ATLANTA REGIONAL COMMISSION

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Task 6

TSMO Deployment Guide for Local Agencies

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With Support from ICF and ConSysTec

Contents

Guide Purpose

The purpose of the Atlanta Regional Commission (ARC) Transportation Systems Management and Operations (TSMO) Deployment Guide is to help local agencies in the Atlanta region gain a better understanding of TSMO and the opportunities available for applying TSMO strategies. This document provides high-level information and guidance on TSMO strategies and deployment opportunities and what to consider for successful implementation. The Deployment Guide also offers a convenient way to access pertinent national reference material and local regional resources.

Introduction to TSMO

What is TSMO?

Transportation Systems Management and Operations (TSMO) is a set of integrated transportation strategies focused on optimizing the performance of the existing transportation network. Essentially, TSMO focuses on getting the most performance out of the transportation infrastructure that we already have. It involves a wide array of strategies applying technology, coordinating across jurisdictional boundaries, and actively managing transportation demand and supply.

TSMO involves actively managing the multimodal transportation network to optimize performance and deliver improved safety and mobility outcomes.

By deploying TSMO solutions, agencies and departments strive to achieve a range of benefits, including ensuring smoother and more reliable traffic flow, improving safety, reducing congestion, decreasing fuel consumption, enabling cleaner air, increasing economic vitality, and providing for a more efficient use of resources. TSMO requires knowledge, skills, and techniques to implement comprehensive solutions quickly and at relatively low cost. This approach enables transportation agencies to ‘stretch’ their funding, benefiting more areas and travelers, as well as helping agencies provide flexible solutions to an ever-changing transportation landscape by leveraging technology and collaboration.

The importance of TSMO is recognized in Federal transportation law, which seeks to create a more performance-based Federal transportation program. The Moving Ahead for Progress in the 21st Century Act (MAP-21) included an enhanced definition of TSMO, noting that TSMO means “*integrated strategies to optimize the performance of existing infrastructure through the implementation of multimodal and intermodal, cross-jurisdictional systems, services, and projects designed to preserve capacity and improve security, safety, and reliability of the transportation system.*” (23 U.S.C. 101(a)(30)). The subsequent Fixing America’s Surface Transportation (FAST) Act—signed into law in December 2015—further supports TSMO and recognizes the importance of TSMO initiatives. The FAST Act promotes an efficient and performance-based program to address safety, mobility, and reliability challenges that transportation systems and agencies across the nation face.

The Federal Highway Administration (FHWA), Federal Transit Administration (FTA), and other organizations encourage states, metropolitan planning organizations (MPOs), and local governments to focus on TSMO as a cost-effective set of strategies to address transportation challenges. As the MPO for the Atlanta region, ARC has developed a coordinated approach to TSMO for the Atlanta metropolitan area.

Implementing TSMO strategies leads to increased safety, reduced congestion, and improved system performance. Some examples of TSMO strategies include:

- Work Zone Management
- Traffic Incident Management
- Special Event Management
- Road Weather Management
- Transit Management
- Freight Management
- Traffic Signal Coordination
- Traveler Information
- Ramp Management
- Congestion Pricing
- Active Transportation and Demand Management
- Integrated Corridor Management
- Access Management
- Improved Bicycle and Pedestrian Crossings
- Connected and Automated Vehicles

(*FHWA, What is TSMO? https://ops.fhwa.dot.gov/tsmo/*)

It is important to note the distinction between Intelligent Transportation Systems (ITS) and TSMO. While some TSMO solutions may leverage ITS technologies for more efficient, effective management and operations of transportation networks, TSMO goes beyond just the technology side of implementable solutions. A robust TSMO approach requires continued management and operations following implementation as well as improved communication, collaboration, and efficient use of resources among transportation partners. This is a multimodal approach, focused on optimizing efficiency and performance for all modes of transportation.

Why is TSMO Critical to the Atlanta Region: The Business Case

TSMO Addresses Key Transportation Issues of Importance to the Region

The Atlanta Metro area is the ninth largest and one of the fastest-growing metro areas in the nation (https://www.metroatlantachamber.com/resources/reports-and-information/executive-profile). People enjoy everything this diverse region has to offer and have continued to vote Atlanta as a leading place to do business. The transportation network is a foundational element to this continued appreciation, growth, and opportunity. The residents of Metro Atlanta recognize the importance of transportation and have identified it as their top concern in the 2019 Metro Atlanta Speaks Survey which included 5,400+ respondents throughout the 13-county region where the survey is conducted on an annual basis. This is the sixth year in a row that transportation was identified as the greatest concern for participants.

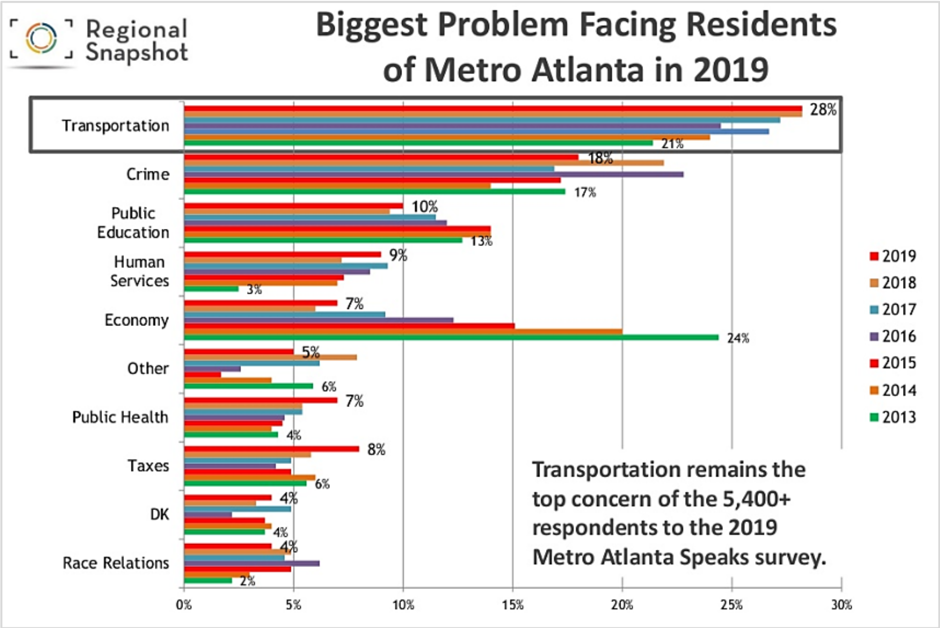

Figure 1: 2019 Metro Atlanta Speaks Survey
(https://atlantaregional.org/atlanta-region/regional-data-resources/metro-atlanta-speaks-survey-report/)

Safe and efficient transportation is an established goal and focus area for those working and living within the metro Atlanta area. In 2018, the State of Georgia suffered over 1500 fatalities due to crashes, with 484[1] of those taking place in the ARC region.[2] Opportunities to increase safety are critical to supporting an effective transportation network.

Likewise, congestion along freeways and arterial roads impact the majority of residents on a daily basis. Congestion creates significant costs to commuters, freight operators, service providers, and the public in the form of time, money, and quality of life. Atlanta has long suffered some of the nation's most congested roadways and if left to the current trend these conditions are only expected to get worse. According to the INRIX 2018 Global Traffic Scorecard[3] that analyzes and ranks over 200 urban areas (across 38 countries), based on congestion and other mobility trends, Atlanta ranks as the 71st worst globally and 11th in the United States. According to the scorecard, on average an Atlanta region resident loses 108 hours annually from being stuck in congestion (10% increase from 2017). This lost time equates to a congestion cost per driver of $1,505 (money wasted on time and fuel, higher costs for goods passed along to consumers, and other expenses). A 2015 travel survey for downtown Atlanta[4] found that over one quarter of individuals alter the time they leave daily to avoid congestion and the same number of respondents change their routes every day in an attempt to avoid congestion. Traffic congestion also contributes to air pollution – the region experiences an average 40 "code orange" days every summer and increased medical issues for residents such as an asthma rate of 11% for the City's children (almost twice the average rate seen in the U.S.). The presence of significant congestion is related to the lack of reliability throughout the region. A congested roadway is much more vulnerable to disturbance from non-recurring congestion, such as an incident, crash, or special event, than a facility that operates below capacity. Unreliable transportation networks present significant costs to public and private users in the form of delay, stress, profitability, quality of life, etc.[5]

As one of the nation's largest hub cities, Atlanta also experiences significant heavy-duty freight vehicles operating within and passing through the city. The American Transportation Research Institute[6] provides an annual measure of freight performance across the United States. Three of the top ten most congested roadways for freight vehicles occurred within Atlanta. Ranked number 2 on this top ten list was Atlanta's I-285 at I-85 (North) intersection often referred to as the "Spaghetti Junction". This area's average speed is approximately 34 miles per hour but can drop to 22 during times of peak use.

With limited funding for transportation, it is critical that regional partners work together to optimize the performance of the transportation network and get the most of the existing system. TSMO strategies can play an important role in managing travel demand on the network, enhancing safety, and improving reliability.

TSMO is Cost-Effective

Non-recurring congestion due to events such as, crashes, roadway incidents, weather conditions, construction, or special events, are typically responsible for over half of the delay on the transportation network in urban areas, according to FHWA. Traditional roadway capacity expansion, i.e. roadway widening, strategies do not directly address these sources of delay and often require

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[1] National Highway Traffic Safety Administration's Fatality and Injury Reporting System Tool (FIRST) https://cdan.dot.gov/query

[2] Henry County, City of Atlanta, Cobb County, Rockdale County, DeKalb County, Gwinnett County, Douglas County, Cherokee County, Fulton County, Fayette County, and Clayton County. https://www.gahighwaysafety.org/research/2018-georgia-traffic-fatality-data/county-data-rankings/

[3] https://inrix.com/scorecard/?

[4] https://www.atlantadowntown.com/_files/docs/downtown-atlanta-travel-survey-vf1.pdf

[5] https://ops.fhwa.dot.gov/publications/fhwahop19062/fhwahop19062.pdf

[6] https://truckingresearch.org/2019/02/06/atri-2019-truck-bottlenecks/

considerable costs. In contrast, TSMO strategies such as incident management, road weather management, and work zone management have demonstrated successful, cost-effective ways to address these issues directly. Furthermore, traditional capacity expansion typically har far more significant capital cost versus typical TSMO strategies. The benefits of TSMO tend to come at a lower cost as compared to traditional capacity expansion, and with higher returns on investment. Figure 2 provides an example of the anticipated benefit to cost ratios of signal timing strategies versus traditional road expansion. This is characteristic of other TSMO strategies as well – optimizing existing infrastructure through technology and low-cost initiatives is cost-effective.

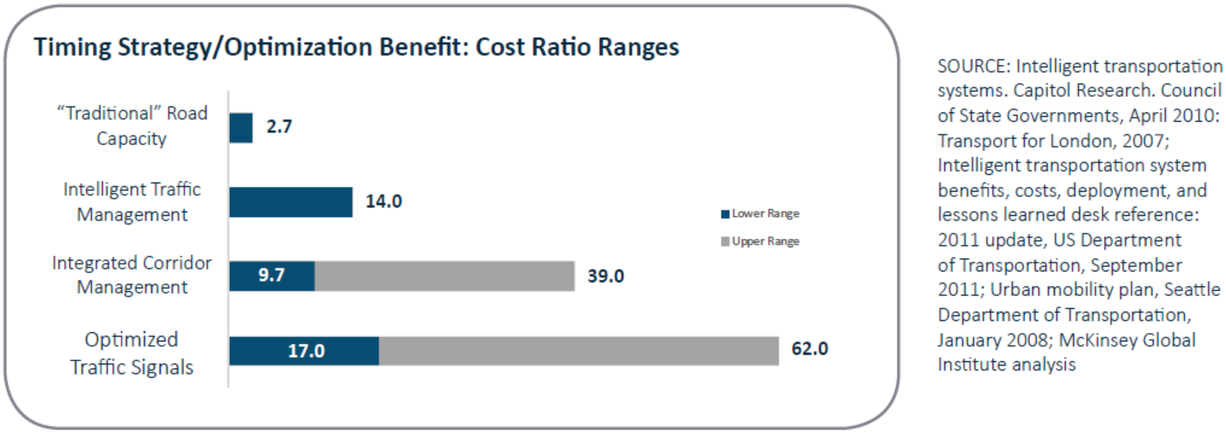


Figure 2: Example TSMO Benefit: Cost Ratio Ranges

This has been proven regionally as well. In a widely cited evaluation study conducted by GDOT in 2006, the 2003/2004 NaviGAtor system was found to provide a 4.4:1 benefit-to-cost ratio[7] with $186.8M in benefits compared with $42.5M cost of the system. The United States Department of Transportation (USDOT) ITS Joint Program Office maintains a clearinghouse of cost and benefit evaluations from across the nation available for review and consideration (https://www.itsbenefits.its.dot.gov/its/benecost.nsf/BenefitsHome).

TSMO Enhances the Traveler's Experience and Quality of Life

Finally, in addition to being cost-effective in addressing safety, delay, and reliability issues, TSMO strategies can enhance the customer experience. Today, people expect real-time information to help them make travel choices and expect that transportation agencies should be using the best available information to manage systems. TSMO can help to ensure more seamless movement between travel options, across jurisdictional boundaries, and simply make life easier for people by improving their experience in transit, on roadways, in bicycling and walking, and in making connections to help them access life's opportunities.

[7] https://ops.fhwa.dot.gov/travelinfo/gdotbenefit/gdotfinalreport_0806.pdf

What is the Vision for TSMO in the Atlanta Region?

TSMO Vision

As part of a strategic planning process, ARC convened stakeholders from across the region to develop a vision for the future of TSMO in the Metro Atlanta region. The resulting vision emphasizes outcomes that support the region's overarching strategy to "Win the Future" through World Class Infrastructure, a Competitive Economy, and Healthy Livable Communities.

The Atlanta region's TSMO vision is as follows:

Transportation systems across the Atlanta region are managed and operated to optimize safe, reliable, and efficient travel for all system users—people and freight—contributing to sustainable economic growth and a high quality of life.

TSMO Goals and Outcomes

This TSMO vision focuses on achieving five overarching goals or outcomes:

Optimizing Safety – *Applying technology and context-sensitive approaches to achieve zero fatalities.*

This goal emphasizes that the way transportation systems are managed and operated should enhance safety of all travelers, including those in vehicles, transit, bicyclists, and pedestrians.

Reliable Travel Times – *Managing planned and unplanned disruptions to reduce unexpected delays.*

This goal involves improving the predictability of travel times by reducing the disruptions associated with nonrecurring sources of delay, such as traffic incidents, weather conditions, work zones, and special events, as well as congestion that disrupts transit schedules and adversely affects on-time performance.

Efficient, Seamless Travel – *Coordinated systems across jurisdictions and modes, and accessible, real-time travel information.*

This goal focuses on the day-to-day travel experience, including the efficiency and connectivity of travel. Strategies to support this goal include coordinated systems across jurisdictions and modes, as well as accessible, multimodal real-time information.

Equitable Access – *People of all ages, abilities, languages, backgrounds, and incomes have access to safe, reliable, efficient mobility options.*

This goal focuses on ensuring that all people benefit from systems management strategies and that these strategies support access, both motorized and nonmotorized.

Environmental Benefit – *Applying technology to reduce energy consumption, improved air quality, and reduced greenhouse gas emissions.*

This goal focuses on ensuring that TSMO strategies support environmental benefits, such as by reducing reduce vehicle travel delay and increasing use of transit, ridesharing, and non-motorized modes.

Foundational Elements

These outcomes will be achieved and delivered through a strong foundation of the following organizational elements:

A regional **operations philosophy focused on moving people and goods**, rather than moving traffic or vehicles, resulting in priority to higher-occupancy modes.

Collaboration across jurisdictional boundaries, public and private sectors, and service providers.

Data sharing across public and private data providers and users.

Advancing application and deployment of innovative technologies and approaches, and fostering **a culture of innovation** and adaptability to change.

These elements were viewed as critical to support the region's TSMO vision and should permeate how local agencies across the region think about transportation technology and TSMO strategy deployments. For instance, in working on strategies to manage traffic congestion, safety, and reliability, local agencies should look for opportunities to collaborate with other local governments and public and private transportation service providers. Collaboration may yield corridor-based or regional solutions, helping to ensure that overall system performance is improved, rather than only spot improvements. In addition, agencies should continually consider not only traffic movement but how system operations can support the mobility of people and goods, resulting in solutions that may identify opportunities to prioritize the speed and reliability of transit, incentivize alternatives to driving alone, or enhance the safety of bicycling and walking.

TSMO Strategies: A Menu of Options

As mentioned previously, there are a number of various strategies and applications that can be used to support ARC's regional TSMO vision and goals. Strategy implementations vary depending on need, context, existing infrastructure and opportunity, on-site technical experience, institutional programmatic and policy environment, etc. It can be difficult to assess and vet potential TSMO strategies, especially if they are unfamiliar. This deployment guide provides basic information about some of the most common TSMO strategy deployments.

It is envisioned that this information will be used as a resource by local agencies in the transportation project development process and as an aide to communicate strategy basics to their staff and/or local decision makers. TSMO strategy sheets are provided at the end of this document and linked below; they are structured as follows:

Strategy Description – briefly describes the TSMO strategy as defined by the Federal Highway Administration (FHWA) and region. The purpose and intent of the strategy is also described.

Support for Regional TSMO Goals – provides a brief description of how the given strategy supports each applicable ARC TSMO goal.

Applications – describes methods and/or applications that are deployed to implement the given strategy. These are typically technology deployments required to support the successful function of the strategy.

Context – TSMO strategies are not applicable in all locations. Understanding the context of a given area is critical to the successful implementation of a strategy. This section provides a brief summary of the varying aspects that need to be considered when implementing a given strategy in various contexts.

Costs, Benefits, and Other Considerations – briefly discusses the costs and anticipated benefits to be considered when pursuing the given strategy.

Regional ITS Architecture and Existing Deployments – this section provides a summary of each application regional ITS Architecture service package. In addition, for those applications that are currently existing throughout the region, some examples are provided for reference.

References – provides some common resources for further, more in-depth information about the given strategy.

The following TSMO strategies and support system have been summarized and are provided in the Appendix.

Traffic Signal Management

Work Zone Management

Connected and Automated Vehicles

Traveler Information

Traffic Incident Management

Emergency Transportation Operations

Transportation Demand Management

Integrated Corridor Management and Managed Lanes

Event Management

Freight Management

Parking Management

Performance Measures

Supporting Deployments

Implementation – Advancing Effective Deployments

Atlanta Regional ITS Architecture

As the federally designated metropolitan planning organization (MPO) for the 20-county Atlanta Transportation Management Area, ARC is responsible for the development, update, and ongoing maintenance of the Atlanta Regional ITS Architecture. The ITS Architecture creates a regional framework that ensures institutional agreement and technical integration for the implementation of ITS projects.

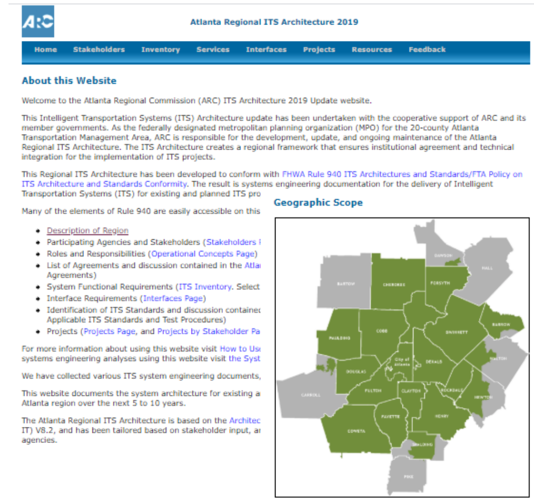


Figure 3: Atlanta Regional ITS Architecture Website

This Regional ITS Architecture has been developed to conform with FHWA Rule 940 ITS Architectures and Standards/FTA Policy on ITS Architecture and Standards Conformity. The result is systems engineering documentation for the delivery of Intelligent Transportation Systems (ITS) for existing and planned ITS projects. The Atlanta Regional ITS Architecture is based on the Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) V8.2, and has been tailored based on stakeholder input, and existing and planned regional ITS projects of stakeholder agencies.

Access to the Atlanta Regional ITS Architecture can be found at: http://www.consystec.com/arc/web/index.htm. This website documents the system architecture for existing and planned ITS system projects that are or will be deployed in the Atlanta region over the next 5 to 10 years.

The website offers many resources to understand existing and planned ITS deployments throughout the region:

- **Stakeholders** – Documents the Stakeholders. Inventory, services, and projects are provided by Stakeholder. In addition, roles and responsibilities (Operational Concepts Page) are defined by Stakeholder.
- **Inventory** – Documents inventory by alphabetical order and by Stakeholder. In addition, physical object definitions are provided.
- **Services** – List of service packages by area and Stakeholder are provided. In addition, service package definitions are provided.
- **Interfaces** – Documents and defines interfacing elements and information flow.
- **Projects** – Planned and ongoing project are listed by name and Stakeholder.
- **Resources** – Provides demonstration of how to best use the ITS Architecture as well as contact information for questions.
- **Feedback** – Outlet to provide general or specific update information.

Local agencies will find the ITS Architecture website to be a useful resource not only for systems engineering information, but also to understand the existing ITS infrastructure and integration throughout the region.

Systems Engineering Framework

Intelligent transportation systems projects funded by the Highway Trust Fund through the FHWA and FTA are required to undergo a systems engineering analysis. Systems engineering is recognized as a proven approach to successfully develop, design, integrate, manage, operate, and eventually, retire an ITS project. Systems engineering analysis considers the complete lifecycle of a proposed project. The lifecycle approach helps define the concept of how a given project will operate, the roles and responsibilities of stakeholders, and the functional requirements early in the process, increasing the efficiency and successful implementation of the project. This is of heightened importance when new project types or systems are being deployed. Clearly defining how the anticipated deployment will work as well as identifying all of the affected stakeholders allows for a more efficient deployment and provides a potential opportunity for collaboration. Coordination conducted at the onset of project development can be hugely beneficial in identifying project pitfalls and integration challenges.

The “V” diagram shown in Figure 4 was first developed in the 1980s and has evolved as a standard way to represent systems engineering for ITS projects.

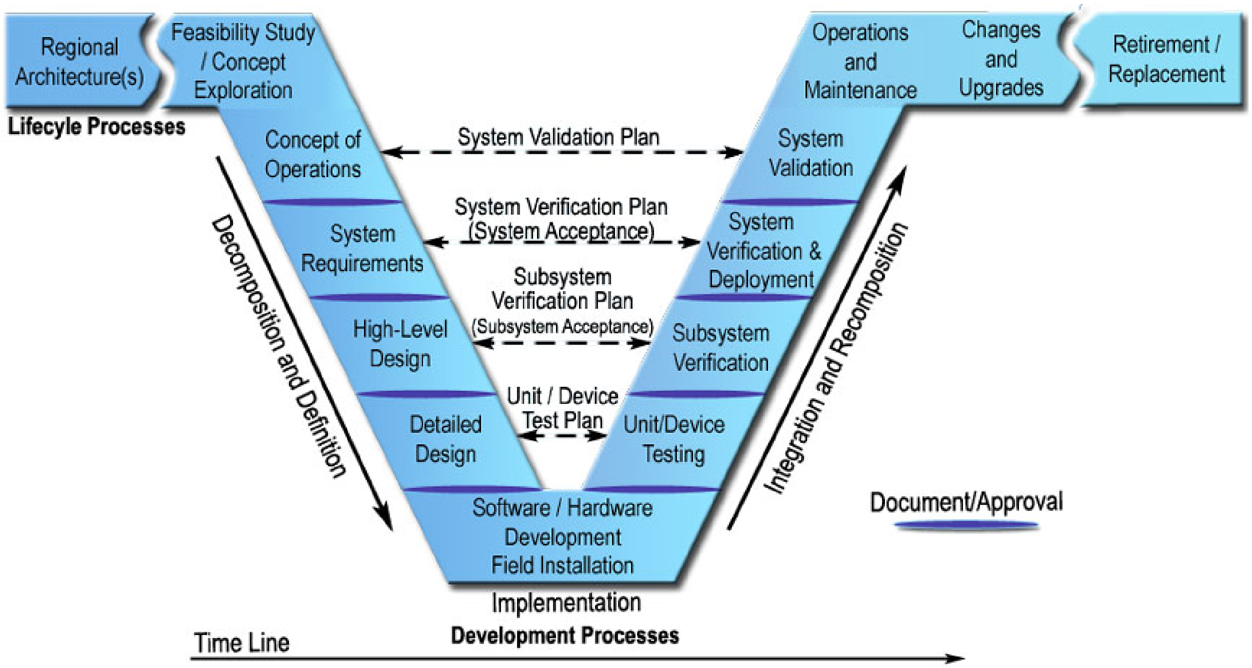


Figure 4: Systems Engineering “V” Diagram – FHWA (source: https://ops.fhwa.dot.gov/publications/seitsguide/index.htm)

The first element identified in the “V” diagram references the Regional ITS Architecture as was described in the previous section. The “V” diagram is symmetrical and reflects the relationship between the left and right sides of the diagram which defines how the deployment will be tested, verified, accepted, and validated. A systems engineering checklist is provided in the **Appendix** to be used as a high-level guide.

Technology Considerations

Technology can be challenging to deploy particularly if it is a new system or requires integration and connectivity with pre-existing systems. Typical technology deployments require increased coordination, often with multiple departments with varying roles, responsibilities, requirements, and technical experience. The use of the systems engineering process is vital to the success of these types of projects as described above.

In addition, the importance of the following considerations is heightened:

Stakeholder Coordination
It is extremely important that all Stakeholders are brought in during the initial stages of development. This includes those who will be responsible for maintaining the system components after it is deployed, often agency Information Technology (IT). It is critical that the goal and key functional requirements be communicated and supported by Stakeholders early in the process so that the system may be designed and implemented in an efficient manner.

Communication Network
As the transportation industry continues to rely more on technology, the dependency upon the supporting communication network continues to grow. Often, the communication network is not managed by the same Stakeholder as who is responsible for the technology deployment. Likewise, these Stakeholders may have different technical experience and responsibilities which can add complexity to the successful deployment and integration of a project. It is critical to consider how the communications network will support the technology deployment during initial deployment and potential future expansion. Things to consider include, bandwidth and latency requirements, uptime requirements, network access, technology hardware and network security, necessary system upgrades, regular system maintenance requirements, etc.

Data Considerations

TSMO projects are by definition cross cutting and data driven. Data access, collection, cleansing, validation, management, integration, processing, storage and analysis are critical elements involved in planning, operating and maintaining data sets. Furthermore, adapting a regional approach to data sharing and governance processes provides a means to “future-proof” and sustain TSMO systems as technologies and technical innovation change. Data governance policies require that data be consistent and complete across modes, agencies, and systems. For example, use of different base maps that have no context (e.g., common street names) will cause inconsistent placement from one base map to another; unpublished data, inconsistent naming conventions, differences in data semantics, and multiple, duplicative values for enumerated types may challenge queries, analysis, and performance metrics. In addition, with the advent of “big data” and data streaming sources such as connected vehicles and internet of things (IoT) sensors, real time data will be added that will need to be considered for sharing.

Regardless of how advanced an agency may be, every organization will likely experience challenges when implementing TSMO strategies. This is in part because TSMO systems are multi-agency and multimodal in nature, requiring organizations to think outside their own structure for data sources and end-users. In addition, data should conform to a minimum quality, standardized formats, and regional terminology and meaning. Many of these challenges may be addressed by establishing clear policies, procedures, and standards that explain processes for managing data. These policies are typically established at an executive level but implemented at a project and local level.

Agencies seeking to deploy any new data-dependent/producing technology/approach, such as TSMO strategies, can increase the maturity of their data management framework by:

- Publishing specifications or conforming to data specifications (e.g., GTFS, Work Zone Data Exchange, Traffic Management Data Dictionary) for data consumed and produced by a project that can be shared with other regional stakeholders.
- Generating a reference data dictionary of the data needs (input/output) to ensure consistent meaning of key data throughout the region, including establishing minimum quality requirements for key data.
- Listing the data set specifications in the Regional Data Set Inventory.
- Provisioning the data with the regional data platform (e.g., GDOT’s Connected Data Platform).

As the regional data management processes mature, data discovery, access and management tools will improve, become easier to use and replace manual processes. Guidance associated with “data considerations” applies to all stages of project management—from initiation to retirement.

Data Policy Considerations

In general, agencies should develop and implement processes for data collecting, cleansing, access and sharing, storage and archiving, analyzing, and protecting the data used for TSMO strategies and projects. The processes should align with regional effort to govern and share relevant information.

- **Data Management -** A detailed description of the data (data descriptions, concepts, and minimum quality requirements), its owners / custodians, and curation processes including the lifecycle procedures, sources, destinations, content, and flow.
- **Data Privacy -** The proposed approach to manage and maintain privacy where needed. This should clearly state the technical, policy, standards, and physical controls that will be used to ensure privacy, including project staff and participants compliance with stablished privacy policies.
- **Data Sharing Issues -** How the data will be shared with the public, within the host agency, with other public agencies and any other interested parties. This should also define the procedures to ensure the proper handling of protected intellectual property rights and personal privacy.
- **Data Governance -** The rules of engagement for how institutions (people and policies) manage and sustain data across the region and over its lifecycle. Establishing data governance goes beyond individual agency needs by describing regional quality / fitness for use, format and semantics, data discovery, access, and storage, and continual data improvement and expansion

Many organizations that adopt data governance practices recognize the need to undergo a cultural transformation, changing the ways individuals and systems handle and process data.

Funding Opportunities

TSMO strategies can be funded through a wide variety of sources, including Federal, State, regional or local funds. When exploring possible deployments of new technologies or seeking to implement new strategies, local agencies should be aware of and consider several possible sources of funds, including regional, state, local, federal, and public-private partnerships.

ARC’s Regional Funding Opportunities

As the federally-designated MPO for the Atlanta region, ARC works with partners to prioritize federal funding for transportation projects in the 20-county region. ARC regularly conducts regional “project solicitations" or "calls for projects" to identify potential projects for funding assistance as part of the development of the Transportation Improvement Program (TIP) for the region (https://atlantaregional.org/transportation-mobility/transportation-planning/tip-project-solicitations/). In total, ARC manages approximately $117 million in federal funds annually. Primary sources of federal funding come from the Surface Transportation Block Grant (STBG) program, including the Transportation Alternatives program, and the Congestion Mitigation and Air Quality Improvement (CMAQ) program. The call for projects does not focus on a single funding category but is universal. ARC staff evaluates the submitted projects using the Project Evaluation Framework (link: https://cdn.atlantaregional.org/wp-content/uploads/project-eval-documentation-2019.pdf), which includes policy filters to determine eligibility and then score the eligible projects to ensure that projects support regional policy, and then evaluate and score the remaining projects on technical merit and additional qualitative factors. TSMO strategies can be incorporated into projects proposed for funding through this process or could be identified as projects within a TSMO category.

Some of the federal funding sources specifically support projects that can include TSMO activities. For instance, the CMAQ program is focused on reducing congestion and improving air quality, and ARC has developed CMAQ program emphasis areas, which include travel demand management, transit service start-up operation, roadway ITS/operations/incident management, bicycle/pedestrian projects, and managed lanes. As a result, federal CMAQ funding may be used to support TSMO-focused projects.

ARC's Livable Centers Initiative (LCI) (https://atlantaregional.org/community-development/livable-centers-initiative) provides funding for studies and transportation projects located in activity and town centers that promote increased density, a mix of land uses, housing for people of all income levels, and multi-modal transportation options. Only certain projects are eligible for LCI funding, and for projects submitted in the TIP call for projects that meet the LCI eligibility criteria, additional evaluation is conducted to determine which projects that are the best fit for the program. These evaluation criteria include promoting walkability, innovation (e.g., curb management for deliveries, shared mobility devices, or connected vehicle technology), and providing access to transit, and TSMO strategies may be integrated into project concepts that could receive LCI funding.

Federal Grants and Funding Opportunities

In addition to federal funding programs managed through the TIP solicitation process, there also have been a number of federal discretionary funding programs solicited over the past several years, and additional federal grant opportunities may emerge in the future. Examples of recent opportunities include the U.S. Department of Transportation's Smart City Challenge (https://www.transportation.gov/smartcity); the Federal Transit Administration's (FTA) research and innovation initiatives such as, Mobility on Demand Sandbox, Integrated Mobility Innovation (IMI) Program, Safety Research and Demonstration (SRD) Program, and the Accelerating Innovative Mobility (AIM) initiative (https://www.transit.dot.gov/research-innovation); the Federal Highway Administration's (FHWA) Advanced Transportation and Congestion Management Technologies Deployment (ATCMTD) initiative (https://ops.fhwa.dot.gov/fastact/index.htm); and the DOT's Accessible Transportation Technologies Research Initiative (ATTRI) (https://www.its.dot.gov/research_areas/attri/index.htm).

State and Local Funds

Other resources may be available from state and local funding sources to support TSMO strategy development and implementation. For instance, Georgia Department of Transportation (GDOT) funds projects using a mix of state and federal funds allocated to the agency. MARTA is funded in part through sales taxes in three counties it serves: Fulton, DeKalb, and Clayton. Many of the region's counties fund transportation and other infrastructure projects with Special Purpose Local Option Sales Taxes (SPLOSTs), and some jurisdictions have Transportation SPLOSTs (T-SPLOST) where 100% of the revenue collected is dedicated to transportation projects. Through these and other funding sources, agencies may implement TSMO-oriented projects which typically require lower capital funding as compared to other traditional transportation projects, making 100% local funding more attainable.

Public-Private Partnerships

Finally, local agencies may have opportunities to partner with the private sector to test and implement new technologies, and there are other opportunities for businesses and the private sector to engage. For instance, by utilizing self-imposed tax revenues from commercial businesses, Community Improvement Districts (CIDs) have opportunities to advance innovations in TSMO. From opportunities to integrate technology into infrastructure to traffic mitigation, shared mobility, and bicycle/pedestrian-oriented projects, CIDs are a mechanism for integrating TSMO into efforts to enhance the local landscape regarding mobility. Increasingly, private sector technology firms and transportation network companies are interested in experimenting with new travel options and create new opportunities for local agencies to work with to improve mobility and transportation system outcomes.

Reference Material

There are a wide array of resources available on TSMO that may be helpful to local agencies. Below are identified some useful starting points and references for learning more about TSMO strategies and effective practices.

General Resources

- Federal Highway Administration (FHWA)
  - TSMO website provides information about TSMO and associated strategies (https://ops.fhwa.dot.gov/tsmo/)
- National Operations Center of Excellence (NOCoE)
  - Provides resources including links to research, case studies, and webinars. Its Knowledge Center features recorded webinars and presentations. (https://transportationops.org/overview-nocoe-and-its-programs)
- Institute of Transportation Engineers (ITE)
  - Provides links to a wide array of publications. (https://www.ite.org/technical-resources/topics/transportation-system-management-and-operations/resources/)

More Specific Resources

More specific resources on state, regional, and national TSMO initiatives are available from various sources. Some potentially useful ones include:

- GDOT Specs
  - The Regional Traffic Operations Program (RTOP) Concept of Operations (ConOps) highlights the role traffic signals play in influencing traffic flow on GDOT's roadways (https://atlantaregional.org/wp-content/uploads/2011-gdot-rtop-con-ops.pdf).
  - The Statewide Traffic Operations and Response Management Program ConOps (2019) informs the process GDOT uses to gather data and implement the Statewide Traffic Operations and Response Management (STORM) program (https://s3.amazonaws.com/gdot-spm/GDOT_STORM-COO.pdf).
  - The State of Georgia Department of Transportation Design Policy Manual establishes design guidelines and standards for GDOT to use to design roadways and related infrastructure (http://www.dot.ga.gov/PartnerSmart/DesignManuals/DesignPolicy/GDOT-DPM.pdf).
- The Manual on Uniform Traffic Control Devices (MUTCD) for Streets and Highways defines standards for road managers to use to install and maintain traffic control devices on all public

streets, highways, bikeways, and private roads open to public travel (https://mutcd.fhwa.dot.gov/).
  - GDOT Presentation on MUTCD highlights what the MUTCD is, its history, how it is put together, requirements, and updates made to it (http://www.dot.ga.gov/AboutGeorgia/Board/Presentations/MUTCD.pdf).
- Urban Street Design Guide
  - The NACTO guide (*not free) provides numerous elements necessary to develop a 21st century street that is safe, livable, economically vibrant, and functions together as a complete street (https://nacto.org/publication/urban-street-design-guide/).
  - ARC Strategic Regional Thoroughfare Plan contains policy and design guidelines developed to help streamline goals for the regional thoroughfare network (RTN) (http://documents.atlantaregional.com/transportation/tp_SRTP_Design_Guidelines.pdf).
  - Georgia DOT Pedestrian and Streetscape Guide contains best practices necessary to design streets and roadways in a manner supportive of safe multimodal travel (http://www.dot.ga.gov/PartnerSmart/DesignManuals/TrafficOps/GDOT%20Pedestrian%20and%20Streetscape%20Guide.pdf).
- Global Street Design Guide
  - The NACTO guide (*not free) sets a global baseline for designing streets and public spaces, and provides measures to rate urban street success factors (https://nacto.org/publication/global-street-design-guide/).
- Urban Bikeway Design Guide
  - The NACTO guide (*not free) provides state of the art solutions to help create complete streets with required, recommended, and optional as the three levels of guidance (https://nacto.org/publication/urban-bikeway-design-guide/).
    - Albeit old, the 2011 free edition provides cities with guidance to help create quality complete streets. (http://www.ocpcrpa.org/docs/projects/bikeped/NACTO_Urban_Bikeway_Design_Guide.pdf).
- Transit Street Design Guide
  - The NACTO guide (*not free) provides details on numerous components necessary to design and promote transit facilities on city streets (https://nacto.org/publication/transit-street-design-guide/).
- Traffic Signals
  - FHWA Traffic Signal Timing Manual (archived version) provides the principles of basic traffic signal timing at an intersection (https://ops.fhwa.dot.gov/publications/fhwahop08024/chapter5.htm).
  - TRB Signal Timing Manual Second Edition (*needs subscription) provides the fundamentals and advanced concepts related to street signal timing relative to operating environments, users and user priorities, and local operational objectives (http://www.trb.org/OperationsTrafficManagement/Blurbs/173121.aspx).
- Highway Capacity Manual (HCM)
  - The TRB HCM (*not free) provides methods for quantifying highway capacity and provides vast details (http://www.trb.org/Main/Blurbs/175169.aspx).
  - FHWA HCM Methodology for Alternative Intersections/Interchanges summarizes the project objectives, project tasks, alternative intersection/interchange designs studied, and contributions to the research team's discussion that went into the development of the HCM (https://www.fhwa.dot.gov/publications/research/operations/datamodelsims/13083/index.cfm).
- FHWA TSMO Planning Guidance

  - "Developing and Sustaining a Transportation Systems Management and Operations Mission for Your Organization: A Primer for Program Planning" is designed to help transportation agencies understand what TSMO is and what the key elements of a TSMO program are (https://ops.fhwa.dot.gov/publications/fhwahop17017/index.htm).
  - FHWA TSMO Plans website gives an overview of TSMO, why some agencies find it beneficial, and provides links for further information (https://ops.fhwa.dot.gov/plan4ops/focus_areas/integrating/transportation_sys.htm)
- FHWA Active Transportation Demand Management (ATDM) Guidance
  - The ATDM Link webpage gives a description of Active Transportation and Demand Management and provides links for further reading (https://ops.fhwa.dot.gov/atdm/index.htm).
- The "Active Traffic Management (ATM) Implementation and Operations Guide" webpage provides an HTML version of a full ATM and Operations Guide, which seeks to improve agencies' capabilities to improve trip reliability, safety, and throughput of the surface transportation system with operational strategies (https://ops.fhwa.dot.gov/publications/fhwahop17056/index.htm).

TSMO Strategies: A Menu of Options

TRAFFIC SIGNAL MANAGEMENT

Effective traffic signal management is proven to be one of the most cost-effective operational improvements; signal retiming typically provides a benefit to cost ratio ranging from 17:1 to 62:1.

Traffic signals, one of the most common form of traffic control, are crucial to a transportation network and can enhance corridor operations. Efficiently managing traffic signals results in reduced congestion, reduced maintenance expenditures, and increased safety. FHWA defines traffic signal management as “organizing for the planning, maintenance, design, and operation of signalized intersections and traffic signal systems.” Traffic signal timing programs can be basic and localized, controlling a single isolated intersection, more advanced, linking multiple intersections together in move vehicles along a corridor, and even more sophisticated, using approach volumes and vehicle density to control how groups of signals operate. Such systems require regular maintenance and frequent monitoring to maintain the efficiency of the signal system.

Support for Regional TSMO Goals

Optimizing Safety

Safety is enhanced with the use of traffic signal management by enhancing progression through intersections, which requires less stop-and-go traffic to reduce the number of crashes. In addition, emergency vehicle preemption reduces the risk for crashes by allowing the emergency vehicle to progress through the intersection with the appropriate signal indication.

Reliable Travel Times

More reliable travel times are realized through traffic signal management by enhancing the operational efficiency of corridors—getting more cars through a given corridor more effectively.

Efficient, Seamless Travel

Traffic signal management supports efficient, seamless travel by synchronizing the movement of vehicles along the corridor, ideally to prevent things such as “hitting every red light.” By maintaining the signal system as well as adjusting the system as needed through frequent monitoring, traffic system management can also support efficient seamless travel by reducing the number of down devices or mistimed intersections due to out-of-date cycles.

Environmental Benefits

Reducing the congestion of high-volumes routes results in fewer vehicles idling and producing emissions. Reducing the amount of starts and stops that a motorist experiences will also reduce the amount of emissions produced by each vehicle.

Applications

Applications used to manage traffic signals vary widely in complexity and technology; from basic signal timings to coordinated systems that rely on real-time detection data and advanced software systems. With the use of coordination and communication between signals, traffic devices can adjust based on current traffic conditions—travel patterns along major corridors change significantly throughout the day due to commuter, school, shopping, special events, and other activities that generate traffic. Having signals and other supportive devices communicate with each other to respond to current conditions provide significant safety and mobility benefits and allows for a flexible system that responds to ever-changing corridor needs.

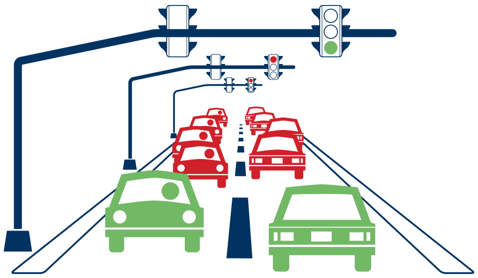
TRAFFIC SIGNAL MANAGEMENT

ATLANTA REGIONAL COMMISSION

Basic Signal Timings

Uncoordinated Operation

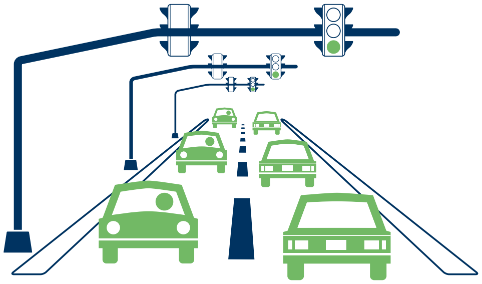
Uncoordinated signal timings serve movements at a single intersection based on current demand by using minimum and maximum timers and detection data. This signal timing works well with low volumes or large distances between signalized intersections. However, the lack of coordination can lead to increased stops, congestion, and driver frustration if a driver is required to stop at every traffic signal along a route.



Advanced Signal Timings

Coordinated Operation

Closely spaced signals with high traffic volumes require more advanced signal timing strategies. By programming traffic signal controllers along a corridor to operate in sync with one another, engineers are able to move platoons of vehicles through an area an minimize stops. By reviewing turning movement count and AADT data, specific signal timing plans are developed and implemented throughout the day in order to keep traffic moving along the major corridor without causing major delays along the side streets. Without coordination, drivers will experience increased stops, major congestion, and an increase in frustration. By connecting coordinated traffic signals to ITS and Communication infrastructure, engineers can ensure that the signals stay in sync throughout the hours of coordinated operation.



Sophisticated Signal Timings

Responsive Signal Timings

Responsive signal timings evaluate real-time data collected from detectors and adjust coordinated signal timings per cycle using parameters defined by *predetermined timing plans*. This signal timing is used when traffic patterns along a signalized corridor are variable and unpredictable, often times during special events, construction, or incidents.

Adaptive Signal Timings

Adaptive signal timings evaluate real-time data collected from detectors and adjust coordinated signal timings per cycle determined by automated calculations of optimal signal timings. The use of automated algorithms vs. predetermined timing plans is the key difference between responsive and adaptive signal timing. This signal timing is used when traffic patterns along a signalized corridor are variable and unpredictable, often during special events, construction, or incidents.

Preemption and Priority

Emergency Vehicle Preemption (EVP)

Emergency vehicle preemption involves communication between an emergency vehicle and traffic signals. The emergency vehicle transmits a signal that is received by the traffic signal controller which then provides a green signal in the direction of travel so that the emergency vehicle can safely and quickly travel through the intersection. This application can be accomplished through a variety of methods:

- Station activation – when an emergency vehicle leaves a given station, the system is activated. The system sends a command to the traffic signals along a predetermined route that then cycle to provide green in the direction of emergency vehicle travel for a given amount of time.
- Dynamic activation – the emergency vehicles are equipped with an on-board unit or piece of hardware which sends a signal to a receiver at a traffic signal. The message is received and the signal cycles to provide green in the direction of emergency vehicle travel for a given amount of time.

Transit Signal Priority (TSP)

Transit signal priority involves communication between a transit vehicle and traffic signals. The communication results in additional green time in the direction of travel so that the transit vehicle may progress through the signal without stopping.

Contexts

Urban

Traffic signal management in an urban setting typically relies on pretimed operation as the signals are closely spaced and coordination is needed in several directions. Creating, updating, and implementing these plans can require significant effort and coordination between city, county, and state agencies. Urban settings also tend to include more modes of transportation than other areas, including public transit, biking, walking, and micro-mobility options. Keeping these modes in mind while planning timing strategies is critical.

Suburban

Suburban routes typically have heavy peak directional traffic, serving inbound and outbound commuters. Creating signal timings that optimize directional flow during these peaks will help reduced congestion and delay experienced by the motorists. Developing off-peak and balanced signal timing plans to operate during less congested times of the day will help support traffic flow throughout the area. Increased connectivity and advancing technology are making it easier to install and operated EVP and TSP systems at all intersections. Installing these devices can help decrease transit travel times and increase safety for emergency vehicles as well as the general public.

Rural

Traffic signal management in rural settings tend to have lower volumes, random vehicle arrivals, and large spacing between traffic signals. Focus is typically on individual signals, uncoordinated movements and intersections. Optimization of uncoordinated timings will help reduce delay for motorists traveling through these areas. New technologies can be installed at these locations to provide EVP opportunities or enhanced safety systems that provide additional time to allow for trucks to safely travel through the intersection.

Regional Examples

The following chart provides a few regional examples of current traffic signal management applications and associated ITS architecture service packages:

Application	Location and Deployment Type
Advanced Signal Timing (TM03: Traffic Signal Control)	GDOT RTOP (throughout RTOP corridors): MaxView/Max Time ARC Region: MaxView/MaxTime (primary) Sandy Springs Transportation Services: TACTICS
Responsive Signal Timing (TM03: Traffic Signal Control)	GDOT RTOP (key RTOP coordinated systems): MaxView/MaxTime
Adaptive Signal Timing (TM03: Traffic Signal Control)	Sandy Springs Transportation Services: SCOOT Marietta Traffic Operations: SCATS Johns Creek Traffic Engineering: CENTRACS Cobb County Department of Transportation: SCATS
Emergency Vehicle Preemption (PS03: Emergency Vehicle Preemption)	Marietta Traffic Operations: Glance Atlanta Office of Transportation: Glance
Transit Signal Priority (PT09: Transit Signal Priority)	Marietta Traffic Operations: Glance

References

The following references are useful for further understanding, planning, and implementing traffic signal management.

Georgia Department of Transportation (GDOT) Traffic Signals

http://www.dot.ga.gov/DS/SafetyOperation/TrafficSignals

The GDOT provides resources, including, the Traffic Signal Design Guidelines, state Qualified Products List (QPL), and general information about current initiatives and Programs.

FHWA Traffic Signal Timing Manual – Second Edition

http://www.trb.org/OperationsTrafficManagement/Blurbs/173121.aspx

This manual offers information on fundamentals and advanced signal timing concepts. In addition, information about the systems engineering process, adaptive signal control, priority/preemption, and strategies for over-saturated conditions, special events, and inclement weather are included.

FHWA Traffic Signal Management Plan Guidebook

https://ops.fhwa.dot.gov/publications/fhwahop15038/index.htm

The FHWA Traffic Signal Management Plan Guidebook provides direction on how to better manage traffic signal systems through systematic alignment of maintenance, design, and operations activities and resources. A well-organized traffic signal management plan will provide multiple benefits to an agency. It will also:

- Document what traffic signal maintenance, operations, and design staff do, why they do it, and how their activities support the agency's goals and objectives.
- Provide a firm basis to support maintenance and operations as well as capital budgets.
- Facilitate succession planning and integration of new staff into the organization.
- Specify a logical framework within which staff training can be planned and organized.
- Help agencies become less dependent on key individuals, reduce ad hoc procedures and provide organization and structure for the agency’s activities.

USDOT ITS Knowledge Resources

https://www.itsbenefits.its.dot.gov/its/benecost.nsf/BenefitsHome

This resource provides an expansive clearinghouse of cost and benefit information pertaining to traffic signal management as well as other transportation technology deployments. Agencies nationwide provide open access to their costs, evaluations, and lessons learned.

WORK ZONE MANAGEMENT

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Work zones are a crucial and necessary component of the infrastructure maintenance and construction process but can also impose safety and congestion challenges. Actively managing work zones mitigates and minimizes these challenges. **Using a consistent, smart approach can increase safety for both motorists and workers, minimize delays, help complete construction more efficiently, and maintain access to residential and business developments.**

Source: Federal Highway Administration

Support for Regional TSMO Goals

Optimizing Safety

The primary purpose of work zones is to provide a safe environment for workers and travelers during the maintenance and infrastructure expansion and improvements. Work zones accomplish this by providing physical separation between traffic and workers, lowering travel speed to reduce the likelihood of crashes, and providing contextual guidance to motorists. Creating and implementing a consistent approach to work zone management will create an environment which increases the safety of both workers and travelers by limiting exposure to unique or ineffective work zone strategies.

Reliable Travel Times

Work zones are a necessary part of maintaining or upgrading transportation networks that can lead to increased travel times by reducing road capacity, lowering speed limits, and creating a working environment that changes to accommodate construction actives. These increased travel times can be minimized or prevented by introducing work zone management strategies that prioritize detour routes, provide real-time traveler information to the public, or limit the hours in which construction activities can occur.

Environmental Benefits

Reducing the congestion in work zones results in fewer vehicles idling and producing emissions. Reducing the amount of starts and stops that a motorist experiences will also reduce the amount of emissions produced by each vehicle.

Applications

Technology applications can be used to increase safety in work zones while minimizing delay. To properly and effectively deploy technologies to increase the effectiveness of work zones, it is important to provide direct and consistent coordination between government agencies, construction managers, and construction companies. This coordination will help clarify current construction schedules, maintain or update work zone plans, and allow government agencies to deploy appropriate technologies that best address the needs in the field.

Real-Time Traveler Information

Real-time traveler information can be provided to motorists using portable, changeable message signs, connected vehicle applications, or Transportation and Demand Management (TDM) strategies. By providing real-time information to travelers at multiple stages of their trip, frustration can be reduced, detour or alternate routes may be selected, or alternate modes and trip times may be selected.

Variable Speed Limits

Variable speed limits monitor the downstream flow speed and adjust the upstream flow accordingly to match. Applying variable speed limits help reduce speed, especially as traffic enters work zones, increasing the overall safety of the work zone and reducing the potential for queueing at bottlenecks within the work zone. This application is typically deployed near the entrance to the work zone, periodically throughout the work zone, and at lane reductions. Variable speed limit signs can be used in conjunction with automated speed enforcement and real-time traveler information to increase its impact.

Source: Federal Highway Administration

Automated Speed Enforcement

Automated speed enforcement utilizes portable devices to display posted speed limit and detect the speed at which motorists are traveling. Active enforcement is considered the most effective way to reduce speeding in work zones, however, work zones are not typically conductive to active enforcement due to the potential lack of safe areas where vehicles can pull off the roadway. Notifying motorists in advance about the presence of the devices helps persuade motorists to follow posted speed limits and can provide them a grace period to recognize the speed at which they are traveling and slow down. Reducing and normalizing the speed of vehicles promotes a safer working environment and reduces the likelihood of speed variation if a crash occurs.

Dynamic Lane Merge

Dynamic lane merge systems function by measuring the downstream flow of traffic and notifying motorists approaching the merge point to merge early, in free flow and low-density conditions, or late in low speed and high-density conditions. Dynamic lane merge systems have been shown to reduce travel time, increase vehicle throughput, and reduce aggressive driving behavior.

Queue Warning System

Queue warning systems utilize portable, changeable message signs and detection systems to alert motorists about stopped traffic before they arrive to the impacted area. Queue warning systems are needed in areas where driver awareness is low such as temporary lane closures or rural locations, and areas of increased safety risk such as locations with large proportion of trucks or locations with limited shoulder access. Queue warning systems have been shown to reduce the likelihood and severity of rear-end crashes and eliminate motorist surprise to stopped or slowed traffic.

Source: Texas A&M Transportation Institute

Construction Management Strategies

Although not a deployment of technology, the following construction management strategies can be deployed to provide a safer and more efficient driving experience while saving time and money.

Coordinating Construction Projects

Large scale coordination of construction projects between agencies can reduce the amount of time that work zones are active, thereby reducing exposure of workers and motorists. This strategy will result in reduced costs by eliminating duplicate work and will provide agencies with a better understanding of upcoming construction projects that impact their areas.

Road Closures

Although complete road closures are undesirable in most conditions, implementing this strategy can limit the motorist and worker exposure. Allowing for strategic complete road closures can increase the speed of construction thereby saving money and reducing the exposure of workers and travelers. This strategy should only be deployed when appropriate detour routes are available.

Design-Build

Design-build projects can speed construction completion by leveraging new technologies and innovations. Work zone performance measures can be deployed in these projects which allow contractors more flexibility to close additional lanes during periods when congestion is low. Performance measures can also be used to provide incentives for contractors to meet certain standards in the work zone. The presence of these incentives can result in work zones that provide safe working and travel conditions

Source: Federal Highway Administration

Night Work/Off-Peak Work

Limiting construction activities to periods of low volumes will reduce the delay caused by construction activities. This strategy will also reduce the exposure to workers and motorists by working during low volume periods. This strategy should be deployed for strategically as the construction period will have to be extended to accommodate a shorter working schedule.

Contexts

Urban

Urban settings typically have less right-of-way (ROW) to complete construction activities compared to Suburban or Rural settings. Less ROW results in a more compact work zone or a greater reduction of lanes. Implementing work zone strategies that prioritize detour routes or alternate mode choice will provide safety and operational benefits in urban settings.

Suburban

Suburban settings are subject to limited ROW, high speeds, and high volumes. These elements combine to create a dangerous situation if the proper work zone strategies are not deployed. Specifically, looking for work zone strategies that support lowering the travel speed will provide a large benefit in suburban settings. Additionally, limiting construction activities to off-peak hours in suburban settings will provide safety benefits as well.

Rural

Rural settings are subject to low volumes but high speeds. Implementing strategies that lower travel speed while alerting motorists to down stream construction activities will provide safety and operational benefits in rural settings.

Regional Examples

The following chart provides a few regional examples of current work zone management application and associated ITS architecture service packages:

Application	Location and Deployment Type
Real-time Traveler Information (TI01: Broadcast Traveler Information and TI02: Personalized Traveler Information)	GDOT Traffic Operations: Georgia 511 Gwinnett County Department of Transportation: GC Smart Commute Cobb County Department of Transportation: Cobb Commute
Variable Speed Limit (TM20: Variable Speed Limits)	This application has been removed by GDOT Traffic Operations.

References

The following references are useful for further understanding, planning, and implementing work zone management.

Georgia Department of Transportation (GDOT) Work Zone Safety
http://www.dot.ga.gov/DS/SafetyOperation/Workzone
The GDOT provides information and resources pertaining to the importance and promoting safety within work zones.

FHWA Work Zone Management Program
https://ops.fhwa.dot.gov/wz/index.asp
The FHWA Work Zone Management Program is working to "make work zones work better" by providing transportation practitioners with high-quality products, tools, and information that can be of value in planning, designing, and implementing safer, more efficient, and less congested work zones. The Work Zone Management Web site serves as a central location for work zone-related resources and is updated with new information and resources on a frequent basis.

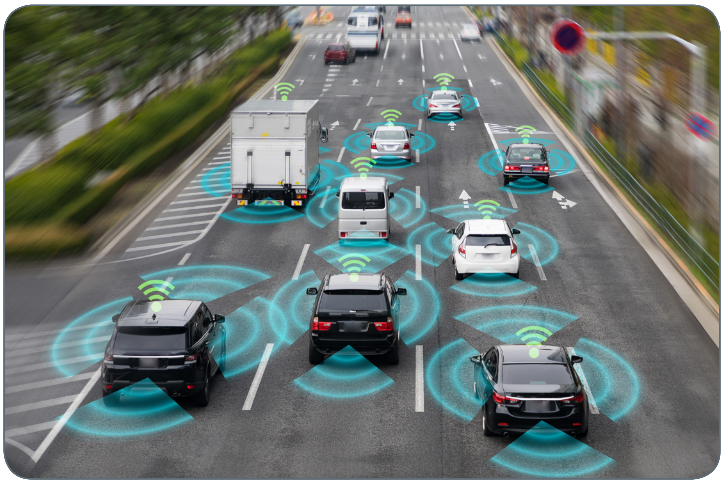
USDOT Work Zone Management Program
https://collaboration.fhwa.dot.gov/wzmp/default.aspx
The Work Zone Management Program Collaboration Site serves as a platform to share specific information on the FHWA Work Zone Management Program initiatives, cross-pollinate best practices and strategies, as well as collaborate on the Work Zone Data Initiative.

USDOT Work Zone Data Initiative
https://collaboration.fhwa.dot.gov/wzmp/wzdi/Forms/AllItems.aspx
Work Zone Activity Data (WZAD) is the "what," "where," and "when" of work zone activities. FHWA's Work Zone Data Initiative (WZDI), launched in 2017, is an effort to enable easier sharing and application of WZAD across the country. To facilitate collaboration, this page provides more information on WZDI and includes resources such as presentations and program materials.

National Work Zone Safety Information Clearinghouse
https://www.workzonesafety.org/swz/
Smarter Work Zones (SWZ) are among a few select initiatives being promoted by the FHWA Every Day Counts initiative. This site provides a number of resources pertaining to the education, training, planning, implementation, demonstration, best practices, and lessons learned.

CONNECTED AND AUTOMATED VEHICLES

Connected and Automated Vehicles (CAV) use advanced communication technologies to connect vehicles to roadside infrastructure (V2I/I2V), vehicle to other vehicles (V2V), or vehicles to everything (V2X) such as pedestrians and cyclists. **The ability for vehicles to communicate in this manner offers the potential for significant enhancements to safety, mobility, and efficiency of the transportation network for all modes of travel.**



Connected vehicles are increasingly becoming more prevalent and are equipped with advanced technology that enables vehicles, trains, buses, roads, smart phones, and other equipped infrastructure to "talk" to one another. Manufactures have been focusing on integrating these technologies to prepare for the future. Automated vehicles are equipped with advanced sensors and rely on communication and computers that replace a variety of functions typically controlled by a human driver. While vehicle autonomy continues to evolve, it is expected to greatly change the transportation environment with significant improvements to safety, mobility, and sustainability.

Support for Regional TSMO Goals

Optimizing Safety

Safety is enhanced by reducing opportunities for human error, which account for 94% of all serious crashes. By reducing opportunity for risky driving behaviors and driver error, safety is improved for everyone on the road, including nearby pedestrians and cyclists.

Reliable Travel Times

CAV will lead to more reliable travel times by enhancing efficiency of the roadways and reducing the number of non-recurring events. Examples include more efficient weaving and merging, removing unnecessary braking, and reducing start up time while getting a green indication at a signal. Additionally, allowing vehicles to talk with infrastructure will help optimize signal timings by providing accurate data back to the signal, allowing for better adaptive signal systems.

Equitable Access

Automated vehicles will provide enhanced mobility options and greater independence for those unable to manually operate a vehicle, such as seniors or those with disabilities. This will become increasingly important as the nation's population continues to age, but additional strategies may be needed to provide automated vehicle access to at-risk and low-income populations.

Environmental Benefits

The introduction of connected and automated vehicles into the transportation network will increase the efficiency of the network itself, thereby reducing the environmental impact of vehicle delay and idling. Benefits of CAV include a decrease in speed changes, reduction in queuing, and the ability for the vehicles to continuously operate at optimal speeds.

CONNECTED AND AUTOMATED VEHICLES

Applications

SPaT Broadcasting

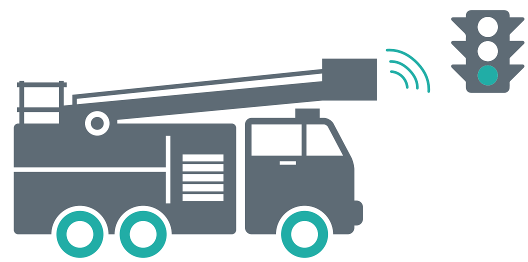
Signal Phase and Timing (SPaT) broadcasting refers to the communication between traffic infrastructure and vehicles. Signalized intersections can be equipped with dedicated short-range communication (DRSC) or cellular infrastructure, generally referred to as Roadside Units (RSU), that broadcast signal and phasing messages. These messages can be received by equipped vehicles or On-board Units (OBU). Applications can be developed to receive the messages and automate a response or notification.

Vehicle to Infrastructure

Vehicle to Infrastructure refers to the communication between vehicles and traffic signals or RSU along a freeway. The traffic signal offers the vehicle information about signal timing, potential pedestrians present in the intersection, and other location specific details.

Emergency Vehicle Preemption (EVP)

Emergency Vehicle Preemption refers to communication between traffic signals and emergency vehicles. The traffic signals adjust signal timings to clear traffic in the direction of travel before an equipped emergency vehicle approaches the intersection, resulting in faster response times and safer travel for all motorists.



Transit Signal Priority (TSP)

Transit Signal Priority refers to communication between traffic signals and transit vehicles. The traffic signals can provide additional green time for transit vehicles to progress through the signal, providing more efficient and reliable transit services. These systems can be configured such that priority is only given when the transit vehicle is behind schedule or has a lot of passengers.

Freight Signal Priority (FSP)

Freight Signal Priority refers to communication between traffic signals and freight vehicles. The traffic signals can provide additional green time for heavy trucks to progress through the signal, providing more efficient and reliable freight services. These systems can be configured such that priority is only given during off-peak travel times or predetermined times of the day.

Advanced Bicycle/Pedestrian Detection

Advanced Bicycle/Pedestrian Detection refers to the communication between bicycle/pedestrian detectors and vehicles. The pedestrian detector can send a message to a device to warn on-coming vehicles about pedestrians in the crosswalk. The Flashing Don’t Walk phase can be extended if more time is needed to clear pedestrians from the intersection. Similarly, a bicycle detector can send a message to a device to warn on-coming vehicles about cyclists in the adjacent bike lane.

Driving Automation

Society of Automotive Engineers (SAE) has defined 6 levels of driving automation as can be seen below, ranging from 0 to 5. Currently, most new vehicles can be characterized as level 0 (no automation), level 1 (driver assistance), or level 2 (partial automation). Automated technology examples include: adaptive cruise control, break assist, lane departure assist, and parking assist. Fully autonomous vehicles operate independently and require no human intervention.

Autonomous Shuttles

Autonomous shuttles, such as the one shown to the right, are becoming increasingly more popular. Cities are partnering with shuttle manufactures to test the vehicles and provide limited service on predesignated routes. These shuttles operate fully autonomous and demonstrate the future possibilities with autonomous vehicles.

Source: Peachtree Corners Twitter

Adaptive Cruise Control (Automated Technologies)

Adaptive cruise control is an automated feature that utilizes front cameras installed in a vehicle to monitor other vehicles ahead and changes the speed based on the speed and distance of the adjacent vehicle. If the adjacent vehicle is too close, the vehicle will warn the driver.

Break Assist (Automated Technologies)

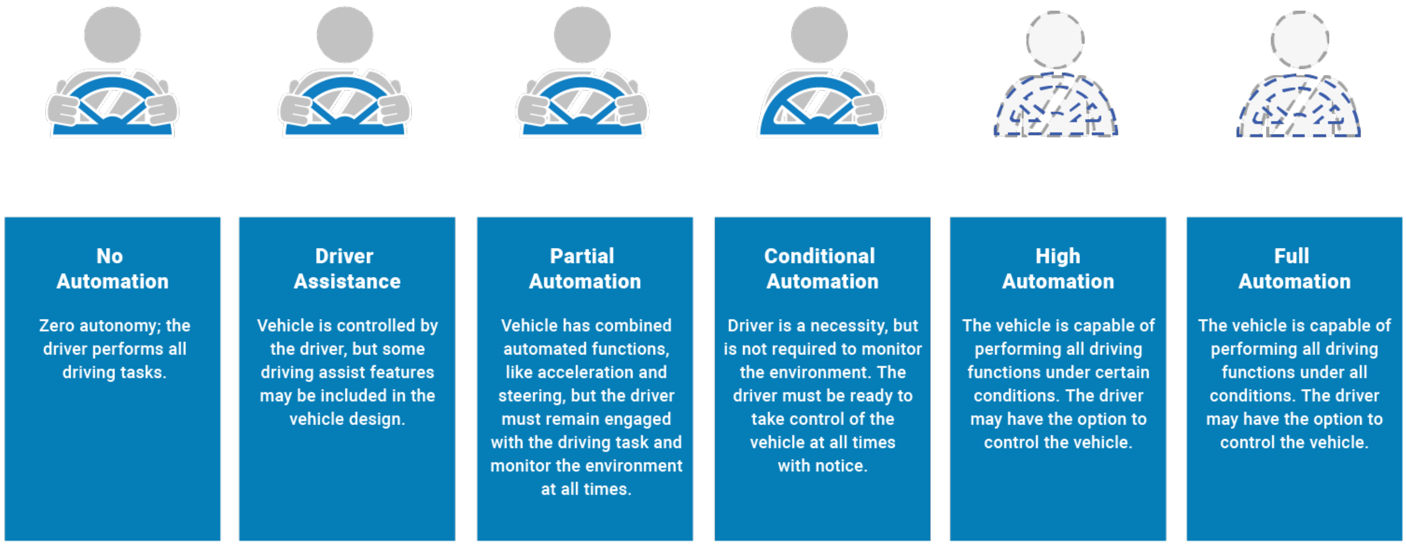
Break assistance is an automated feature that utilizes front cameras installed in a vehicle to monitor the speed and distance of other vehicles directly ahead. If the adjacent vehicle is too close, the vehicle will warn the driver and automatically break to avoid a rear end collision.

Lane Departure Assist (Automated Technologies)

Lane departure assistance is an automated feature that utilizes front cameras installed in a vehicle to monitor lane lines. If the vehicle begins to cross over lane lines and the turn signal is not activated, the vehicle will notify and warn the driver.

Parking Assist (Automated Technologies)

Parking assistance is an automated feature that utilizes front cameras, backup cameras, and sensors installed in a vehicle to monitor parking lanes and the surrounding environment. If the vehicle begins to cross over parking lines or is too close to an object identified as an obstruction in the surrounding parking environment, the vehicle will notify and warn the driver.



Source: Society of Automotive Engineers

Contexts

Urban

In an urban context, connected vehicle technology improves signal progression through the use of SPaT broadcasting; enhances safety and reduces response times through the use of EVP; and increases reliability of transit through the use of TSP. Advanced pedestrian and bicycle technology enhances safety by providing information to vehicles navigating in the dense urban environment about the presence of pedestrians or bicycles.

Suburban

In the suburban context, connected vehicle technology increases throughput on arterials, most notably at high volume intersections. The ability for a vehicle to connect and share data with infrastructure and the vehicles that are surrounding it allows decisions to be made based on the efficiency of the maneuver, not the assumed benefit that the user experiences. In addition to operational benefits, connected vehicle technology also increases the safety of high-volume corridors and intersections by utilizing the advanced vehicle and pedestrian detection embedded directly in the vehicles.

Rural

In rural settings, connected vehicle technology can add significant safety benefits at signalized intersections through the use of EVP. Emergency vehicles traversing rural intersections can be more at risk for severe crashes due to the speed and lack of congestion. EVP has the opportunity to reduce the risk by providing the emergency additional green time to travel through the intersection safely.

Regional Examples

The following chart provides a few regional examples of current CAV applications and associated service packages and associated ITS architecture service packages:

Application	Location and Deployment Type
SPaT Broadcasting - DSRC (V2X) (TM04: Connected Vehicle Traffic Signal System)	GDOT Traffic Operations: Cohda (select RTOP corridors)
SPaT Broadcasting - Cellular (V2N) (TM04: Connected Vehicle Traffic Signal System)	Marietta Traffic Operations: Glance
Transit Signal Priority (PT09: Transit Signal Priority)	Marietta Traffic Operations: Glance
Emergency Vehicle Preemption (PS03: Emergency Vehicle Preemption)	Marietta Traffic Operations: Glance Atlanta Office of Transportation: Glance
Autonomous Shuttle	Peach Traffic Corners Curiosity Lab: Olli Doraville Assembly Yard: NAVYA

References

The following references are useful for further understanding, planning, and implementing emergency transportation operations.

FHWA Connected and Automated Vehicles

https://ops.fhwa.dot.gov/publications/fhwahop17001/ch1.htm

FHWA primer for transportation operation professionals who are implemented CAV-enabled ICM strategies.

USDOT ITS Joint Program Office Vehicle-to-Infrastructure Resources

https://www.its.dot.gov/v2i/

USDOT provided resources that help planners, transportation engineers, decision-makers, and other stakeholders involved with the ITS deployment process with valuable information about V2I technologies.

FTA Signal Priority

https://www.transit.dot.gov/research-innovation/signal-priority

FTA Office of Research, Demonstration and Innovation provides information and guidance on the deployment of transit signal priority.

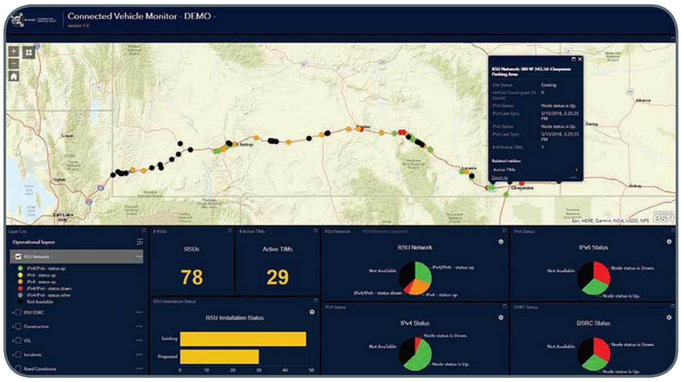
USDOT Automated Vehicle Activities

https://www.transportation.gov/AV

The USDOT is committed to facilitating a new era of transportation innovation and safety and ensuring that the United Stated remains a leader in automation.

TRAVELER INFORMATION

Traveler information systems provide real-time information so that users are better informed to make route, departure time and mode decisions. The information is typically provided through a traveler information portal which has been entered at a Traffic Management Center (TMC) or automatically populated. Traveler information typically focuses on weather events, road closures, congestion, closed circuit television (CCTV) camera coverage, and crash incidents. **When such real-time information is made available to the public, roadways become more efficiently utilized, resulting in less congestion and better traffic flow.**



Source: Federal Highway Administration

There are various forms in which traveler information can be conveyed through. Dynamic message signs (DMS) and portable changeable message signs (PCMS) are commonly used to display short messages that would impact a motorist's trip along a corridor. Users are also given the option to set up personalized alerts via email or smart phone, which increases participation in the program. Personalized alerts are also typically used to alert users about upcoming unsafe conditions, including planned construction, special events, and severe weather.

Support for Regional TSMO Goals

Optimizing Safety

Traveler information portals provide motorists with up to date information about safety hazards and traffic congestion, allowing them to alter their route to avoid them or have a heightened vigilance within the area.

Reliable Travel Times

Traveler information portals provide motorists with up to date traffic conditions, allowing them to reroute or select an alternate mode to get to their destination, thereby limiting their exposure to congestion and enhancing reliability. When paired with flexible work schedules, traveler information portals can also help motorists decide when to depart on a commuter trip, reducing congestion during peak hours.

Efficient, Seamless Travel

When combined with 3rd party applications and information, traveler information portals allow users to plan their entire journey, not just a specific portion of it. Added functionality can allow users to purchase transit fares in advance increasing the efficiency of their journey. The increased functionality will also allow users to select the best mode or multiple modes for travel.

Equitable Access

Traveler information portals support equity when they are designed to provide access to all users regardless of ability, socioeconomic class, language, etc. through use of several outputs and translations. By providing users with accurate data, they can select a mode that works best for them, allowing more travel freedom. Additional functionality can allow these users to pay fares in advance or at a reduced rate.

Environmental Benefits

Reducing congestion on all roadways provides a significant reduction in emissions caused by idling vehicles. Supporting and promoting alternate mode choices will also result in a reduction in emissions.

Applications

Traveler Information Portals

Traveler information portals serve as a central hub for all traveler information and include helpful links to other DOT-related web services. The portal will typically contain information about up-to-date weather, road, and bridges statuses, as well as CCTV and DMS information. It is helpful for users to check travel information portals prior to taking a trip to stay up to date with road conditions. This application is supported by drivers when a call-in number is provided, allowing drivers to self-report hazards or crashes as well as allowing them a place to make service requests. The service requests can help technicians and engineers locate problems with signal timings or infrastructure, resulting in a more efficient and operational network. Links to transit or micro mobility options can be included in the portal, allowing users to view local options in the area they are traveling to.

Third Party Coordination

Working with third party applications can increase the amount of information that can be shared through a traveler information portal as well as enhance the functionality of the portal itself. Partnering with big data providers can increase the accuracy and reliability of the information hosted on the portal, increasing user satisfaction and reach. The portal itself can share critical information with other travel services including current construction mapping, emergency transportation operations information, and crash information, increasing the efficiency of travel for all users. Third parties can host additional information through the portal including current parking status and rates, transit services and fares, and micro mobility options; all allowing for a more seamless experience for all users. Similarly, working with adjacent states and sharing information will allow users to plan for longer trips.

Social Media

Social media connects travelers instantly to traveler information and can be used to send out critical messages about severe weather alerts, road closures, and construction activity. Critical messages being delivered through social media allows users to access the information without having to access the portal directly, resulting in more awareness and, therefore, potentially less congestion on the transportation system. Social media services also provide a location for users to submit service requests. Following up on these requests or allowing users to track them provides additional transparency to the system. When creating an online presence, multiple platforms should be explored to have a broader reach.

In-vehicle Services

In-vehicle services provide a platform to send motorists messages in their vehicle using wireless communications. Critical messages about conditions on the motorists' selected route can be delivered in real time, allowing for the user to make the necessary adjustments to continue safely or select a new route. By opting in, motorists can provide anonymous data back to the TMC to help determine compliance rates and identify potential safety issues.

Contexts

Urban

In an urban environment, traveler information helps users select a mode that suits their needs based on real time data, potentially lowering congestion throughout the network. Traveler information services also provide users with street closure and construction information, helping them make routing decisions in a congested environment.

Suburban

In a suburban environment, congestion information allows users to better plan their trips to avoid congestion or select an alternative mode. Additionally, information and updates on work zones and construction can help alleviate driver frustration. Both of these features result in a transportation system that is safer and easier to navigate.

Rural

In a rural environment, traveler information portals can provide information on long term construction projects and work zone plans that can have major impacts to route selection. Traveler information portals provide reliable trip data prior to departure in areas where mobile broadband is not always available.

Regional Examples

The following chart provides a few regional examples of current traveler information applications and associated ITS architecture service packages:

Application	Location and Deployment Type
Traveler Information Portals (TI01: Broadcast Traveler Information / TI02: Personalized Traveler Information)	GDOT Traffic Operations: Georgia 511 Gwinnett County Department of Transportation: GC Smart Commute Cobb County Department of Transportation: Cobb Commute
Third Party Coordination	GDOT Traffic Operations/ARC Region: Google Maps/Waze Coordination
Social Media	GDOT Traffic Operations: Georgia 511 Cobb County Department of Transportation: Cobb Commute
In-vehicle Services	Marietta Traffic Operations: Glance Atlanta Office of Transportation: Glance

References

The following references are useful for further understanding, planning, and implementing traveler information.

FHWA Real-Time Traveler Information Program
https://ops.fhwa.dot.gov/travelinfo/about/aboutus.htm
The Real-Time Traveler Information program focuses on information for all sorts of travel on surface transportation networks.

USDOT ITS Joing Program Office – Dynamic Mobility Applications Program
https://www.its.dot.gov/research_archives/dma/bundle/enableATIS_plan.htm
Enabling Advanced Traveler Information Services seeks to facilitate, support and enable advancements and innovations that provide transformative traveler information.

Georgia 511
http://www.511ga.org
Georgia's 511 service provides information on travel conditions around the State.

TRAFFIC INCIDENT MANAGEMENT

Each minute that a primary incident impedes traffic, the likelihood of a secondary crash increases. Implementing planned strategies is critical to reducing secondary crashes and fatalities, and to decrease the total incident time.

Traffic Incident Management (TIM) is a process of detecting, responding, and clearing of incidents to restore traffic flow. Successful TIM programs are collaborative efforts between emergency responders (police, fire, emergency medical services), transportation officials, towing and recovering, hazardous material collection services, and the public. Each group has its own responsibility, and coordination is necessary to ensure safety across all groups.

Source: Florida Department of Transportation

According to the FHWA, each minute that a primary incident impedes traffic, the likelihood of a secondary crash increases by 2.8%. Additionally, it is estimated that 20% of all crashes on freeways and 18% of fatalities on interstates are secondary crashes. Implementing planned strategies is critical to reducing secondary crashes and fatalities, and to decrease the total incident time. Keeping first responders safe and lowering the duration and impact of traffic incidents are also made possible by policies implemented by effective TIM programs.

Support for Regional TSMO Goals

Optimizing Safety

Quickly removing property damage only or minor injury crashes from the roadway results in safer travel conditions for all motorists, including those involved in the crash. Moving the crashes from the roadway to a shoulder or side street also promotes the safety of the first responders. TIM also supports the training and certification of individuals who work crashes. The knowledge gained at these training exercises will help them keep crash investigations consistent and safe for all involved.

Reliable Travel Times

Clearing crashes from the roadway in a timely matter reopens travel lanes. During peak periods, the closure of a single lane can result in large increases in congestion and delay. Once crashes are cleared, contingency signal timings can be implemented to provide additional time to mainline motorists, allowing the congestion to clear in an efficient and safe manner. These preprogrammed timings should exist on high-volume corridors and can be implemented manually through Transportation Management Center (TMC) staff or automatically using traffic responsive programming.

Environmental Benefits

By improving and encouraging reliable travel times, TIM strategies provide environmental benefits by reducing congestion and increasing the speed of travel, both of which result in less emissions. Additionally, TIM strategies for hazardous waste cleanup seek to remediate spills in a manner that protects the surrounding environment.

Applications

Legislative/Administrative Authorization

Legislative/administrative authorization uses a top-down approach for joint operation and resource sharing which keeps the program strong and equitable for all agencies involved. Developing the TIM vision at this level allows organizations to combine or obtain funding from sources unavailable at a localized level, ensuring that the program remains strong as it grows. This type of implementation will help foster and maintain relationships between partner agencies, encourage discussion and growth of TIM strategies, and help incorporate TIM into the planning and design process.

Operational Policies

Operational policies provide clear, written guidelines for on-scene and remote operations. These policies set up and determine a clear chain of command during incident management that supports the on-site personnel without compromising their safety or the efficiency with which they can clear the incident from the roadway. These policies provide consistency across jurisdictional boundaries by laying out crash investigation policies, hazardous materials removal policies, traffic control standards, emergency lighting procedures, and quick clearance/towing and recovery policies. Standardizing these policies creates a safe working environment for first responders. These policies can also create classification levels for incidents that determine which agencies need to be involved with each incident, ultimately lowering the exposure of all first responders.

Source: Georgia Department of Transportation

Service Patrols

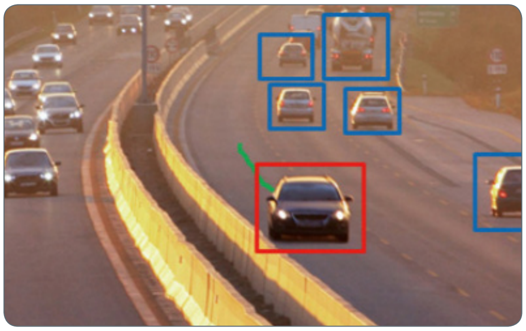
The implementation of service patrols has proven valuable as a tactic to increase the safety and reliability along roadways. Service patrols can assist with traffic management at an incident, assist stranded motorists, provide support for work zone management, assist with Emergency Traffic Operation plans, and provide reporting coverage in areas without closed circuit television (CCTV) availability. Since service patrols employees are trained in and have the right equipment for these operations, they are best suited for these roles, allowing other first responders to focus on the actions they are taking during incident management. Service patrols can be deployed in a 24/7 capacity or can be regulated to peak hours of travel, providing support only when it is most needed.

Ongoing Training

Ongoing training ensures that skills are kept up-to-date with standards and creates a lasting bond between agencies. Training opportunities help introduce new TIM procedures into standard policy and help determine the usefulness and need for new tools and equipment. Training sessions provide an area for open dialog between multiple organizations, allowing for and encouraging discussion about TIM policies and procedures. Training with multiple organizations also helps determine where gaps existing in the TIM strategy and process. Highlighting these will help the program grow and expand.

Automating Incident Detection

At any given time, there are only so many TMC employees that can be tracking the movement of traffic on interstates, freeways, and arterials. This unfortunately creates situations where incidents are not seen until 911 dispatch alerts the TMC or another motorist or passerby calls in the incident. Automating the process of detection incidents using cameras and software helps remove this burden from TMC employees, alerting them when the system detects an incident that they are able to review and escalate accordingly.



Source: Panasonic

Contexts

Urban

High volume roadways with limited right of way (ROW) can make TIM strategies difficult to implement in an urban environment. Wherever possible, automating the process using ITS devices will prove incredibly valuable. By automating incident detection, pushing alternative traffic signal timings to keep detoured traffic moving, and relying on permanent dynamic message signs (DMS) placement to convey additional information to drivers, manpower can remain focuses on clearing the incidents themselves. Additionally, mapping out hotspots of critical routes and high crash locations can help TMC and TIM employees focus on areas that provide the most benefit.

Suburban

In suburban areas, it is important to clear incidents from arterials and freeways in an efficient and safe manner, especially during peak hours, when commuter traffic is heavy and driver frustration is high. The additional ROW that is found in suburban settings can provide areas for first responders to clear vehicles from the road, removing themselves from harms way while allowing them to finalize the incident investigation. Suburban areas also provide storage location opportunities for TIM equipment such as vehicles, traffic control equipment, or dry storage for salt and sand.

Rural

It is important to build out ITS and CCTV equipment in rural areas to maximize coverage and support stranded motorists. On low volume, high speed roads, it is possible for a crash to go unnoticed for some time, possibly resulting in a loss of life. Placing these devices at critical locations, such as interchanges or around roadway bends, will help maximize the benefit of these devices. Other TIM policies and strategies may need to be modified to be successful in rural settings, thinking outside the box and removing constraints to be successful in these areas will prove beneficial.

Source: Georgia Department of Transportation

Regional Examples

The following chart provides a few regional examples of current traffic incident management applications and associated ITS architecture service packages:

Application	Location and Deployment Type
Operational Policies (TM08: Traffic Incident Management System)	GDOT Traffic Operations: TMC Operations Counties and local agencies: TCC Operations
Service Patrols (PS08: Roadway Service Patrols)	GDOT Traffic Operations: HERO (Atlanta Metro), CHAMP (statewide)
Ongoing Training (TM07: Regional Traffic Management)	GDOT Traffic Operations FHWA National TIM Responder Training Program
Automated Incident Detection (TM08: Traffic Incident Management System)	GDOT Traffic Operations: Pilot deployment

References

The following references are useful for further understanding, planning, and implementing traffic incident management.

FHWA Emergency Transportation Operation - Traffic Incident Mangament
http://www.ops.fhwa.dot.gov/eto_tim_pse/about/tim.htm
The FHWA provides resources and guidance on implementing TIM strategies and practices.

FHWA National Traffic Incident Management Responder Training Program
https://www.fhwa.dot.gov/goshrp2/Solutions/Reliability/L12_L32A_L32B/National_Traffic_Incident_Management_Responder_Training_Program
Training for safer, faster, stronger, more integrated response.

TIME Task Force – Traffic Incident Management Guidelines
http://timetaskforce.com/time-initiatives/tim-guidelines/
Georgia's TIME Task Force provides resources and guidance on Georgia TIM guidelines, policies, and forms.

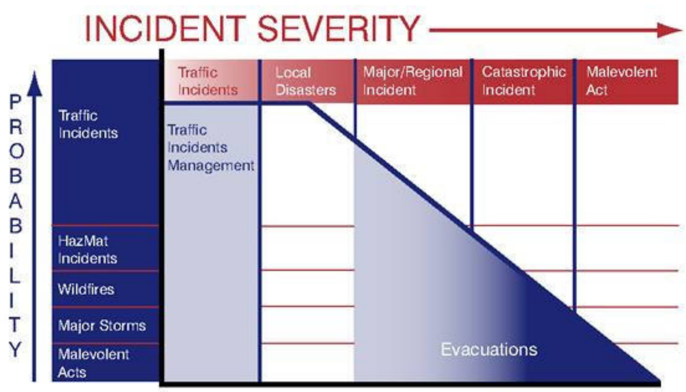
Atlanta Regional Commission – Open Roads Policy
http://timetaskforce.com/time-initiatives/open-roads-policy/
Georgia's Open Roads Policy focuses on clearing closed and partially blocked travel lanes to reopen the roadway as soon as possible.

GDOT – Highway Emergency Response Operators (HERO) program
http://www.dot.ga.gov/DS/Travel/HEROs
Highway Emergency Response Operators (HEROs) are dispatched to traffic-related incidents in metro Atlanta with the primary duty to clear roads so that normal traffic flow is restored.

EMERGENCY TRANSPORTATION OPERATIONS

Emergency Transportation Operations (ETO) is the practice of coordinating a response to emergencies, large scale non-recurring events (i.e. catastrophic weather), or malevolent acts. During these events, it is critical to utilize the transportation system for evacuation routes, resource delivery, and accessibility to impacted areas. **Preparedness is necessary to have a successful ETO program—once an event occurs, there is little to no time to develop and implement a plan.**

In order to ensure a successful ETO implementation, multiple agencies need to function as one unit. Typically, these agencies include law enforcement, fire and rescue, emergency medical personnel, transportation management center (TMC) staff, traffic operations staff, communications and media staff, the National Guard, and Homeland Security. The nature of the event dictates which agencies are involved with the implementation of ETO. To prepare for ETO events, these agencies must work together to develop communication plans, determine evacuation routes, create a clear agency hierarchy, assign roles and responsibilities to departments, practice with all agencies involved, and determine measures of effectiveness so performance can be improved in the future. Planning for ETO events should consider, and be consistent across, the entire state and should include adjacent states to ensure evacuation routes are feasible.



Source: Federal Highway Association

Support for Regional TSMO Goals

Optimizing Safety

One of the primary goals of ETO is to enhance the safety and security of all citizens in the event of a disaster. Consistent messaging, properly designated evacuation routes, and clear lines of communication between agencies all support the safety of the citizens during these events.

Reliable Travel Times

Pre-planned evacuation routes should be timed, to the extent possible, to provide reliable speeds away from the area being evacuated. ETO supports this by determining which routes have the capacity to serve as primary or secondary evacuation routes and by implementing special timings during the evacuation to get the citizens out of dangerous areas.

Equitable Access

ETO supports equitable access by including all socioeconomic classes in the planning and operation process. Planning for and providing alternative travel modes and solutions for all citizens during an evacuation or emergency event is critical to the development of these plans. Additionally, planning past the initial evacuation and providing support services where needed is critical to the successful implementation of these plans.

Environmental Benefits

Reducing the congestion of evacuation routes results in fewer vehicles idling and producing emissions. Creating timing plans that result in efficient travel along evacuation routes will reduce emission produced during the evacuation.

Applications

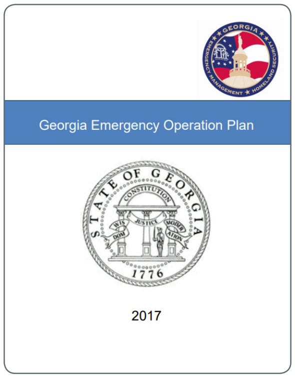
Working Groups

In addition to formal agreements and training, working groups provide a structure that allows for coordination across multiple agencies. The goal of working groups is to create a forum for cooperation, collaboration, focused discussion, and problem solving. Working groups should be made up of both private and public agencies in order to broaden the scope of expertise and introduce new solutions to ETO problems. These working groups can be temporary, in order to solve specific problems, or permanent, in order to conduct assessments on the current state of preparedness or develop ongoing training routines and actives.

Source: Lowndes County

Emergency Operations Plan

An emergency operations plan (EOP) defines effective modes of communication and a hierarchy between agencies involved in the ETO program. The EOP should define specific hierarchy if needed based on the type of emergency (i.e. natural disaster vs hazardous materials vs malevolent event). ETO should look to support and reinforce the EOP throughout the state. The EOP sets guidance for designing and planning with ETO in mind, such as providing guidance for minimum turning radii that accommodate emergency vehicles or planning the location of stored emergency equipment. The EOP also creates the performance measures used to gauge past performance for the purpose of consistently improving the plan.



Source: The State of Georgia

Training Exercises

Training exercises should be regularly scheduled and include all members of the interagency team. The training exercises will help identify any gaps in the program or the preparedness of the group as well as build bonds between inter-agency teams. A review system consisting of multiple teams for each training exercise is critical to advancing towards preparedness. This review system should include and allow for feedback from the participants. Their input is incredibly valuable as they will be the on the front lines in the event of an emergency. Building bonds between the interagency teams is equally as important as progressing the program forward. These bonds will translate to efficiencies during emergency events, resulting in safer and more reliable operations.

Source: START Group

Contexts

Urban

A mass evacuation from an urban setting can cause gridlock on local roads and highways and overwhelm nearby rural evacuation centers. Providing clear lines of communications to citizens on when and when not to evacuate is extremely important in planning for ETO to avoid these issues. Providing clear instructions on evacuation routes through dynamic messaging signs (DMS) or portable changeable message signs will help control the flow of traffic out of an urban environment. Response and recovery efforts in urban environments can also prove challenging as the number of residents in need of support can overwhelm the planned deployment.

Suburban

During ETO, high capacity arterials can be re-purposed as evacuation routes using signal timing adjustments along with strategically placed portable changeable message signs to provide context. With proper planning, these signal timing plans can provide higher throughput on the mainline while still servicing the side street volumes. Additionally, these high capacity roads can be contra-flowed to provide even greater benefits to evacuating traffic. Suburban areas also provide opportunities to stage equipment in the public right of way for the response and recovery efforts.

Rural

In rural settings, it is important to ensure that evacuation routes are well maintained and have intelligent transportation systems and closed circuit television coverage in critical locations, such as high capacity interchanges and areas that have presented a safety challenge in the past. This functionality is important in remote locations as the man power needed to cover these areas will be stretched over long distances. DMS boards along rural highways help provide additional information to evacuating traffic, especially in areas where cell phone coverage can be spotty.

Regional Examples

The following chart provides a few regional examples of current emergency transportation operations applications and associated ITS architecture service packages:

Application	Location and Deployment Type
Working Groups (PS12: Disaster Response and Recovery)	Multi-agency: TIME Task Force
Emergency Operations Plan (EOP) (PS12: Disaster Response and Recovery)	Georgia Emergency Management and Homeland Security Agency Gwinnett County Office of Emergency Management
Training Exercises (PS12: Disaster Response and Recovery)	Multi-agency: TIME Task Force

References

The following references are useful for further understanding, planning, and implementing emergency transportation operations.

FHWA Emergency Transportation Operations
https://ops.fhwa.dot.gov/eto_tim_pse/index.htm
The FHWA Office of Operations provides tools, guidance, capacity building and good practices that aid local and State DOT's in their efforts to improve safety when a non-recurring event interrupts or overwhelms transportation operations.

Georgia TIME Task Force
http://timetaskforce.com/
The Georgia TIME Task Force was formed to address the critical issues of mobility and safety related to incident management in the Metro Atlanta region.

Georgia Emergency Management and Homeland Security Agency
https://gema.georgia.gov/
The Georgia Emergency Management and Homeland Security Agency coordinates the state's preparedness, response and recover efforts to disasters.

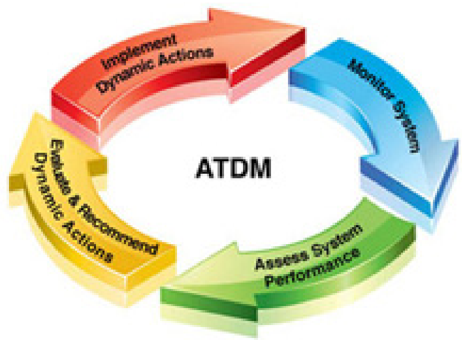
Gwinnett County Office of Emergency Management

https://www.gwinnettcounty.com/web/gwinnett/Departments/Police/EmergencyManagement

The Gwinnett County Office of Emergency Management handles a variety of tasks involving planning for emergencies and disasters, responding to incidents, directing mitigation, and assisting with recovery.

TRANSPORTATION DEMAND MANAGEMENT

Transportation Demand Management (TDM) is the practice of understanding users' mode choice decision making and providing alternative options to optimize all available transportation resources. Transportation options that may be encouraged include transit, rideshare programs, biking, walking, and teleworking. **By providing information about and incentives to alternate transportation modes, TDM can lead to reduced traffic congestion and better traffic flow.** Clearly defined TDM goals, objectives, strategies, and performance measures support successful implementation.



Source: U.S. DOT

Support for Regional TSMO Goals

Reliable Travel Times

Encouraging travelers to use alternative modes of transportation can lead to reduced congestion and strain on the roadway network during peak periods, providing more reliable travel times. TDM strategies can also inform users on when it is most efficient to travel. For users that participate in alternative work schedules, this can help them determine which times of the day to avoid travel, lowering the number of vehicles on the road during peak periods. For users who are traveling for personal reasons, this information can help them avoid commuter traffic.

Efficient, Seamless Travel

TDM services provide information on many different modes of transportation, allowing users to pick the one that best suits their needs at a given time. In some cases, this results in multiple mode choices during a single trip. The ability to house all of this information in one place makes these trips seamless to the users. Expanding these services to allow users to purchase and use transit fares, search for travel-on-demand services, or unlock micro mobility devices, greatly increases the value of the TDM service.

Equitable Access

TDM supports equitable access to all transportation options and modes by making information on these services available at little to no cost and encouraging the adoption of services aimed at service the traveling public as a whole.

Environmental Benefits

Reducing the congestion during peak hours results in fewer vehicles idling and producing emissions.

Applications

Rideshare Programs (TNCs)

Rideshare programs utilize transportation network companies (TNCs) to connect passengers with vehicles via a website or mobile application. To support traffic flow efficiency, pick-up/drop-off locations are often times marked, and directional signage are added in the area.

Source: RIDESHARE Etc.

Carpool Programs
Carpool programs are often incentivized to encourage users to carpool. Incentives include reduced parking fees, free parking, preferred parking, and/or reward programs. In cases where there is a larger number of participants and a more formal arrangement, vanpooling is another option.

Transit Subsidies
Transit subsidies encourage users commute via mass transit. Agencies can purchase discounted metro or bus passes and have the option to subsidize part or all of the cost for its users.

Bikeshare/Scootershare Programs
Bikeshare programs include self-service bikes/bike stations and a system of payment. Bikes can either be rented through a membership fee for a predetermined time period (longer-term use) or pay a fee based on time usage (shorter-term use).

Flexwork
Flexible work arrangements, also known as flexwork, give employees the opportunity to telework, have flexible shifts, or have compressed work weeks. As a result, employees can work more efficiently and reduce traffic congestion during peak hours.

Informational/Incentive Programs
Informational and incentive programs encourage employees to use alternative transportation options. When users are well-informed of all possible transportation resources, the likelihood of using alternative modes can increase. Incentive programs, such as cash incentives or a rewards system, can be implemented to encourage users to carpool or use alternate modes.

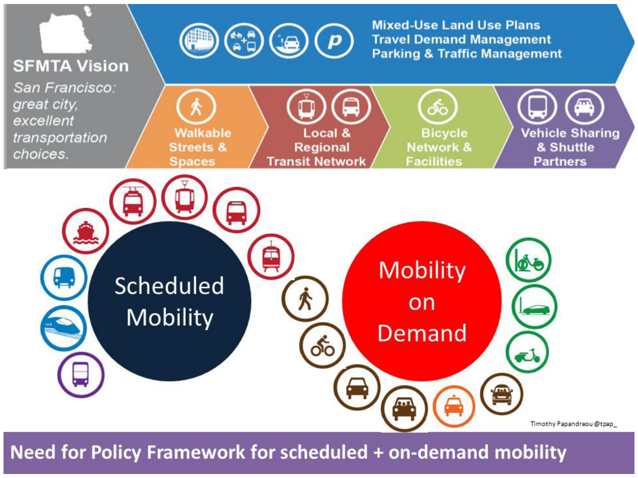
GEORGIACOMMUTEOPTIONS

Source: Georgia Commute Options

Contexts

Urban
In urban settings, micromobility services can be allowed to thrive in controlled and regulated environments. Making sure that the benefits that these services provide are available to those who need them without creating safety hazards or a nuisance. Additionally, promoting telecommuting and flexwork schedules will remove motorist from dense urban roads, relieving congestion in critical areas and reducing emissions.

Suburban
In suburban settings, TDM can help drive demand for transit, overtime making it more available to users in the suburban environment and resulting in more funding being provided. Reduced congestion caused by alternative modes of transportation or by telecommuting or flexwork schedules will reduce congestion on heavily traffic commuting arterials, resulting in fewer emissions being produced and less wear and tear on the infrastructure.



Source: Timmy Papandreou

Rural
As TDM promotes the possibilities of telecommuting, more people will be able to live further away from dense urban environments, revitalizing rural areas and reducing the impact that employment deserts have on rural communities. TDM also promotes ridesharing, allowing more people to travel in an environment that may lack public transit or micromobility options.

Regional Examples

The following chart provides a few regional examples of current transportation demand management applications and associated ITS architecture service packages:

Application	Location and Deployment Type
Rideshare Programs (TNCs) (TI06: Dynamic Ridesharing and Shared Use Transportation)	Regionwide: Uber/Lyft
Carpool Programs (TI06: Dynamic Ridesharing and Shared Use Transportation)	ARC Mobility Service Division: Georgia Commute Options - Select Counties Regionwide: Waze Carpool
Transit Subsidies	Atlanta Metro Area: MARTA, STRA Xpress Gwinnett County: Gwinnett County Transit Cobb County: Cobblinc
Bikeshare/Scootershare Programs (TI06: Dynamic Ridesharing and Shared Use Transportation)	Atlanta Metro Area: JUMP Electric Bike and Scooter Share, Relay Bike Share, BIRD Scooter Cobb County Department of Transportation: Zagster
Flexwork	ARC Mobility Service Division: Georgia Commute Options - Select Counties Atlanta Office of Transportation: Central Atlanta Progress
Incentive/Informational Programs	ARC Mobility Service Division: Georgia Commute Options

References

The following references are useful for further understanding, planning, and implementing transportation demand management.

FHWA Active Transportation and Demand Management

https://ops.fhwa.dot.gov/atdm/index.htm

The FHWA Office of Operations supports agencies and regions considering moving towards an active approach to transportation demand management.

FHWA Priced Vehicle Sharing and Dynamic Ridesharing

https://ops.fhwa.dot.gov/congestionpricing/strategies/not_involving_tolls/dynamic_sharing.htm

FHWA supports the use of advanced technologies to arrange short-notice, one-time, shared rides.

Atlanta Reiongal Commission Regional Transportation Demand Management Plan

https://atlantaregional.org/transportation-mobility/transit/regional-transportation-demand-management-plan/

The ARC TDM plan is a long-range plan that defines a strategic framework for developing and integrating TDM strategies into planning, project development and systems operations.

INTEGRATED CORRIDOR MANAGEMENT

ATLANTA REGIONAL COMMISSION

As traffic along a corridor increases, motorists will respond by finding alternative routes, adjusting their time of travel, or will remain in the congested corridor. All of these movements impact the overall flow within a transportation system and understanding how those impacts affect surrounding facilities can lead to better transportation management. FHWA defines integrated corridor management (ICM) as "an approach designed to actively monitor for atypical recurring and nonrecurring events that impact traffic on the most visibly congested highways or freeways that define a corridor." **ICM applications leverage existing surrounding infrastructure and optimize mobility to efficiently manage transportation networks to increase traffic flow along a corridor.**

Corridor management includes the proactive use of managed lanes. FHWA defines managed lanes as "highway facilities or a set of lanes where operational strategies are implemented and managed (in real time) in response to changing conditions to preserve unimpeded flow." Agencies can proactively manage lanes by controlling pricing, vehicle eligibility, and access control.

Source: Federal Highway Association

Support for Regional TSMO Goals

Optimizing Safety

ICM applications such as dynamic speed limits and queue warning systems alert drivers of changing conditions ahead. In the case of queue warnings, insufficient sight distance can hide queues behind obstacles; the warning provides drivers with the opportunity to adjust their speed and approach areas prone to queuing more cautiously. In addition, ICM applications can included enhanced safety service patrol coverage.

Reliable Travel Times

ICM applications are focused on increasing the reliability of travel times during peak periods including congestion pricing, reversible lanes, dynamic shoulder lanes, and adaptive ramp metering. Congestion pricing and adaptive ramp metering controls volumes entering a network through price controls or by metering the flow of entering traffic; both increase the travel speed along the mainline, enhancing reliability. Reversible lanes and dynamic shoulder lanes accomplish the same objective by temporarily increasing the capacity of the network during peak periods.

Environmental Benefits

ICM applications reduce congestion of the transportation network by adding temporary capacity or limiting the volume that is able to enter the network. Both strategies reduce the amount of emissions produced by the transportation network by increasing speed of travel, reducing delay caused by congestion, or encouraging other methods of travel.

Applications

Congestion Pricing

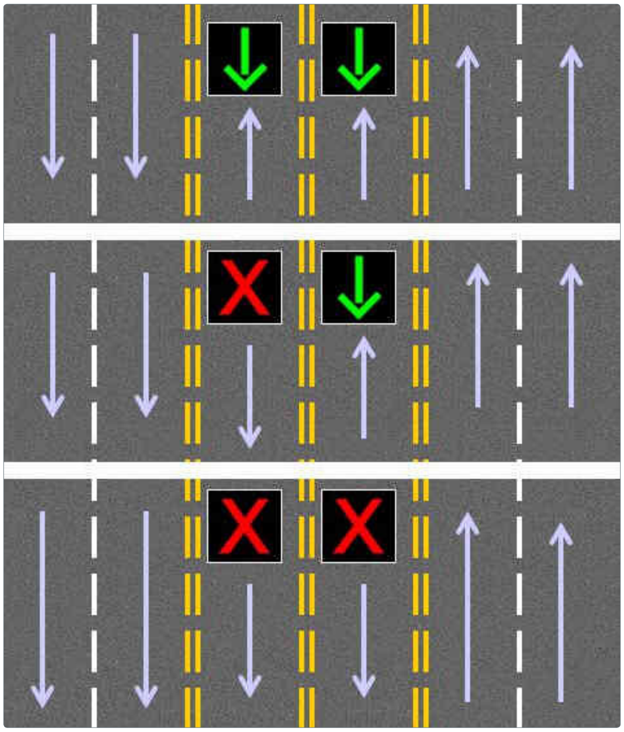
Congestion pricing adjusts toll rates based off of time-of-day patterns, typically increasing toll rates during peak hours. Toll rates may also be adjusted in real time to respond to congested traffic along a corridor.

Electronic Toll Collection

Electronic toll collections read registered tags or license plates on moving vehicles that go through toll facilities, eliminating the need for vehicles to stop. Electronic toll collections will either charge the moving vehicle or notify authorities of unregistered vehicles.

Reversible Lanes

Reversible lanes allow traffic to travel in either direction based on current conditions and are utilized in constricted arterials that experience heavy inbound and outbound traffic patterns during peak hours. The use of an additional lane can reduce speed variability and increase capacity when needed. Overhead signals are typically used to signify the lane direction.



Source: Rubén M. Cenzano

Dynamic Shoulder Lane

Dynamic shoulder lanes are used on highways during peak periods and can decrease traffic congestion along a corridor. The use of dynamic shoulder lanes incentivizes drivers to use high capacity highways instead of seeking alternate routes. Overhead signals are typically used to signify when dynamic shoulders can be used.

Dynamic Speed Limit

Dynamic speed limits decrease the speed limit when safety conditions are present or when congestion is occurring, resulting in a safer and less frustrating drive.

Adaptive Ramp Metering

Adaptive ramp metering limits on-ramp volumes and increases average speeds. As a result, peak congestion on the freeway and potential for crashes at ramps are reduced.

Queue Warning

Queue warning is implemented in heavily congested areas and alerts drivers to conditions ahead. Doing so increases safety and reduces driver frustration.

Contexts

Urban

In urban environments, congestion pricing is used to discourage non-essential trips into dense urban environment in an effort to reduce congestion, network deterioration, and pollution in the area. The potential negative impacts of congestion pricing can be reduced by implementing a strong mass transit system in the area, providing micromobility options that reduce the need for last mile trips, and by supporting alternative work schedule programs.

Suburban

In suburban environments, a mix of ICM strategies will be observed during a daily commute including adaptive ramp metering, reversible lanes, and dynamic speed limits. The mix of ICM strategies supports multiple TSMO goals and can help increase the lifespan of the transportation network without adding capacity.

Rural

Rural areas typically do not deploy ICM strategies listed above as the peak hour volumes experienced in these areas are typically able to be handled by the existing infrastructure. Safety features such as dynamic speed limits and queue warnings can provide safety benefits in areas that have greater sight distance issues. Electronic tolling can reduce the impact and size of tolling facilities in rural areas, reducing the amount of stops caused by these facilities and the work force that needs to travel to them.

Regional Examples

The following chart provides a few regional examples of current integrated corridor management and managed lanes applications and associated ITS architecture service packages:

Application	Location and Deployment Type
Congestion Pricing (ST06: HOV/HOT Lane Management)	SRTA: Time-of-day pricing is currently used. Dynamic pricing has been removed.
Electronic Tolls Collection (ST06: HOV/HOT Lane Management)	SRTA: I-85 Toll Lanes
Reversible Lanes (TM16: Reversible Lane Management)	GDOT Traffic Operations: I-75 Reversible Lanes, I-575 Reversible Lanes
Dynamic Shoulder Lanes (TM22: Dynamic Land Management and Shoulder Use)	SRTA: I-85 GDOT Traffic Operations: SR 400
Dynamic Speed Limit (TM20: Variable Speed Limits)	GDOT Traffic Operations: I-285 has been removed
Adaptive Ramp Metering (TM05: Traffic Metering)	GDOT Traffic Operations: Regionwide

References

The following references are useful for further understanding, planning, and implementing integrated corridor management and managed lanes.

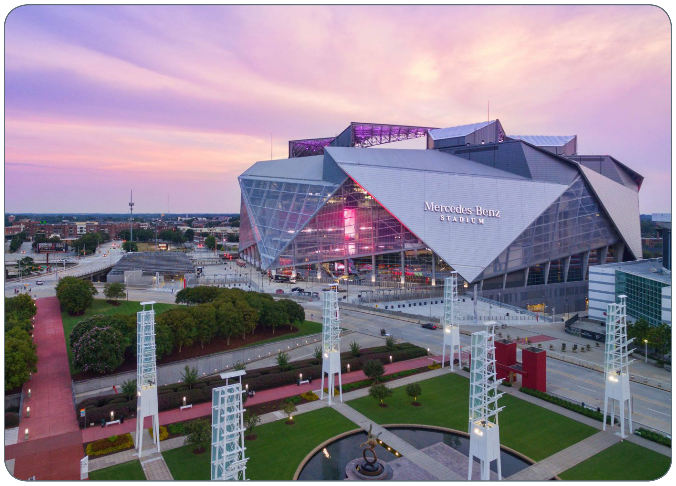
FHWA Corridor Traffic Management
https://ops.fhwa.dot.gov/program_areas/corridor_traffic_mgmt.htm
The FHWA Office of Operations provides tools, guidance, and good practices that aid local and State DOT's in their efforts to implemented Integrated Corridor Management

FHWA Integrated Corridor Management, Managed Lanes, and Congestion Pricing
https://ops.fhwa.dot.gov/publications/fhwahop16042/index.htm
The FHWA Office of Operations primer developed for State and local DOT's MPOs, transit agencies, and other stakeholders to introduce Integrated Corridor Management Concepts

FHWA Planning for Transportation Systems Management and Operations Within Corridors: A Desk Reference
https://ops.fhwa.dot.gov/publications/fhwahop16037/fhwahop16037.pdf
A desk reference design to equip State, regional, and local professionals with the knowledge and tools necessary to effectively plan for and implement TSMO strategies within a corridor.

EVENT MANAGEMENT

Whether a planned special event at a local stadium or an unplanned snow storm, event management can be used to maintain safety, mobility, and reliability of the transportation network during atypical events. **Event management applications can be focused on planned special events, such as sporting events or large concerts; expected weather events such as large rain storms or snow and ice; transit system reroutes or changes; etc.** These types of events have significant impacts to the transportation network that can be planned for and minimized through use of applications and supporting deployments such as special event management systems, weather event management systems,traffic signal management, traveler information, etc. These systems work together to enhance safety, mobility, and reliability.



Source: Mercedes-Benz Stadium

Support for Regional TSMO Goals

Optimizing Safety

Event management supports safety goals in a multitude of ways. Special event management focuses on both vehicular and pedestrian safety by creating signal timing plans that support heavy pedestrian movements close to the event location while simultaneously providing sufficient time for vehicles to clear from parking lots and exit the area. Road weather management focuses on altering behavior in the lead up and during inclement weather events, adjusting DMS boards and dynamic speed limit signs to provide relevant information while using traveler information portals and social media to encourage divers to postpone their trips. Road weather management also focuses on clearing debris, vehicles, or people who may be temporarily trapped on roadways.

Reliable Travel Times

Event management focuses on moving vehicles while there is greater congestion than normal, such as after a sporting event or during a storm. By programming signal timing plans for these occasions, traffic will continue to flow through or out of an area during these events. Creating plans that produce reliable conditions will increase driver satisfaction and safety during these events.

Efficient, Seamless Travel

Event management focuses on the operation of vehicular, pedestrian, and public transit, relying on the integration of these systems to provide the highest level of service for the users. Integrating different modes into special event management can be as simple as making attendees aware of the alternative modes of travel that are available and included in the plan. During road weather events, keeping users aware of what modes are available for use saves them time and energy that may be wasted.

Environmental Benefits

By reducing congestion during and after events and promoting alternate modes of transportation, event management provides environmental benefits, reducing idling time while waiting to exit parking lots and reducing the noise and air pollution near large crowds.

Applications

Special Event Management

Special event management is the method of understanding how events affect the overall transportation system with increased traffic along a corridor and developing a plan to reduce the impact. Real-time monitoring and coordination between agencies as well as traffic signal management can lead to successful special event management.

Road Weather Management

Road weather management is the method of understanding how inclement weather can affect the safety and mobility of roadways and developing strategies to reduce those impacts. Traffic signal management can be used to efficiently manage traffic during weather events such as hurricane evacuations, flooding, ice, etc.

Traffic Signal Management

Traffic signal management is a TSMO strategy that can be applied to event management for the purposes of optimizing traffic along arterial routes during an event. Preset timing plans can be developed and implemented remotely via traffic signal communications to provide additional green time where needed.

Traveler Information

Traveler information strategies and applications can be used to disseminate important information to travelers about events and alternative routes and methods of transportation.

Transportation Demand Management

Transportation demand management can be used to strategically encourage alternative methods, routes, and/or schedules of transportation demand. For example, information campaigns are sometimes used to encourage travelers to use transit to large special events.

Contexts

Urban

Large entertainment venues are typically located in urban areas, making special event management critical to maintaining or improving the functionality of the transportation network in urban environments. The access to multiple modes of transportation in these areas allows special event plans to focus on modes outside of vehicles and reduce the overall strain on the network. During road weather management events, ensuring that users stay up to date on the current operating conditions of public transit services and the roadways themselves will reduce any unnecessary travel in the area, reducing congestion and increasing safety.

Suburban

Suburban environments can play host to large entertainment venues as well but typically do not have the public transit infrastructure that is found in urban environments. In these cases, using signal timing plans that focus on moving traffic towards large arterials or highways will provide significant reduction in congestion and event clear time. During road weather events, keeping users updated through traveler information portals or social media about the current roadway conditions will help discourage unnecessary trips and increase the safety of those who must travel.

Rural

Entertainment venues do exist in rural environments but typically don't have the traffic signal or public transit infrastructure that are available in urban or suburban environments. Creating a plan that manages the vehicles exiting the venue can reduce the impact to the local transportation network. Similarly, to urban and suburban areas, providing users with information through a traveler information portal or social media during road weather events will help discourage unnecessary trips and increase the safety of those who must travel.

Regional Examples

The following chart provides a few regional examples of current event management applications and associated ITS architecture service packages:

Application	Location and Deployment Type
Special Event Management (TM08: Traffic Incident Management System)	GDOT Traffic Operations: Area surrounding Mercedes Benz Stadium, State Farm Arena Atlanta Office of Transportation: Various venues Gwinnett County Department of Transportation: Infinite Energy Center Cobb County Department of Transportation: Truist Park -
Road Weather Management (WX02: Weather Information Processing and Distribution, PS12: Disaster Response and Recovery)	GDOT Traffic Operations: Road Weather Information System

References

The following references are useful for further understanding, planning, and implementing event management.

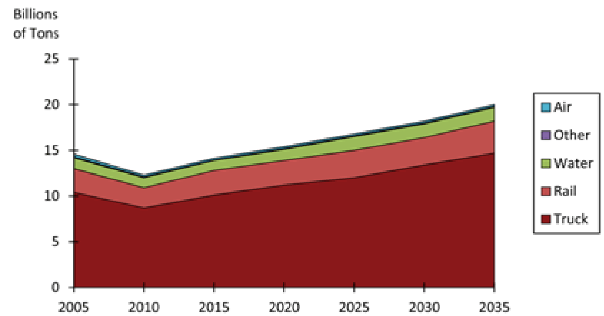
FHWA Traffic Management for Planned Special Events
https://ops.fhwa.dot.gov/eto_tim_pse/about/pse.htm
The FHWA provides handbooks, training and checklists to help practitioners as they develop plans using information regarding the planning and coordination to develop operational strategies needed to control traffic.

FHWA Road Weather Management
https://ops.fhwa.dot.gov/weather/
The FHWA Road Weather Management Program seeks to better understand the safety and mobility impacts of weather on roadways, and promote strategies and tools to mitigate those impacts.

FREIGHT MANAGEMENT

Service Description

The movement of goods throughout the transportation network is vital to the growth and prosperity of the region, however, the movement of these goods can increase congestion, damage infrastructure, and produce air and noise pollution. **Freight management seeks to understand the performance and impact that freight movements have on the transportation system and address the challenges that come with them.**



Source: HIS-Global Insight, Inc.

Support for Regional TSMO Goals

Optimizing Safety

Freight management supports the regional safety goal as it seeks to create standards for planning, designing, and operating the transportation network with freight in mind. Designing and operating the transportation network with freight operators in mind will result in a safer environment for all users.

Reliable Travel Times

Freight management supports the regional goal of reliable travel times by implementing strategies that support the movement of goods while also realizing the impact that this movement can have on network wide travel times. These strategies are structured to help both the freight operators and passenger vehicles reach target locations at specific times in a reliable manner. Keeping the transportation network reliable helps freight operators and logistic companies better plan for the area and allows them to schedule deliveries at opportune times.

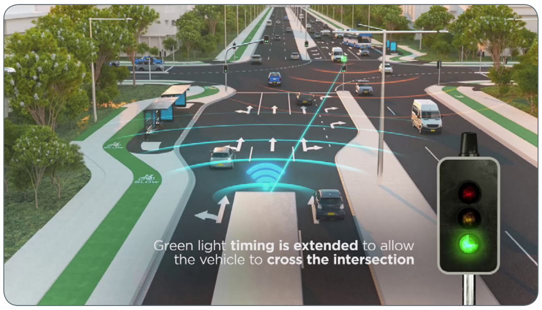
Environmental Benefits

By implementing strategies to keep travel times reliable, freight movers can avoid sitting in congested conditions and emitting air pollution. Similarly, by increasing the safety of freight operators, will reduce the likelihood that a crash would occur and jeopardize the local environment.

Applications

Freight Signal Priority

Freight signal priority extends green light timing at an intersection to allow an approaching truck to make it through the intersection without having to stop. This increases safety by reducing the likelihood that a truck will run a red light or have to come to a stop at high speed and cause a rear end collision. Additionally, this helps reduce the overall delay and congestion as trucks take longer to accelerate during the next signal cycle. This application can be installed using detection equipment that can determine the type of vehicle that is approaching or by using vehicle to infrastructure communication that allows the truck to "request" additional green time.



Source: Cohda Wireless

Truck Parking

Section 1401 of Moving Ahead for Progress in the 21st Century (MAP-21), known as "Jason's Law," was established to address the shortage of long-term parking for commercial vehicles on the National Highway

System. The inadequate supply of truck parking has negative consequences of truck drivers continuing to drive while tired or choosing to park at unsafe locations such as shoulders and exit ramps. Both scenarios reduce the safety of the transportation network for all users. Keeping an updated inventory of truck parking in the metropolitan area and designing systems that allow truck drivers to find available parking will increase the safety of the local transportation network.

Freight Logistics

Freight logistics seeks to effectively use the labor, capital, and materials of the current transportation and freight network. As the transportation network has improved and reliability has increased, freight logistics has allowed freight operators to improve their on-time performance, reorganize to better serve their clients, and increase employment rates. By supporting freight logistic policies, the transportation network will be better served.

Peak Period Restrictions

Peak period restrictions are designed to encourage freight operators to shift truck traffic off of congested transportation networks during peak periods, reducing the congestion and demand during these periods. Peak period restrictions can take the form of regulatory limits or financial incentives for using the transportation network outside of the peak periods. Passenger and transit vehicles benefit from this by experiencing reduced congestion during the peak periods and freight operators benefit by reduced congestion, labor, and fuel costs.

Source: Flatiron 23rd Street Partnership

Contexts

Urban

In urban settings, all of the applications listed above have the portential to provide significant benefits to all users of the transportation network. Reducing the amount of freight traffic in these dense environments reduces congestion and provides a safer operating environment for the remaining users. Freight operators also benefit from these applications by having more room to maneuver during off peak periods and avoiding the need to circle a warehouse or delivery point when freight logistics are keeping everything operating efficiently.

Suburban

In suburban settings, truck parking, logistics, and peak period restrictions offer benefits to all users of the transportation network. Removing freight traffic from peak hour commuting traffic will hep reduce the delay and congestion experienced by all users during these times. By improving truck parking access, highways within the suburban area will become safer overall.

Rural

In rural settings, truck parking applications have the potential to provide significant benefits to all users. Providing tired truckers with a safe area to park will increase the safety of the highways in these rural areas.

Regional Examples

The following chart provides a few regional examples of current freight management applications and associated ITS architecture service packages:

Application	Location and Deployment Type
Freight Signal Priority (CVO06: Freight Signal Priority)	GDOT Traffic Operations: Pilot locations

References

The following references are useful for further understanding, planning, and implementing freight management.

FHWA Freight Management and Operations
https://ops.fhwa.dot.gov/freight/
The FHWA Office of Freight Management works to improve gods movement on the U.S. transportation system and across borders.

FHWA Rountable on the Freight Economy: Atlanta, Georgia
https://www.fhwa.dot.gov/freighteconomy/atlanta.cfm
Summary of the multimodal freight economy in the State of Georgia.

FHWA Truck Parking
https://ops.fhwa.dot.gov/freight/infrastructure/truck_parking/
The FHWA provides tools, quidance, and good practices that aid local and State DOT's in their efforts to improve truck parking.

Washington State DOT Freight of Truck Signal Priortiy
https://tsmowa.org/category/signal-operations/freight-or-truck-signal-priority
The Washington State DOT provides guidance and implementation strategies for freight signal priority.

FHWA Freight Transportation Improvements and the Economy
https://ops.fhwa.dot.gov/freight/freight_analysis/improve_econ/index.htm
The FHWA provides information on the linkages between transportation improvements and economic performance.

Texas A&M Transportation Institute Truck Incentives & Use Restrictions
https://mobility.tamu.edu/mip/strategies-pdfs/traffic-management/technical-summary/truck-incentives-and-use-restrictions-4-pg.pdf
Texas A&M Transportation Institute provides information and guidance on peak period restriction and incentive programs.

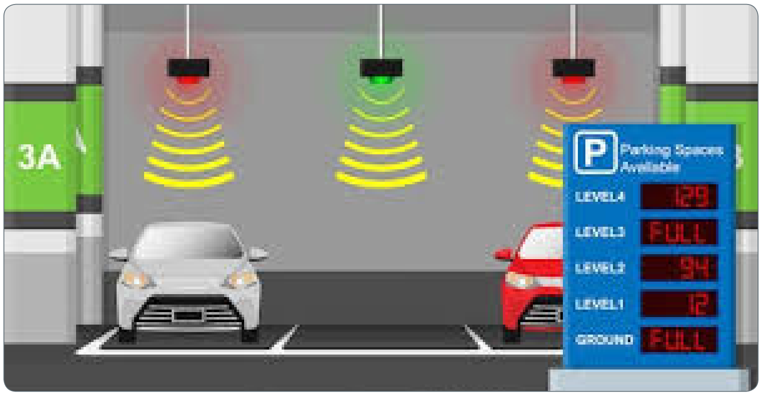
Atlanta Regional Commission Freight Mobility Plan
https://atlantaregional.org/transportation-mobility/freight/freight-transportation/
ARC's Freight Mobility Plan is designed to enhance the movement of freight and improve the region's economoic competitiveness, while minimizing the environmental and community impacts of truck movement.

GDOT Freight
http://www.dot.ga.gov/IS/GeorgiaFreight
The goal of GDOT's Freight Department is to use a strategic approach to provide well-planned transportation investments to accommodate freight growth and logistic needs statewide.

PARKING MANAGEMENT

Parking management is a strategy that seeks to actively manage parking in populated areas to reduce congestion, ensure the seamless transition between transportation modes, and reduce air and noise pollution.

A study by IBM suggests that up to 30% of traffic on urban roadways are vehicles looking for parking, resulting in drivers spending approximately 17 hours a year looking for a parking space. This can be caused by insufficient parking spaces or an inefficient parking system, but the results are the same - increased congestion on urban roadways and increased air and noise pollution from the vehicles. By implementing parking management strategies, the urban environment becomes a more efficient and effective place to live and work.



Support for Regional TSMO Goals

Reliable Travel Times

Parking management supports the regional goal of reliable travel times by supporting applications that optimize existing parking infrastructure and that help users find parking efficiently as opposed to driving on surface streets looking for an open spot. Additionally, parking management can help support transit operations by providing on-site parking facilities near commuter stations, ultimately reducing the congestion on the roadway.

Efficient, Seamless Travel

Parking management supports the regional goal of efficient, seamless travel by supporting applications that seek to increase alternative modes of travel. Applications like dynamic parking pricing encourage transit ridership by increasing the parking price during peak hour periods. Additionally, by ensuring that parking is available at commuter stations, the likelihood that users will choose an alternative mode is increased.

Environmental Benefits

By reducing congestion of arterial streets and removing vehicles that are searching for a parking spot, parking management supports efforts to reduce noise and air pollution.

Applications

Dynamic Pricing

Dynamic parking pricing can control the number of users looking to park within a geographic area by increasing or decreasing the cost of parking. Pricing can be controlled by a time-of-day schedule or dynamically over a set period of time, typically several months. These pricing adjustments allow metropolitan areas to capture the total cost of parking and allow users to make an economical choice of whether to drive and park within the area or to choose other modes of transportation.

Parking Guidance

Parking guidance systems help guide users to available parking facilities. These systems typically require smart parking meters or parking sensors that are able to track the current parking usage. Information can be delivered by a smart phone app for real time information or can be viewed through a transportation information portal prior to departure so the user has an understanding of the parking availability and the costs associated with parking in the area they are traveling to.

Train Station	Parking Lot	Lot Status
Brookhaven	Front Lot	Open
Brookhaven	Back Lot	Open
Chamblee	Main Lot	Open
Chamblee	Overflow Lot	Open
College Park	Main Lot	Open
College Park	Long Term Deck	Open
College Park	Overflow Lot	Open
Doraville	Deck	Open
Dunwoody	Deck	Open
Kensington	Paid Lot	Open
Kensington	Front Lot	Open
Lenox	Lot	Open
Lenox	Long Term Deck	Open
Lindbergh Center	Deck	Open
North Springs	Deck	Open
North Springs	Peachtree Dunwoody Local Lot	Open
Sandy Springs	Deck	Open

MARTA Parking Lot Status

Dynamic Overflow Transit Parking

Dynamic overflow transit parking allows transit stations or park-and-ride facilities to use adjacent parking facilities when they are at or near capacity. Overflow parking lots are typically underutilized lots during commuting hours. Transit agencies can make arrangements with the overflow lots as to when and how transit users have access to them. This option can take the place of constructing new parking facilities at existing transit stations if ridership has increased.

Transportation Allowances

Businesses that operate in urban environments often provide parking benefits to employees, allowing them to park in shared parking decks. By allowing employees to opt out and instead receive a transportation allowance to spend on transit options or other modes of transportation, employees will be free to make the choice that makes the most sense to them economically. Metropolitan areas should make efforts to support these types of programs and offer information on how and where they can be implemented most effectively.

Contexts

Urban

All of the above applications work well in an urban environment where the need for parking will be high. All users of the transportation network will see the benefit of reduced congestion and more seamless travel. Educating users who park in urban areas and providing them with choices where possible will help them make the decision that is most economically sound to them.

Suburban

In suburban settings, Dynamic overflow transit parking provides a great benefit to users who are looking to use transit to commute but are unable to park at the transit station or park and ride facility. By increasing the reliability of parking in these areas, users are more likely to use them.

Regional Examples

The following chart provides a few regional examples of current parking management applications and associated ITS architecture service packages:

Application	Location and Deployment Type
Dynamic Pricing (PM01: Parking Space Management)	City of Decatur Community Development: TOD Parking Prices
Parking Guidance (PM01: Parking Space Management, PM02: Smart Park and Ride System)	Atlanta Office of Transportation: Shops at Buckhead, Mercedes Benz Stadium, Ponce City Market
Dynamic Overflow Transit Parking (PM02: Smart Park and Ride System)	MARTA: Overflow lots, select locations

References

The following references are useful for further understanding, planning, and implementing parking management.

FHWA Active Parking Management

https://ops.fhwa.dot.gov/atdm/approaches/apm.htm

The FHWA Office of Operations provides tools, guidance, and good practices that aid local and State DOT's in their efforts to actively manage parking.

FHWA TSMO in Smart Connected Communities

https://ops.fhwa.dot.gov/publications/fhwahop19004/index.htm#toc

Provides information and implementation guidance on parking management strategies in smart cities and communities.

FHWA ATDM Program Brief: Active Parking Management

https://ops.fhwa.dot.gov/publications/fhwahop12033/fhwahop12033.pdf

FHWA program brief that focuses on active parking management strategies and implementations.

FHWA Congestion Pricing - Parking Pricing

https://ops.fhwa.dot.gov/congestionpricing/strategies/not_involving_tolls/parking_pricing.htm

FHWA Office of Operations focuses on parking policies that rely on market forces to influence the decision to drive, including variable pricing of curbside parking.

IBM Global Parking Survey

https://www-03.ibm.com/press/us/en/pressrelease/35515.wss

IBM conducted survey of commuters who drive to work.

FHWA Contemporary Approaches to Parking Pricing: A Primer

https://ops.fhwa.dot.gov/publications/fhwahop12026/index.htm#toc

FHWA Tolling and Pricing Program discusses programs and policies of parking management across the United States.

PERFORMANCE MEASURES

ATLANTA REGIONAL COMMISSION

The implementation of performance measures is critical to the success of TSMO strategies, reflecting the objectives-driven performance-based approach as recommended by the FHWA. Review of existing performance measures are critical in the development of TSMO goals and objectives for a region. Using performance measures to guide the operations and gauge the success of specific initiatives, strategies, or applications allows for better management and operations. In addition, monitoring performance measures allows us to understand and document the benefits of TSMO strategies which can be shared with decision makers.

Support for Regional TSMO Goals

Safety

Developing and implementing performance measures that aggregate crash and speed data in a single location, making it more accessible to end users, will assist in identifying safety hotspots within the transportation network. Generating metrics for vehicular, pedestrian, or bicyclists will help designers identify alternatives that promote a safer transportation network sooner, allowing them to propagate these features throughout the network.

Reliable Travel Times

Traffic signal performance measures and probe data can be used to identify bottlenecks and signal timing issues in the transportation network. These tools can function in the background, allowing users to focus on solutions as opposed to searching for problems. Automated delivery of failing performance measures through customized alerts can help users stay up to date with how their transportation network is working.

Efficient, Seamless Travel

Combining traffic signal performance measures with transit performance measures will help users make a trip using multiple modes in a seamless fashion. Allowing users to see how long their wait will be at a transit stop will help encourage the use of transit in all environments.

Environmental Benefits

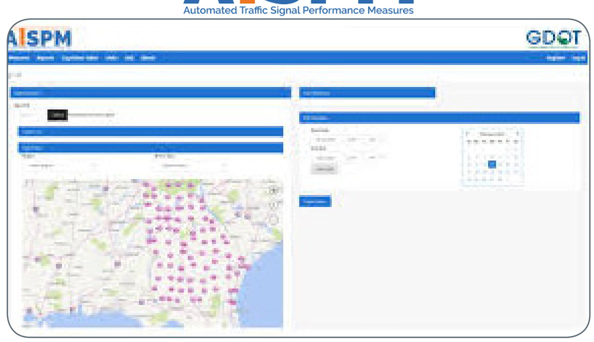
Allowing users to determine the location of bottle necks within the transportation network allows them to take corrective action before the problem becomes worth. This type of preventative maintenance allows the network to operate more efficiently and reduce the likelihood of negative environmental consequences.

Applications

Automated Traffic Signal Performance Measures (ATSPM)

ATSPM systems use traffic signal controller and detector data to populate different metrics that identify the efficiency with which a traffic signal is operating. These metrics can be populated for a single peak period instance, an entire day, or averaged over multiple periods or days. They allow traffic signal engineers and technicians to review how the signal was operating at the time a service request and validate timing changes with actual data. ATSPM data can also help DOT's save time and money by automatically collecting approach volume and turning movement count data, allowing for those dollars to be spent directly on efforts.

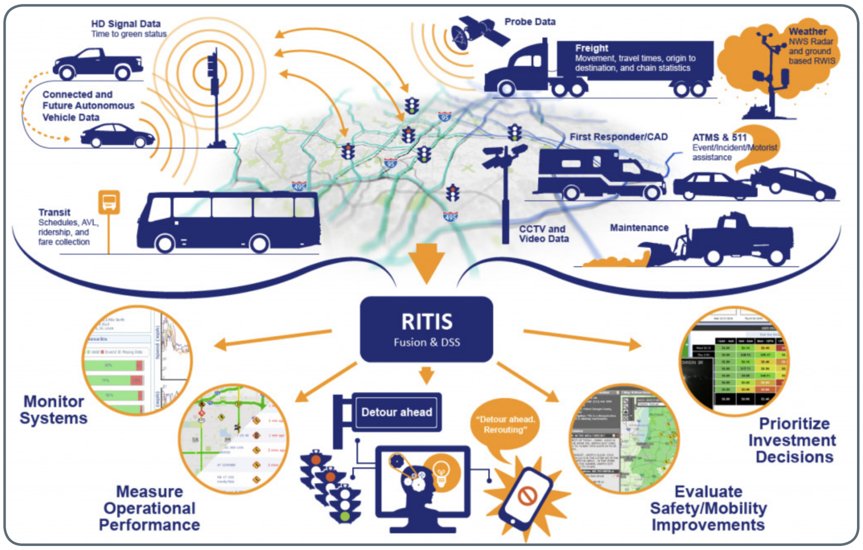
ATSPM
Automated Traffic Signal Performance Measures



Probe Data

Probe data uses information collected by agency owned or third-parties to aggregate and display travel speed performance measures. All states and MPOs have access to the National Performance Management Research Data Set (NPMRDS) which provides a historic speed and travel time data set for the National Highway System (NHS). The NPMRDS includes speed and travel times for passenger vehicles, trucks, and a combination of the two. This data set allows users to download, manipulate, and visualize large portions of the roadway network allowing them to focus their funding in areas that will be impacted the most.

The NPMRDS can be expanded to include the arterial network which covers the majority of arterials in metropolitan and rural areas. The full arterial network is nearly double the NHS network and provides the same speed and travel time information in a near real-time manner. In addition, GDOT provides access to Regional Integrated Transportation Information System (RITIS) at no charge to local jurisdictions throughout the State. RITIS is comprised of a suite of monitoring, analytic, and visualization tools used to better understand and manage transportation networks.



Source: I-95 Corridor Coalition

Transit Performance Measures

Transit performance measures can be broken into two categories, one that measures the performance of the transit infrastructure and one that measures the performance of the transit service. Transit infrastructure performance is measured rolling stock, equipment, facilities, and infrastructure.

- Rolling stock and equipment measure the percentage of revenue (rolling stock i.e. buses, light rail vehicle, streetcar) and non-revenue (equipment i.e. maintenance vehicles) that have met or exceeded their Useful Life Benchmark (ULB).
- Facilities measures the quality of two overarching facility types (Administrative and Maintenance, Passenger and Parking) by the percentage of facilities that are rated less than 3.0 on the Transit Economic Requirements Model (TERM) Scale.
- Infrastructure measures the percentage of track segments that have performance restrictions due to rail defects, maintenance, or track geometrics.

In general, while measuring the performance of transit infrastructure, lower values equate to a better state of repair.

Transit service performance measures cover a wide range of categories from availability to safety and security. Some highlights, discussed in TCRP Report 88, are:

- Stop accessibility measures the ease in which users can walk, bike, or drive to a transit stop.
- Vehicle coverage measures the amount of vehicle miles traveled versus the size of the network.
- Transit ridership measures the number of users that use the transit network.
- Transit productivity measures the ratio of total passengers to the revenue or service hours in a given period.
- Customer satisfaction measures, through market research, the overall satisfaction with the transit agency.

Transit agency goals and objectives will vary by agency, and it is up to each agency to determine which performance measures are best suited to their needs.

Regional Examples

The following chart provides a few regional examples of current performance measures applications:

Application	Location and Deployment Type
ATSPM	GDOT Traffic Operations: ATSPM (statewide)
Probe Data	GDOT Traffic Operations: RITIS (statewide) - available to local agencies with agreement at no cost GDOT Traffic Operations: iPeMS (statewide)
Transit Performance Measures	MARTA: Regional Gwinnett County: Gwinnett County Transit Cobb County: CobbLinc

References

The following references are useful for further understanding, planning, and implementing performance measures.

FHWA Automated Traffic Signal Performance Measures
https://ops.fhwa.dot.gov/arterial_mgmt/performance_measures.htm
The FHWA Arterial Management Program highlights the benefits of using ATSPM.

FHWA Operations Performance Measurement
https://ops.fhwa.dot.gov/perf_measurement/index.htm
The FHWA Office of Operations provided data on Urban Congestion Reports, Urban Congestion Trends, and Travel Time Reliability Measures.

FTA Performance Management
https://www.transit.dot.gov/PerformanceManagement
The FHWA program brief that focuses on active parking management strategies and implementations.

FHWA Congestion Pricing - Parking Pricing
https://ops.fhwa.dot.gov/congestionpricing/strategies/not_involving_tolls/parking_pricing.htm
The FTA provides explanations and resources to Transit Performance Measures.

TCRP Report 88 - A Guidebook to Developing a Transit Performance-Measurement System
http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_88.pdf
A guidebook that provides a step-by-step process for developing a performance-measurement program that includes both traditional and non-traditional performance indicators that address customer-oriented and community issues.

SUPPORTING DEPLOYMENTS

Intelligent Transportation Systems (ITS) and communication infrastructure supporting deployments are foundational to a number of successful TSMO strategies. ITS deployments can support safe, reliable, efficient, and equitable management and operations of the transportation system. Uses of ITS and communications supporting deployments vary widely, but typically support strategies that offer significant benefits, particularly when compared with traditional capacity expansion projects, i.e. roadway widening. For example, integrated corridor management strategies which rely on cameras, communication, and dynamic message signs have been found to have benefit versus investment ratios of up to 39 times the investiment while traditional capacity expansion, i.e. roadway widening, only offers about three times the return on the investment.

FHWA defines ITS as "electronics, communications, or information processing used singly or in combination to improve the efficiency or safety of a surface transportation system."

Support for Regional TSMO Goals

Safety

ITS and communications deployments support TSMO strategies such as incident management, emergency operations management, traveler information, warning systems, etc. These strategies improve safety through reduction in response, clearance, and recovery times; notifying or rerouting travelers to avoid unsafe conditions; and even warning travelers of dangerous curves or conditions, etc.

Reliable Travel Times

ITS and communications deployments support TSMO strategies such as traffic signal management, transportation performance measures, traveler information, event management, etc. Reliable travel times are better realized through the use of these strategies by optimizing existing traffic, managing recurring and non-recurring congestion, disseminating information in real-time so that travelers may plan accordingly, and offering information and providing incentives for use of alternative modes of transportation.

Efficient, Seamless Travel

Efficient, seamless travel is primarily made possible through the use of well-coordinated, technology-based strategies. These strategies are supported through ITS and communication deployments such as dynamic message signs (DMS) or network connections between various modes of transportation.

Environmental Benefits

Environmental benefits are realized through enhanced mobility, transportation demand management (TDM), increased use of non-vehicular or more efficient vehicles, etc. TSMO strategies supported by ITS and communications infrastructure provide these elements to achieve environmental benefits.

Applications

Communications Network

The communications network is the critical foundation that supports technology based deployments such as ITS devices and/or various systems used to transport data. These deployments and systems are used to enhance coverage for better transportation management and operations. Different communication methods are used within the communications network including legacy copper, fiber optic cable, wireless radios, and cellular radios. The communication method can depend on existing conditions, bandwidth needs, available funds, and the environment in which they will be utilized. While copper is no longer installed at new locations, it is still being used in some areas where infrastructure has not been upgraded. Fiber optic cable is the most reliable; however, it typically requires the greatest capital cost to build. On the other hand, wireless and cellular radios are easy to install but offer limited bandwidth and can be susceptible to enviornmental elements. The development and installation of a robust, redundant, resiliant, and scaleable communications network is the best way to prepare for the deployment of any transportation technology solutions in the future.

Closed Circuit Television (CCTV) Cameras

Closed Circuit Television (CCTV) Cameras are used for remote surveillance of physical and operational roadway conditions including safety hazards, traffic incidents, and congestion with zoom, pan, and tilt capabilities. CCTV Cameras have the ability to verify device functionality and can be used in conjunction with supported software to troubleshoot problems. CCTV Cameras provide engineers with the information needed to more efficiently and effectively complete tasks such as signal timing and traffic monitoring thus saving time and money.

Dynamic Message Signs (DMS)

Dynamic Message Signs (DMS) are LED matrices used to display continuous messages to the public providing near real-time traveler information to drivers along interstates and freeways. Typical information communicated on these boards include work zone locations, crashes, weather, real-time travel speeds, amber alerts, and friendly safety reminders.

Detection

Detection is used primarily to detect motor vehicles, pedestrians, and cyclists traveling along freeways or signalized road networks with the use of inductive loops, wireless magnetometers, radar, video, microwave, and pedestrian push buttons. Detection can also obtain count, speed, classification, and other information about vehicles, pedestrians, and cyclists. Detection systems are critical to providing performance metrics for the roadway network such as arrival on green percentages, congestion levels, travel times, and incidents. Other operational functionalities that rely on detection data include adaptive signal timing, responsive signal timing, and traffic coordination.

Ramp Metering

Ramp metering is used to control the pace of traffic entering a controlled access facility allowing vehicles to merge more smoothly and effectively. Traffic platoons are broken up as vehicles approach freeways in a safer manner by reducing the number of weaving crashes. Ramp metering also helps control the volume of vehicles entering the facility, especially during peak hours, which helps increase operating speeds and minimize congestion on the freeway.

Warning Systems

Warning systems can be of various types but is used primarily to detect an unwanted behavior including wrong-way maneuvers. This system will alert a vehicle entering opposing traffic and warn the driver and the traffic management center of the unsafe condition. Warning systems can help avoid injury to the driver and other public users on the facility.

Road Weather Information Systems (RWIS)

Road Weather Information Systems (RWIS) uses sensors to obtain real-time data on weather indicators such as temperature, pressure, fog, wind, humidity, ice conditions, and other road-weather related information. It provides information to end users and increases the safety of the roadway network by allowing users to better determine driving visibility and pavement conditions.

References

The following references are useful for further understanding, planning, and deploying ITS and communications infrastructure.

Intelligent Transportation Systems Benefits, Costs, and Lessons Learned 2017 Update Report

https://www.itsknowledgeresources.its.dot.gov/its/bcllupdate/pdf/BCLL_2017_Combined_JPO-FINALv6.pdf

The report has been developed as a collection of factsheets presenting information on the performance of deployed ITS, as well as information on the costs, and lessons learned regarding ITS deployment and operations.

USDOT ITS Knowledge Resource

https://www.itskrs.its.dot.gov/its/itsbcllwebpage.nsf/KRHomePage

This website presents summaries on the benefits, costs, deployment levels, and lessons learned for ITS deployment and operations from over 20 years of ITS evaluation studies, research syntheses, handbooks, journal articles, and conference papers tracking the effectiveness of deployed ITS.

Lennie Lightwave's Guide to Fiber Optics

https://www.thefoa.org/Lennie/

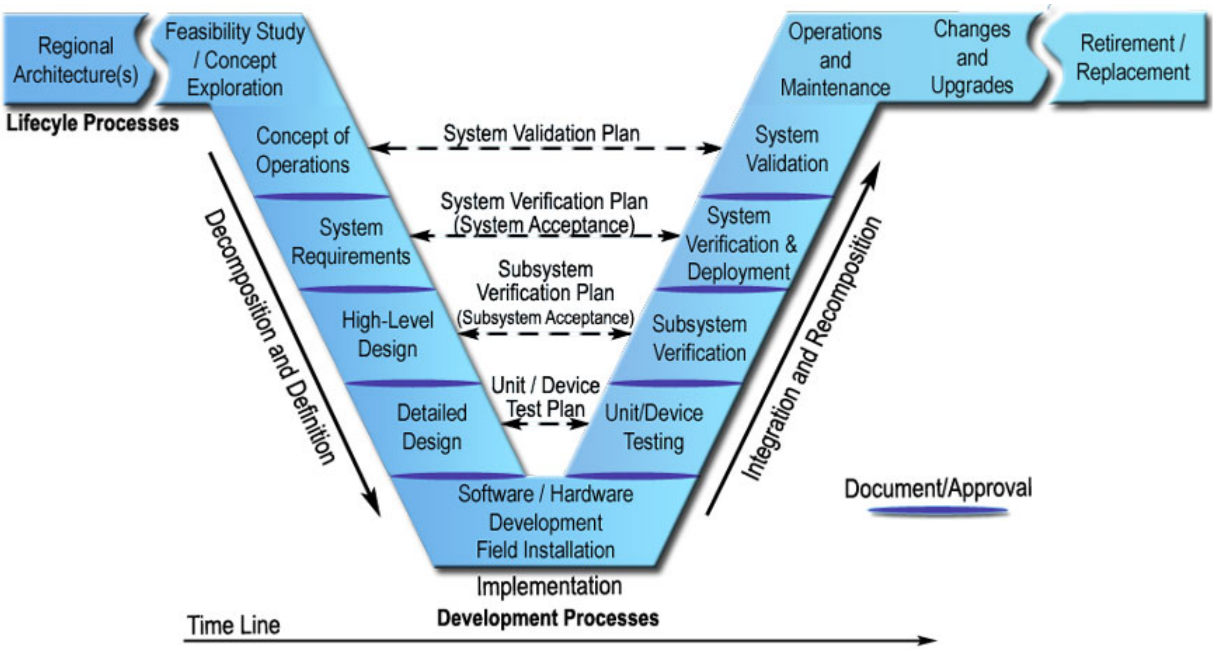
The Fiber Optic Association (FOA) provides materials for self-guided learning about fiber optic communications design, operations, management, and maintenance.

Appendix: Systems Engineering Checklist

SYSTEMS ENGINEERING CHECKLIST

ATLANTA REGIONAL COMMISSION

This checklist serves as a guide for regional ITS project developments. The statements follow the systems engineering approach, using the "V" diagram to guide project development, design, integration, management, operations, and retirement. The checklist serves as a resource to remind users of the steps recommended for successful systems engineering process completion, though not all steps may be relevant to some projects. *Check the following boxes if applicable to project development.*



Source: Federal Highway Administration

Regional Architecture

- [ ] This project is included in the regional and/or statewide ITS architecture.

Stakeholders

- [ ] Stakeholders anticipated to be involved in the project (i.e. departments, jurisdictions, agencies) are identified.
- [ ] Preliminary project collaboration with identified stakeholders has occurred.
- [ ] Existing interagency agreements will assist with facilitating this project development.
- [ ] Future agreements are developed to support project development.

Feasibility Study

- [ ] A feasibility study is necessary for this project.
- [ ] Preliminary risks are identified.
- [ ] High-level cost is estimated.
- [ ] Future agreements are developed to support project development.
- [ ] Anticipated benefits are developed.

SYSTEMS ENGINEERING CHECKLIST

Concept of Operations

- [ ] The stated goal of project is developed.
- [ ] Proposed system operations, including the roles and responsibilities for all applicable stakeholders, are developed.
- [ ] There is a list of stakeholder resource needs that are anticipated to manage and operate this system.
- [ ] Evaluation criteria for the performance of the proposed system, including management and validation, are developed.

System Requirements

- [ ] A high-level list of system requirements that are necessary to meet stakeholder needs is developed.
- [ ] A Verification and Acceptance Plan for the proposed system (upon completion) is identified and developed.

Design

- [ ] A high-level design is completed.
- [ ] A detailed design is completed.
- [ ] Evaluation for how the system components (i.e. units/devices) are tested is developed.

Implementation

- [ ] Implementation is completed.

Unit/Device Testing

- [ ] The unit/device testing is completed by the defined test plan.

Verification and Acceptance

- [ ] All systems and subsystems are verified and accepted based on the Verification and Acceptance Plan.

System Validation

- [ ] A before and after study/evaluation is conducted.
- [ ] Key performance measures and related metrics for validating system performance are identified.
- [ ] Evaluation for how the results of the validation will be used to optimize the system is conducted.

Operations and Maintenance

- [ ] Operations and maintenance of the proposed system is identified.
- [ ] A list of resources necessary to maintain and manage the system is identified.
- [ ] Operations and maintenance of the proposed system is funded.

Retirement/Replacement

- [ ] The person responsible for life-cycle and/or retirement of the system is identified.