Smarter Work Zones Planning and Operations with WISE in Maryland

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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
TSM&O Program in MD – WZ Context
TSM&O Program in MD – WZ Context

Vision: Maximize mobility and reliable travel for people and goods within Maryland by efficient use of management and operations of transportation systems.

Mission: To establish and maintain a TSM&O program and implement supporting projects within Maryland SHA improving mobility and reliability for all people and goods through planned operations of transportation facilities.

GOAL 1. Develop a sustainable TSM&O program within SHA to implement TSM&O.

GOAL 2. Improve travel time reliability for both people and freight on both arterials and freeways.

GOAL 3. Develop data and performance driven approaches to support TSM&O planning, programming, implementation and evaluation decisions.

GOAL 4. Improve the travelling public's experience on Maryland highways by enabling customers with information & choices.
Outcome based Performance Management

- Business Processes
- Systems and Technology
- Input & Output Measures

Analytical Engines

Reliable Datasets

Data Business Plan

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
TSM&O Program in MD – WZ Context

MARYLAND TRANSPORTATION OPERATIONS AND MANAGEMENT – THE BIG PICTURE

- TSM&O Strategic Plan
- BAA
- Connected Vehicles
- Freeway-Arterial Master Plan
- I-270 Innovative Congestion Management
- US 1 Smart Corridor
- Adaptive Traffic Signal Systems
- SOC Reconfiguration
## TSM&O Program in MD – WZ Context

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

The Work Zone Dashboard

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

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.

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.

Click on a tool tip for explanations and definitions.

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

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

Use the scroll bars to move through the list.
Work Zone Dashboard

The Individual Work Zone Profile

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

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.

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.
Work Zone Dashboard

2 Current Conditions

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

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.

Maryland Department of Transportation

Maryland University of Maryland

National Transportation Center
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)
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

www.matoc.org
Integration of WISE and MITAMS for Optimal Work Zone Planning, Scheduling, and Operations Decision Support in Maryland
Background: MITAMS

Maryland Integrated Travel Analysis Modeling System
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
A parallel effort, funded by U.S. DOE, is to extend model coverage to the entire D.C.-Baltimore region.
### 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.
MITAMS TSM&O Model Applications

Legend
- Road Way
- Connector
- Sensor
- Road Sign
- Application

(Cumulative) Land Development Impact Study
Dynamic Message Sign and Incident Management
Time of Day Tolling
Ramp Metering and VSL
Dynamic Lane Control and Work Zone operations
BRT Analysis
Road Diet

MODYT
MARYLAND DEPARTMENT OF TRANSPORTATION
STATE HIGHWAY ADMINISTRATION
CATT
CENTER FOR ADVANCED TRANSPORTATION TECHNOLOGY
MUNIVERSITY OF MARYLAND
National Transportation Center
Work Zone Planning/Operations

- Estimate work zone impacts at corridor and network levels
- Analyze and recommend operational strategies

MACRO
- Proposed work zone

MESO

MICRO
- UNIVERSITY OF MARYLAND National Transportation Center

MARYLAND DEPARTMENT OF TRANSPORTATION STATE HIGHWAY ADMINISTRATION

CATT CENTER FOR ADVANCED TRANSPORTATION TECHNOLOGY
Integrated WISE and MITAMS

Work Zone Planning/Scheduling

- Code WISE algorithms and data processes and Integrate them with MITAMS
- Smart work zone scheduling based on dynamic traffic assignment

Work Zone Operations

- Optimal work zone plans and schedule
- Evaluate and Optimize Work Zone Operations Strategies

- Work Zone Planning/Scheduling
  - R11 WISE Software
    - Work zone scheduling based on assignment results
  - MITAMS TSMO Model
    - Smart work zone scheduling based on dynamic traffic assignment

- Work Zone Operations
  - Real-Time Data
    - Online Calibration
  - MITAMS TSM&O Model
  - Operations Strategies
Break
10am~10:15am
How WISE works with MITAMS

AgBM Behavior Model
- Model travelers’ behavior responses
- Traveler’s Travel Experience e.g. travel time, delay, distance
- Traveler’s Behavior Adjustments e.g. departure time, route choice

DTALite Traffic Simulation
- Model dynamic traffic conditions
- Provide a feasible work zone sequence and schedule; reduced road way capacity due to work zones

WISE Algorithm
- Heuristic method to find new work zone schedules and optimal project sequencing and scheduling to minimize total cost
- Provide overall traffic condition under current work zone schedule, calculate total cost

Optimal Project Sequence and Schedule

List of Work Zone Projects to schedule

Begin

End
WISE Work Zone Scheduling

WISE Meta-heuristics Algorithm

- Minimize total cost:
  \[ \text{Total Cost} = \text{Agency Cost} + \text{User Cost} \]

- 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
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
Small Network Demo Results

<table>
<thead>
<tr>
<th></th>
<th>Jan</th>
<th>Feb</th>
<th>Mar</th>
<th>Apr</th>
<th>May</th>
<th>Jun</th>
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<td>-</td>
<td>1.4</td>
<td>1.5</td>
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<td>WZ 1</td>
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<td>WZ 2</td>
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- Takes several minutes to run the models
- WISE-MITAMS gives an optimal schedule such that total agency and user costs during construction is minimized
WISE-MITAMS Use Case Applications and Model Demonstration in the Real-World
WISE-MITAMS Use Cases

- Future Construction Projects in Consolidated Transportation Plan (CTP)

- I-270 Innovative Congestion Management Project Work Zone Planning
Real-World Application

Optimally Schedule 10 Work Zone Projects

Legend
- Projects
## Work Zone Project Details

<table>
<thead>
<tr>
<th>ID</th>
<th>Route</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>MD 355</td>
<td>Replace Bridge 10086 over Bennett Creek.</td>
</tr>
<tr>
<td>2</td>
<td>MD 355</td>
<td>Replace Bridge 15053 over Little Bennett Creek.</td>
</tr>
<tr>
<td>3</td>
<td>I 270</td>
<td>Resurface/Rehabilitate</td>
</tr>
<tr>
<td>4</td>
<td>MD 355</td>
<td>Intersection Capacity Improvements</td>
</tr>
<tr>
<td>5</td>
<td>I 270</td>
<td>Construct a new I-270 interchange at Watkins Mill Road. Bicycle and pedestrian improvements will be included where appropriate.</td>
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<tr>
<td>6</td>
<td>I 270</td>
<td>Traffic Management</td>
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<td>7</td>
<td>I 270</td>
<td>Safety/Spot Improvement</td>
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<tr>
<td>8</td>
<td>I 495</td>
<td>Replace Bridge 15136 over I-495.</td>
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<tr>
<td>9</td>
<td>I 495</td>
<td>Construct a full interchange along I-95/I-495 at the Greenbelt Metro Station.</td>
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<tr>
<td>10</td>
<td>I 495</td>
<td>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).</td>
</tr>
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# Business-as-Usual Schedule

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<tr>
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<th>2017</th>
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<th>2019</th>
<th>2020</th>
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- **Feasible Time**
- **BAU Scheduled Time**
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.
# Network-Wide WISE Benefits

<table>
<thead>
<tr>
<th>MOE</th>
<th>Change with WISE</th>
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<tr>
<td>Total Delay (Hours)</td>
<td>279,000</td>
</tr>
<tr>
<td>Total Delay Cost ($)</td>
<td>-4.03 Million</td>
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</table>
I-270 Innovative Congestion Management

REAL-TIME TRAFFIC MGMT & COMMUNICATION
Every Mile

INTELLIGENT TRAFFIC MANAGEMENT
controls corridor access & flow

VIDEO DETECTION
POLLED WITH INTEGRATED DETECTOR
IN RAMP TRAFFIC

ADDITIONAL LANE TO IMPROVE TRAFFIC FLOW
New Third Local Lane

ADDITIONAL TRAVEL LANES BETWEEN INTERCHANGES

OPERATIONAL IMPROVEMENT TO ENHANCE FLOW

FUTURE WATKINS MILL RD. INTERCHANGE

RESTRICTING FOR ADD'L LANES WITHIN EXISTING PAVEMENT

AUTOMATED TRUCK WEIGH STATION
I-270 Work Zone Summary

SMART ADAPTABLE I-270

1 AUTOMATED SMART TRAFFIC SYSTEM

14 BOTTLENECKS BROKEN

23 NEW LANE MILES

25+ REAL-TIME TRAFFIC COMMUNICATION SIGNS

30+ INTELLIGENT SIGNALS

MORE TIME WITH YOUR FAMILY?

PRICELESS
**I-270 Work Zone Details**

**INFRASTRUCTURE**

**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)

**Technology**

**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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**University of Maryland**

**State Highway Administration**

**Center for Advanced Transportation Technology**

**National Transportation Center**
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.)
Users switch to carpool to take the advantage of HOV/HOT Lanes in the corridor

Users switch to transit to avoid freeway delays
Most agents depart earlier to avoid peak-hour congestion

A few agents depart later to avoid peak-hour congestion
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
Questions / Discussion
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