ICM Analysis, Modeling, and Simulation (AMS) Primer

Presented to:
NJ NE & 495-ICM Stakeholders

Presented by:
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Agenda

• Abridged Overview of ICM
• Role of AMS in ICM
• AMS Approach Worksteps
• Lessons Learned from the ICM Pioneer Sites
Webinar Goal

Provide a primer on the applying Analysis, Modeling and Simulation (AMS) tools and concepts in support of planning and deploying Integrated Corridor Management (ICM).

Please ask questions as they come up!
Introductions

- Name & Agency
- Expectations?
- Experience with AMS methods?
Overview of ICM
What is Integrated Corridor Management?

ICM

- Improved situational awareness
- Enhanced response and control
- Better-informed travelers
- Dynamic management of supply relative to demand
- Optimization of existing infrastructure
- Joint Response
- Multi-Modal
- Multi-Jurisdictional
- Multi-Agency
- Pro-Active Management
- Multi-User
- Common Objectives
Examples of ICM Strategies

- Active Traffic Management
- Managed lanes
- Congestion pricing
- En-route information
- Incident response policies
- Integrated electronic payment
- Real-time traffic signal management
- Ride-sharing
- Advanced parking systems
- Advanced ramp metering
- Inter-agency information sharing
- Regional data integration
- 3rd party integration
- Transit supply increase
- Transit signal priority
- Connection protection
- Real-time decision support
7-Phase ICM Implementation Process

1. Get Started
2. Establish Goals
3. Plan for Success
   - 3.1 PMP
   - 3.2 SEMP
   - 3.3 Con Ops
4. Specify & Design
   - 4.1 Architecture
   - 4.2 Requirements
   - 4.3 Detailed Design
5. Build & Test
6. Operate & Maintain
7. Retire/Replace

Continuous Improvement

Conduct Analysis Modeling & Simulation of ICM Strategies and Scenarios of Interest
Role of AMS in ICM
Why Planning for Operations?

Sources of Congestion
Over 50% of congestion is directly attributable to large fluctuations in demand (such as special events), poor signal timing, traffic incidents, inclement weather, and work zones.
Role of Analysis Tools

- Analyze alternatives to optimize transportation system
- Intuitive presentation to stakeholders
- Improved decision-making
Application of AMS Tools at Pioneer Sites

10-year Monetary Costs in Millions of Dollars

- Minneapolis: 4
- San Diego: 12
- Dallas: 14

Cost
Benefit

Cost
Benefit

Minneapolis: 82
San Diego: 104
Dallas: 264
Analysis Tool Capabilities

Archived Operations Data – Monitor, Evaluate, Data Source

Simulation

Travel Demand Models

Deterministic Tools

Sketch Planning

Preliminary Screening

Alternatives Analysis

Define Operational Strategies/Design

Role in Planning Process

Order of Magnitude

Analysis Sensitivity

Detailed
Multi-level Analysis Tools Provide Comprehensive Insight

- Regional patterns and mode shift; Transit analysis capability
- Traveler information, HOT lanes, congestion pricing and regional diversion patterns
- Traffic control strategies such as ramp metering and arterial traffic signal control
What is ICM AMS Methodology?

• Assists in forecasting and assessing the potential benefits and implications of ICM
• Analyzes different operational conditions (recurrent and non-recurrent congestion) across time and modes and across a large enough geographic area to absorb all impacts
• Enables agencies to understand system dynamics at the corridor level
ICM AMS - Testimonial

“AMS engages ICM partners in conversation around what it really means to operate the transportation system differently.”

Robert Sheehan,
USDOT ICM Initiative Demonstration Site Liaison, FHWA
ICM AMS Challenges

- Significant data are needed
- Staff skill levels must be suitable to the challenge
- Costs are significant

*The ICM AMS approach is neither inexpensive nor easy to accomplish. However, the value gained outweighs the expense and pays dividends throughout an ICM Initiative.*
Performance Measures

- Mobility
- Reliability
- Emissions and Fuel Consumption
- Benefits and Cost Comparison
Value of ICM AMS

• Invest in the right strategies
• Invest with confidence
• Lower risk associated with implementation
• Continually improve implementation
Traffic Analysis Toolbox
Volume XIII:

Integrated Corridor Management Analysis, Modeling, and Simulation Guide

www.its.dot.gov/index.htm
May 5, 2012
FHWA-JPO-12-074

## ICM AMS Guide

<table>
<thead>
<tr>
<th>What?</th>
<th>Step-by-step approach to implementation of ICM AMS methodology, with lessons learned from its application to three ICM Pioneer sites and a test corridor.</th>
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</thead>
<tbody>
<tr>
<td>Who?</td>
<td>Technical and/or program managers who may oversee implementation of ICM and/or an ICM/AMS initiative. Helpful reference for <em>all</em> stakeholders involved in AMS.</td>
</tr>
<tr>
<td>Why?</td>
<td>Help corridor stakeholders implement the ICM AMS methodology successfully and effectively.</td>
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Organization of the Guide

Section 1.0 – Introduction and Background
Section 2.0 – Overview of Recommended Approach
Section 3.0 – AMS Worksteps (1-5)
Section 4.0 – Lessons-Learned
Appendix A – USDOT Guidance on Performance Measures
Appendix B – San Diego Data Collection Plan
Companion Documents

• ICM AMS Methodology
• ICM Implementation Guide
• Pioneer Site Analysis Plans (also called “Experimental Plans”)
• Pioneer Sites AMS Reports
• FHWA Traffic Analysis Toolbox
• National Highway Institute (NHI) course “Planning and Managing Successful Applications of Traffic Analysis Tools” (Course Number: 133108)
ICM AMS Approach Worksteps

1. Develop Analysis Plan
2. Develop Data Collection Plan and Collect Data
3. Model Setup and Calibration
4. Alternatives Analysis and Documentation
5. Continuous Improvement
Workstep 1
Develop Analysis Plan
Value of Workstep

- Identify flaws or technical issues in the ConOps
- Communicate the scope of the project
- Identify project challenges and plan mitigation
- Identify and prioritize resources to project objectives
- Better understand existing corridor conditions and deficiencies
- Set expectations of project participants and define roles and responsibilities
- Utilize AMS in an iterative manner with the design process to refine alternatives
- Document the analysis planning process
Workstep 1: Analysis Plan

TIP: Develop the Analysis Plan in close collaboration with, and ideally in parallel with, the development of ICM ConOps and Requirements documents.
Workstep 1: Analysis Plan

Supporting Substeps:
- Substep 1.1: Develop Initial Project Scope
- Substep 1.2: Describe Corridor and Existing Operational Conditions
- Substep 1.3: Identify Analysis Scenarios and ICM Strategies to be Analyzed
- Substep 1.4: Identify Preliminary Data Needs and Availability
- Substep 1.5: Define Output Performance Measures
- Substep 1.6: Select/Determine AMS Tools
- Substep 1.7: Provide Summary of Analysis Settings
- Substep 1.8: Describe AMS Approach
- Substep 1.9: Summarize Guidance for Model Calibration
- Substep 1.10: Budget/Resources, Timeframe and Key Project Roles

Continuous Improvement

Alternatives Analysis and Documentation

Model Setup and Calibration
Example Outline for Analysis Plan

1. Introduction and Initial Project Scope:
   a. Corridor Overview
   b. Project Background and Guiding Principles
   c. Project Goals and Objectives
2. Corridor Description and Existing Operational Conditions
3. Analysis Scenarios and ICM Strategies
4. Data Needs and Availability
5. Output Performance Measures
6. AMS Tools and Methodology
7. Summary of Analysis Settings
8. Summary of AMS Approach
9. Guidance for Model Calibration
10. Budget, Schedule and Key Responsibilities
Workstep 1: Analysis Plan

Workstep Outputs

• Project and initiative-level kickoff meeting presentations and materials
• Memoranda of Agreement/Understanding (MOA/MOU) among initiative stakeholder organizations documenting project scope, and anticipated roles and levels of effort
• Draft and Final Analysis Plan
Workstep 1: Analysis Plan

Workstep Timeframe

• Approximately 4-6 months
• In parallel with development of ConOps and Requirements
• Not to be completed until the full definitions of the anticipated ICM strategies are finalized
• Continues as a “living document” throughout the analysis lifecycle
Workstep Challenges

- Poor specification of ICM strategies
- Unfamiliar and/or non-specific performance measures
- Analysis expands beyond “average day” conditions
- Selecting analysis tools
Workstep 2
Develop Data Collection Plan and Collect Data
Value of Workstep

Build on the data requirements outlined in the Analysis Plan to develop a detailed Data Collection Plan, which will guide the compilation, analysis, and archiving of data that will be required to support the conduct of the AMS.
Workstep 2: Data Collection Plan/Collect Data

Develop Analysis Plan

Continuous Improvement

Alternatives Analysis and Documentation

Model Setup and Calibration

2

Approximate LOE 10-20%

Supporting Substeps:
1) Research and identify available data for the study area
2) Identify information/data gaps and recommend an approach to filling the information/data gaps
3) Identify data management strategies
4) Develop Data Collection Plan
5) Collect Data
6) Assemble Existing Conditions Report
Data Challenges

- Transportation system coverage
- Data quality
- Data format/resolution
- Data integration
- Standards/consistency/metadata
- Backup, recovery, archiving
- Resources
Private Sector Data Helping to Address Some Challenges

• Combine information from multiple probe technologies such as cell phones, toll tags, crowd-sourcing, and fleet-based GPS probe vehicles, as well as data from existing fixed-sensor networks such as loop- or radar-based detection

• Data are then fused to provide real-time travel time estimates and incident information
Example Data Collection Plan Outline

1. Introduction and Background
2. Data Collection Methodology
3. Documentation Review
4. Summary of Input Data for AMS
5. Summary of Data Requirements for Approaches and Strategies
6. Current State of Required Data and Gap Identification
   6.1 Arterial-Related Data
   6.2 Freeway-Related Data
   6.3 Transit-Related Data
7. Summary of Data Collection Methods
Workstep 2: Data Collection Plan/Collect Data

Supporting Substeps:
1) Research and identify available data for the study area
2) Identify information/data gaps and recommend an approach to filling the information/data gaps
3) Identify data management strategies
4) Develop Data Collection Plan
5) Collect Data
6) Assemble Existing Conditions Report
Workstep Timeframe

- Approximately 2-4 months
- Dependent on the types, quantity and quality of data required, data collection methods, and availability of archived data from automated sources
- Data collection/assembly often occurs in parallel with the development of the Data Collection Plan
Workstep Challenges

- Data related to nonrecurring congestion
- Concurrent data collection at different facilities and modes
- Insufficient data quality for modeling
- Limited data on traveler behavior
- Archiving/maintaining data
Workstep 3
Model Setup and Calibration
Value of Workstep

- List example model calibration criteria
- List the steps to determine travel demand for a baseline year
- Describe key activities in model calibration
Workstep 3: Model Setup and Calibration

Supporting Substeps:
1) Summarize Model Calibration Criteria
2) Develop Baseline Model Network Including Relevant Transportation Facilities and Modes
3) Conduct Demand Modeling for Existing Baseline Year
4) Calibrate Simulation Model
Substep 3.2: Develop Baseline Model Network

Subareas and networks may need to be extracted from the regional travel demand model. Factors to consider:

- Availability of network data in the regional travel demand model
- Network size capabilities of the simulation model and desired processing times
- Modes being considered in the analysis, any specialized transit links
- ICM strategies being considered and their likely impacts
- Diversion routes
- Location of major multimodal transfer locations
- Origin-destination patterns of corridor travelers
- Jurisdictional boundaries
- Availability and quality of coverage of supporting network data
- Special generators
- Any additional specialized analysis or reporting needs
Calibration of Baseline Model

- Identify model calibration targets
- Select model parameter values to best match locally measured **corridor capacities**
- Select model parameter values that best reproduce current **route choice patterns**
- Calibrate overall model against overall **system performance** measures
Substep 3.4: Calibrate Simulation Model

Additional Calibration Steps

1. Calibrate model for known incident conditions
2. Validate roadway model
3. Validate model for transit, HOV, and park and ride facilities
4. Summarize model calibration approach and findings in Calibration/Validation Report
Workstep 3: Model Setup and Calibration

Workstep Outputs

- Baseline model networks and trip tables
- Calibrated simulation model
- Calibration/Validation Report
Workstep Timeframe

- Approximately 2-10 months
- Model development, refinement, and calibration can vary in terms of level of effort and time required
Workstep Challenges

• Requires investment of time/resources
• Analysis may require expansion of the “typical” peak periods evaluated in travel demand models
• Stakeholders need to participate in development and review of model calibration settings
• Correct calibration will determine the success of the analysis and project itself
Workstep 4
Alternatives Analysis and Documentation
Objective of Workstep

Develop the alternative scenarios within the models developed and calibrated in Workstep 3. Includes the major investment decisions and the ability to assist planners and operators in devising appropriate operating parameters and concepts of operation to optimize the impacts of the selected strategies.
Value of Workstep

Prioritization of potential ICM investments and a clear communication of the potential project benefits.
Workstep 4: Alternatives Analysis and Documentation

Supporting Substeps:
1) Develop Future Baseline Model Networks and Trip Tables for All Operational Conditions
2) Conduct Analysis of ICM Strategies for All Operational Conditions
3) Assess Performance Measures
4) Conduct Benefit-Cost Evaluation for All Performance Measures
5) Document Analysis Results in AMS Report

Approximate LOE 15-25%
Substep 4.2: Conduct Analysis of ICM Strategies for all Operational Conditions

**Evaluate** the initial operational assumptions using AMS, scrutinizing the results for any underperforming or counterintuitive metrics.

**Brainstorm** causes for the underperformance and a potential set of “what if” adjustments.

**Assess** the impacts and benefits of adjustments to the operational assumptions.

**Analyze, compare, and refine** to identify the optimal operating parameters.

**Document** the tested scenarios and results

**Re-conduct** the refinement process in a continual feedback loop.
Substep 4.3: Assess Performance Measures

The sum of benefits should be weighted across the multiple operational conditions to reflect their likelihood of occurrence (i.e., the frequency in which the scenario would be expected to occur).
Substep 4.4: Conduct Benefit-Cost Evaluation for all Performance Measures

- Capital Costs
- Operations and Maintenance (O&M) Costs
- Annualized Costs
- Infrastructure Costs
- Incremental Costs
## Pioneer Sites ICM AMS Results

<table>
<thead>
<tr>
<th></th>
<th>San Diego</th>
<th>Dallas</th>
<th>Minneapolis</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Annual Travel Time Savings (Person-Hours)</strong></td>
<td>246,000</td>
<td>740,000</td>
<td>132,000</td>
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<tr>
<td><strong>Improvement in Travel Time Reliability</strong></td>
<td>10.6%</td>
<td>3%</td>
<td>4.4%</td>
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<tr>
<td>(Reduction in Travel Time Variance)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Gallons of Fuel Saved Annually</strong></td>
<td>323,000</td>
<td>981,000</td>
<td>17,600</td>
</tr>
<tr>
<td><strong>Tons of Mobile Emissions Saved Annually</strong></td>
<td>3,100</td>
<td>9,400</td>
<td>175</td>
</tr>
<tr>
<td><strong>10-Year Net Benefit</strong></td>
<td>$104M</td>
<td>$264M</td>
<td>$82M</td>
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<tr>
<td><strong>10-Year Cost</strong></td>
<td>$12M</td>
<td>$14M</td>
<td>$4M</td>
</tr>
<tr>
<td><strong>Benefit-Cost Ratio</strong></td>
<td>10:1</td>
<td>20:1</td>
<td>22:1</td>
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San Diego I-15 ICM Total Estimated Annual Benefits

<table>
<thead>
<tr>
<th></th>
<th>Emissions</th>
<th>Fuel</th>
<th>TT Reliability</th>
<th>Travel Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>SB I-15</td>
<td>$3.5</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>SB Managed Lanes</td>
<td>-$2.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NB I-15</td>
<td>-$0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NB Managed Lanes</td>
<td>-$0.1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arterials</td>
<td>$6.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Arterials</td>
<td>$6.4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$13.7</td>
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</table>

U.S. Department of Transportation
Federal Highway Administration
Workstep 4: Alternatives Analysis and Documentation

Workstep Outputs

- Performance measures for all alternatives
- Benefit/cost analysis for each alternative
- A prioritized list of response strategies for each scenario
Workstep 4: Alternatives Analysis and Documentation

Workstep Timeframe

- Alternatives Analysis: 1-4 months (varies based on number/complexity of test scenarios)
- Documentation: 1 month plus review time
Workstep Challenges

- Weighing model outputs against expected outcomes
- Fully understand capabilities and limitations of models and datasets
- Resources
Workstep 5
Continuous Improvement
Value of Workstep

Ensures the maintenance of the models and datasets, greatly reducing the costs, enhancing the ease with which future analyses may be performed on the corridor, and improving the effectiveness in which future investment decisions are made.
Workstep 5: Continuous Improvement

Approximate LOE 5% (in most cases this process is beyond the immediate project scope)

Supporting Substeps:
1) Validate AMS Approach
2) Maintenance of Datasets and Models

Develop Analysis Plan

Develop Data Collection Plan and Collect Data

Alternatives Analysis and Documentation

Model Setup and Calibration
Workstep 5: Continuous Improvement

Workstep Outputs

- Technical memo summarizing findings
- Archive of models and datasets
- Documentation and data dictionaries
Workstep Challenges

- Tendency to forego this task
- May require a mindset change
Lessons Learned from the ICM Pioneer Sites
The Role of AMS

- Requires analytical complexity, but is invaluable
- Helps identify deficiencies in the design process
- Identifies key prospective benefits from proposed ICM improvements
- Enhances existing tools and capabilities
- Must be continually refined and improved
AMS Framework and Methodology

- Different tool types have different advantages and limitations
- An integrated approach can support corridor management planning, design, and operations by combining the capabilities of existing tools
- There are key modeling gaps in existing tools’ capabilities
  - Traveler Information
  - Tolling and congestion pricing
  - Short-term mode shift
Data and Performance Measures

• Seek out peer information on unfamiliar datasets
• Thoroughly assess data quality from all sources
  – Specify data quality procedures and minimal data quality requirements
• Concurrent data collection can be demanding
• Archive and maintain datasets and dictionaries
Model Development

- Often the riskiest task
- Analysis of incidents and ICM strategies may require the expansion of the “typical” peak periods evaluated in the travel demand models
- In assessing the model results, weigh the model outputs against the expected outcomes identified in the Analysis Plan carefully
Thanks & Questions?

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