Integrated Corridor Management (ICM) 4 U

Leveraging Technology & Collaboration to Improve Safety and Mobility
Brad Freeze, Traffic Operations Division Director, TDOT
Evolution of a TSM&O Program

Conventional Systems
- Incident Management
- Traveler Info (DMS)
- Traffic Signal Control
- Ramp Metering

Smart Systems
- Traveler Info (Social Media)
- Active Traffic Management (ATM)
- Adaptive Signal Control
- Bus Rapid Transit (BRT)
- Adaptive Metering

Integrated Systems
- ICM
- ATDM

The Future
- Connected Vehicle
- Automated Vehicles
- Cloud Computing
Integrated Corridor Management (ICM)

The vision of Integrated Corridor Management (ICM) is that transportation networks will realize significant improvements in the efficient movement of people and goods through institutional collaboration and aggressive, proactive integration of existing infrastructure along major corridors.

-FHWA
Integrated Corridor Management (ICM)

ICM combines two fundamental concepts: active management and integration. Active management involves monitoring and assessing the performance of the system and, at the same time, dynamically implementing actions and providing services in response to fluctuations in demand.

-FHWA
Why ICM?

• Pro-actively Manage Congestion
• Provide Choices
• Maximize System Capacity
• Improve Coordination/ Interoperability
• Manage and Operate Across Modes and Agencies
Integration on 3 Levels

- **Institutional Integration**
  - Commitment - collaboration between various agencies, modes, and jurisdictions that transcends institutional boundaries

- **Operational Integration**
  - All inclusive customer focus - Joint operational objectives and strategies to manage and balance the total capacity and demand of the corridor

- **Technical Integration**
  - Sharing and distribution - of information and system operations control functions to support the analysis and immediate response
ICM, The Ultimate Goal

- Active, But Not Integrated
  - Early in Active and/or Integrated Operations
  - Integrated, But Not Active
- DESIRED END STATE: Active and Integrated

Source: Federal Highway Administration
FHWA ICM Demonstration Sites

**Dallas, TX: US-75**

- ICM Corridor covers a 28-mile segment of US-75 and is the primary connector between Dallas and northern suburbs.
- Serves commuter, commercial, and regional trips.
- Weekday mainline traffic volumes reach 250,000 vehicles with 30,000 on frontage roads.
- 167 miles of arterial roadways.
- High Occupancy Vehicle (HOV) lanes, Light Rail Transit (LRT), Bus Service, and Park-and-Ride lots.

For more information about the Dallas, TX, Demonstration Site contact:

**Koorosh Olyai**  
Dallas Area Rapid Transit (DART)  
olyai@dart.org

**San Diego, CA: I-15**

- ICM Corridor covers a 21-mile segment of I-15 and runs from SR-78 in the north to SR-163 interchange in the south.
- Serves commuter, goods, and services movement from northern San Diego to the downtown area.
- Weekday traffic volumes range from 170,000 to 290,000 vehicles on general purpose lanes.
- Managed Lanes and Bus Rapid Transit (BRT) that will operate in the Managed Lanes.
- Dynamic variable pricing in the managed Lanes will help manage traffic flow.

For more information about the San Diego, CA, Demonstration Site contact:

**Alex Estrella**  
San Diego Association of Governments  
aes@sandag.org
## FHWA ICM Demonstration Sites

### Strategies and Partners at the ICM Demonstration Sites

<table>
<thead>
<tr>
<th>Example DSS Response Plan Strategies</th>
<th>Partners</th>
</tr>
</thead>
</table>
| • Divert onto frontage roads, arterials, and/or light rail, depending on severity of event on freeway  
• Implement dynamic signal timing to maximize throughput on diversion routes  
• Provide real-time information on traffic conditions (including speeds), public transit, and parking availability through 511 system  
• Provide diversion recommendations (including mode shift to light rail) on dynamic message signs, under certain conditions | • Dallas Area Rapid Transit  
• City of Dallas  
• Town of Highland Park  
• North Central Texas Council of Governments  
• North Texas Tollway Authority  
• City of Plano  
• City of Richardson  
• Texas Department of Transportation  
• City of University Park |
| • Provide en-route and pre-trip traveler information and enhanced transit network information through a new 511 smartphone app for trip decision-making  
• Coordinate signal timing with ramp meters to optimize mode shifts between the freeway and arterials  
• Deploy dynamic wayfinding signs on arterials to re-direct diverted traffic back to freeways | • San Diego Association of Governments (SANDAG)  
• California Department of Transportation  
• City of Escondido  
• Metropolitan Transit System  
• North County Transit District  
• City of Poway  
• City of San Diego |
Other Notable Examples

I-80 Corridor, CA

- 20-mile transportation and freight corridor (270,000 cars per day)
- The most congested corridor in the region, 4-5 hours of delay in each peak period
- Carpool lane is 3+
- Major transit corridor
I-80 ICM Project Elements

- 44 On-ramps
- 67 Variable Advisory Speed Signs
- 11 Gantries with Lane Use Signs
- 6 Information Display Boards
- 34 Arterial Trailblazer Signs
- 4 Arterial Changeable Message Signs
- TSP, CCTV Cameras, Microwave Vehicle Detection, Variable Message Signs
- Local Workstations at 12 Agencies
- 160 Traffic Signals on 3 Signal Systems
- Central Equipment
I-24 SMART CORRIDOR
The Need

• Interstate 24 (I-24) is an integral part of the Nashville transportation network and a major route for commuters and freight.

• Traffic volumes along the I-24 corridor have experienced exponential growth rates over the past decade. Since 2005, traffic volumes have increased more than 60% on I-24 near Murfreesboro.

• Currently, peak hour volumes exceed capacity and even a minor incident can have a severe impact on travel time reliability.

• Due to physical, environmental, and financial constraints along the Corridor there are no viable, short term roadway widening projects.
Area Map
I-24 Congestion Contributors

Traffic Incidents 27%

Incidents Breakdown 2015
(Total Crashes: 1,661)

Contributors to Congestion

- Bottlenecks 55%
- Traffic Incidents 27%
- Poor Signal Timing 5%
- Special Events 5%
- Bad Weather 3%
- Work Zones 5%
- Single-Veh Crash 3%
- Multi-Veh Crash 20%
- Abandoned Veh 32%
- Disabled Veh 43%
Crash History & Analysis
## I-24 Section Crash Rate

<table>
<thead>
<tr>
<th>Section Location</th>
<th>Actual Crash Rate</th>
<th>Severe Crash Rate</th>
<th>Fatal Crash Rate</th>
<th>Incapacitating Injury Crash Rate</th>
<th>Other Injury Crash Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statewide Average Crash Rate (2012-2014)</td>
<td>1.036</td>
<td>0.029</td>
<td>0.005</td>
<td>0.024</td>
<td>0.226</td>
</tr>
<tr>
<td>SR-155 (Briley Pkwy) to Harding Pl (L.M. 18.38 to 20.43)</td>
<td>2.086</td>
<td>0.013</td>
<td>0.003</td>
<td>0.010</td>
<td>0.543</td>
</tr>
<tr>
<td>Harding Pl to Haywood Ln (L.M. 20.43 to 21.74)</td>
<td>2.099</td>
<td>0.033</td>
<td>0.000</td>
<td>0.033</td>
<td>0.666</td>
</tr>
<tr>
<td>Haywood Ln to Bell Rd (L.M. 21.74 to 24.12)</td>
<td>1.529</td>
<td>0.033</td>
<td>0.012</td>
<td>0.021</td>
<td>0.447</td>
</tr>
<tr>
<td>Bell Rd to Hickory Hollow Pkwy (L.M. 24.12 to 24.81)</td>
<td>1.097</td>
<td>0.017</td>
<td>0.017</td>
<td>0.000</td>
<td>0.296</td>
</tr>
<tr>
<td>Hickory Hollow Pkwy to Old Hickory Blvd (L.M. 24.81 to 27.18)</td>
<td>0.883</td>
<td>0.010</td>
<td>0.003</td>
<td>0.008</td>
<td>0.220</td>
</tr>
<tr>
<td>Old Hickory Blvd to Waldron Rd (L.M. 27.18 to 1.23)</td>
<td>0.925</td>
<td>0.045</td>
<td>0.007</td>
<td>0.037</td>
<td>0.251</td>
</tr>
<tr>
<td>Waldron Rd to Sam Ridley Pkwy (L.M. 1.23 to 3.22)</td>
<td>0.856</td>
<td>0.038</td>
<td>0.006</td>
<td>0.032</td>
<td>0.238</td>
</tr>
<tr>
<td>Sam Ridley Pkwy to Almaville Rd (L.M. 3.22 to 6.80)</td>
<td>0.808</td>
<td>0.033</td>
<td>0.009</td>
<td>0.024</td>
<td>0.225</td>
</tr>
<tr>
<td>Almaville Rd to SR-840 (L.M. 6.80 to 11.47)</td>
<td>0.530</td>
<td>0.026</td>
<td>0.004</td>
<td>0.023</td>
<td>0.137</td>
</tr>
</tbody>
</table>

*Note: Numbers shown in red are greater than statewide average rates.*

Crash Rate Data represents information collected between 2013-2015.
System Performance Review
Travel time for I-24 between I-40/Exit 52 and TN-96/Exit 78

Averaged by 5 minutes in 2014 (every weekday), 2015 (every weekday), and 2016 (every weekday)

Westbound

Travel time: Time it will take to drive along the stretch of road (Distance Traveled / Speed).

- 2014 (every weekday) - NPMRDS (Trucks and passenger vehicle)
- 2015 (every weekday) - NPMRDS (Trucks and passenger vehicle)
- 2016 (every weekday) - NPMRDS (Trucks and passenger vehicle)
Travel time for I-24 between I-40/Exit 52 and TN-96/Exit 78

Averaged by 5 minutes in 2014 (every weekday), 2015 (every weekday), and 2016 (every weekday)

Eastbound

Travel time: Time it will take to drive along the stretch of road (Distance Traveled / Speed).

- 2014 (every weekday) - NPMRDS (Trucks and passenger vehicle)
- 2015 (every weekday) - NPMRDS (Trucks and passenger vehicle)
- 2016 (every weekday) - NPMRDS (Trucks and passenger vehicle)
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Travel time for I-24 between I-40/Exit 52 and TN-96/Exit 78

Averaged by 5 minutes in 2014 (every weekday), 2015 (every weekday), and 2016 (every weekday)

Eastbound

Travel time: Time it will take to drive along the stretch of road (Distance Traveled / Speed).

2016 (every weekday) - NPMRDS (Trucks and passenger vehicle)
2016 (every weekday) 5th and 95th percentile - NPMRDS (Trucks and passenger vehicle)
AM Peak Period Travel Time
I-24 From I-840 to Briley Pkwy.

High Variability
**Reliability**

From Exit 78 (SR-96) & Exit 53 (I-440 Interchange), 25 miles

### Westbound Travel (Weekdays 2014-2016)

<table>
<thead>
<tr>
<th>Buffer time (minutes)</th>
<th>Planning time (minutes)</th>
<th>Travel time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00 AM - 9:00 AM</td>
<td>3:00 PM - 7:00 PM</td>
<td></td>
</tr>
<tr>
<td>39.64</td>
<td>69.32</td>
<td>30.14</td>
</tr>
<tr>
<td>43.98</td>
<td>73.64</td>
<td>31.04</td>
</tr>
<tr>
<td>43.57</td>
<td>73.22</td>
<td>31.18</td>
</tr>
</tbody>
</table>

### Eastbound Travel (Weekdays 2014-2016)

<table>
<thead>
<tr>
<th>Buffer time (minutes)</th>
<th>Planning time (minutes)</th>
<th>Travel time (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5:00 AM - 9:00 AM</td>
<td>3:00 PM - 7:00 PM</td>
<td></td>
</tr>
<tr>
<td>2.76</td>
<td>27.22</td>
<td>45.71</td>
</tr>
<tr>
<td>2.86</td>
<td>27.31</td>
<td>48.69</td>
</tr>
<tr>
<td>1.97</td>
<td>26.43</td>
<td>52.38</td>
</tr>
</tbody>
</table>
2014

**Delay cost:**
- Total: $49,529,063.56
- Per VMT: $0.04

**Hours of delay:**
- Person-hours: 2,200,712h 50m 29s
- Vehicle-hours: 1,796,500h 16m 43s

**Vehicle miles traveled (VMT):**
- Total: 1,146,999,316 miles
- Passenger: 1,032,299,384 miles
- Commercial: 114,699,932 miles

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**2015**

**Delay cost:**
- Total: $62,221,638.77
- Per VMT: $0.05

**Hours of delay:**
- Person-hours: 2,764,678h 57m
- Vehicle-hours: 2,256,880h 46m 32s

**Vehicle miles traveled (VMT):**
- Total: 1,150,831,939 miles
- Passenger: 1,035,748,745 miles
- Commercial: 115,083,194 miles

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**2016**

**Delay cost:**
- Total: $63,826,374.28
- Per VMT: $0.05

**Hours of delay:**
- Person-hours: 2,835,981h 46m 24s
- Vehicle-hours: 2,315,087h 9m 43s

**Vehicle miles traveled (VMT):**
- Total: 1,153,704,781 miles
- Passenger: 1,038,334,303 miles
- Commercial: 115,370,478 miles
Previous Studies

I-24 Multimodal Corridor Study

• Identified short- and long-term solutions for improving problem spots along the entire corridor.

• Investigated a range of multimodal solutions to address future travel demands, with emphases on:
  o managing congestion,
  o improving safety,
  o maximizing the potential for freight diversion, and
  o preserving/enhancing the corridor's economic benefits.
## I-24 Multimodal Corridor Study
### Recommended Capacity Improvement Projects

<table>
<thead>
<tr>
<th>I-24 Location</th>
<th>Description of Project</th>
<th>Length</th>
<th>Recommended Build year</th>
<th>I-24 Corridor Study Project ID</th>
<th>Year of Expenditure Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exit 54 to Exit 57</td>
<td>Widen from 8 to 10 lanes from SR-155 (Briley Pkwy) to Haywood Lane</td>
<td>3.4</td>
<td>2020</td>
<td>306</td>
<td>$ 59,528,734</td>
</tr>
<tr>
<td>Exit 57 to Exit 62</td>
<td>Widen from 6 to 8 lanes from Haywood Lane to SR-171/Old Hickory Blvd</td>
<td>5.4</td>
<td>2020</td>
<td>307</td>
<td>$ 94,545,629</td>
</tr>
<tr>
<td>Exit 62 to Exit 70</td>
<td>Widen from 6 to 8 lanes from SR-171/Old Hickory Blvd to SR-102/Nissan Drive</td>
<td>6.8</td>
<td>2020</td>
<td>308</td>
<td>$ 119,057,468</td>
</tr>
<tr>
<td>Exit 70 to Exit 74</td>
<td>Widen from 6 to 8 lanes from SR-102/Nissan Drive to I-840</td>
<td>4.8</td>
<td>2030</td>
<td>309</td>
<td>$ 119,698,082</td>
</tr>
<tr>
<td>Exit 74</td>
<td>Implement new collector-distributor roads at I-840 EB and WB to remove weaving section</td>
<td>N/A</td>
<td>2040</td>
<td>254</td>
<td>$ 39,496,352</td>
</tr>
</tbody>
</table>

**Total:** $ 432,326,265
Strategies identified during the study and considered for urban areas include:
  - Variable Speed Limit (VSL)
  - Road Weather Information System (RWIS)
  - Ramp Metering

Recommended to install ramp metering components and system software in urban locations along I-24.

Recommended to install arterial ITS instrumentation and communications on SR-1 between I-440 interchange and SR-96 (Murfreesboro)
Previous Studies

I-24 Congestion Mitigation Report

- Build on operational recommendations from I-24 Multimodal Corridor Study
- Assessed the potential to manage congestion and improve travel reliability by applying the following strategies:
  - Bus on Shoulder (BOS) System
  - Ramp Metering
  - Variable Speed Limits (VSL)
  - Active Arterial Management (AAM)
- The initial analysis of the strategies showed a strong potential for crash reduction and improvement in travel time reliability.
Recent Program Expansions

HELP Program

• TDOT was awarded a federal Congestion Mitigation and Air Quality grant that allowed the department to add more HELP Operators and trucks, as well as expand the routes of the HELP program.

• The I-24 route east of Nashville now covers from downtown to SR-96 in Murfreesboro and has two additional operators.
Recent Program Expansions

Intelligent Transportation System

- 24 CCTV
- 9 DMS
- 47 RDS
Area Project Stakeholders

- City of Nashville*
- City of La Vergne*
- Town of Smyrna*
- City of Murfreesboro*
- Rutherford County*
- Rutherford County Sheriff’s Department*
- THP/ TN Dept. of Safety*
- Federal Highway Administration (FHWA)*
- Metro Transit Authority (MTA)*
- Regional Transportation Authority (RTA)*
- TN. Dept. of Economic Development
- Rover – Murfreesboro Transit Agency*
- Transportation Management Association (TMA)*

*Note: Collaboration underway
Goals & Objectives

Goals
• Enhance safety along the corridor
• Optimizing existing travel capacity
• Manage demand across all modes
• Enhance the traveling public’s experience
• Convey accurate, timely travel information both on and off route

Objectives
• Reduce the number and severity of traffic incidents
• Reduce incident clearance times
• Improved reliability of travel times
• Increase the availability of real-time traffic information
• Increased transit ridership
The Initiative

• TDOT is forming partnerships with local authorities to implement the I-24 Smart Corridor Initiative, an Intelligent Transportation System (ITS) project that is targeted to improve the safety and reliability of travel.

• The initiative will focus on providing drivers accurate, real-time information and active traffic management in order to create a more efficient system without adding additional capacity.
Active Freeway Management

Description
A combination of congestion management techniques to dynamically manage traffic based on current and near-term expected conditions. Includes:
• Variable Speed Limits
• Temporary Shoulder Use
• Queue Warning
• Dynamic Merge Control

How will this help?
• Increased reliability
• Decreased crash rates
• Delays onset of congestion
• Provides tools for managing congestion

Implementation Examples
WSDOT’s Smarter Highways, MnDOT’s Smart Lanes

Target: Freeway
Work Required: ITS
Cost: ★★★★★
Ramp Metering

**Description**
The installation of traffic signals at freeway on-ramps to control vehicle flow onto the freeway

**How will this help?**
- Increased reliability
- Decreased crash rates
- Increased volume throughput and speed

**Implementation Examples**
More than 23 metropolitan areas in US utilize ramp meters

<table>
<thead>
<tr>
<th>Target: Freeway</th>
</tr>
</thead>
<tbody>
<tr>
<td>Work Required: Striping, Signing, Ramp Widening, and ITS</td>
</tr>
</tbody>
</table>

**Cost:** ⭐⭐⭐⭐⭐⭐
Bus On Shoulder

**Description**
Allows only transit vehicles to utilize the designated shoulder in specific conditions and driving regulations

**How will this help?**
- More reliable transit service
- Possible increase to transit ridership
- Could serve as hard shoulder running in future

**Implementation Examples**
Currently operating in California, Delaware, Florida, Georgia, Illinois, Maryland, Minnesota, New Jersey, Virginia, and Washington

**Target:** Transit and Freeway

**Work Required:** Paving, Striping, and Signing

**Cost:** ★★★★★★☆☆☆☆☆
Active Arterial Management

Description
Actively managing and operating traffic signals to improve mobility and safety along a corridor.

How will this help?
• Increased reliability
• Decreased crash rates
• Increased volume throughput and speed
• AAM supports freeway operation
  • Diversion strategies
  • Keeping local trips local

Implementation Examples
GDOT’s Regional Traffic Operations Program (RTOP)

Target: Arterial and Freeway
Work Required: ITS
Cost: ★★★★★★
Purpose: The technical advisory committee is an assembly of stakeholder technical staff whose purpose is to support the development, design, and deployment of the I-24 Smart Corridor Initiative. The requested support will take many forms but will specifically address the following processes:

- Proposed System Concept of Operations
- System Requirements
- High-Level Design Support
- System Verification & Deployment
- System Validation
Meetings: We will plan to hold both in person and Teleconference/Internet based meeting monthly, and as needed.

Stakeholders: Additional stakeholders will be added as they are identified during the development process.

Resolution of Support: A resolution of support document is under development and will be distributed to all stakeholders. We will look to have this document signed by the leadership of each stakeholder agency.

Committee Charter: A TAC Charter will be developed and shared with the membership
System Engineering Analysis

Lifecycle Processes
- Regional Architecture(s)
- Feasibility Study / Concept Exploration

Concept of Operations

Development Processes
- Implementation
- Development

Integration and Recomposition
- Software / Hardware Development
- Field Installation

Decomposition and Definition
- High-Level Design
- Detailed Design

System Validation Plan
- System Validation
- Subsystem Verification
- System Verification & Deployment

System Verification Plan
- System Acceptance
- Subsystem Acceptance

Unit / Device Test Plan
- Unit/Device Testing

System Verification Plan
- System Verification
- Subsystem Verification

Operations and Maintenance
- Changes and Upgrades

Retirement / Replacement