UNITED STATES
DEPARTMENT OF TRANSPORTATION

ITS ePrimer
Module 3: Application of ITS in Transportation Systems Management and Operations (TSMO)

ITS Professional Capacity Building Program
ITS Joint Program Office
U.S. Department of Transportation

United States Department of Transportation
Office of the Assistant Secretary for Research and Technology
Intelligent Transportation Systems Joint Program Office

INTELLIGENT TRANSPORTATION SYSTEMS
PROFESSIONAL CAPACITY BUILDING

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- 25 Years Experience
- BS and MS in Civil Engineering
- Senior Project Manager at Gannett Fleming

- ITS Systems Engineering & Design
- TSMO Program Planning
- TSMO Workforce Development
- Traffic Incident Management
- Traffic Operations Research

Learning Objectives

- Understand how ITS enables an organization to achieve its TSMO goals and objectives
- Understand the fundamental ITS building blocks that collectively provide real-time and historical information to help maximize existing transportation network capacity while maximizing safety
- Learn how organizations need to evolve their workforce to meet emerging needs
- Introduce several emerging issues and technologies related to ITS in TSMO

Module Overview

1. Introduction
2. Transportation Management Centers
3. Freeway Management
4. Arterial Management
5. Integrated Corridor Management
6. Other Applications and Modes
7. Emerging Technologies
8. Workforce Management and Development
9. Summary and Future Considerations

Introduction

Defining TSMO

"An integrated set of strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system."

- FHWA, "What is TSMO?" Website

Benefits

- Improved quality of life
- Smoother and more reliable traffic flow
- Improved safety
- Reduced congestion
- Less wasted fuel
- Cleaner air
- Increased economic vitality
- More efficient use of resources (facilities, funding)

Introduction

Fundamental Elements of ITS that enable TSMO

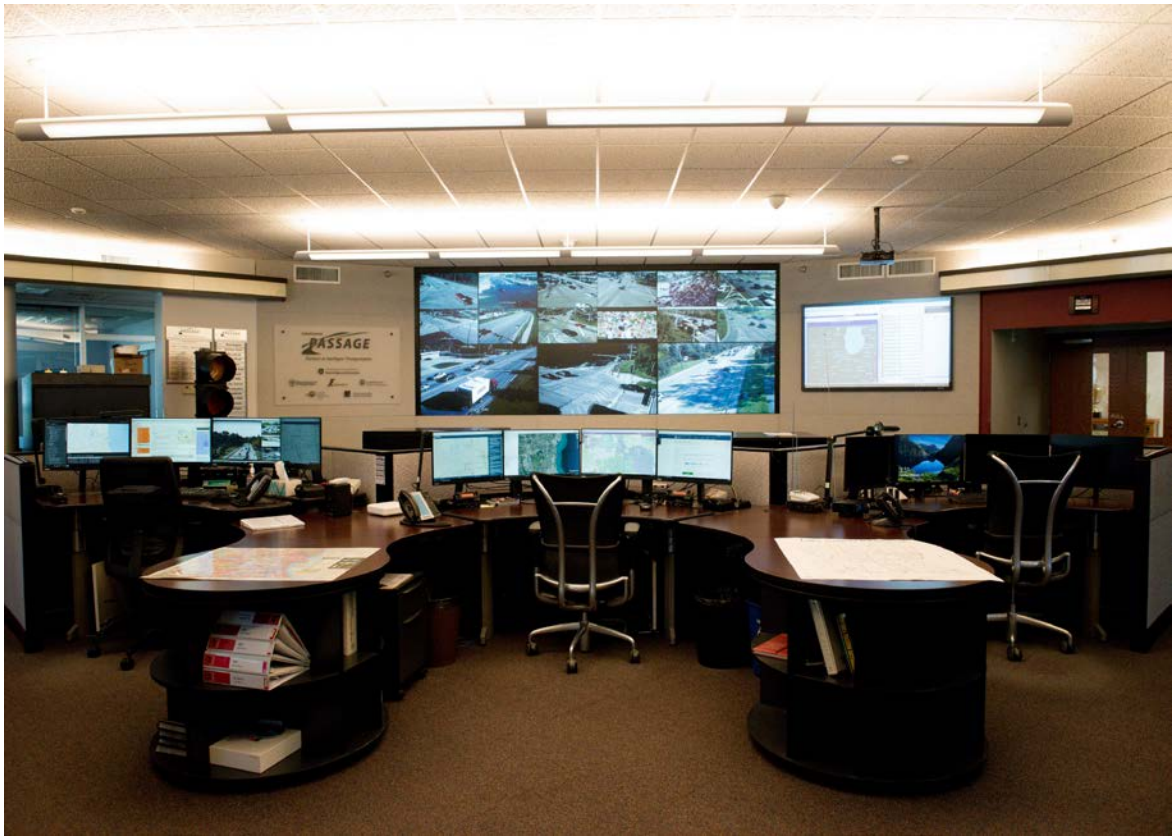
- Centers - Gather information from a variety of sources
- Field Devices – Equipment that provides data and supports command and control decisions
- Communications – Connectivity between the field and center
- Vehicles, Pedestrians, Bicycles, and other forms of Surface Transportation – Primary sources of data

Transportation Management Centers

Many Types of TMCs

- Functions – Freeway, Arterial, Transit, Maintenance, Tolling, Long-Term Work Zone, Special Events
- Geographic Coverage – Multistate, Statewide, Region, County, Municipality, Project
- Agencies – Single, Multiple, Different Disciplines
- Staff Types – Public, Private, Combination, Law Enforcement Liaisons

Transportation Management Centers



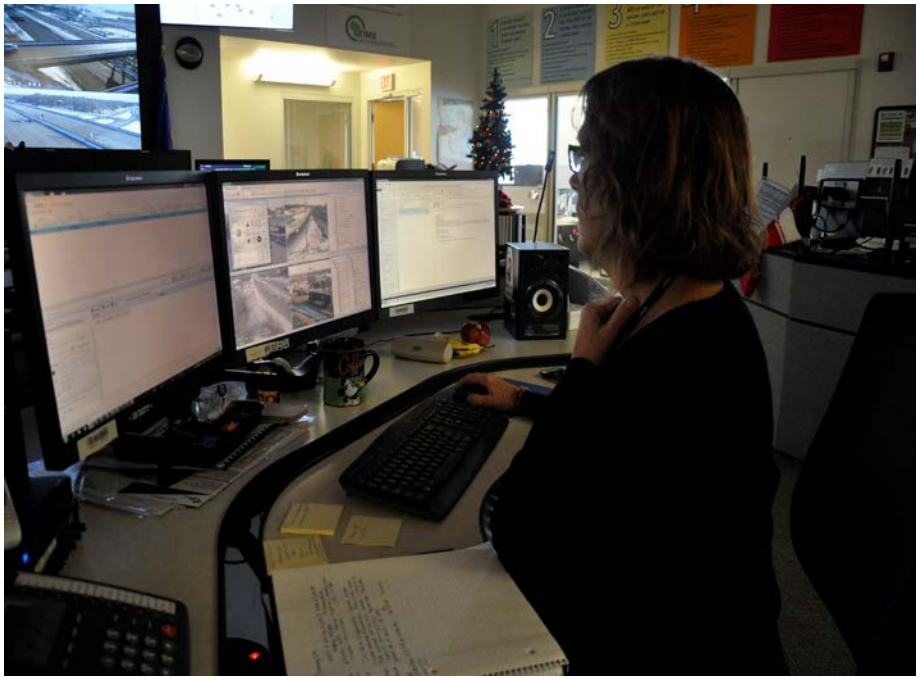
Transportation Management Centers

Transportation Management Centers

Transportation Management Centers

TMC Command and Control

- Control Room
- Workstations
- Server Room
- High-Visibility Displays
- Dedicated Staffing
- Partner Organization Coordination



Transportation Management Centers

TMC TELECOMMUNICATIONS

- Redundant TMC Telecommunications
- Redundant Field Telecommunications

SUPPORTING TMC FACILITY FEATURES

- Facility Resilience
- Long-Term Event Capabilities
- Areas for Collaboration
- Areas for Media

Transportation Management Centers

TYPICAL TMC TOOLS

- Freeway-Oriented Advanced Traffic Management System (ATMS)
- Arterial-oriented ATMS
- Advanced Traveler Information System (ATIS)
- Multi-modal / Integrated Corridor Management (ICM) Decision Support
- Work Zone/Special Event Management
- Emergency Management
- Dispatching
- Network (Telecom) Operations

Transportation Management Centers

CENTER TO FIELD NETWORK CONNECTIVITY

- Direct Wired
- Direct Leased Wired
- Licensed Wireless
- Unlicensed Wireless
- Cellular

CENTER TO CENTER CONNECTIVITY

- Other TMCs
- Transit Management/ Dispatch Centers Emergency Management Centers
- Public Service Answering Points
- Regional Data Archiving
- Public Health Systems

Transportation Management Centers

TYPICAL OPERATIONS EXAMPLES

- Planned Events
- Unplanned Events
- Traffic Signal Control
- Freeway Control
- Operational Technology Maintenance Coordination
- Communications with Partners
- Other Operations

TMC-ENABLED ANALYSIS & PERFORMANCE REPORTING

- Logs, Database Management, System Admin.
- Data, Voice, and Video Archiving
- Device Maintenance/Asset Management
- Safety Analysis
- Traffic Operations Studies
- Investment Evaluation

Freeway Management

URBAN & SUBURBAN AREA FOCUS

- Congestion management
- Quick clearance

RURAL AREA FOCUS

- Freight flow management
- Weather management
- Traffic incident management

Freeway Management

ACTIVE TRAFFIC MANAGEMENT

- Dynamic Lane Use
- Part-Time Shoulder Use
- Variable Speed Limits
- Queue Warning
- Adaptive Ramp Metering
- Speed Harmonization
- Dynamic Lane Merge

Freeway Management

ACTIVE TRAFFIC MANAGEMENT

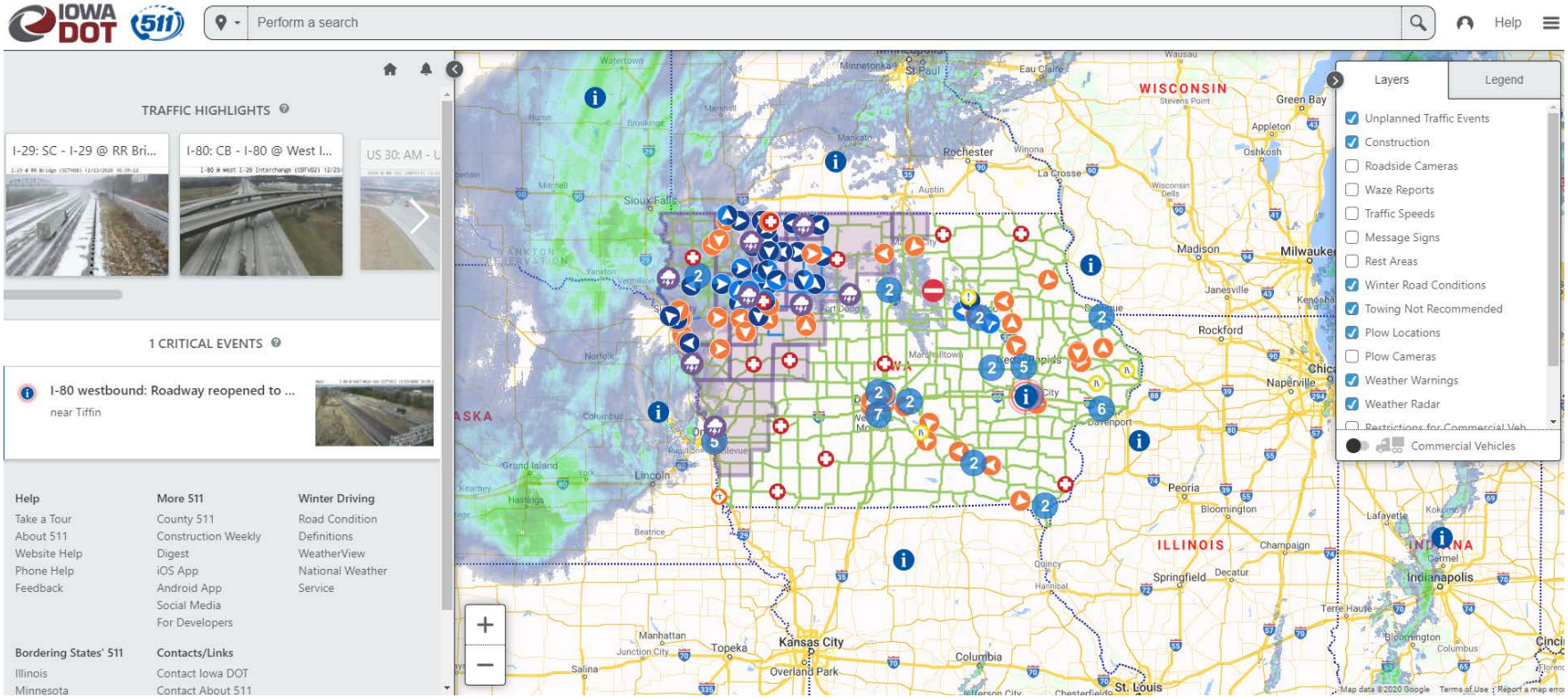
Freeway Management

TRAVELER INFORMATION

- Dynamic Message Signs
- Highway Advisory Radio
- 511 Phone
- 511 Web
- Kiosks
- Private Sector TI Providers Data Sharing

Freeway Management

TRAVELER INFORMATION



Freeway Management

TRAFFIC INCIDENT MANAGEMENT

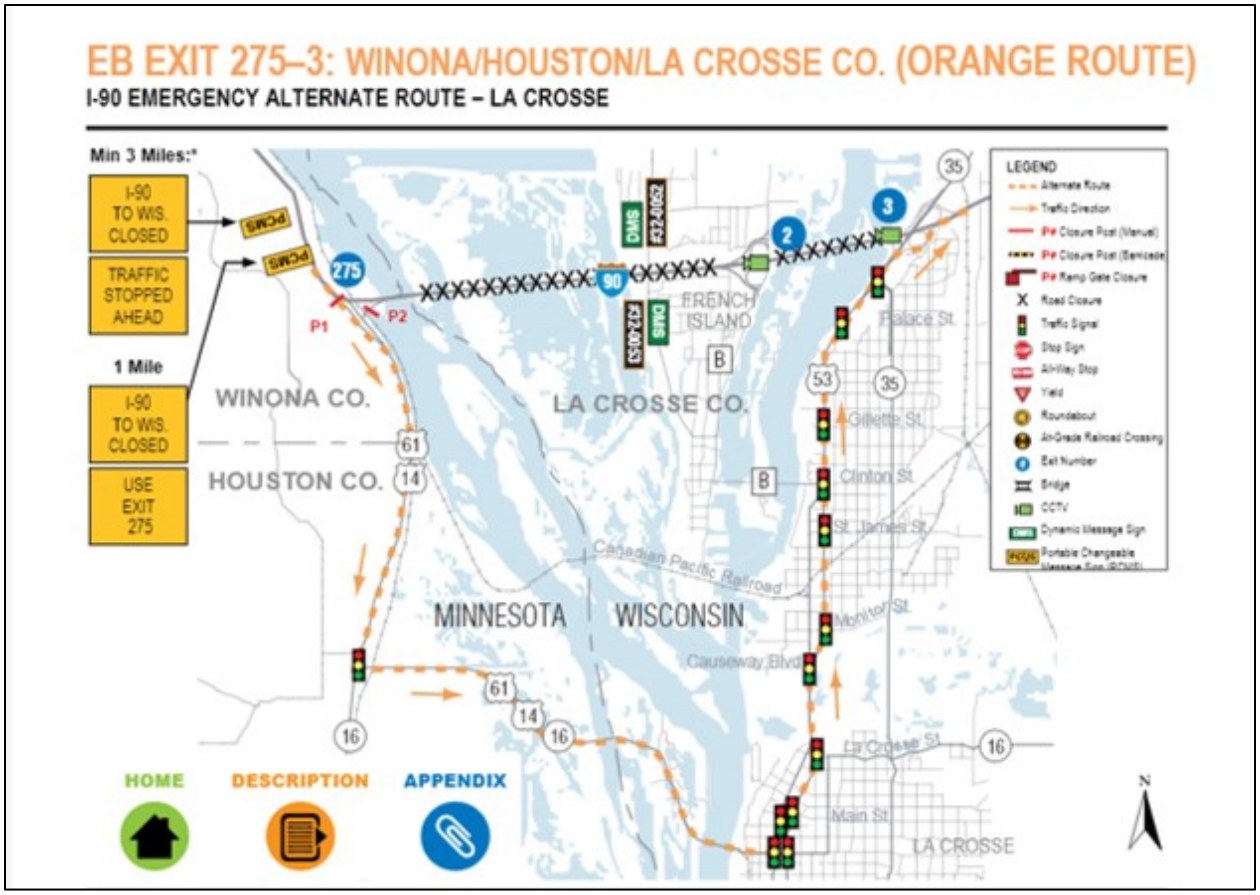
- Identify and verify incidents quickly
- Alert approaching motorists
- Coordination w/ Emergency Response Partners
- Dispatch Agency Resources
- Pre-Defined Detour/Alternate Routes

Freeway Management

TRAFFIC INCIDENT MANAGEMENT

Freeway Management

TRAFFIC INCIDENT MANAGEMENT



Freeway Management

WORK ZONE MANAGEMENT

- Supplemental Work Zone Monitoring
- Work Zone Travel Time Systems
- Dynamic Lane Merge Systems
- Trucks Entering/Exiting Systems
- Work Zone Intrusion Systems
- Smart Arrow Boards

Freeway Management

MANAGED LANES

- Value-Priced Lanes
- Toll Lanes
- High-Occupancy Vehicle (HOV) Lanes
- Truck Lane Restrictions
- Express Lanes
- Reversable Lanes
- High-Occupancy Toll (HOT) Lanes
- Busways
- Transit Lanes
- Truck Lanes

Freeway Management

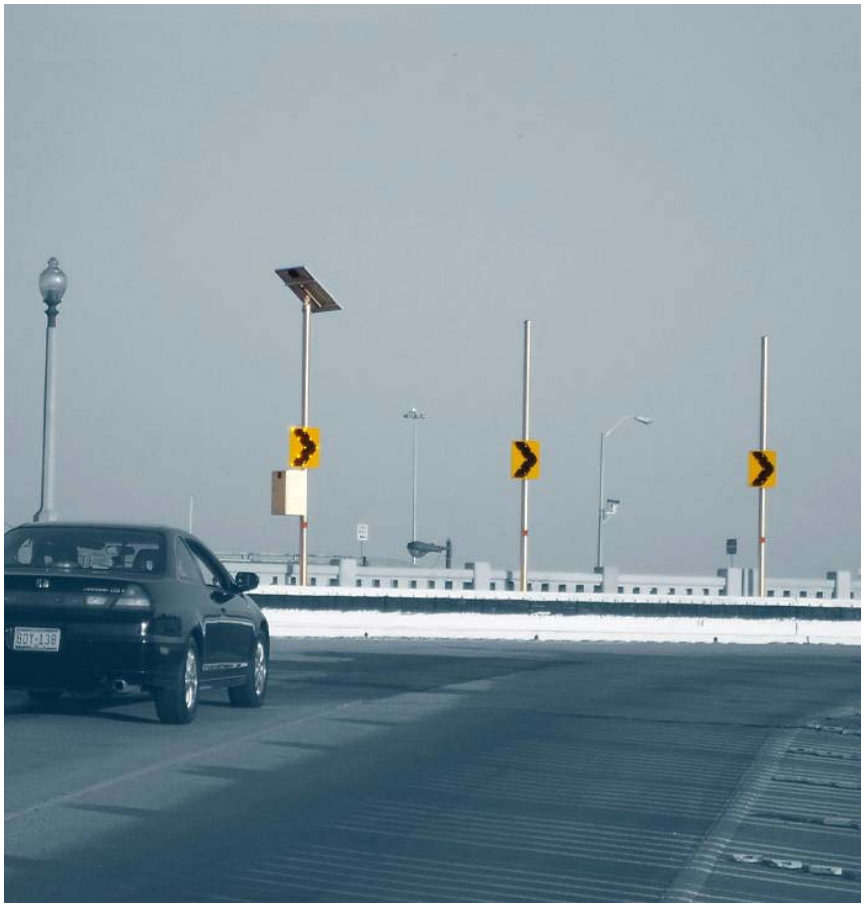
SAFETY SYSTEMS

- Wrong-Way Driving Systems
- Curve Warning Systems
- Over-height Warning Systems
- Virtual Weigh-in Motion Systems

WEATHER WARNING SYSTEMS

- Fog
- Dust
- High water
- High wind
- Visibility
- Ice/surface friction
- Smoke

Freeway Management



Arterial Management

- Systematic approach that focuses on improved traffic signal and related infrastructure:
  - Design
  - Operations
  - Maintenance practices
- Leads to increased safety, mobility and efficiency for all users

Arterial Management

Hierarchy of Traffic Signal Control Strategies

Category of System Operation	Level of Detection
Uncoordinated Signals	None
Time Base Coordination	None
Interconnected Control	None
Traffic Adjusted Control	Moderate
Traffic Responsive Control	High
Traffic Adaptive Control	High

Arterial Management

Many Types of Traffic Detection

Intrusive	Non-intrusive
• Induction loops • Magnetometer	• Infrared - Passive and Active • Video Image Processing • Thermal Imaging • Microwave - Doppler and Radar • Passive Acoustic Array • Pulsed and Active Ultrasonic

Arterial Management

Preemption and Priority

- *Priority control* - signal timing extended or slowed to allow vehicle to pass-through intersection
  - Predominantly Bus/LRT to improve schedule adherence
  - Applications expanding
    - Oversize/overweight freight
    - Plowing
- *Preemption* - all lanes stopped to allow emergency vehicle to pass-through intersection

Arterial Management

Automated Traffic Signal Performance Measures

- Approach delay
- Approach volume
- Arrivals on red
- Coordination diagram
- Purdue split failure
- Pedestrian delay
- Phase termination
- Preemption details
- Split failure
- Split monitor
- Turning movement counts

Arterial Management

Connected Vehicle Traffic Signal Applications

- Red light violation warning
- Pedestrian in signalized crosswalk warning
- Intelligent traffic signal system
- Signal priority for freight
- Mobile accessible pedestrian signal system

Arterial Management

Information and Guidance Systems

- Parking Information Systems
- Dynamic Trailblazer Signing Systems
- Special Event Reversible Lane Systems

Safety Management Systems

- Intersection Collision Avoidance Systems
- Pedestrian Safety
- Speed Awareness Systems

Arterial Management

Arterial Traffic Incident Management

- Similar to freeway application
- Less popular but interest growing

Signal System Maintenance/Asset Management

- Field equipment life-cycle history
- Dispatch scheduling and on-call notification planning
- Trouble ticketing
- Real-time equipment tracking and reporting
- Access to documentation

Integrated Corridor Management

Approach to improve transportation along a corridor that considers all elements, including highways, arterial roads, and transit systems.

GOALS

- Improving travel time
- Increasing corridor throughput
- Improving travel time reliability
- Improving incident management
- Enabling intermodal travel decision
- Improving safety for all travelers

Integrated Corridor Management

CASE STUDIES

Dallas ICM Project

- Decision-Support System
- Actionable Traveler Information
  - Interactive Voice Response (IVR) 511
  - Website
  - Email alerts
  - Comparable travel times
- Rerouting of Traffic
  - Coordinated timing and adaptive signal control
- Mode Shift
  - Parking management
  - Real-time service adjustments based on automated passenger counters

KEY FINDINGS

- ICM programs should build on existing institutional arrangements to build consensus
- ICM programs are successful when they benefit all agencies involved
- The easiest way for an ICM program to begin is through data sharing
- ICM must be in regional ITS plans so agencies are committed
- ICM improves collaboration among network partners
- A scaled down version of an ICM decision support system (DSS), when used by capable operators, can effectively manage the corridor

Integrated Corridor Management

CASE STUDIES

San Diego ICM Project

- Automated DSS
- Actionable traveler information
  - 511 (phone and website)
  - Comparable travel times
- Managed lanes
- Rerouting of traffic
  - Coordinated timing and responsive signal operations
  - Coordinated ramp metering and traffic signals
  - Wayfinding roadway signs for diversion routes
- Mode shift
  - Bus rapid transit
  - Transit signal priority
  - Real-time transit information

KEY FINDINGS

- ICM is a fundamental change in the traffic management paradigm that has offered a more detailed understanding of the corridor and its operations
- Interagency cooperation and coordination were a big success
- Operators reported better situational awareness of corridor conditions, although there were opportunities to improve
- DSS is valuable for better situational awareness, decision-making, and response
- Incident and congestion specific traveler information improved

Integrated Corridor Management

Attributes of a Successful Site

1. Institutional support
2. Willingness to change
3. Public engagement
4. Optimization of existing transportation systems
5. Readily available alternative transit options
6. Successful procurement practices
7. Centralized data hub
8. Multimodal capabilities
9. Infrastructure availability
10. Significant congestion and unreliable travel times

Other Applications and Modes

Active Parking Management

- Dynamic Overflow Transit Parking
- Dynamic Parking Reservation
- Dynamic Wayfinding
- Dynamically-Priced Parking
- Truck Parking Information Management Systems (TPIMS)

Other Applications and Modes

Other Applications and Modes

Active Transportation and Micromobility

- Micromobility - refers to several different modes of human and electric-powered transport that are low-speed (comparable to a bicycle), small, lightweight, and typically used for short distance trips

Examples

- Bikes
- Ebikes
- Electric scooters
- Electric skateboards
- Share bikes
- Electric pedal assisted (pedelec) bikes
- Other variations

Other Applications and Modes

Other Applications and Modes

Smart City/Smart Community Applications

- Smart Infrastructure
- Smart Environment
- Smart Public Safety
- Smart Government

Freight – covered in another module

Transit – covered in another module

Emerging Technologies

- Edge Computing Transportation Applications
  - Predictive traffic signal operations
  - Improved localized weather condition detection
  - Improved video analytics
- ATMS Hardware in the Loop/Near Real-Time Simulation
- Connected and automated vehicles

Emerging Technologies

Artificial Intelligence

AI Function	Transportation Uses
Clustering	Identifying specific classes of drivers based on driver behavior.
Control Functions	Signal control of traffic at road intersections, ramp metering on freeways, dynamic route guidance, and traffic flow harmonization.
Decision Making	Deciding whether to build a new road, how much money should be allocated to maintenance and rehabilitation activities and which road segments or bridges to maintain, and whether to divert traffic to an alternative route during a traffic incident.
Deep Learning	Video detection analytics and short-term traffic prediction.
Nonlinear Prediction	Traffic demand modeling; modeling the transportation infrastructure health as a function of traffic, construction, and weathering.
Pattern Recognition	Automatic incident detection, image processing for traffic data collection.
Planning	Support simulation and activity-based models.

Emerging Technologies

Unmanned Aerial System (UAS) Applications for TSMO

- Accelerated crash investigation - photogrammetry and mapping
- Improved real-time situational awareness
  - High-definition video and photography
  - Sensors-traffic, heat, motion, electronic signals, etc.
  - Relay to TMC and others
  - Safety service patrol tethered monitoring for queue and alternate route monitoring
- Guided mobile data collection

Workforce Management and Development

To meet existing and future needs

- **Need to evolve existing positions**
- **Rethink types of positions transportation agencies hire**

- A TSMO Workforce Development Guidebook was published as part of an NCHRP project in 2019 to look at the types of positions transportation agencies need to start considering

Workforce Management and Development

Professional Position

Traffic Data Scientist/Statistician	Cyber Security Engineer
TSMO Manager/Chief/Bureau Director	Transportation Data Ethicist
TSMO Program Manager	Surface Weather Specialist
Computer Engineer	Systems Engineer
Artificial Intelligence Scientist	TSMO Modeling Specialist
Telecommunications Engineer	Emerging Technologies Industry Liaison
Data Management Specialist	Trans. Systems Performance Manager
Visualization Specialist	Integrated Corridor Management Manager
Connected and Automated Vehicles (CAV) Program Manager	Transportation Management Center Manager
Traffic Incident Management (TIM) Program Manager	

Workforce Management and Development

Paraprofessional Positions

- TMC Operators
- TMC Operations Supervisors (non-degreed)
- Safety Service Patrol Staff
- ITS Maintenance Staff
- Roadway Maintenance Staff
- Major Roadway Traffic Incident Support Staff

Future Considerations

- Alternative business models to maintain the latest technology
- Continued compression of agency staffing and need for new partnerships
- New ways to plan, fund, and program ITS to support TSMO strategies
- Expanding use of ITS to leverage its data to generate critical output metrics for TSMO performance management
- Developing novel approaches to making the business case for ITS

Future Considerations

- Impacts of connected vehicle technologies which will drive more vehicle-to-infrastructure interactions
- New modes of transit and improvements to existing service including rapid growth of transit hubs with seamless transfer between modes
- Innovations in micromobility and last-mile connections
- AI-augmented mobility applications
- Increased demand for robust cyber security
- TSMO's growing role in freight management and operations

Summary

- ITS plays a significant role in enabling and maturing TSMO throughout transportation organizations
- ITS helps to provide better network performance through a variety of strategies
- While module focus was primarily on ITS - important to recognize the people, planning, policies, procedures, and collaboration required to gain maximum benefit
- With rapid and accelerating technology, critical transportation organizations evolve existing positions and create new ones to meet needs

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Questions

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