Intelligent Transportation Systems
Joint Programs Office

The Potential Benefits of Dynamic Mobility Applications (DMA)

DCM/DMA 2013 Winter Webinar Series

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James Colyar, FHWA

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Webinar Purpose

- Informational webinar presenting the activities being conducted to assess the potential impacts of mobility applications:
  - The assessment plan
  - Preliminary results from the first stages, including an estimate of congestion reduction benefits
  - A status update on the next key activity: the joint DMA-ATDM Analysis, Modeling and Simulation (AMS) Testbed
    - DMA: Dynamic Mobility Applications
    - ATDM: Active Transportation and Demand Management
Webinar Agenda

- Introduction (*Kate Hartman*)
  - Overview of Dynamic Mobility Applications (DMA)
  - DMA impact assessment

- Overview of performance measures and target goals for DMA (*Brian Cronin*)

- Results from a preliminary study of congestion impacts of DMA (*Brian Cronin*)

- Update on the DMA – Active Transportation and Demand Management (ATDM) Analysis, Modeling and Simulation (AMS) effort (*James Colyar*)

- Summary (*Kate Hartman*)
Dynamic Mobility Applications

- The Dynamic Mobility Applications (DMA) Program seeks to create applications that fully leverage frequently collected and rapidly disseminated multi-source data gathered from connected travelers, vehicles and infrastructure, and that increase efficiency and improve individual mobility while reducing negative environmental impacts and safety risks.
DMA Program Vision and Objectives

- **Vision**: Expedite development, testing, commercialization and deployment of innovative mobility applications that:
  - Maximize system productivity
  - Enhance mobility of individuals within the system

- **Objectives**
  - Create applications using frequently collected and rapidly disseminated multi-source data from connected travelers, vehicles (automobiles, transit, freight) and infrastructure
  - Develop and assess applications showing potential to improve nature, accuracy, precision and/or speed of dynamic decision making
  - Demonstrate promising applications predicted to significantly improve capability of transportation systems
  - Determine required infrastructure for transformative applications implementation, along with associated costs and benefits
The Mobility Program

Real-time Data Capture and Management

Dynamic Mobility Applications

Data Environment

- Vehicle Status Data
- Weather Data
- Truck Data
- Infrastructure Status Data
- Transit Data
- Location Data

- Reduce Speed
  - 35 MPH
- Weather Application
- Transit Signal Priority
- Real-Time Travel Info
- Fleet Management/Dynamic Route Guidance
- Signal Phase & Timing Adjusts
- Real-Time Conditions
- Safety Alerts and Warnings
## Dynamic Mobility Application Bundles

<table>
<thead>
<tr>
<th>Program</th>
<th>Description</th>
<th>Contact</th>
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<tbody>
<tr>
<td>MMITSS:</td>
<td>Multimodal Intelligent Traffic Signal System</td>
<td>Ben McKeever</td>
</tr>
<tr>
<td>INFLO:</td>
<td>Intelligent Network Flow Optimization</td>
<td>Mohammed Yousuf</td>
</tr>
<tr>
<td>Enable ATIS:</td>
<td>Enable Advanced Traveler Information Systems</td>
<td>Bob Rupert</td>
</tr>
<tr>
<td>IDTO:</td>
<td>Intelligent Dynamic Transit Operations</td>
<td>Ron Boenau</td>
</tr>
<tr>
<td>FRATIS:</td>
<td>Freight Advanced Traveler Information Systems</td>
<td>Randy Butler</td>
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Other Programs: ICM, ATDM, Weather
DMA Impact Assessment Activities

The DMA program includes an ongoing set of activities to develop and continually refine estimates of the impact mobility applications:

- Application Prototyping and Testing
- Analyses of Isolated Bundles / Applications
- Analyses of Regional Deployment of Multiple Bundles / Applications using DMA – ATDM AMS Simulation Testbed
- Integrated Demonstrations of Applications

National Mobility Impacts Estimation

2012
Transformative Targets

2013
Prototyping Results

2014
Simulation Testbed Results

2015
Demo Results

Preliminary Estimates of Congestion Benefits from the Literature

V2I Mobility Benefits Estimates
Performance Measures and Target Goals

- Performance metrics have been defined for each high priority mobility application in each bundle.
- Target goals have been set for each application bundle and in some cases for specific applications.
- Target goals have been set for three time periods:
  - Near-term: next 5 years
  - Mid-term: 5-10 years out
  - Long-term: > 10 years out
- The initial target goals were vetted by ITS stakeholders at the Mobility Workshop held in April of 2012.
- More information on the aspirational goals for each bundle is available at: http://www.its.dot.gov/presentations/MWII5_Bundles_v4_files/frame.htm
# Performance Measures and Aspirational Goals

## Long Term Performance Goals for M-ISIG:

<table>
<thead>
<tr>
<th>Performance Measure</th>
<th>&gt; 10 Years Target Goal</th>
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<tbody>
<tr>
<td>Overall Vehicle Delay</td>
<td>Reduce by 25%</td>
</tr>
<tr>
<td>Throughput</td>
<td>Increase by 15%</td>
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<tr>
<td>Queue Length</td>
<td>Reduce by 15%</td>
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<tr>
<td>Average Pedestrian Wait Time</td>
<td>Reduce by 20%</td>
</tr>
<tr>
<td>Average Transit Delay</td>
<td>Reduce by 35%</td>
</tr>
<tr>
<td>Average Commercial Vehicle Delay</td>
<td>Reduce by 15%</td>
</tr>
<tr>
<td>Average Emergency Vehicle Delay</td>
<td>Reduce by 40%</td>
</tr>
<tr>
<td>Extent of System-Wide Congestion (i.e., failure to clear queue in a cycle)</td>
<td>Reduce by 25%</td>
</tr>
<tr>
<td>Duration of System-Wide Congestion</td>
<td>Reduce by 40%</td>
</tr>
<tr>
<td>Duration of Response to a Traffic Incident (overall incident clearance time)</td>
<td>Reduce Total Response Time by 30%</td>
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Benefits of Dynamic Mobility Applications: Preliminary Estimates from the Literature

- **Purpose of study:** Use currently available quantitative information to develop a rough estimate of the potential benefits of mobility applications.

- **Scope:** Although mobility applications will provide safety and environmental benefits as well, the scope was limited to mobility benefits (including transit and freight).

- **Approach:** Search the literature for quantitative information on the potential mobility benefits of the connected vehicle Dynamic Mobility Applications (DMA) or similar applications.
  - Benefits can come from new applications, e.g., Cooperative Adaptive Cruise Control.
  - Benefits can come from wide deployment of existing technologies, enabled by lower cost of deployment, e.g., Ramp Metering.
Sources of Information

- Reviewed 45 resources, including:
  - Mobility Application Bundles Concepts of Operation
  - Mobility Application Bundles literature surveys
  - The ITS Knowledge Resources Portal
  - ICM study Reports
  - Over a dozen additional papers and reports
Causes of Congestion

- In order to calculate national benefits, the percentage improvement for each application had to be prorated by the type(s) of congestion they reduce:

Causes of Congestion (Source: Federal Highway Administration)
Major Caveats and Assumptions

- Data was very limited. Despite a desire to develop national estimates on delay, travel time variability, capacity increases, etc., in the end, only developed estimates on the percent reduction in congestion.

- Not all applications apply to all roadway types, some are limited to signalized arterials, others to freeways.
  - Assumed ½ of all congestion occurs on arterials, ½ on freeways, with negligible delay on unsignalized minor roads

- When multiple applications yield benefits on the same type of roadway, assumptions must be made about their interactions.
  - Double-counting was avoided
  - Assumption is that each application is independent
  - Example: assume three mobility applications have each been separately shown to reduce congestion by 33%. Aggregate remaining congestion is taken to be \((1-0.33)*(1-0.33)*(1-0.33) = 30\%\) of congestion, e.g., a 70\% reduction.
Major Caveats and Assumptions

- If only travel time reduction was reported, the delay reduction was set equal to the travel time reduction
  - Delay reduction percentage will always be greater than the travel time percentage reduction

- If only capacity increase information was available, the delay reduction is taken to be the inverse of the capacity increase (e.g., a doubling of capacity is assumed to reduce delay by 50%)
  - Conservative estimate, as delay often increases more rapidly as capacity limits are reached.

- If no quantitative data was available for an application, it is not included in the calculations
Example Calculation: Intelligent Traffic Signal Control (ISIG) Application

- Arterials are assumed to account for 50% of delays due to congestion, freeways the remaining 50%
- Literature (Quantifying the Benefits of Coordinated Actuated Traffic Signal Systems: A Case Study) indicated that real-time optimization of signal controls can provide a 30% reduction in arterial delay
- Other analysis had shown that Cooperative Adaptive Cruise Control (CACC) and Speed Harmonization could reduce delays due to congestion on freeways by 34%
- Combined benefit of ISIG, CACC, and Speed Harmonization is then:

\[
30\% \text{ADR} \times 50\% \left( \frac{DR}{ADR} \right) + 34\% \text{FDR} \times 50\% \left( \frac{DR}{FDR} \right) = 32\% \text{DR}
\]

\[
ADR = \text{Arterial Delay Reduction} \\
DR = \text{Total Delay Reduction} \\
FDR = \text{Freeway Delay Reduction}
\]
Results

- Mobility applications will reduce the impact of all six causes of congestion while simultaneously increasing safety and benefiting the environment.

- Based on the limited data currently available from modeling and field trials of similar applications, full deployment of the set of mobility applications may be capable of eliminating over 1/3rd of the travel time delay caused by congestion.

- While outside the scope of this study, the Dynamic Mobility Applications will also reduce crashes, improve safety, and provide emissions reductions

- Report documenting the analysis is currently in the publication process.
DMA-ATDM AMS Testbed

- Both ATDM and DMA programs have invested significant resources in the development of advanced concepts and foundational research.

- An AMS (Analysis, Modeling, and Simulation) Testbed provides a virtual computer-based simulation environment for targeted, integrated testing prior to field deployment.

- An AMS Testbed is used in analysis to identify the impacts of:
  - predictive, more active systems management (ATDM Strategies)
  - integrating transformative applications enabled by new data from wirelessly connected vehicles, travelers, and infrastructure (DMA Applications)

- Proceeding in 2 Phases:
  - Testbed Planning (current)
  - Testbed Development and Evaluation (upcoming)
AMS Testbed Planning Project Objectives

- Plan for **multiple** Analysis, Modeling, and Simulation (AMS) Testbeds to support the DMA and ATDM Programs in evaluating and demonstrating the impacts of deploying application bundles and strategies in a simulation environment:
  - Identify AMS Requirements for a portfolio of Testbeds
  - Develop preliminary evaluation plans, one each for the DMA and ATDM Programs
  - Develop a framework for an AMS Testbed
  - Conduct an initial screening of AMS Testbed locations
Testbed Planning Objective #1: AMS Testbed Requirements

- **Purpose**
  - Develop requirements for a portfolio of AMS Testbeds that support the DMA and ATDM Programs

- **Approach**
  - Review materials previously developed for ATDM and DMA Programs:
    - AMS ConOps; AMS Capability Assessment; AMS Analysis Plans
    - DMA Analytical Needs Assessment
  - Define requirements for the ATDM analysis packages and DMA bundles
    - Assign to each requirement a priority, which is a function of the technical risk and criticality of the requirement
  - Engage internal and external stakeholders to solicit feedback

- **Status and schedule:**
  - Internal informational webinar held on 18 December, 7 January
  - External stakeholder workshop held at TRB on 13 January
  - Finalized requirements in late March 2013
Testbed Planning Objective #2: AMS Testbed Preliminary Evaluation Plans

- **Purpose**
  - Develop two preliminary evaluation plans, one each for the DMA and ATDM Programs to:
    - evaluate the impacts of the DMA bundles/ATDM strategies
    - identify potential conflicts and synergies between the bundles/strategies

- **Approach**
  - Discuss of evaluation objectives and hypotheses with internal stakeholders from the DMA and ATDM Programs separately
  - Plans considered "preliminary", used as input and finalized during AMS Testbed Development/Evaluation task

- **Status and schedule:**
  - Draft Plans complete in early April 2013
  - Final Plans to be complete in May 2013
Testbed Planning Objective #3: AMS Testbed Framework

- **Purpose**
  - Establish a framework for developing an AMS Testbed

- **Approach**
  - Framework will unlikely serve needs of all AMS Testbeds; each AMS Testbed activity will tailor the framework according to the needs of the portfolio of bundles/strategies being modeled
  - Solicit input from AMS expert stakeholders on framework

- **Status and Schedule:**
  - Draft AMS Testbed Framework Report complete in early April 2013
  - Final AMS Testbed Framework Report to be complete in May 2013
Testbed Planning Objective #4: AMS Testbed Initial Screening

- **Purpose**
  - Conduct a screening of AMS Testbed locations, and shortlist 7 to 10 candidates

- **Approach**
  - Develop screening criteria for shortlisting candidate testbeds:
    - Sufficient geographic scope (spatial scale) and temporal scale
    - Multi-modal to capture mode shifts and transit operations
    - Capable of generating data needed for AMS

- **Status and Schedule:**
  - Draft AMS Testbed Initial Screening Report completed in early April 2013
  - Final Testbed Initial Screening Report to be complete in May 2013
What the AMS Testbed Can Reveal: Effect of Increased Connected Vehicle Market Penetration on Impacts

Average Time Between V2I Communications (Minutes)

Connected Vehicle Market Penetration

More Connected Vehicle/Travelers

Most Effective Deployment Path

More Frequent Communications

Total System Delay Impact Contours

-33%

-25%

-20%

-15%

-10%

-5%

0%

Upper Bound
Webinar Summary (1 of 2)

- Connected vehicle mobility applications will provide substantial mobility, safety, and environmental benefits

- Performance measures have been defined, and target goals set

- A multi-faceted program is underway to develop and continually refine quantitative estimates of the benefits
  - These estimates will be used to support investment decisions regarding both research and deployment

- Based on the limited data currently available, full deployment of mobility applications may be capable of eliminating over 1/3rd of the travel delay that is caused by congestion
Webinar Summary (2 of 2)

- Next Steps:
  - V2I Mobility Benefits Estimates (results in summer 2013)
  - Completion of AMS Testbed Planning (November 2013)
  - Application prototyping and testing (FRATIS underway, others to begin later this year)
  - National Mobility Impacts Estimation (task order award pending)
For more information …

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