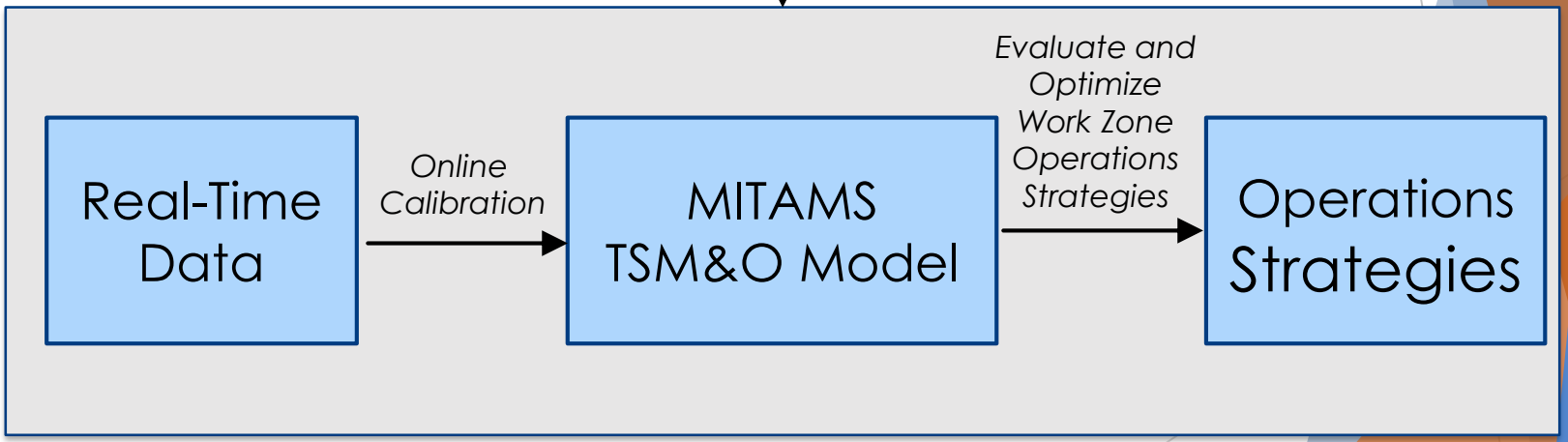
# Integrated WISE and MITAMS

- **Work Zone Planning/Scheduling**




- **Work Zone Operations**

Optimal work zone plans and schedule

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# Break
# 10am~10:15am

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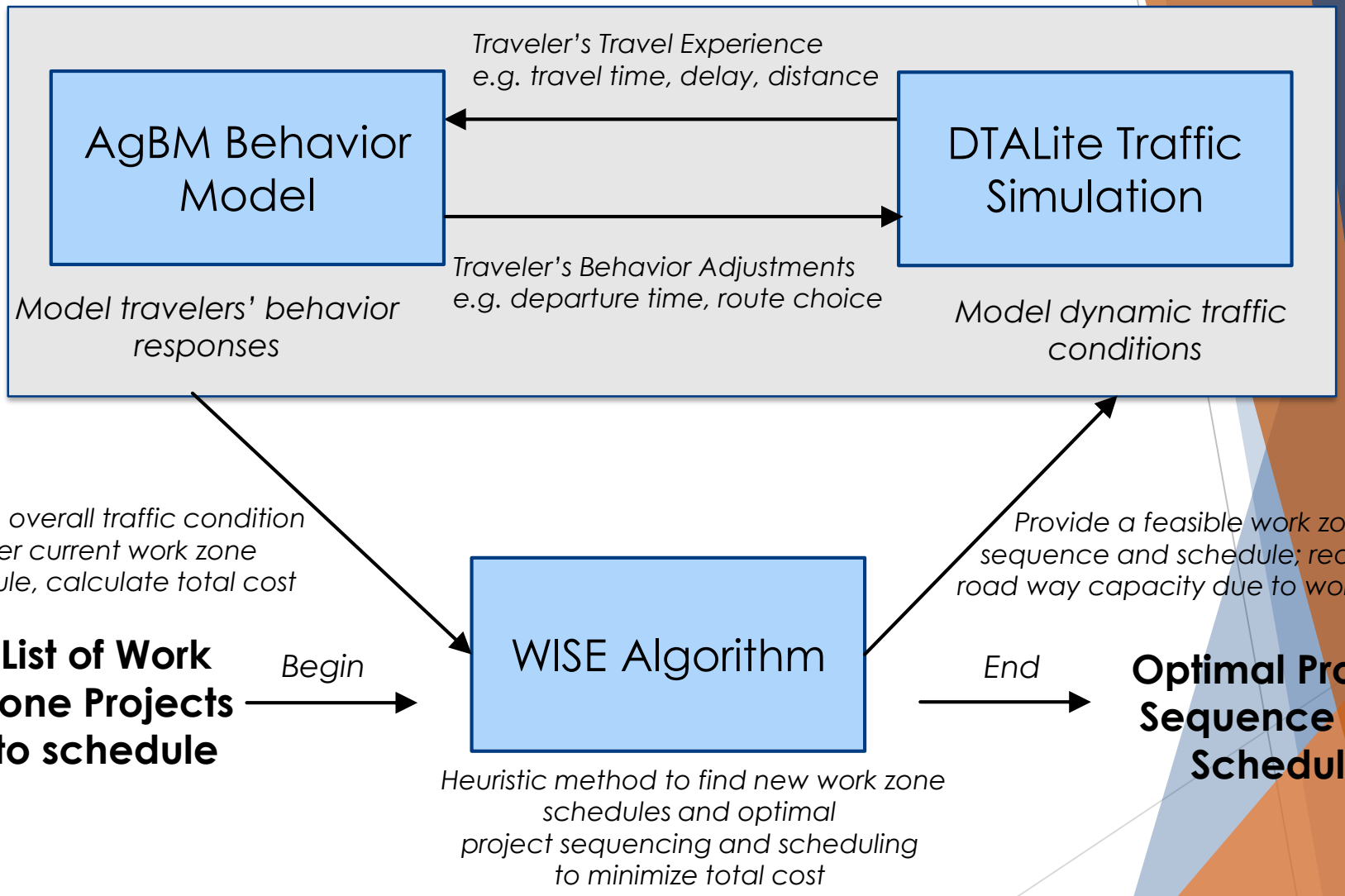
# How WISE works with MITAMS

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# WISE Work Zone Scheduling

## WISE Meta-heuristics Algorithm

- Minimize total cost:

  Total Cost = Agency Cost + User Cost

- Tabu search to find optimal sequence of projects with user-defined starting month time window, and construction mode (daytime, night time, or both)
- Search: for each project and each month, if construction is feasible (mode and start time), evaluate the cost via DTALite
- If the result reduces total cost, schedule this project and update the current solution
- Stop if a predefined maximal iteration number is reached, or in the most recent five continuous iterations, the algorithm does not find a solution with improved objective function value

# Key Considerations in WISE

## Work Zone Cost

- Agency cost (construction)
- User cost (traffic delay)

## Agency Cost Evaluation

- Work zone duration (number of months)
- Working mode (work in daytime or night)

## User Cost Evaluation

- Traffic congestion calculated via MITAMS agent-based (AgBM) and dynamic traffic assignment (DTALite) model
- Travelers' value of time (VOT)
- MITAMS approach can capture any short-term and long-term user behavior change (route, departure time, mode, etc.) due to work zones and the resulting traffic impact

# Model/Software Development

## MITAMS: AgBM-DTA Model Enhancement

- Background network, demand, and behavior modeling framework
- DTALite model calibration and validation with observed traffic data

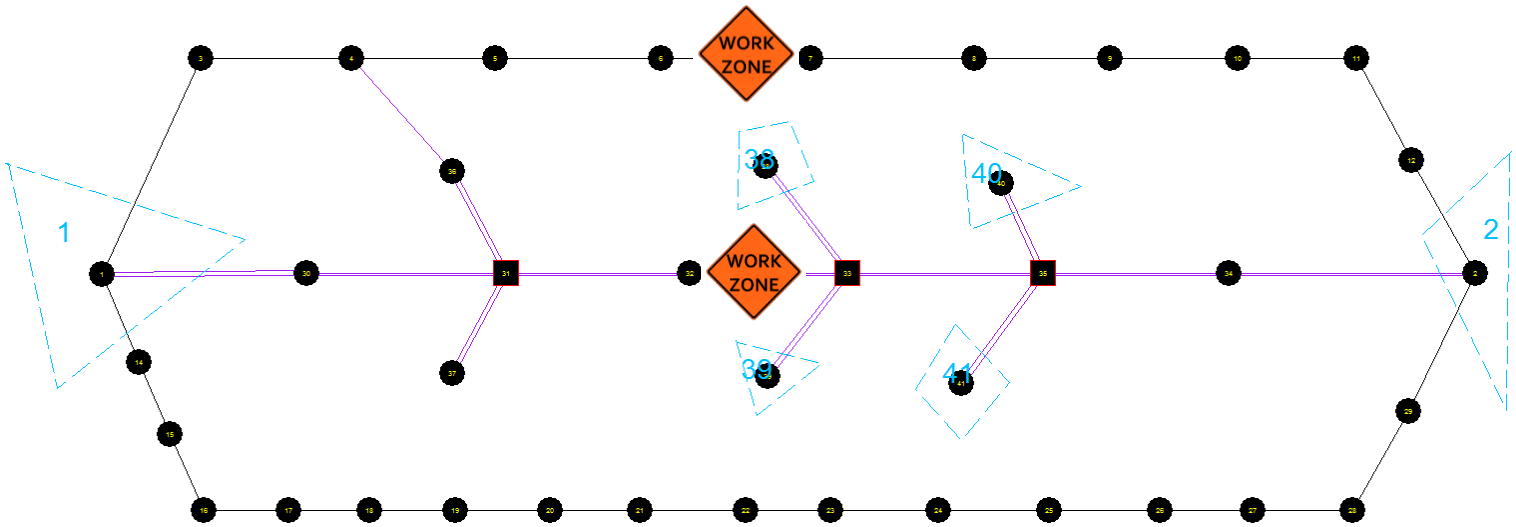
## WISE Algorithm Coding and Enhancement

- Recode WISE Heuristic algorithm, work zone cost evaluations to work with MITAMS AgBM-DTA model

## WISE-MITAMS Model Demonstration

- WISE algorithm tested on small network
- Actual work zone data for real-world demonstration

# Small Network Demo




## Scenario Description

- Two work zone projects to schedule: WZ 1 needs 6 months to complete, and WZ 2 needs 3 months.
- Demand factors and user preferences vary by month

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# Small Network Demo Results

| | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pref. | N | Y | Y | Y | Y | N | Y | N | Y | Y | N | N |
| Factor | - | 1 | 0.7 | 1.5 | 0.8 | - | 0.5 | - | 1.4 | 1.5 | - | - |
| WZ 1 | | | | | | | | | | | | |
| WZ 2 | | | | | | | | | | | | |

- Takes several minutes to run the models
- WISE-MITAMS gives an optimal schedule such that total agency and user costs during construction is minimized

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# WISE-MITAMS Use Case Applications and Model Demonstration in the Real-World

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# WISE-MITAMS Use Cases

- Future Construction Projects in Consolidated Transportation Plan (CTP)
- I-270 Innovative Congestion Management Project Work Zone Planning

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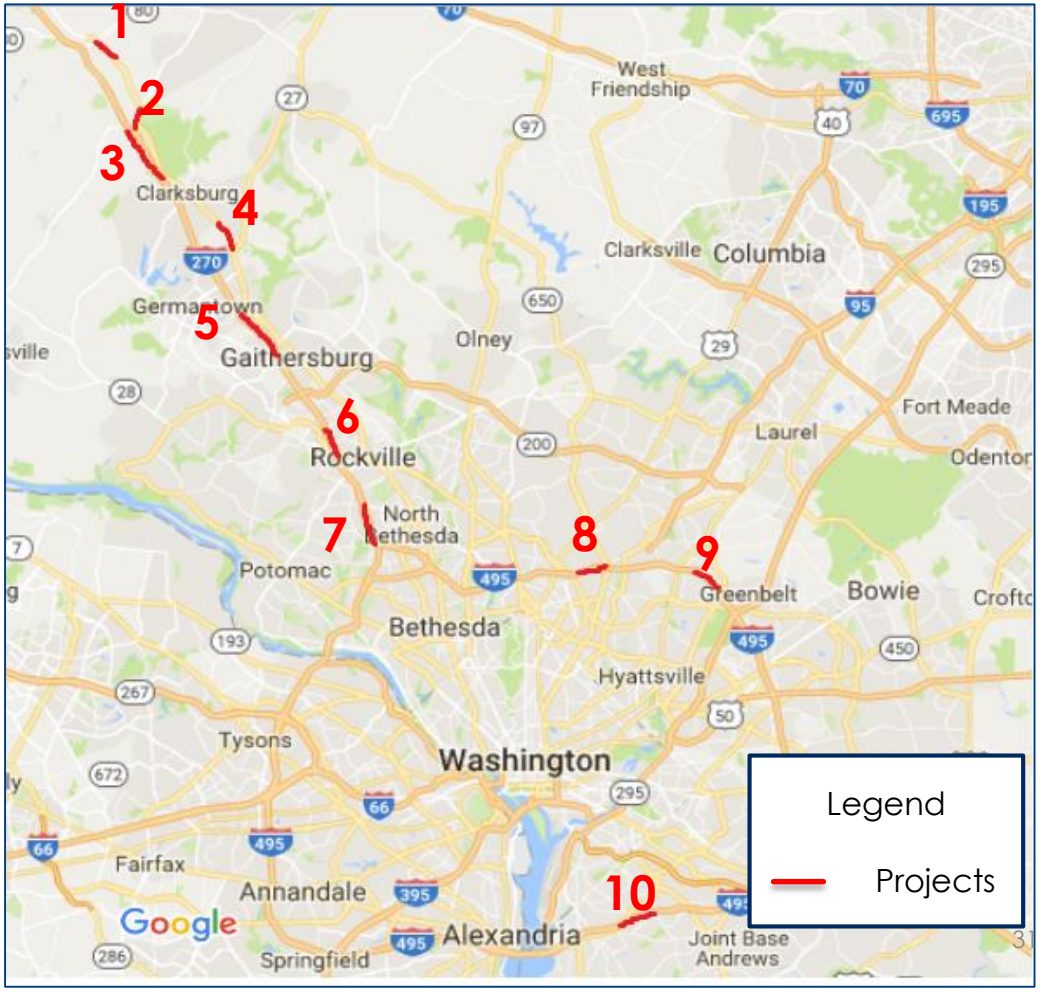
# Real-World Application

## Optimally Schedule 10 Work Zone Projects

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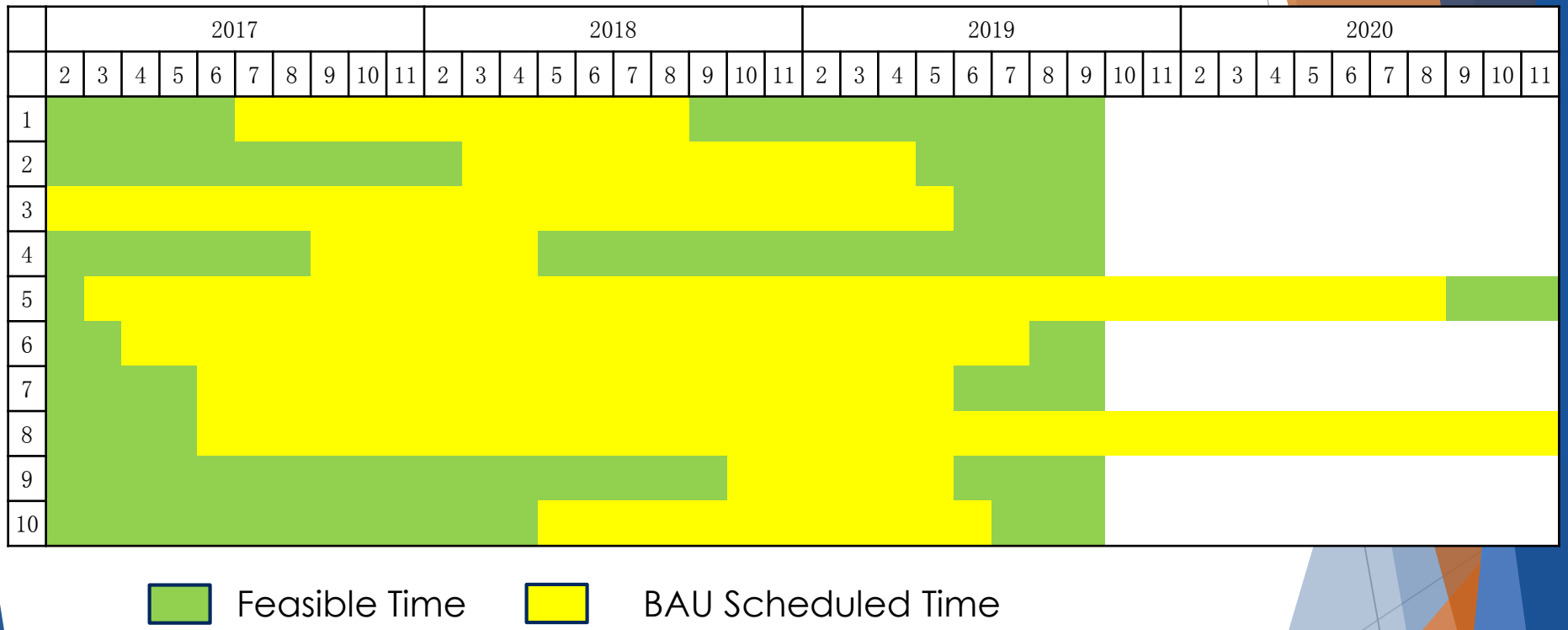
# Work Zone Project Details

| ID | Route | Description |
|---|---|---|
| 1 | MD 355 | Replace Bridge 10086 over Bennett Creek. |
| 2 | MD 355 | Replace Bridge 15053 over Little Bennett Creek. |
| 3 | I 270 | Resurface/Rehabilitate |
| 4 | MD 355 | Intersection Capacity Improvements |
| 5 | I 270 | Construct a new I-270 interchange at Watkins Mill Road. Bicycle and pedestrian improvements will be included where appropriate. |
| 6 | I 270 | Traffic Management |
| 7 | I 270 | Safety/Spot Improvement |
| 8 | I 495 | Replace Bridge 15136 over I-495. |
| 9 | I 495 | Construct a full interchange along I-95/I-495 at the Greenbelt Metro Station. |
| 10 | I 495 | Phase 2 Access improvements from MD 5 (Branch Avenue) and I-95/I-495 to the Branch Avenue Metro Station including improvements to the Access Road, pedestrian bridge, and the County Roads (Auth Road, Auth Place and Auth Way). |

# Business-as-Usual Schedule

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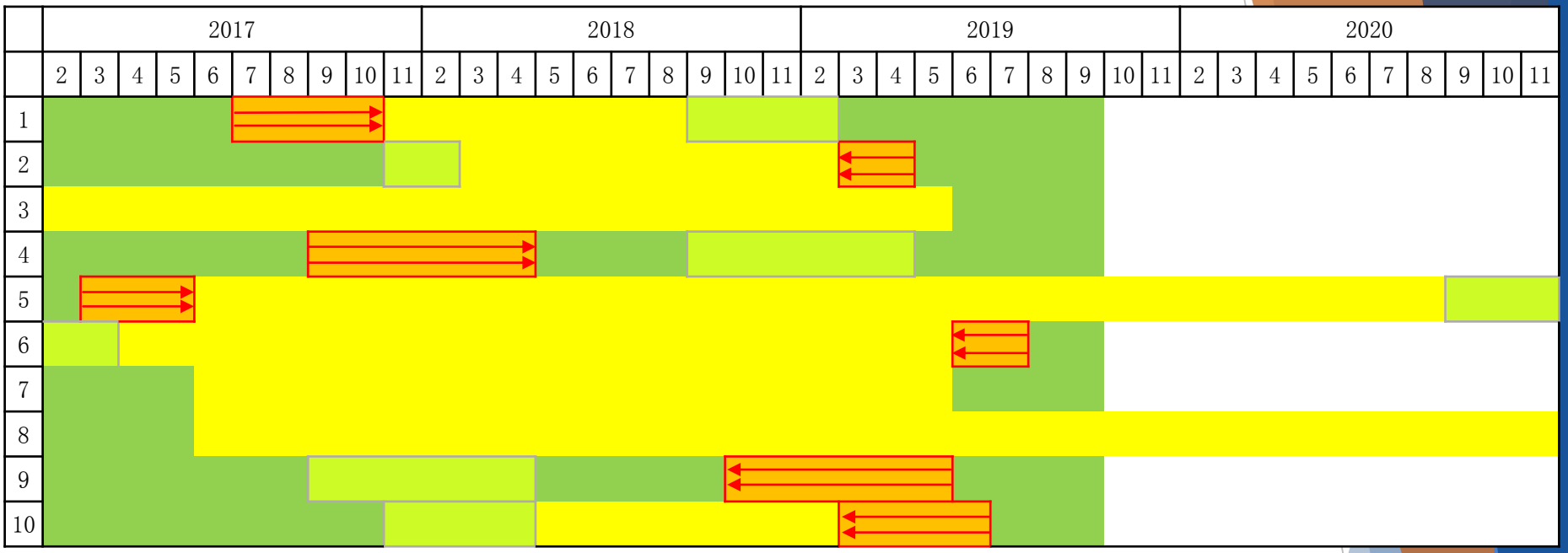
# Work Zone Network Results : WISE Case




Brought Forward  Held Backward  WISE New Schedules

- WISE gives an optimal schedule that reduces work zone costs, which considers dependencies among project groups (e.g. projects 1 and 2; projects 5 and 7; projects 9 and 10)
- Total user cost savings from WISE is $4.03 million.

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# Network-Wide WISE Benefits

| MOE | Change with WISE |
| --- | --- |
| Total Delay (Hours) | 279,000 |
| Total Delay Cost ($) | -4.03 Million |

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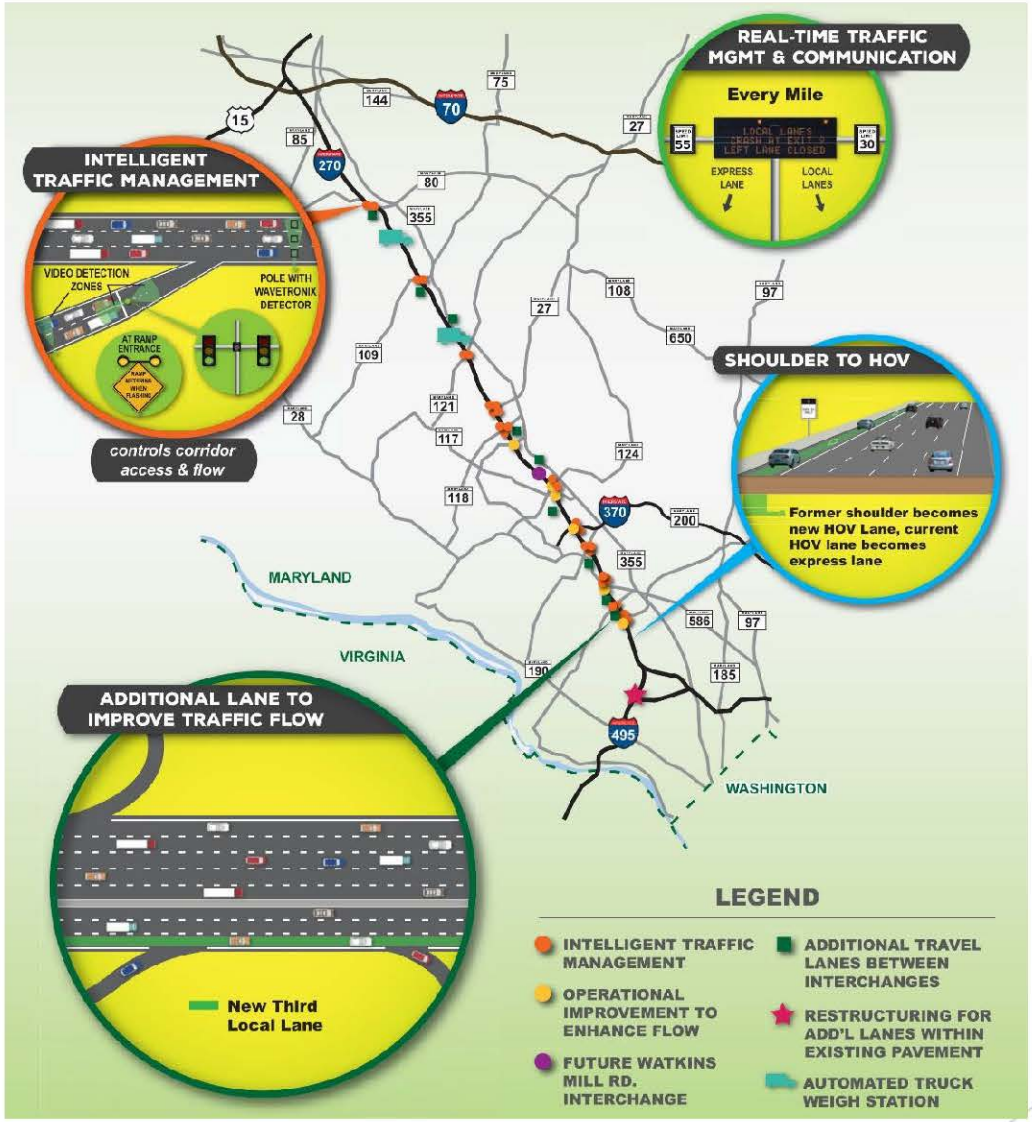
# I-270 Innovative Congestion Management

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# I-270 Work Zone Summary


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# I-270 Work Zone Details

**INFRASTRUCTURE** + **TECHNOLOGY** + **INFORMATION**

## RESTRUCTURING EXISTING PAVEMENT FOR ADD'L LANES

**Extended Merge Lanes**
*MD 80 (SB)*
*MD 109 (SB)*
*MD 121 to Comus Road Bridge (NB)*

**Additional Exit Lane**
*I-270 SB at I-370 Exit*

**Continuous Flow Lane**
*I-270 SB HOV to I-495 WB*

**New Third Local Lane**
*MD 124 to*
*New Watkins Mill Rd. Interchange (NB)*
*New Watkins Mill Rd. Interchange to Middlebrook Rd. (NB)*
*Shady Grove Rd. to South of Gude Dr. (SB)*
*MD 28 to MD 189 (NB & SB)*
*MD 189 to Montrose Rd. (SB)*

**Shoulder becomes HOV lane**

**New Express Lane**
*Montrose Rd. to Democracy Blvd. (NB & SB)*

## AUTOMATED SMART TRAFFIC FLOW MANAGEMENT

*Cameras and sensors communicate traffic density / vehicle type to entrance ramp signals.*

*Traffic is optimized when sensors detect gaps creating smoother and safer commutes.*

## REAL-TIME COMMUNICATION TRAFFIC MANAGEMENT

*Technology-based traffic optimization and dynamic messaging signs provide real-time communication to drivers.*


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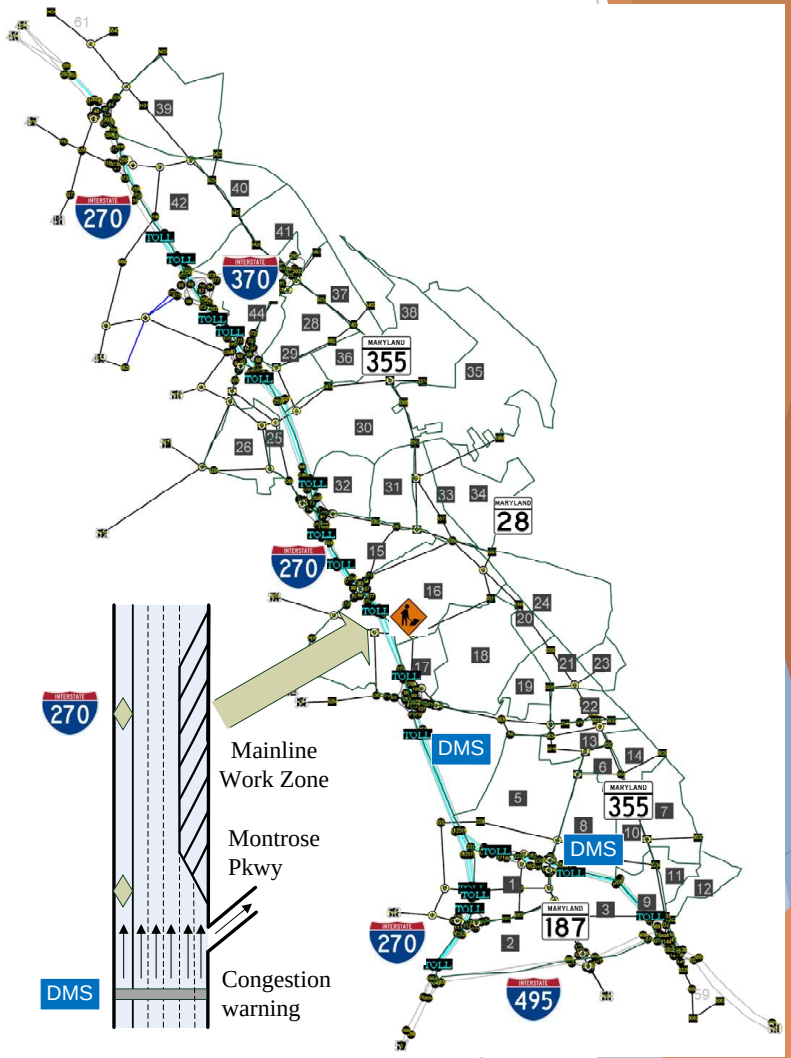
# Work Zone Information Provision

## Scenario Setting

- A major work zone on a commuting corridor
- Work zone blocks two right lanes on the
- Work zone blocks two right lanes on the freeway

## Information Provision

- Pre-trip (radio, social media, etc.)
- En-route (radio, DMS, etc.)

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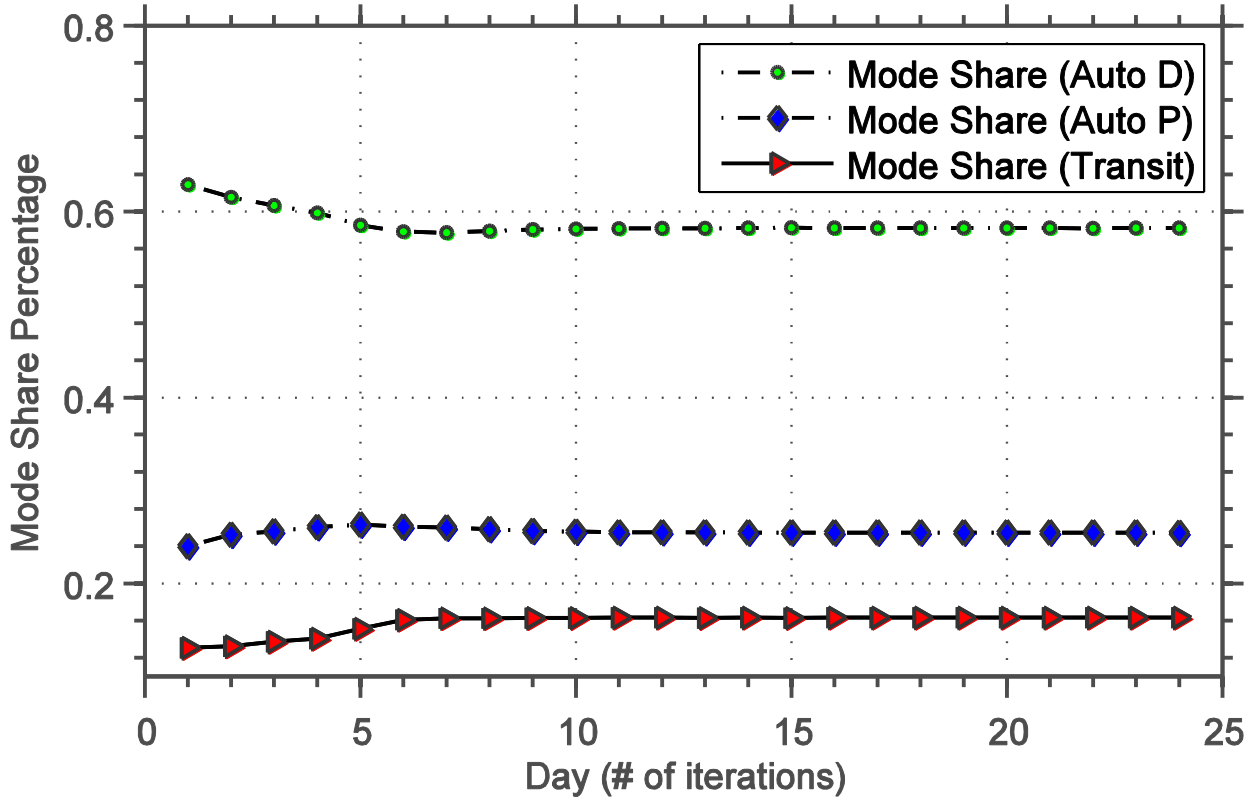
# Mode Share Responses




- Users switch to carpool to take the advantage of HOV/HOT Lanes in the corridor
- Users switch to transit to avoid freeway delays

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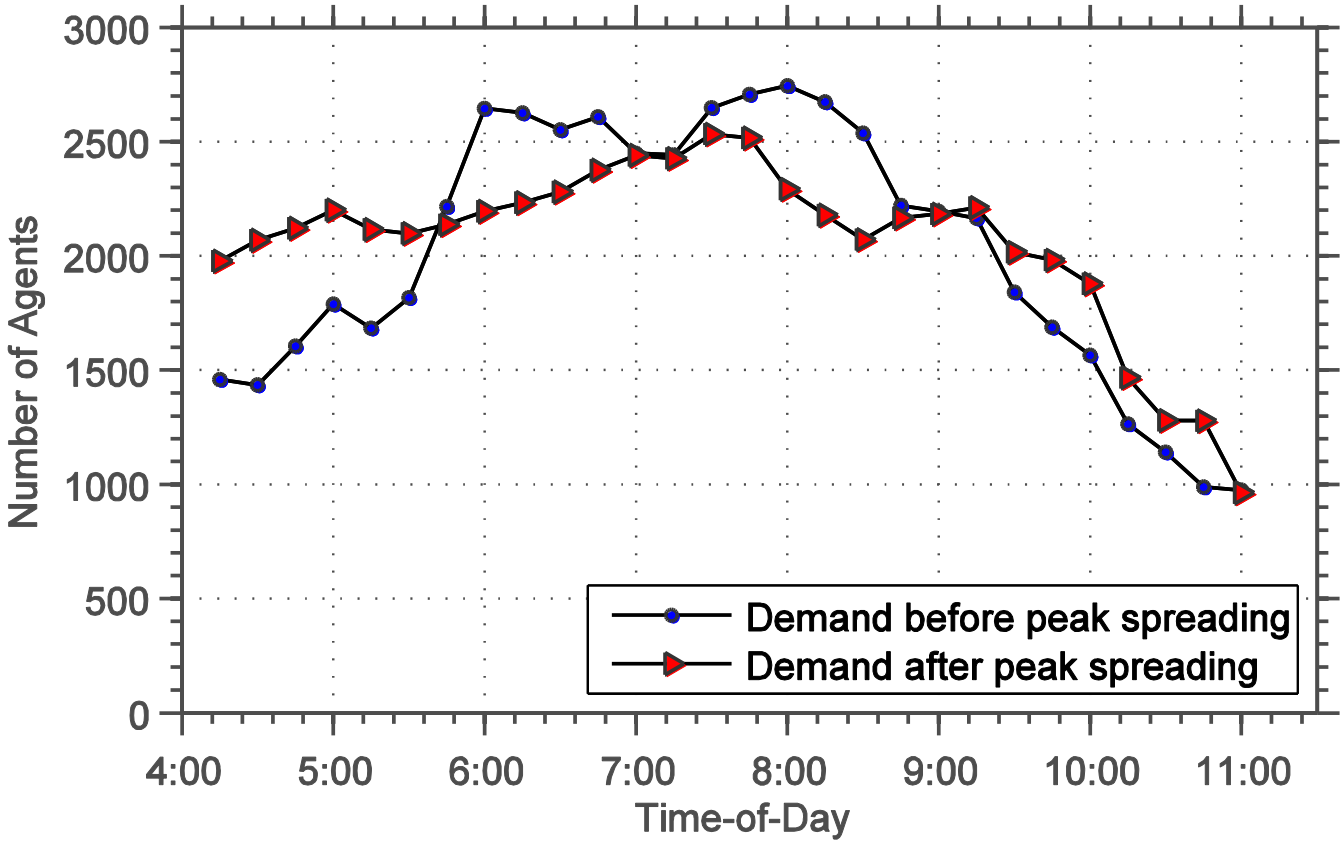
# Departure Time Responses




- Most agents depart earlier to avoid peak-hour congestion
- A few agents depart later to avoid peak-hour congestion

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# Next Steps

## Limitations

- The WISE algorithm based on Tabu search algorithm can be improved with advanced simulation-based optimization (SBO) methods to further decrease the total work zone-related cost
- Running time required by the original WISE on large networks.
- Performance measures are from the original WISE R11 project, and may not be specific to Maryland

## Ongoing Work

- More advanced optimization algorithms that improves WISE performance and benefits
- WISE-MITAMS is being enhanced to support work zone traffic operations
- Real-time simulation for work zone traffic and demand management, integrated active corridor traffic management, demand management and ATIS guidance
- Integrate Maryland DOT-SHA work zone performance measures

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# Questions / Discussion

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