TxDOT Statewide TSMO Standard Operating Procedures

February 2021

Version 1.1

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DOCUMENT CONTROL		
Date	Version	Description
8-26-2020	1.0	Traffic Operations Safety Division Review (Prepared by ATG, Reviewed By AECOM)
2-15-2021	1.1	Addresses internal AECOM comments.

List of Acronyms

Acronym	Definition
ACS	Adaptive Control Strategies
AID	Automated Incident Detection
AMS	Asset Management System
ATC	Advanced Traffic Controllers
ATIS	Advanced Traveler Information Systems
ATM	Active Traffic Management
ATMS	Active Traffic Management System
ATSPM	Automated Traffic Signal Performance Measures
AVL	Automated Vehicle Location
CCTV	Closed Circuit Television
DMS	Dynamic Message Sign
DSRC	Dedicated Short Range Communications
DSS	Decision Support System
EOC	Emergency Operations Center
FAST Act	Fixing America's Surface Transportation Act
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration
HERO	Highway Emergency Response Operator
HSR	Hard Shoulder Running
ICM	Integrated Corridor Management
ITS	Intelligent Transportation System
LRTP	Long-Range Transportation Plan
MAP-21	Moving Ahead for Progress in the 21st Century Act
MOD	Mobility on Demand
MOT	Maintenance of Traffic
MOU	Memorandum of Understanding
MPO	Metropolitan Planning Organization
MTBF	Mean-Time Between Failure
O&M	Operations and Maintenance
RIMS	Regional Incident Management System
SOP	Standard Operating Procedures
SPaT	Signal Phasing and Timing
TAMP	Transportation Asset Management Plan
TIM	Traffic Incident Management
TIP	Transportation Improvement Program
TMC	Traffic Management Center
TRF	Traffic Safety Division
TSMO	Transportation Systems Management and Operations
TxDOT	Texas Department of Transportation

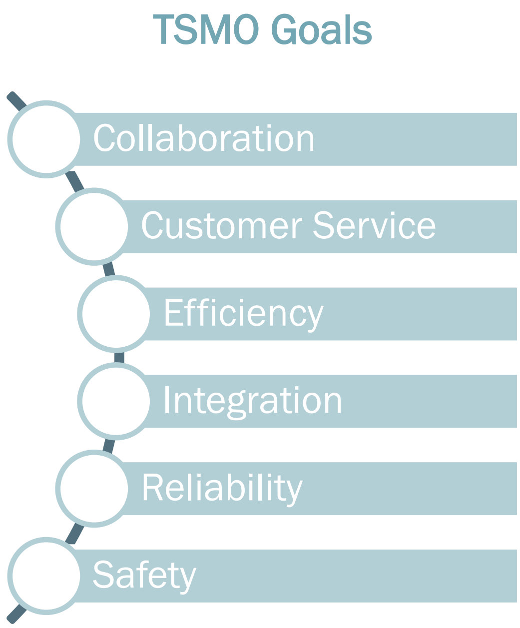
1. Introduction

Ever increasing congestion, limited funding and the increasing role technology plays in our lives has now more than ever highlighted the need for transportation agencies to prioritize operations and management. For this reason, transportation system operations and management (TSMO) is emerging as a separate industry discipline. TSMO represents a philosophical shift in how transportation agencies approach the management of their transportation systems. Simply put, TSMO:

- Requires a shift in how we approach the management of our transportation systems to optimize existing infrastructure and focus on the end user.
- TSMO encourages all stakeholders to consider operations throughout the project development process and prioritize the quality of life of the road user including safety and maintenance of a facility.
- Involves a collaborative effort through multiple agencies and regional partnerships to ensure that mobility and efficiency is upheld throughout the project life cycle.
- Includes strategies that focus on operational improvements and address both recurring and non-recurring congestion to improve system reliability, while still preserving capacity when possible.
- Prioritizes the quality of life of the road user along with safety and maintenance of the overall system.
- Advocates for funding for mobility strategies through cost-saving coordination.

There is significant focus on the issue of traffic safety and congestion at the national level. At the state level, here in Texas, there is a commitment by Texas leadership, the Transportation Commission and TxDOT to address these issues. As such, TxDOT has defined the following as the **TSMO Vision and Mission** statements:

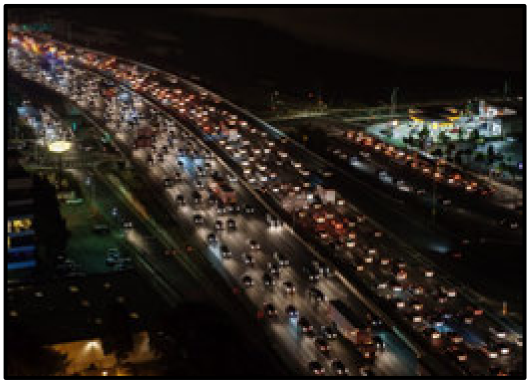
- **TSMO Vision Statement:** Improve Safety and Mobility for All Modes of Transportation by Integrating Planning, Design, Operations, Construction, and Maintenance Activities and Acknowledging All Opportunities for Innovation
- **TSMO Mission Statement:** Through Innovation, Collaboration, and Performance-Based Decision Making, Transportation Facilities are Developed, Constructed, Maintained, and Operated Cost-Effectively, with the End User in Mind



This shift in focus comes from a growing understanding of the extensive impacts on traffic that result from incidents, reconstruction, weather conditions, emerging technologies (such as connected and autonomous vehicles), and greater access to and use of real-time information. Managing and operating the transportation system now needs to move beyond implementing specific ad hoc projects to become a structured core function of a transportation agency as well as a sustained part of its mission.

NEED

Building the necessary infrastructure and maintaining it have historically been the core attributes of the TxDOT planning process, while operating and managing the infrastructure has historically been left out of the planning process. Operation strategies and the supporting ITS technologies should therefore become a formal core program with the same emphasis in the planning and programming processes.



Between the years of 2017 and 2018, Texas' population added 380,000 new people and over that same period, vehicle miles traveled by Texans grew by 3.31% which equals to over 282 billion miles. According to the *FHWA Traffic Congestion and Fatality Report,* the growing travel delay per year totals 8.8 Billion Hours and has resulted in 54 Hours Lost per Commuter per Year. The cost of gridlock has totaled $166 Billion per Year. This growing traffic demand will require growing budgetary needs and the use of innovation applying TSMO strategies that meet the growing needs of Texas.

The Long-Range Transportation Plan (LRTP) developed by MPOs, should guide the selection of projects that are funded in the Transportation Improvement Program (TIP). As such, regions that place importance on TSMO in the LRTP have a strong basis for assigning funding to these strategies. The process of developing agreement on regional goals and objectives that includes system operations can help to support dedication of funding to TSMO strategies or development of project prioritization processes in programming that enable TSMO strategies to effectively compete for funding. In other words, operations should be mainstreamed into the regional transportation planning process.

PURPOSE

The purpose of creating the Standard Operating Procedures (SOP), detailed in the following pages, is to introduce TSMO strategies to be considered during the early phases of project development and preliminary engineering. These SOPs address the following TSMO strategies: Active Traffic Management, Emergency Management, Equipment Failure Management, Incident Management, Integrated Corridor Management, and Special Event Management. They will support data-driven decisions and further the integration and prioritization of mobility strategies with existing efforts. Each SOP includes:

- A **definition** of the TSMO strategy which aligns with TxDOT's TSMO Vision and Mission.
- A description of the different **components** of each TSMO strategy including how they can be used to improve safety and mobility.
- **Benefits** of the TSMO strategy and how it aligns with TxDOT's Mission & Values.
- Unit **Cost Estimates** for Implementation, Operations, and Maintenance.
- Identification of **Planning and Institutional issues** that should be considered in developing the strategy.
- Identification of **Design and Construction issues** that should be considered in implementing the strategy.
- Identification of **Operation and Maintenance issues** that should be considered once the strategy is deployed.

TSMO can be the innovative tool that can benefit all road users and can produce a benefit to all who invest in the program. Typically, TSMO strategies cost less and can be implemented faster than new construction. The following SOPs can be used to help guide each TxDOT district in choosing a TSMO strategy that best fits their needs.

2. Standard Operating Procedure - Active Traffic Management

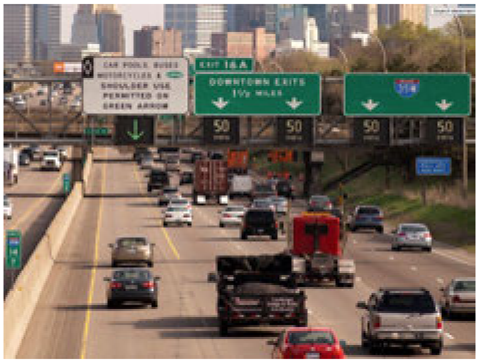
What is ATM?

Active traffic management (ATM) is the ability to dynamically manage recurrent and non-recurrent congestion based on prevailing and predicted traffic conditions. Focusing on trip reliability, it maximizes the effectiveness and efficiency of the facility. It increases throughput and safety through the use of integrated systems with new technology, including the automation of dynamic deployment to optimize performance quickly and without delay that occurs when operators must deploy operational strategies manually. ATM focuses on influencing travel behavior with respect to lane/facility choices and operations.

What are the components of an ATM system?

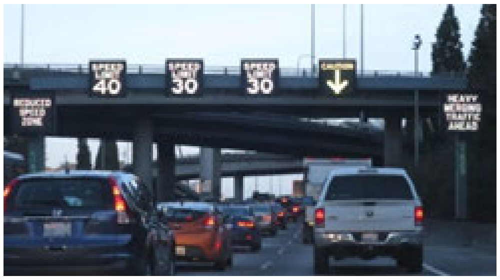
ATM strategies can be deployed singularly to address a specific need or can be combined to meet system-wide needs resulting in synergistic performance gains. The following ATM strategies should be considered as part of implementing District TSMO Program Plans, as applicable. While there are other ATM strategies identified by FHWA, the following three do not appear viable for deployment within Texas at this time: Dynamic Speed Limits, Dynamic Merge Control and Dynamic Junction Control.

Dynamic Shoulder Lanes: This strategy enables the use of the shoulder as a travel lane(s), known as Hard Shoulder Running (HSR) or temporary shoulder use, based on congestion levels during peak periods and in response to incidents or other conditions as warranted during non-peak periods. In contrast to a static time-of-day schedule for using a shoulder lane, an ATM approach continuously monitors conditions and uses real-time and anticipated congestion levels to determine the need for using a shoulder lane as a regular or special purpose travel lane. This ATM strategy would not operate 24/7.

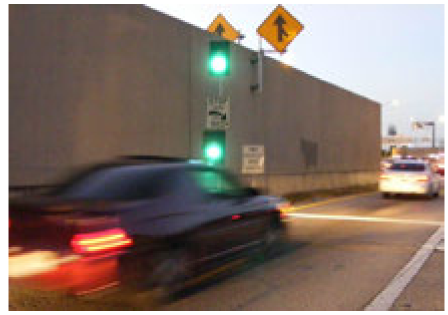


Dynamic Lane Use Control: This strategy involves dynamically closing or opening of individual traffic lanes as warranted and providing advance warning of the closure(s) (through Lane-Use Control Signals), in order to safely merge traffic into adjoining lanes. As the network is continuously monitored, real-time incident and congestion data is used to control the lane use ahead of the lane closure(s) and dynamically manage the location to reduce rear-end and other secondary crashes.

Queue Warning: This strategy involves real-time displays of warning messages (typically on dynamic message signs and possibly coupled with flashing lights) along a roadway to alert motorists that queues or significant slowdowns are ahead, thus reducing rear-end crashes and improving safety. In an ATM approach, as the traffic conditions are monitored continuously, the warning messages are dynamic based on the location and severity of the queues and slowdowns.



Adaptive Ramp Metering: This strategy consists of deploying traffic signal(s) on ramps to dynamically control the rate vehicles enter a freeway facility. This smooths the flow of traffic onto the mainline, allowing efficient use of existing freeway capacity. Adaptive ramp metering utilizes traffic responsive or adaptive algorithms (as opposed to pre-timed or fixed time rates) that can optimize either local or system-wide conditions. Adaptive ramp metering can also utilize advanced metering technologies such as dynamic bottleneck identification, automated incident detection and integration with adjacent arterial traffic signal operations. In an ATM approach, real-time and anticipated traffic volumes on the freeway facility will be used to control the rate of vehicles entering the freeway facility. Based on the conditions, the ramp meter rates will be adjusted dynamically.



Dynamic Lane Reversal or Contraflow Lane Reversal: This strategy consists of the reversal of lanes in order to dynamically allocate the capacity of congested roads, thereby allowing capacity to better match traffic demand throughout the day. In an ATM approach, based on the real-time traffic conditions, the lane directionality is updated automatically in response to or in advance of anticipated traffic conditions. Contraflow Lane Reversal may be used as part of an emergency evacuation operation.

Adaptive Traffic Signal Control: This strategy continuously monitors arterial traffic conditions and the queuing at intersections and dynamically adjusts the signal timing to optimize one or more operational objectives (such as minimize overall delays). Adaptive Traffic Signal Control approaches typically monitor traffic flows upstream of signalized locations or segments with traffic signals, anticipating volumes and flow rates in advance of reaching the first signal, then continuously adjusting timing parameters (e.g., phase length, offset, cycle length) during each cycle to optimize operational objectives.

Transit Signal Priority: This strategy manages traffic signals by using sensors to detect when a bus nears a signal-controlled intersection, turning the traffic signals to green sooner or extending the green phase, thereby allowing the bus to pass through more quickly. In an ATM approach, current and predicted traffic congestion, multi-agency bus schedule adherence information, and number of passengers affected, may all be considered to determine conditionally if, where, and when transit signal priority may be applied.

Active Arterial Management focuses on the implementation of strategies to proactively monitor and manage arterial roadways. It is a performance-based program with the primary goal of improving travel time and travel time reliability on arterial roadways while moving vehicles and pedestrians as safely, efficiently, and quickly as possible. Operations staff monitor arterial performance in real-time, detect problem areas and make signal timing adjustments “on the fly” at a local, corridor and network scale.

What are the benefits of an ATM system?

ATM Component	Increase People Throughput	Reduce Primary Crashes	Reduce Secondary Crashes	Improve Trip Reliability	Delay Freeway Breakdown	Reduce Air Emissions	Reduce Fuel Consumption
Dynamic Shoulder Lanes	x			x	x	x	x
Dynamic Lane Use Control	x	x	x	x	x	x	x
Queue Warning		x	x				
Adaptive Ramp Metering	x	x	x	x	x	x	x
Dynamic Lane Reversal/Contraflow	x			x	x	x	x
Adaptive Traffic Signal Control	x	x		x		x	x
Transit Signal Priority				x		x	x
Active Arterial Management	x	x		x		x	x

How much does an ATM system cost?

Note: Cost figures below are for planning purposes based upon recent TxDOT and municipal project cost estimates and informal quotes from sample vendors.

Dynamic Shoulder Lanes - *$2.5 million/mile (initial) and $62,000 annual O&M costs*

Dynamic Lane Use Control - *$600,000/mile (initial) and $10,000 annual O&M costs*

Queue Warning - *$40,000/site (initial) and $3,000 annual O&M costs*

Adaptive Ramp Metering - *$150,000/interchange (initial) and $5,000 annual O&M costs*

Dynamic Lane Reversal and Contraflow Reversal- *$3 million/mile (initial) and $75,000 annual O&M costs*

Adaptive Traffic Signal Control - *$35,000/signal (initial) and $3,000 O&M costs*

Transit Signal Priority - *$33,000/signal (initial) and $2,000 annual O&M costs*

Active Arterial Management - *$35,000/signal (initial) and $2,500 O&M costs*

What Planning and Institutional issues should be considered in developing an ATM System?

Coordinate with State Highway Patrol to address enforcement and develop appropriate MOU.

Develop the ATM program in accordance with the Systems Engineering Process.

Develop an ATM Concept of Operations to be approved by TRF.

Conduct an ATM outreach program to educate motorists, truckers, media and political leaders.

Coordinate with MPOs to include ATM in their planning, programming and funding.

Select an initial operating segment to deploy ATM as a pilot project.

Define appropriate performance measures (e.g., trip reliability, crashes) and collect base data.

Allocate appropriate operations and maintenance funding to support the ATM program.

What issues should be considered in Designing and Constructing an ATM System?

Develop ATM design standards and typical sections for each ATM strategy.

Assess trade-offs in using a slim gantry (lower costs, aesthetics) vs. a gantry with catwalk (less MOT needed).

Design of Emergency Refuge Areas along “dynamic shoulder lanes” lanes.
Coordinate with existing and planned roadway, ITS and managed lanes improvement projects.
Develop a formalized process to consider design exceptions for ATM components.
Define typical placement of ATM field equipment (e.g., cabinets) and provide crash protection.
Conduct pavement analysis for existing shoulders to accommodate “dynamic shoulder lanes”.
Assess and resolve conflicts between ATM, ITS and existing signing systems.
Address design issues in deploying “dynamic shoulder lanes” lanes through interchanges.
Consider offsite locations to pre-assemble gantries and other ATM components.
What issues should be considered in Operating and Maintaining an ATM System?
Overall hours of operation for each ATM strategy or grouping of ATM strategies.
Update TMC SOPs to reflect the ATM strategies to be deployed.
Update Traffic Incident Management procedures to include ATM strategies.
Reconfigure TMC video wall and workstations to accommodate ATM strategies.
Define knowledge, skills and abilities for TMC staff to be assigned to operate the ATM program.
Train TMC operations and maintenance staff to manage the ATM program.
Incorporate the ATM devices into the Asset Maintenance Management System.
Acquire or develop Lonestar™ ATMS software modules to accommodate operations of ATM devices.
Develop transition procedures for activating and deactivating the ATM program components.
Define interface of ATM with other operational systems (e.g., ITS, managed lanes).
Test new messages to be used on dynamic message signs before operational start-up.

3. Standard Operating Procedure - Emergency Management

What is Emergency Management?

Emergency Management is the process of planning and implementing responses to major emergencies. This includes preparing for a response, managing the response, mitigating the effects of the emergency, and recovering from the emergency. Emergencies include man-made or natural extreme weather events that lead to loss of life, personal injury, or extensive property damage. Emergency Management involves five components: Policy, Planning, Coordination, and Equipment & Maintenance.

Effective Emergency Management can save many lives during a time of crisis. It is paramount that agencies allocate resources appropriately to save as many people as possible, salvage critical infrastructure, and reduce property damage as much as possible. Effective Emergency Management can also increase the safety of the transportation system and increase its reliability. Emergency Management strategies can reduce primary and secondary crashes by helping travelers avoid areas where an emergency situation has arisen or avoid traveling completely during the emergency.

What are the components of Emergency Management?

Policy, Planning and Coordination Strategies: Coordination between federal, state and regional transportation agencies and public-safety agencies is needed to define the roles between each agency during a time of crisis. Agencies can prepare for a response for any type of emergency by using best practices and by specifying standard operating procedures and best practices. These procedures can then be practiced by the emergency responders of each agency through drills related to specified emergency scenarios. Agencies can also participate in trainings from the FEMA Emergency Management Institute.

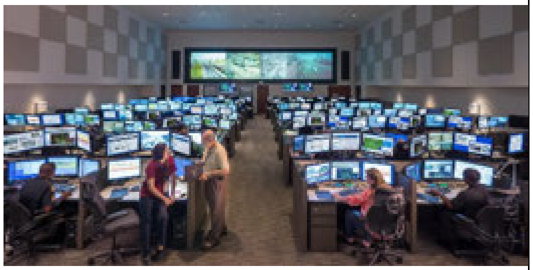
Fema.gov

The public can also be involved in drills and be warned of what each citizen's responsibilities are during an emergency, especially in areas where specific emergencies are likely to occur (e.g. hurricanes in coastal regions, locations where tornados are common, floods in or near flood plains, ice-prone areas, or cities on active seismic fault lines).

Emergency Operations Center: Emergency Operations Centers (EOC) deployed throughout a state can allow for regional response to a local emergency or can have a statewide response to an emergency that affects multiple regions of the state. EOCs can bring together key personnel from necessary agencies allowing for quick coordination and diverse expertise in close proximity to act swiftly and effectively, dispatching necessary resources and directing the public of next steps.

FHWA.gov

Traffic Management Center (TMC): This component works as a central dispatch. The TMC operates as a collection point for information coming from field devices and as a central coordination point for dispatching emergency-response personnel and vehicles to the scene of an emergency and passing information to decision makers at Emergency Operations Centers. TMC staff can quickly verify incidents flagged by the detection systems and can identify incidents not flagged by the system. TMC staff can route emergency-response vehicles and personnel and monitor the status of the response. The TMC staff can also determine if any ramp or road closures are needed and can alert the public through several forms of media (e.g. local news/radio, social media, dynamic message signage, and traveler information systems). The TMC can help manage post emergency activities, such as roadway debris removal, dispatch for equipment repair, and return of any evacuees. A TMC can be a large center with numerous staff or as small as a single workstation as long as the workstation operator can monitor traffic conditions and coordinate with field response staff and other agency staff. TMCs can be co-located with or adjacent to Emergency Operations Centers.

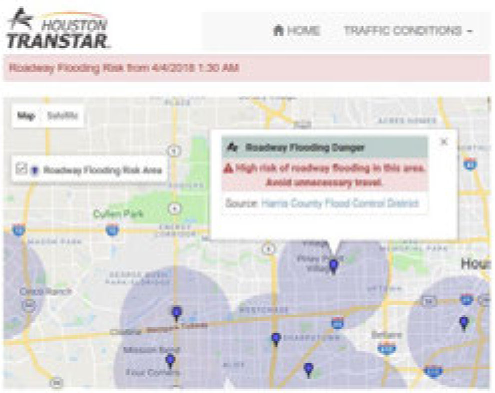


texite.org

Central Traffic Signal Management Software: Central Traffic Signal Management software allows the operators of a TMC to give priority to specific approaches or corridors. Operations staff can use the software to view and change traffic signal timings along parallel corridor routes to manage increased traffic due to diversions. Signal timings at intersections immediately downstream of freeway off-ramps can be adjusted to reduce spillback onto freeway traffic lanes. This can reduce traffic incidents.

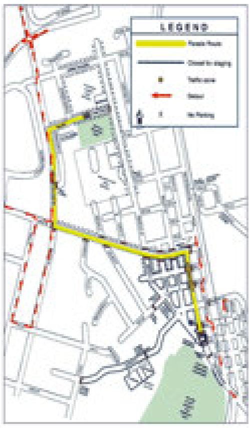
FHWA.gov

Regional Incident Management System (RIMS): This is a software system shared across agencies to collect and distribute information in realtime and coordinate emergency response. A RIMS can assign operator responsibilities, manage manpower and equipment resources. Emergency evacuation shelter and medical facility information, including capacity and available services, is stored for use by the appropriate agencies and can be updated in real time. Tasks and resources can be assigned, scheduled, and tracked. The software should be web based and integrated across multiple districts and agencies so functions and information are distributed to the appropriate operator in real-time.



houstontranstar.org

Pre-programmed Emergency Management Response Plans: Many emergencies occur in areas prone to certain types of events and incidents. Coastal areas are subject to tropical storms and hurricanes. Areas in or near floodplains are subject to flooding. Some regions are prone to high wind events or tornados. Certain areas are more prone to winter weather events and ice. Locations on fault lines are prone to earthquakes. These emergencies can be planned for in advance. Transportation agencies and emergency responders should develop management plans for events. These plans should include arterial and freeway detours, lane or street closure plans, special traffic signal timing, staging of emergency response resources, special transit routes and services, and hazardous area evacuation plans.



ops.fhwa.dot.gov

Traveler Information Systems: This component can inform drivers of an emergency situation before they start a trip or are near the event. Smartphones and smart devices are key tools that have become more accessible to the general public. Providing information to the public while they are still planning their trips will allow for greater reliability and can reduce congestion and improve the safety of travelers near the event. Data can be shared with regional 511 systems, social media, and third-party navigation systems like Waze.

Marketwatch.com

When a TMC is in place, operations staff can route emergency-response personnel and equipment to the emergency as quickly as possible. The TMC staff can also determine if any ramp or road closures are needed and can alert the public through several forms of media (e.g. local news/ radio, social media).

Highway Advisory Radio: This component can inform drivers on the road near an emergency. While smartphones and smart devices are key tools used to deliver information to the public, in an extreme weather event, cellular service may be interrupted, and radio information systems can be a hardened, resilient communications tool.

FHWA.gov

Road Weather Information Systems: This component measures atmospheric, pavement, and weather conditions and transmits the data to a central location. This information can be shared with road users through dynamic message signs and other traveler information systems.

Road and weather conditions can alert emergency-response personnel where there has been excessive rain, wind or ice and can allow them to stage emergency-response vehicles to locations where they expect crashes or other safety incidents.

FHWA.gov

Flood Gauges: If water levels rise too high on the road electronic flood gauges can quickly notify emergency-response personnel to set up barricades and warning signs at low-water crossings. Flood gauges can also be equipped with message signs that advise road users how high the water is and warn drivers if the road is impassable. Gauge readings can be shared online and through interactive maps or local news media can inform drivers which roads to avoid.

DriveTexas™ TxDOT Highway Conditions

DriveTexas.org

Stationary Dynamic Message Signs: Stationary Dynamic Message Signs alert the public of future or ongoing events on or near a route. Alerting the public of an emergency event can increase the public awareness of the ongoing or impending emergency. Warning drivers to stay off the roads or plan for an evacuation will allow for emergency-response resources to be used only when necessary.

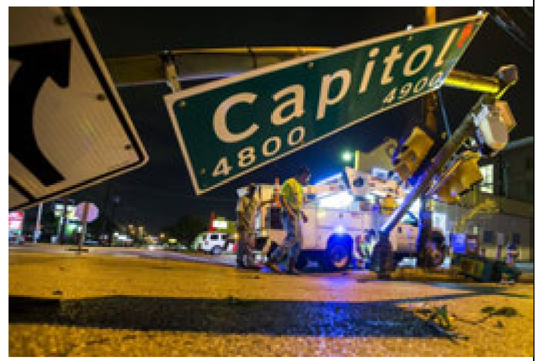
FHWA.gov

In the case of an evacuation, dynamic message signs can direct drivers to fuel up before leaving the impacted area, direct drivers in a specific direction based on evacuation routes, or to return to their homes if the driver misses the evacuation window. Dynamic message signs can also alert drivers of any road closures in the area or warn drivers planning or about to travel through an affected area to seek alternate routes.

Portable Dynamic Message Sign: Portable Dynamic Message signs serve a similar function to Stationary dynamic message signs. A portable sign may be chosen instead of a stationary sign due to their lower cost and their flexibility to be relocated quickly.

Highriveronline.com

Maintenance and Design Element Management: The purpose of Maintenance and Design Element Management, as it relates to Emergence Management, is to take the steps necessary to ensure that the vehicle, equipment and facilities needed for Emergency Management are designed to operate under extreme conditions and operate at a high level of performance and relibility. In areas known to be prone to certain types of natural distasters, design standards for transportation and ITS equipment should be in place to ensure that equipment can accomodate high winds, icing, heavy rain, flooding, and high and low temperature extremes. Maintenance and Design Element Management should include review of placement and elevation of electronic equipment in flood-prone areas. Pavement management and asset management systems should incorporate data fields to monitor vunerabilities due to weather extremes. Maintenance cycles and standards should also be evaluated in disaster prone areas.



Dallasnews.com

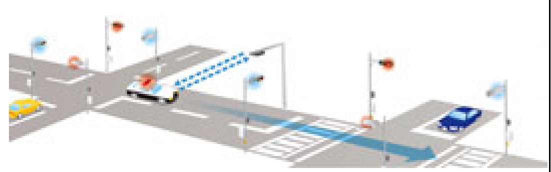
Emergency Response: This component involves the use of dedicated personnel and vehicles to clear roadways of disabled vehicles and other obstructions. Emergency-response personnel can be dedicated law enforcement officials or dedicated maintenance crews.

Txdot.gov

During an evacuation, some vehicles stall or run out of fuel due to lack of maintenance or forgetting to fuel up before the evacuation. This can delay the evacuation and increase the likelihood of drivers that evacuated later not being able to leave the affected area. A quick response to remove the vehicle from the road or quickly refuel it will greatly increase the throughput of the roadway.

Emergency response will also be required to close down any high-risk roads and bridges during a disaster. Closing roads that are deemed high risk (e.g. low water crossings, bridge failures, near the emergency) will free up personnel and vehicles to respond to the emergency and attend to those that have already been affected.

Emergency Vehicle Preemption: Emergency Vehicle Preemption provides traffic signal priority for emergency vehicles and can reduce the response time for an emergency situation. Response time is a key factor in increasing the probability of survival if there is a severe injury as part of the emergency. It also reduces the probability of secondary crashes due to speed differential and the standing queue of vehilces caused by blocked lanes.



Global-sei.com

What are the benefits of an Emergency Management system?

Emergency Management Component	Improve Coordination Between Transportation Agencies and First Responders	Improve Emergency Response Time	Security & Crowd Management	Improve Evacuation from Hazardous Area	Facilitate Delivery of Information to Decision Makers	Inform Travelors about Emergency information
Policy Planning & Coordination	x	x	x	x	x	x
Emergency Operations Center	x	x	x	x	x	x
Traffic Management Center	x	x		x	x	x
Central Traffic Signal Management Software		x		x		
Regional Incident Management System	x	x	x	x	x	x
Pre-programmed Emergency Management Response Plans	x	x	x	x	x	x
Traveler Information Systems		x	x	x		x
Highway Advisory Radio			x	x	x	x
Road Weather Information System	x	x	x	x	x	x
Flood Gauges	x	x	x	x	x	x
Stationary Dynamic Message Signs		x	x	x		x
Portable Dynamic Message Signs		x	x	x		x
Maintenance and Design Element Management		x		x		
Emergency Response	x	x	x	x	x	
Emergency Vehicle Preemption	x	x		x		

How much does an Emergency Management system cost?

Note: Cost figures below are for planning purposes based upon recent TxDOT and municipal project cost estimates and informal quotes from sample vendors.
Local, State, Federal Emergency Management Training - $1,000/person annual
Travel Information System Integration - $50,000/integration (initial) and $1,000 annual O&M costs
Highway Advisory Radio - $15,000/Radio Relay (initial) and $750 annual O&M costs
Road Weather Information System - $30,000/Weather Sensor (initial) and $1,000 annual O&M costs
Flood Gauge - $25,000/Flood Gauge (initial) and $1,000 annual O&M costs
Dynamic Message Signs - $125,000/Sign (initial) and $5,000 annual O&M costs
Incident Response Vehicles- $60,000/Vehicle (initial) and $3,000 annual O&M costs
Dedicated Incident Responders - $50/Hr (Hourly costs)
Traffic Management Center Employees - $50/Hr (Hourly costs)

Emergency Vehicle Preemption - $4,000/traffic signal (initial) and $250 annual O&M costs
What Planning and Institutional issues should be considered in developing an Emergency Management System?
Determine roles and responsibilities for each agency during an emergency.
Develop an Emergency Response Standard Operating Procedure for most likely emergencies.
Ensure that each agency has an effective communication protocol and system available during normal times so that communication is clear and effectively carried out during an emergency.
Allocate appropriate operations and maintenance funding to support the Emergency Response program.
What issues should be considered in Designing and Implementing an Emergency Management System?
Determine where and what type of natural or man-made emergency is most likely to occur.
Determine emergency evacuation routes.
Determine what systems need to be upgraded to respond to the full range of emergencies.
Create backup response plans in case the primary response cannot be executed.
Determine how often training, drills, and stress tests should be conducted.
Determine how emergencies and their status should be communicated to the public.
What issues should be considered in Operating and Maintaining an Emergency Management System?
Develop or refresh Business Continuity Plans.
Test new messages to be used on Highway Advisory Radio and Dynamic Message Signs with users before operational start-up.
Ensure that the public can easily access emergency communications during an emergency.
Define the necessary knowledge, skills and abilities for staff to be assigned to operate the Emergency Operations Center.
Train emergency-response personnel in the Emergency Response Standard Operating Procedures.
Train TMC operations and maintenance staff to implement the Emergency Response procedures.

4. Standard Operating Procedure - Equipment Failure Management

What is Equipment Failure Management?

The transportation industry is rapidly evolving with advanced technology. Roadways are becoming increasingly complex, with communications and security technology, sensors and cameras, and other technologies and supporting infrastructure. Travelers and commercial vehicle operators rely on the hardware, software, and people necessary to dynamically manage and operate the system in real-time from virtual and physical transportation management centers. The reliance on transportation assets for TSMO is expected to accelerate as transportation becomes increasingly connected and automated. Equipment Failure Management is a TSMO strategy that focuses on maintaining this equipment while minimizing downtime.

Due to recent transportation funding bills (MAP-21 and the FAST Act), federal law requires each state to *"develop and implement a Risk-Based Asset Management Plan for the National Highway System (NHS) to improve or preserve the condition and performance of the system".* TxDOT has developed the Texas Transportation Asset Management Plan (TAMP) to satisfy this requirement. Traditional forms of roadway system asset management focus on pavement and bridge management. A core aspect of TSMO is leveraging technology to achieve operational goals. Equipment Failure Management is a TSMO strategy that adds to traditional forms of asset management through the management of ITS hardware, software, network, and communication systems.

What are the components of Equipment Failure Management?

Asset Management System: A digital Asset Management System (AMS) can be used to track individual ITS and other field equipment. The system should include details such as field equipment make, model, serial numbers, purchase and installation dates, and routine device maintenance frequency. Data from the system can be analyzed to develop equipment life-cycle costs and future device replacements to be planned, prioritized, and programmed. This would support agencies in replacing these assets on a more consistent and timely basis. Any equipment serviced and placed back into the field would be tracked for service history. AMS can automatically schedule and prioritize preventive maintenance based upon manufacturers' recommendations, agency policy, or regulatory requirements.

Houstonstranstar.org

Work Order Management System: A Work Order Management System can be used in conjunction with an Asset Management System or as a stand-alone application. The Work Order Management System is a centralized system for all tasks related to equipment management. The system should track labor hours, estimate part costs, and help organize and prioritize maintenance efforts. The system can help standardize work procedures and can be a repository for standard documents and equipment repair manuals. Reports from the system can be used to improve budgeting and planning for both capital projects and maintenance activities.

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Fleet Management System: In addition to ITS equipment, fleet equipment should also be managed and tracked as assets as part of any TSMO program. Different types of ITS equipment may require different types of fleet vehicles to aid in repair and maintenance. A Fleet Management System can assist in dispatching an appropriate vehicle at the right time. When used in conjunction with a Work Order Management System, vehicle preventative maintenance can be scheduled around field equipment maintenance activities to minimize the downtime of both field and fleet equipment. Reports from the system can be used to improve budgeting for fleet replacement. Agencies set maintenance expenditure and downtime thresholds in the system software to determine when to replace individual vehicles.

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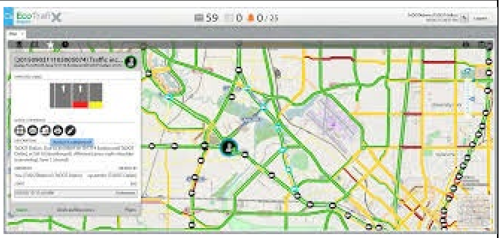
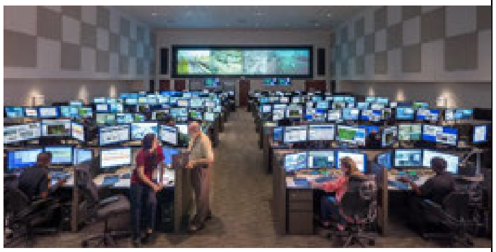
Automated Vehicle Location System (AVL): An AVL system tracks the location of fleet vehicles and can be used to improve crew dispatch and response times. When an AVL system is integrated with a Work Order Management System, jobs can be assigned to the closest crew with the appropriate equipment and experience for the particular work order. The latest AVL systems use routing software that monitors traffic conditions and can direct field crews to the work-order location factoring in congestion, traffic incidents, work zones, or street closures. AVL systems may be used to monitor safe-driver behavior improving the safety of the crew and the public and reduce fleet equipment downtime due to traffic incidents.



Itscalifornia.org

Traffic Management Center (TMC): This component works as a central dispatch. The TMC operates as a collection point for monitoring the status and health of field equipment. TMC staff can detect failed equipment, generate work orders, and dispatch field repair crews. A TMC can be a large center with numerous staff or as small as a single workstation as long as the workstation operator can monitor traffic conditions and coordinate with field response staff and other agency staff.



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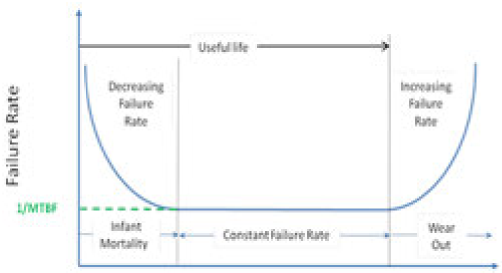
Life Cycle Planning: All electronic field equipment, including ITS field equipment, has a life expectancy and a useful life. Equipment failure can be categorized into three modes: age related, non-age related, and infant mortality. Failure rates, measured in mean-time between failure (MTBF), generally increase as equipment gets older. Monitoring and planning for the expected useful life of field equipment can be as simple as assigning a set replacement schedule for each device based upon recommendations from manufacturers and institutional knowledge. If an Asset Management System is in place, the useful life for a particular piece of equipment can be calculated by analysing failure data collected from the system. Replacing equipment before failure at a time just before the end of expected useful life can minimize equipment downtime and reduce the need for emergency repair and possibly reduce overtime expenses. Infant-Mortality failure occurs when a piece of equipment fails when first deployed or within a short period. Manufacturers' warranties are supposed to protect the purchaser for this type of failure. If equipment is purchased in bulk and deployed over time, care should be taken to work with equipment manufacturers and vendors to base warranties on the date of installation rather than date of purchase. Life Cycle Planning can be used to improve budgeting and planning for capital projects and maintenance activities.



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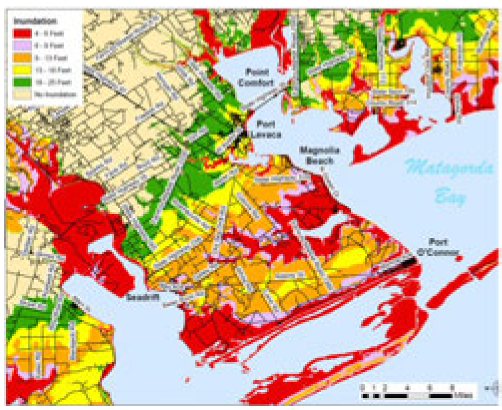
Risk Management Prioritization: This component identifies areas at high risk for emergencies, identifies equipment key to emergency response, and prioritizes managing and mitigating equipment failure and downtime in these high-risk areas. Many areas are prone to specific types of emergency events and incidents. Coastal areas are subject to tropical storms and hurricanes. Areas near floodplains are subject to flooding. Some regions are prone to high wind events or tornados. Some areas are more prone to winter weather events and ice. Maintenance activities should be planned around times when the chances of a natural disaster are increased. In areas known to be prone to cetrain types of natural emergency, design standards for transportation and ITS equipment should be in place to accomodate high winds, icing, heavy rain, flooding, and high and low temporature extremes. Reviews should be conducted for the placement and elevation of electronic equipment in flood prone areas. Asset management systems should incorporate data fields to monitor vunerabilities due to weather extremes. Maintenance cycles and standards should be evaluated in emergency prone areas. Downtime during emergencies can be mitigated if redundant systems are put in place.



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What are the benefits of an Equipment Failure Management system?

Equipment Failure Management Component	Improve Asset Uptime	Life Cycle Cost Efficiency	Real-Time Situational Awareness	Supports Audit Requirements	More Efficient Use of Resources (Facilities, Funding)	Faster Resolution of Trouble Tickets
Asset Management System	X	X	X	X	X	X
Work Order Management System	X	X	X		X	X
Fleet Management System	X	X	X	X	X	X
Automating Vehicle Location System	X		X		X	X
Traffic Management Center	X		X		X	X
Life Cycle Planning	X	X		X	X	X
Risk Management Prioritization	X	X	X		X	X

How much does an Equipment Failure Management system cost?

Note: Cost figures below are for planning purposes based upon recent TxDOT and municipal project cost estimates and informal quotes from sample vendors.

Asset Management System - *$500/device (initial) and $50 annual O&M costs*

Work Order Management System - *$300/device (initial) and $30 annual O&M costs*

Fleet Management System - *$500/vehicle (initial) and $50 annual O&M costs*

AVL System Software with dispatch routing - *$400/vehicle (initial) and $40 annual O&M costs*

AVL vehicle hardware - *$300/vehicle (initial) and $30 annual O&M costs*

Traffic Management Center Employees- *$50/Hr (Hourly costs)*

What Planning and Institutional issues should be considered in developing an Equipment Failure Management system?

Determine best investment strategy of operating, maintaining, replacing, and improving equipment.

Allocate appropriate O&M funding to support the Equipment Failure Management system program.

Evaluate current and future planned capital projects and plan for the O&M costs of project equipment.

Update ITS design standards to favor equipment with long Mean Time Between Failure (MTBF) rates.

What issues should be considered in Designing and Implementing an Equipment Failure Management system?

Determine the current state of technology assets.

Determine the required levels of service and performance delivery.

Determine which assets are critical to sustained performance.

Consider building in redundancy for critical assets.

Develop a Concept of Operations and system requirements prior to procuring an Equipment Management System.

What issues should be considered in Operating and Maintaining an Equipment Failure Management system?
Develop (or refresh) Standard Operating Procedures for preventive, corrective, and emergency maintenance of ITS, communications. and emerging technologies.
Develop preventive-maintenance schedules for each type of equipment.
Adjust planned pre-failure equipment replacement schedules with planned capital projects.
Track equipment warranty expiration dates and schedule equipment inspection before expiration.
Define knowledge, skills and abilities for staff to be assigned to operate the Equipment Failure Management system.
Train maintenance staff to collect and input asset management data.

5. Standard Operating Procedure - Incident Management

What is Traffic Incident Management?

Traffic Incident Management is a process for quickly detecting, verifying, responding to, and clearing a traffic incident that has resulted in a blocked lane(s) or full road closure. Traffic Incident Management strategies are best deployed for interstate highways, toll roads, and strategic arterials where incidents produce the greatest delay impacts and may increase the probability of secondary crashes if not cleared quickly.

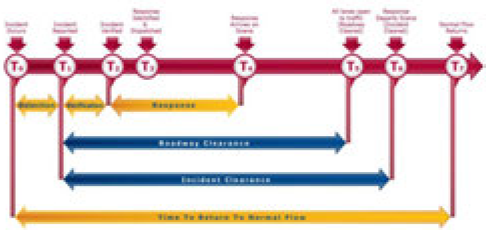
Traffic Incident Management involves three components:

- technologies to detect the traffic incident,
- Traffic Management Center to verify and monitor the incident, and
- response to clear the incident.

Effective Traffic Incident Management improves the safety and reliability of the roadway by removing the vehicles involved in the incident in a safe and efficient manner. On average, every one-minute of traffic lane closure results in four minutes of traffic delays and queueing for each approaching vehicle. For example, if a traffic lane is closed for 30 minutes, a two-hour delay is anticipated for each approaching vehicle. Similarly, for every one-minute that an incident remains uncleared, the probability of a secondary crash increases by 2.8%. Finally, the quicker the vehicle occupants involved in the crash can receive medical attention by the first responders, their chances of survival significantly improves.

What are the components of Traffic Incident Management?

Traffic Incident Management (TIM) Teams: TIM Teams are active in some of the TxDOT Districts. The teams include operations staff representing TxDOT, State Police, HERO operators, fire-rescue, municipalities, emergency operations centers, incident responders, tow truck companies, public information specialists, and others responsible for incident management. TIM teams meet on a regular basis where they share best practices, conduct after action reviews of major incidents, conduct FHWA TIM self-assessments, plan for special and emergency events, conduct TIM training and other relevant activities to improve incident management.



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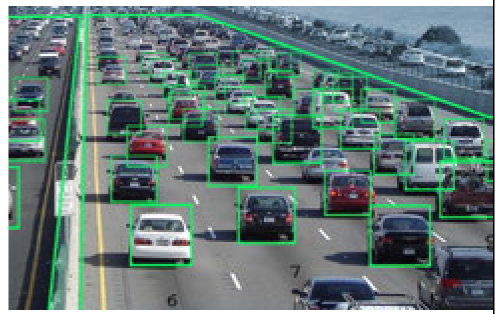
Traffic Monitoring Equipment & Systems: Traffic Monitoring Equipment including Pan-Tilt-Zoom Cameras, and vehicle detection equipment can be used to monitor traffic conditions. Operations staff use cameras to verify traffic incidents. When planning and dispatching an incident response, operations staff use monitoring equipment to determine the level of emergency response needed, such as minor roadside assistance or emergency response. Vehicle detection systems can monitor congestion due to traffic incidents.

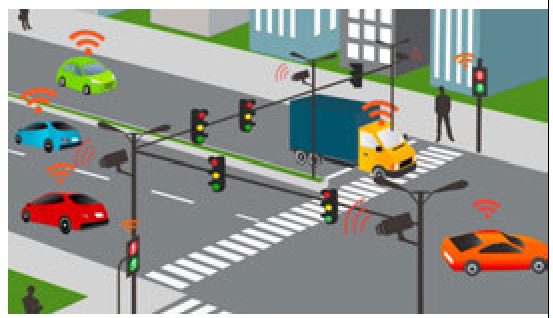
Phase1vision.com

Roadway Technologies: This component involves detecting disabled vehicles on the roadway and communicating the information to a central dispatch such as a Traffic Management Center. Automated Incident Detection system software algorithms are used to detect incidents such as collisions, vehicular breakdowns, debris in the roadway, pedestrians or animals in travel lanes, and wrong-way driving incidents. These systems analyze speeds and movement of vehicles and will notify dispatch if there is a large decrease in speed or if vehicles have completely stopped.



Trafficvision.com

Connected Vehicles: Quick detection of a delay caused by a traffic inicident is key in alerting and dispatching necessary emergency services. Connected-vehicle technology can be harnessed to detect incidents. Communication between roadway infrastructure and vehicles can deliver two-way messages between vehicles and operations staff. Connected vehicles can transmit to operations staff messages about evidence of an incident such as an air-bag deployement or sudden deceleration. Connected-vehicle equipment such as DSRC radios and Cellular 5G systems can be integrated into traffic signals along arterials or integrated into freeway roadside traffic monitoring equipment locations.



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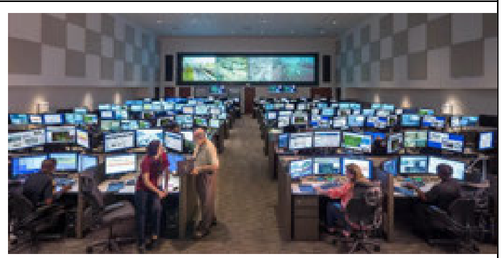
Traffic Management Center (TMC): This component works as a central dispatch. The TMC operates as a collection point for information coming from field devices and as a central coordination point for dispatching incident response. TMC staff can quickly verify incidents flagged by the detection systems and can identify incidents not flagged by the system. TMC staff can route emergency-response vehicles and personnel and monitor the status of the response. The TMC staff can also determine if any ramp or road closures are needed and can alert the public through several forms of media (e.g. local news/radio, social media, dynamic message signage, and traveler information systems). A TMC can be a large center with numerous staff or as small as a single workstation as long as the workstation operator can monitor traffic conditions and coordinate with field response staff and other agency staff.



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Central Traffic Signal Management Software: Central Traffic Signal Management software allows for the TMC to give priority to specific approaches or corridors. Operations staff can use the software systems to change traffic signal timings along parallel corridor routes to manage increased traffic due to diversions. Signal timings at intersections immediately downstream of freeway off-ramps can be adjusted to reduce spillback onto freeway traffic lanes. This can reduce secondary incidents.

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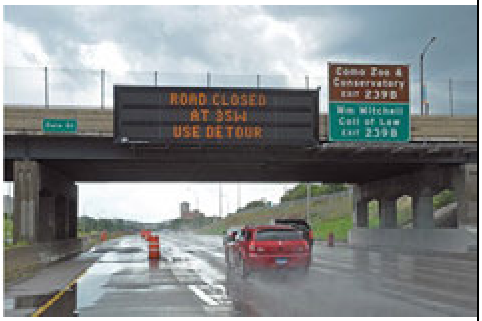
Dynamic Message Signs: Operations staff use Dynamic Message Signs to provide advance warning of incidents and traffic queues. Roadway users can be advised to safely merge onto adjoining lanes upstream of the incident or directed to a diversion route. Ample advanced warning of slow-downs and necessary lane changes will allow drivers more time to safely change lanes and reduce sideswipe, rear-end and other secondary crashes while the incident is being cleared.



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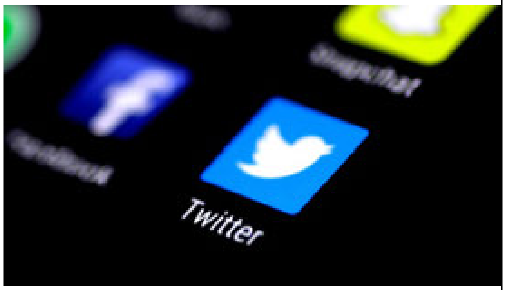
Traveler Information Systems: This component can inform drivers before they take the road or when they are near an incident. Smartphones, smart devices, and on-board navigation systems are tools that communicate directly to drivers and have become more accessible to the general public. Information can be shared with regional 511 systems, social media, and third-party navigation systems like Waze. Operations staff can also determine if any ramp or road closures are needed and can alert the public through several forms of media (e.g. local news/radio, social media and navigation systems).



Marketwatch.com

Emergency Response: This component involves the use of dedicated personnel and equipment to clear roadways of disabled vehicles and other obstructions. Emergency response can be dedicated law enforcement officials or dedicated maintenance crews.

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This component can be highly effective in urban areas and on highways with no or limited improved shoulders where disabled vehicles can be stopped and stored until repaired or removed. In the past, disabled vehicles had to wait for a tow truck or other maintenance vehicle, which may not be within the vicinity of the incident, but with staged or patrolling maintenance vehicles the incident could be cleared within minutes. If the incident is expected to take a long time to clear, response personnel can set up roadway controls such as traffic cones, barrels, large arrow boards, or portable Dynamic Message Signs to warn drivers to move over to adjacent lanes.

Emergency response personnel should be trained in Quick Clearance procedures and agencies should adopt Quick Clearance policies. Quick clearance reduces the probability of secondary incidents and reduces potential for injury to incident responders working in the travel way. Emergency responders can use Scene Photo software systems to increase the speed of incident data collection.

Emergency Vehicle Preemption: Emergency Vehicle Preemption provides traffic signal priority for emergency vehicles and can reduce the response time for an emergency situation. Response time is a key factor in increasing the probability of survival if the crash is severe. It also reduces the probability of secondary crashes due to speed differential and the total delay caused by blocked lanes.

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What are the benefits of a Traffic Incident Management system?

TIM Component	Reduce Primary Crashes	Reduce Secondary Crashes	Improves First Responder Safety	Delay Freeway Breakdown	Minimizes Delay for Commercial Goods Movement	Reduce Air Emissions	Reduce Fuel Consumption
Traffic Incident Management (TIM) Teams		X	X	X	X	X	X
Traffic Monitoring Equipment & Systems		X	X	X	X	X	X
Roadway Technologies		X	X	X	X	X	X
Connected Vehicles	X	X	X	X	X	X	X
Traffic Management Center		X	X	X	X	X	X
Central Traffic Signal Management Software		X	X	X	X	X	X
Dynamic Message Signs		X	X	X	X	X	X
Traveler Information Systems	X	X	X	X	X	X	X
Emergency Response		X	X	X	X	X	X
Emergency Vehicle Preemption	X	X	X	X	X	X	X

How much does a Traffic Incident Management system cost?

Note: Cost figures below are for planning purposes based upon recent TxDOT and municipal project cost estimates and informal quotes from sample vendors.

Vehicle Detection and Cameras - $9,000/Detection Device (initial) and $500 annual O&M costs

Automated Incident Detection System - $1,000/Camera (initial) and $100 annual O&M costs

Emergency Vehicle Preemption - $4,000/traffic signal (initial) and $250 annual O&M costs

Dedicated Incident Responders - $50/Hr (Hourly costs)

Incident Response Vehicles- $60,000/Vehicle (initial) and $3,000 annual O&M costs

Traffic Management Center Employees- $50/Hr (Hourly costs)
Travel Information System Integration - $50,000/integration (initial) and $1,000 annual O&M costs
Connected Vehicle Communication Hardware and Software - $5,000/location (initial) and $500 annual O&M costs
Scene Photo Sharing System - $200,000/System (initial) and $15,000 O&M costs
Dynamic Message Signs - $125,000/Sign (initial) and $5,000 annual O&M costs
What Planning and Institutional issues should be considered in developing a Traffic Incident Management System?
Coordinate with State Highway Patrol on a plan to achieve acceptable response times and develop an appropriate Memorandum of Understanding (MOU).
Develop Traffic Incident Management Response Plans for reoccurring incidents.
Coordinate with Metropolitan Planning Organizations (MPOs) to include Traffic Management Centers in their planning, programming and funding.
Prepare a Statewide TIM Strategic Plan and apply to TxDOT districts.
Expand TIM Team program to all districts.
Establish database of lessons learned based on TIM Team “After Action Reviews”
Define and collect data for appropriate performance measures (e.g., time to clear incidents, secondary crash rates).
Allocate appropriate operations and maintenance funding to support the Traffic Incident Management program.
Determine roadway segments that need ITS deployments to enhance incident detection, verification, and monitoring.
Encourage emergency response agencies to adopt Quick Clearance policies and train personnel in the application of those policies.
What issues should be considered in Designing and Implementing a Traffic Incident Management System?
Determine where crashes and breakdowns are most likely to occur in the system.
Determine if Incident Response should be staged or use HERO patrols.
Develop a statewide specification for a fully equipped HERO vehicle and apply it to procure these vehicles for TxDOT districts.
Inventory existing Traffic Incident Management field equipment.
Coordinate with existing and planned roadway improvement projects to install CCTV Pan/Tilt/Zoom cameras and Dynamic Message Signs where needed as part of an ITS Master Plan.
Define typical placement of Traffic Incident Management field equipment.
What issues should be considered in Operating and Maintaining a Traffic Incident Management System?
Define hours of operation for Traffic Incident Management strategies.
Update TMC operating procedures to reflect the Traffic Incident Management strategies to be deployed.
Apply performance measures to continuously improve incident response and clearance times of lane blockage events.
Conduct quality control audits of HERO vehicles and operations.

Conduct joint training between TMC and HERO operations staff. This may include “ride-alongs” by TMC staff to gain an appreciation of incident operations in the field.
Establish a Customer Satisfaction survey to obtain feedback on the quality of motorist assists.
Define knowledge, skills and abilities for TMC staff to be assigned to operate the Traffic Incident Management program.
Train Incident Responders in Traffic Incident Management standard operating procedures.
Train TMC operations and maintenance staff to manage the Traffic Incident Management program.

6. Standard Operating Procedure - Integrated Corridor Management

What is Integrated Corridor Management?

Integrated Corridor Management (ICM) is the management of a corridor as a system rather than management of the individual transportation modes and networks (e.g., rail lines, bus routes, arterials, freeways) within a corridor. Coordination among jurisdictions and agencies is critical to improve the management of traffic congestion and moving people and goods more effectively. ICM strategies involve shared responsibility for freeway, transit, arterial, and parking systems within a corridor as a single system rather than as separate individual transportation networks. This coordination can help reduce congestion, increase efficiency, and integrate multiple modes such as transit and bicycles. This coordination can be useful at both the planning and operations levels and may include mechanisms ranging from personal relationships to formal memoranda of understanding (MOU). Corridor stakeholders may include agencies responsible for freeway operations, local arterial and street operations, transit services, incident and emergency response services, media and traveler information service providers.

Interagency coordination policies and procedures established for corridor management can serve as the basis for various other operations to organize and improve their own coordination activities. Emergency operations, in particular, are greatly enhanced by having mechanisms and processes in place for interagency coordination because effective emergency response requires participation from a wide range of agencies, including roadway operators, fire, paramedic, police, and hazardous materials cleanup crews, among others.

The goal of ICM is to improve a corridor's level of service, including efficiency, reliability, and safety, by a more effective use of its infrastructure. As ICM is targeted to optimize the entire corridor, rather than individual sub-systems, combination of different control strategies, interactions between different sub-systems, and integration of all system performance describe the broadness of ICM. All sub-systems of the corridor need to be considered and managed systematically to achieve this goal. The sub-systems considered in ICM include different infrastructure (such as freeways, ramps, and local streets), different transportation modes (such as passenger car, bus, and rail), and different control systems (such as traffic signals, and dynamic message signs).

What are the components of an Integrated Corridor Management system?

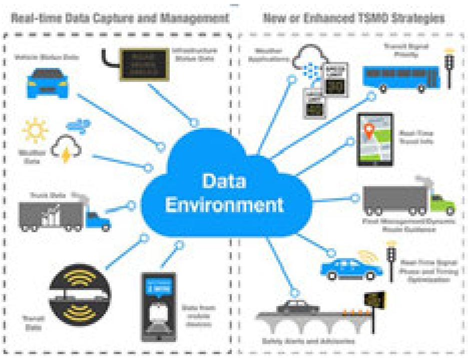
Institutional Integration: This component consists of agreement among agencies and jurisdictions working together to jointly operate a corridor. These agencies need agreement on the vision and common goals among agencies to guide policy development as well as the guidelines, schedules, and communications plans. Agreement mechanisms need to be documented and executed such as memoranda of understanding (MOU), joint operating policies, and interagency agreements.

ops.fhwa.dot.gov

Operational Integration: Agencies and jurisdictions can either operate a joint co-located Traffic Management Center (TMC) or an interconnected virtual joint TMC. Agencies share: real time traffic data collection; performance metrics; advanced traveler information systems (ATIS); adaptive control strategies (ACS); monitor off-ramp spill back; and develop and implement traffic signal response plans. Inter-agency communication needs to be continuous with regular joint operations meetings held to discuss system performance, reliability, and incident management.

txdot.gov

Technological Integration: Agencies and jurisdictions capture real-time data and share it through cloud-based or otherwise connected networks including: closed circuit television (CCTV) video; traffic signal status and signal phase and timing (SPaT); dynamic message sign data; corridor volume and speed; and incident information. These networks of shared data provide access to information about local infrastructure that control systems and inform system managers about current and anticipated conditions. This connectivity includes a wide variety of public and private sector services, including transportation, energy, emergency services, health services, government services, and many others. Information is also passed to the public through regional 511 websites and shared to third-party consumer traffic services like Google/Waze.



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TMC Traffic Management Center (TMC): This component works as a central dispatch. The TMC operates as a collection point for information coming from field devices and as a central coordination point for dispatching incident response and monitoring. As a part of ICM, cooperating agencies can operate a joint TMC or separate TMCs as long as information is shared and incident/event responses are coordinated across agencies. TMC staff can quickly verify incidents flagged by the detection systems and can identify incidents not flagged by the system. TMC staff can route emergency response and monitor the status of the response. The TMC staff can also determine if any ramp or road closures are needed and can alert the public through several forms of media (e.g., local news/ radio, social media, dynamic message signage, and traveler information systems). A TMC can be a large center with numerous staff or as small as a single workstation as long as the workstation operator can monitor traffic conditions and coordinate with field response and other agency staff.

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Central Traffic Signal Management Software: Often the traffic signals along a corridor are operated by multiple agencies. Each of these agencies may have separate traffic signal management software. Central Traffic Signal Management software allows for TMC staff to monitor status of signals, keep traffic signals in synchronization, and implement timing plan changes. As a component of ICM, agencies can choose to share a single system or maintain separate systems. Signal timing plans should be coordinated across agencies along the shared corridor. Special event and incident plans should be agreed upon and ready for implementation as part on a coordinated response. Separate systems can be linked through cloud-based systems or through the use of Center to Center data protocols.

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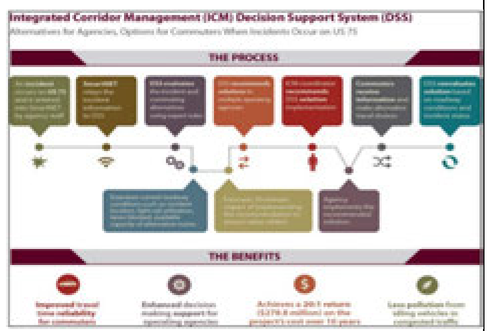
Decision Support System (DSS): A decision support system is a technical tool facilitating the application of institutional agreements and operational responses the corridor stakeholders agreed to through the planning process. The DSS gathers traffic data from the deployed ITS equipment along the managed corridor and uses the information to quickly forecast immediate future conditions. When an incident or event generates congestion beyond predetermined thresholds, the DSS makes a forecast and selects a response plan. The response plans are based on the business rules established for the response. The DSS alerts the agency operators of the recommended response plan and they accept or reject the response plan. If accepted, the operators implement the plan. The DSS continues to monitor congetstion conditions and will recommend when to terminate the response plan and return to normal operations.



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Incident Response: This component involves the use of dedicated HERO patrollers to clear a lane(s) blockage along a roadway, disabled vehicles, and other obstructions. Incident response can be dedicated law enforcement officials or dedicated maintenance crews. As part of ICM, multiple municipal, county, and state law enforcement agencies will need to coordinate response along a corridor. Shared corridors also may involve multiple paramedic and ambulance services, including private sector providers.

Txdot.gov

This component can be highly effective in urban and metro areas and on highways with no or limited improved shoulders. In the past, disabled vehicles had to wait for a tow truck or other maintenance vehicle which may not be within the vicinity of the incident, but with staged or patrolling maintenance vehicles the incident could be cleared within minutes. If the incident is expected to take a long time to clear, response vehicles can set up temporary maintenance of traffic controls such as traffic cones, barrels, large arrow boards, or portable DMS signage to warn drivers to move over to adjacent lanes.

Agencies should work together to develop and adopt Quick Clearance Policies and use these policies to train their staff. Quick clearance reduces the probability of secondary incidents and reduces potential for injury to incident responders while working in the travel way. Incident responders can use Scene Photo software systems to speed incident data collection. Responders may use specially calibrated cameras to capture incident photos tagged with geographic coordinates. The software generates precise incident diagrams. Incident scene information is collected quicker than systems using traditional surveying, allowing the incident to be cleared quicker.

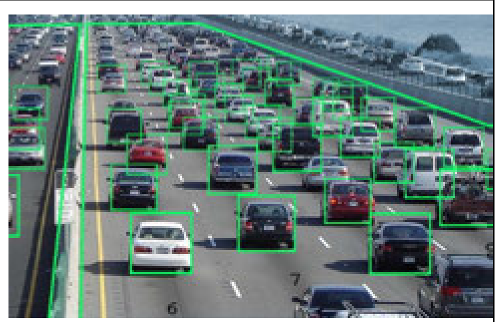
Traffic Signal Preemption and Priority: Emergency Vehicle Preemption provides traffic signal prioirty for emergency vehicles and can reduce the response time for an emergency situation. Response time is a key factor in increasing the probability of survival if the crash is severe; in reducing secondary crashes due to speed variances; and reducing total delay caused by blocked lanes. Transit Signal Priority can be used to prioritze light rail or buses at traffic signals to improve transit reliability (i.e., schedule adherence) thus improving user experience.

Global-sei.com

Traffic Monitoring Equipment & Systems: Traffic Monitoring Equipment including Pan-Tilt-Zoom CCTV cameras, and vehicle detection equipment can be used to monitor traffic conditions. Operations staff use cameras to verify traffic incidents. When planning and dispacthing an incident response, operations staff use monitoring equipment to determine the level of emergency response needed, such as minor roadside assistance or emergency response. Vehicle detection systems can monitor congestion due to traffic incidents. Traffic monitoring equipment also collects data on corridor performance and congestion.

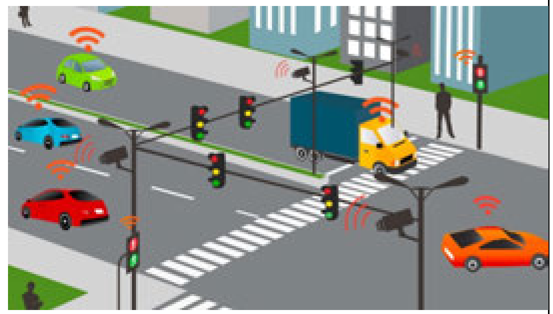
Phase1vision.com

Roadway Technologies: This component involves multiple technologies to monitor traffic conditions and assist operations staff with decision making. Disabled vehicles can be detected on the roadway and information relayed to a central dispatch such as a Traffic Management Center (TMC). Automated Incident Detection (AID) system software algorithms are used to detect incidents such as collisions, vehicular breakdown, debris in roadway, pedestrians or animals in travel lanes, and wrong way driving incidents. These systems analyze speeds and movement of vehicles and will notify dispatch if there is a large decrease in speed or if vehicles have completely stopped. Traffic signals equipped with modern vehicle detection systems and Advanced Traffic Controllers (ATC) can collect Automated Traffic Signal Performance Measures (ATSPM). ATSPM data can be used to evaluate the performance of a traffic signal system along a managed corridor to assist operations staff to make informed decisions about signal timing plan updates as well as evaluating performance during incidents, special events, holidays and weekends.



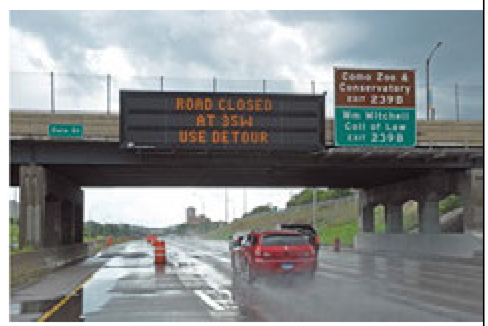
Trafficvision.com

Connected Vehicles: Quick detection of a delay caused by a traffic inicident is key in alerting the necessary emergency services. Connected vehicle technology can be harnessed to detect incidents and transmit other information about corridor congestion and conditions. Communication between roadway infrastructure and vehicles can deliver two way messages between vehicles and operations staff. Connected vehicles can transmit messages such as speed, air bag deployement or sudden deceleration to operations staff. Connected vehicle equipment such as DSRC (Dedicated Short Range Communications) radios and Cellular 5G systems can be integrated into traffic signals along arterials or integrated into freeway roadside traffic monitoring equipment locations.



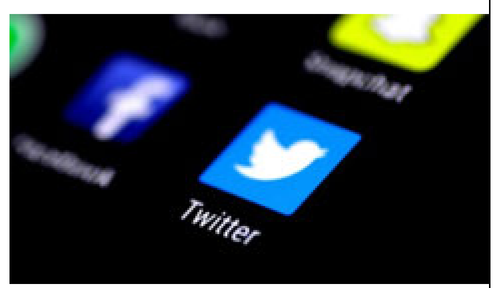
Ohm-advisors.com

Dynamic Message Signs: Operations staff use Dynamic Message Signs (DMS) to provide advance warning of incidents and communicate corridor conditions. Roadway users can be advised to safely merge onto adjoining lanes upstream of the incident or directed to a diversion route. Ample advanced warning of slow-downs and necessary lane changes will allow drivers more time to safely change lanes and reduce sideswipe, rear-end and other secondary crashes while the incident is being cleared. As part of ICM, users can be advised of specific alternative routes that are being managed as part of the coordinated response to an incident or event.



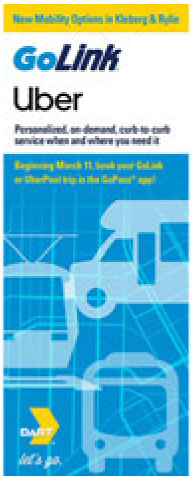
fhwa.dot.gov

Traveler Information Systems: This component can inform drivers before they take the road about an incident or an event. Smartphones, smart devices, and onboard navigation systems are tools that have become more accessible to the general public. Information can be shared with regional 511 systems, social media, and third-party navigation systems like Waze. Operations staff can also determine if any ramp or road closures are needed and can alert the public through several forms of media (e.g. local news/radio, social media and navigation systems).



Marketwatch.com

Mobility on Demand (MOD): Emerging transportation alternatives such as bike sharing, car sharing, and other on-demand services are additional components that may be considered as part of ICM. Integration of these services into operations increases opportunities for mode shift. Travelers hesitant to use transit may choose to use MOD services for door-to-door convenience. MOD services also provide customers with alternatives for first mile/last mile options used in conjunction with transit. During a major incident on a freeway, travelers may be advised to consider transit or another mode. MOD services offer to the traveler choices. Transportation agencies should raise awareness of MOD options and can integrate ticketing and fares. Real-time information should be shared between TMCs and MOD providers.



dart.org

What are the benefits of an ICM system?

ICM Component	Increase People Throughput	Reduce Primary Crashes	Reduce Secondary Crashes	Improve Trip Reliability	Delay Freeway Breakdown	Reduce Air Emissions	Reduce Fuel Consumption
Insitutional Integration	X		X	X	X	X	X
Operational Integration	X	X	X	X	X	X	X
Technological Integration	X	X	X	X	X	X	X
Traffic Management Center	X		X	X	X	X	X
Central Traffic Signal Management Software	X		X	X	X	X	X
Decision Support System	X		X	X	X	X	X
Emergency Response	X		X	X	X	X	X
Traffic Signal Preemption & Priority	X	X	X	X	X	X	X
Traffic Monitoring Equipment & Systems	X		X	X	X	X	X
Roadway Technologies	X		X	X	X	X	X
Connected Vehicles	X	X	X	X	X	X	X
Dynamic Message Signs	X		X	X	X	X	X
Mobility on Demand	X	X	X	X	X	X	X
Traveler Information Systems	X	X	X	X	X	X	X

How much does an ICM system cost?
Note: Cost figures below are for planning purposes based upon recent TxDOT and municipal project cost estimates and informal quotes from sample vendors.
Vehicle Detection Equipment - *$9,000/Detection Device (initial) and $500 annual O&M costs*
CCTV Traffic Monitoring Cameras - *$7,500/Camera (initial) and $500 annual O&M costs*
Automated Incident Detection System - $1,000/Camera *(initial) and $250 annual O&M costs)*
Emergency Vehicle Preemption - *$4,000/traffic signal (initial) and $250 annual O&M Costs*
Transit Priority System - *$4,000/traffic signal (initial) and $250 annual O&M costs*
Traffic Management Center Employees- $*50/Hr (Hourly costs)*
Travel Information System Integration - *$50,000/integration (initial) and $1,000 annual O&M costs*
Decision Support System - *$25,000 for hardware, $1,000,000 for software development, and $30,000 annual O&M costs.*
Connected Vehicle Communication Hardware - $1,000/location (*initial) and $100 annual O&M costs*
Dynamic Message Signs - $125,000/Sign (initial) and $5,000 annual O&M costs)
Advanced Traffic Controllers (ATC) - $2,500/traffic signal *(initial) and $300 annual O&M costs*
Automated Traffic Signal Performance Measure (ATSPM) equipment - $1,000/traffic signal *(initial) and $100 annual O&M costs*

What Planning and Institutional issues should be considered in developing an ICM System?
Select an initial operating corridor to deploy ICM.
Form ICM Stakeholder Committee made up of operations personnel from all agencies involved in operating the ICM corridor.
Coordinate with law enforcement and emergency response agencies to address incident management.
Develop appropriate MOUs, Joint Operating Policies, and interagency agreements between operating agencies.
Develop an ICM Concept of Operations.
Coordinate with Metropolitan Planning Organizations (MPO) to include ICM in their planning, programming and funding.
Define appropriate performance measures (e.g., trip reliability, crashes, person throughput) and collect base data.
Allocate appropriate operations and maintenance funding to support the ICM program.

What issues should be considered in Designing and Implementing an ICM System?
Develop ICM design standards and guidelines for each ICM component.
Develop ICM Decision Support System.
Coordinate with existing and planned roadway, ITS and other transportation improvement projects.
Develop a formalized process to consider design exceptions for ICM components.
Define typical placement of ICM field equipment (e.g., cabinets) and provide crash protection.
Involve Information Technology (IT) personnel from Stakeholder Agencies to ensure computer network security for shared systems and data streams.

What issues should be considered in Operating and Maintaining an ICM System?
Conduct regular ICM Stakeholder Committee meetings to review corridor performance measures and apply findings and recommendations to improve the effectiveness of corridor operations.
Update response plans, including signal timing plans, based on performance measure data (e.g., ATSPM data).
Determine overall hours of operation for TMC(s) and implementation of ICM strategies.
Update TMC operating procedures to reflect the ICM strategies and components to be deployed.
Update Traffic Incident Management procedures to include ICM components and strategies.
Reconfigure TMC video wall and workstations to accommodate ICM components.
Define knowledge, skills and abilities for TMC staff to be assigned to operate the ICM program.
Train TMC operations and maintenance staff to manage the ICM program.
Incorporate the ICM devices into the Asset Maintenance Management System.
Develop Lonestar™ (or other) ATMS software upgrades to accommodate the operations of ICM devices and shared data streams.
Define interface and integration of ICM with other operational systems (e.g., ITS, ATM, managed lanes).
Test new messages to be used on dynamic message signs with users before operational start-up.
Provide quick-clearance training for emergency response personnel.

7. Standard Operating Procedure - Special Event Management

What is Special Event Management?

Special Event Management is a coordinated approach to planning for and mitigating increased travel demand for a planned, permitted, or continuous special event. A special event could be a one-time or recurring event at a permanent venue, like a large sporting event or concert. Fairs and festivals are examples of continuous special events that can last multiple days or weeks. Another example of a special event is a street-use event, such as a parade. Special events can generate significant increases in people and traffic within a specific area. Special Event Management strategies and components are best deployed on or near high capacity venues, near central business districts, and on high-priority arterials, highways, and freeways.

Special Event Management involves planning, coordination, real-time traffic monitoring and management, dynamic traveler information, and possibly supplemental transit services to meet the needs of the traveling public. Effective Special Event Management strategies improve travel-time reliability, throughput and reduce delays. The benefits of Special Event Management include:

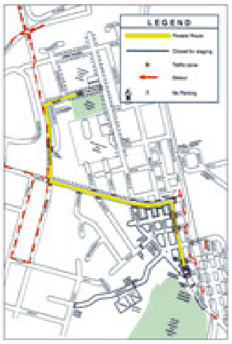
- delaying the onset and shortening the duration of congestion
- facilitating efficient entry and exit of event participants
- improving safety, security and accessibility of people using all modes of transportation attending events
- encourages use of non-motor-vehicle transportation modes

What are the components of Special Event Management?

Planning and Coordination: The event managers, transportation agencies, public transportation agencies, and law enforcement should work together to identify which vehicles and routes will need priority, organize communications during the event, and coordinate how to respond to unexpected incidents. Transportation planners, public transportation agencies, and event managers may choose to promote non-personal-vehicle transportation options prior to the event to minimize congestion. Street and lane closures may require permitting from either TxDOT or local municipalities, counties, or other agencies.

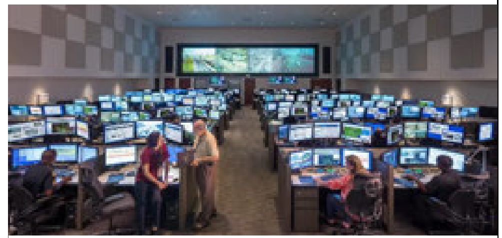
dallascityhall.com

Pre-programmed Management Plans: Many events are recurring or planned by organizers in advance. Transportation agencies and event organizers should develop management plans for events. These plans should include arterial and freeway detours, lane or street closure plans, special traffic signal timing, staging of emergency response, special transit routes and services, and special/temporary parking accommodations.



ops.fhwa.dot.gov

Traffic Management Center (TMC): This component works as a central dispatch where local and regional transportation operations are coordinated. The TMC can quickly monitor the special event, coordinate response plans, and detect unplanned incidents related to the special event. The TMC can then route emergency response to reach the incident as quickly as possible. The TMC can also determine if any ramp/road closures are needed and can alert the public through several forms of media (e.g. local news/ radio, social media). A TMC can be a large center with numerous staff or as small as a single workstation as long as the workstation operator can monitor traffic conditions and coordinate with field response staff and other agency staff.



Texite.org

Traffic Monitoring Equipment & Systems: Traffic Monitoring Equipment including Pan-Tilt-Zoom Cameras, and vehicle detection equipment can be used to monitor traffic conditions at critical areas around the planned event. This equipment can assist operations staff to make informed decisions while executing Special Event Management Plans. These devices should be connected back to TMCs with a high speed communications system. Video analytics software can also detect unusual or unexpected congregations of people around events. This may be effective in special applications such as crowd control under normal conditions (e.g., university football games, South by Southwest) or during special situtations (e.g., protests, COVID social distancing). These video systems aid operations staff in making adjustments to security or support staff response, improve safety, and aid in more efficient event ingress and egress.

Phase1vision.com

Central Traffic Signal Management Software: Central Traffic Signal Management software allows for the Traffic Management Center to give priority to specific approaches or corridors. When special events begin and end a high volume of vehicles, possibly greater than typical week day peak hour volumes, occupy the adjacent roadways. Adjusting signal timings near the event allows the operations staff to adjust the existing timings to increase vehicle throughput either towards or away from the venue and incentivize vehicles to take the major arterials instead of using minor roads and adjacent neighborhoods. Signal timings can be adjusted to accomodate heavy pedestrain movements in areas around events.

FHWA.gov

Traveler Information Systems: This component can inform drivers before they take the road or are near the event. Smartphones and smart devices are a key tool that have become more accessible to the general public. Providing information to the public while they are still planning their trips will allow for greater reliability and can reduce congestion near the event. Data can be shared with regional 511 systems, social media, and third-party navigation systems like Waze. Mobility on Demand applications have the potential to integrate multiple mode options (e.g., vehicles, transit, scooters, bikes, parking) providing the user flexible trip planning and fare payment options on their smartphones. When a TMC is in place, operations staff can then route emergency response to reach the incident as quickly as possible. The TMC staff can also determine if any ramp/road closures are needed and can alert the public through several forms of media (e.g., local news/ radio, social media).

Marketwatch.com

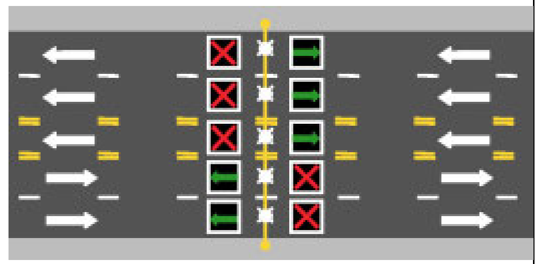
Stationary Dynamic Message Sign: This component involves alerting the general public of future or ongoing events on/ near a route. Alerting the public of the event will increase reliability by allowing drivers to plan ahead or choose an alternate route. Dynamic Message signs can also be used to route the public to event parking. Drivers may choose to navigate themselves directly to the venue when selecting a route, but parking for the event may require drivers to use a different road/exit. Operations staff should take care to ensure messages on signs are accurate, reliable, timely, and provide useful, actionable information to the public.

Dot.ny.gov

Portable Dynamic Message Sign: Portable Dynamic Message signs serve a similar function to stationary Dynamic Message Sign (DMS)s. A portable sign may be chosen instead of a stationary sign due to their lower cost. They can also be used for events that occur at venues or locations that only have events a few times or even once a year. Similar care should be taken to ensure messages on signs are accurate, reliable, timely, and provide useful, actionable information to the public.

Hollandsigns.com

Reversible Lanes: Reversible lanes can be used as an effective tool to optimize avaliable roadway capacity in accommodating peak surges in traffic before, during, and after the event. This component is best applied to regular recurring events (e.g., stadiums, large entertainment venues) and not one-time or rare events.



Azdot.gov

Emergency Response: During special events, this component involves the use of dedicated personnel to direct traffic, set up traffic control, as well as quickly remove any disabled vehicles near the event. Dedicated service patrols can assist with incident detection, verification, response, and removal in the event of an incident within the planned event area. If local/regional Traffic Incident Management (TIM) Teams are in place, these teams can be used to review past response actions and explore ways that special event management can be improved. These teams also conduct training and should be active in traffic management planning for special events.

Txdot.gov

What are the benefits of a Special Event Management system components?

Special Event Management Component	Congestion Management	Multi-modal Safety	Security & Crowd Management	Access Ingress/Egress efficiency	Improve Customer Satisfaction	Encourage Use of Non-motor Vehicles	Reduce Air Emissions	Reduce Fuel Consumption
Planning and Coordination	x	x	x	x	x	x	x	x
Pre-programmed Management Plans	x	x	x	x	x	x	x	x
Traffic Management Center	x	x	x	x	x		x	x
Traffic Monitoring Equipment & Systems	x	x	x	x	x		x	x
Central Traffic Signal Management Software	x	x		x	x		x	x
Traveler Information Systems	x	x	x	x	x	x	x	x
Stationary Dynamic Message Signs	x	x		x	x	x	x	x
Portable Dynamic Message Signs	x	x	x	x	x	x	x	x
Reversible Lanes	x			x	x		x	x
Emergency Response	x		x	x	x		x	x

How much does a Special Event Management system cost?

Note: Cost figures below are for planning purposes based upon recent TxDOT and municipal project cost estimates and informal quotes from sample vendors.

Dynamic Message Signs - *$125,000/Sign (initial) and $5,000 annual O&M costs*

Portable Dynamic Message Signs - *$15,000/Sign (initial) and $500 annual O&M costs*

Reversible Lane Equipment - *$150,000/location (initial) and $15,000 annual O&M costs*

Integration with Traveler Information Systems - *$50,000/system (initial) and $3,000 annual O&M costs*

Dedicated Social Media Staff - *$50/Hr (Hourly costs)*

Incident Response Vehicles- *$60,000/Vehicle (initial) and $3,000 annual O&M costs*
Traffic Management Center Employees - $50/Hr (*Hourly costs)*
Central Traffic Signal Management Software - $1,000/signal *(initial) and $100 annual O&M costs*
What Planning and Institutional issues should be considered in developing a Special Event Management System?
Coordinate with local/regional Traffic Incident Management team as well as local event coordinator, law enforcement, and traffic agency to address roles and responsibilities during the mobilization phase, during the event and demobilization phase, and after the event; document in a Memoranda of Understanding..
Develop Pre-Programmed Management Plans for known special events.
Define appropriate performance measures (e.g., congestion level, safety, complaints) and collect base data.
Allocate appropriate operations and maintenance funding to support the Special Event Management program.
What issues should be considered in Designing and Constructing a Special Event Management System?
Determine where bottlenecks, potential incidents and breakdowns are most likely to occur in the system.
Determine if Emergency Response should be staged at a location or patrolling the event area.
Coordinate with existing and planned roadway, traffic control and ITS improvement projects to install cameras and DMS as part of an ITS Master Plan.
Define recommended placement of field equipment.
Identify and coordinate the integration of 3rd party Traveler Information Systems and Mobility on Demand applications into TMC software systems.
What issues should be considered in Operating and Maintaining a Special Event Management System?
Test new messages to be used on dynamic message signs with users before operational start-up.
Update TMC operating procedures to reflect the Special Event Management strategies to be deployed.
Define knowledge, skills and abilities needed for TMC staff to operate the Special Event Management standard operating procedures.
Coordinate with IT networking staff on the integration of 3rd party Traveler Information Systems and Mobility on Demand applications to ensure ongoing data integrity and security of transportation operations control network.
Train Emergency Responders in Special Event Management standard operating procedures.
Train TMC operations and maintenance staff to manage the Special Events Management program.

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