New Approaches to Transportation Management (Task 1)

Congestion continues to be a challenge in Texas and throughout the United States, and it is increasing, leading to longer delays, higher fuel consumption, and related crashes. Recognizing the inability to easily add capacity to their systems, transportation agencies have relied on operations and maintenance strategies to help manage congestion.

Over the past two decades, there have been several success stories and advances in freeway management, arterial management, and regional coordination. Today, most agencies can detect and operate their systems in ways that would have been unimaginable two decades ago. However, changing travel patterns, growing demand, changes in traveler behavior, and increasing expectations are all requiring agencies and policy makers to ask the question of "what is the next generation of management strategies that can address the new challenges?"

The purpose of this policy brief is to present an overview of next-generation strategies for transportation management designed to increase system efficiency and manage congestion more effectively. Faced with limited funding for new infrastructure, agencies are finding success with these new approaches, which include integrated corridor management, variable speed limits, dynamic lane use control, and other operational innovations.

Transportation Management Strategies – State of the Practice

Technology-supported traffic management strategies have become fairly standard and commonplace across the U.S. These strategies include traffic signal coordination, road weather information systems, display of travel times on electronic message signs and electronic tolling. More recently, active traffic management (ATM) has emerged as the evolutionary offshoot of more traditional strategies that exploit technology to manage traffic flow. These strategies are more common in Europe, where a number of agencies have made it a primary goal to maximize efficiency rather than add highway capacity.

ATM, simply put, is the ability to dynamically manage congestion on an entire facility by continuously measuring traffic conditions and responding with proactive measures. ATM strategies result in greater efficiency of a facility while increasing throughput and enhancing safety by reducing and smoothing the "shock waves" that are a major cause of congestion. For the end user, these active strategies offer a more consistent and reliable speed, and all travelers are able to save time and avoid collisions.

ATM strategies use integrated systems with new technology, including comprehensive sensor systems, real-time data analysis, and automated deployment of necessary actions. This approach helps optimize the system quickly and without the delay that occurs when operators have to manually deploy operational strategies. When various ATM strategies are implemented at the same time, they can work to fully optimize a facility and provide measurable benefits to both the transportation network and the traveling public. As shown in Figure 1, these strategies represent a range of applications, each of which addresses a specific problem or condition, but which are collectively considered strategies supporting active traffic management. Definitions of these strategies are included in the appendix at the end of this brief.

The following sections describe some of these rapidly evolving strategies in traffic management. The list is not meant to be exhaustive but to highlight the trends towards active management and those strategies which may hold particular promise for improving roadway operations for both freeways and arterial roadways in Texas.

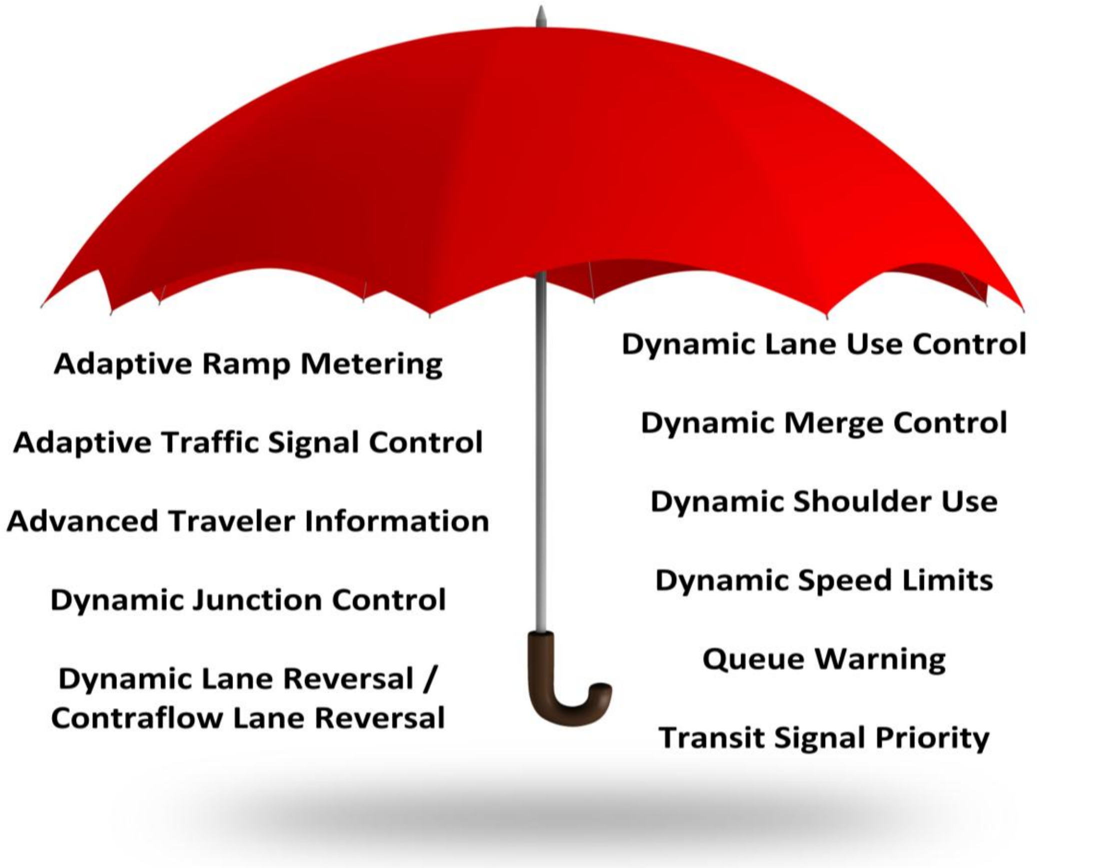

Figure 1. ATM Operational Strategies.

Advanced Traveler Information

Traveler information availability has been growing steadily through the increase in demand for real-time or near-real-time information, comparative travel times, and the entry of the private sector into this market. For agencies operating both freeways and arterials, the most common

way of sharing traveler information is through agency websites and electronic message signs followed by 511, the federally-assigned 3-digit dialing code for travel information.
Traveler information has significantly improved in recent years. Pre-trip information via agency websites is still the primary source for traveler information, though the amount of information available to the traveler now often includes multi-modal information, weather alerts, and trip planning support. In addition, en-route traveler information is growing rapidly through the increased use of signing, 511, and Smartphone applications. Figure 2 shows a deployment of traveler information in Seattle, Washington that provides comparative travel times along different routes into the downtown area.

Figure 2. Travel time signs, Seattle, Washington (Source: WSDOT).

Dynamic Speed Limits

Dynamic speed limits, also known as variable speed limits (VSL), or speed harmonization, are widely used in Europe to improve traffic flow, and are being used in several locations in the United States. VSL systems typically use changeable speed limit signs posted on the freeway (or even over individual freeway lanes) to regulate speeds based on prevailing traffic conditions. Speeds can be lowered when congestion is ahead or when there is slow traffic due to road construction, an incident, or weather conditions such as rain, snow, ice, and fog. Dynamically-changing VSL systems are based on real-time traffic conditions, while less dynamic versions may change speeds according to the time of day.

In 2010, the Minnesota Department of Transportation (Mn/DOT) opened the Interstate-35 West (I-35W) "Smart Lanes," which included the installation of structures every half-mile with digital signs over every lane through the corridor. Motorists receive information on closed lanes and/or advisory speeds during incidents or when weather and road conditions warrant slower speeds (Figure 3).

The Washington State Department of Transportation (WSDOT) currently operates VSL and lane control signage on Interstate-5 (I-5), Interstate-90 (I-90), and State Route 520 (SR 520). The signs automatically post VSL (Figure 4) to warn drivers of congestion or driving hazards and help smooth traffic approaching an incident. Note, as in Minnesota, these overhead signs also show lanes that are closed and warn drivers of incidents. This advance notification and the VSL are intended to reduce secondary collisions that cause backups and stop-and-go traffic. Figure 5 shows a weather-related application of VSL over Snoqualmie Pass outside of Seattle where safe speeds are displayed based on weather conditions.

Figure 3. Variable advisory speed and white diamond use, Minneapolis, Minnesota (Source: Mn/DOT).

Figure 4. Variable speed limit signs on I-5, Seattle, Washington (Source: TTI).

Figure 5. Weather VSL at Snoqualmie Pass, Seattle, Washington (Source: WSDOT).

VSL can also be used in construction work zones. The last major construction contract of the Woodrow Wilson Bridge Project in Virginia was expected to severely impact traffic during construction. At the encouragement of FHWA, a VSL system was implemented along I-95/I-495 to evaluate its effectiveness as a work zone congestion management tool and help mitigate traffic impacts. This evaluation concluded that using VSL for work zone management is beneficial if motorists are informed of work zone conditions, automated speed limit enforcement is used, and motorists have adequate time to utilize alternate routes. Other examples of variable speed deployments for congestion include a VSL system on I-4 in Florida, VSL systems on I-80 in Wyoming for high winds, and variable advisory speeds on I-270 in Missouri.

The Texas Department of Transportation (TxDOT), with the assistance of TTI, is currently working to implement a variable speed limit pilot program. This program authorized by HB 2204 in 2013 and established by the Texas Transportation Commission as part of the Texas Administrative Code Title 43, Part 1, Chapter 25, Subchapter B, Rule §25.27, will be composed of VSL pilot studies in three locations (Brownwood District, Waco District, San Antonio District) for the purposes of assessing the impacts and potential benefits of VSL under weather conditions, within an active work zone, and under congestion conditions, respectively. Figure 6 and Figure 7 show the experimental VSL displays that will be used in the pilot program.

Figure 6. TxDOT VSL Display, 70 mph (Source: TTI).

Figure 7. TxDOT VSL Display, 55 mph (Source: TTI).

The deployment of the TxDOT VSL pilot projects is underway with the systems expected to go live in early June 2014. TTI will analyze the impacts of the VSL on travel speeds, safety, users' perception, and costs and benefits and provide TxDOT with a report that will be made available to the Legislature in December 2014.

Dynamic Lane Use Control/Dynamic Shoulder Lanes

Dynamic shoulder lanes, sometimes deployed with VSL, address capacity bottlenecks on the freeway network. The idea is to open a roadway shoulder for use during periods of congestion when it is needed most. Dynamic shoulder use for travel lanes is a low-cost approach to expanding capacity on roadways. These applications vary, particularly the extent to which they are dynamic.

Shoulder use on I-66 in Virginia is a good example of a shoulder-use treatment during heavy commute times (Figure 8). On I-66, the Virginia Department of Transportation (VDOT) allows vehicles to use the eastbound and westbound shoulders at specified morning and evening peak periods, respectively, using both fixed and electronic signs. While the potential is there for more dynamic operations of the shoulder, VDOT currently manages the lane on a time-of day manner, with ongoing plans for more dynamic lane use and control.

Figure 8. Time-of-day shoulder use, Virginia (Source: VDOT).

Dynamic shoulder lanes, as well as lane control strategies, are used on I-35W in Minnesota. During peak travel times, the left shoulder is opened dynamically to add capacity. During a crash or other roadway incident, a transportation management center (TMC) operator can identify the lane(s) and precise milepost information for the incident. The system then automatically shows the appropriate information on the lane control signals to tell drivers which lanes to avoid (see Figure 9). For example, if the shoulder is open at the time of an incident, it could be closed to allow emergency responders to quickly get to the incident. If it is closed at the time of an incident, it could be opened to ease congestion caused by the incident. The dynamic signs allow for the flexible use of that shoulder as needed.

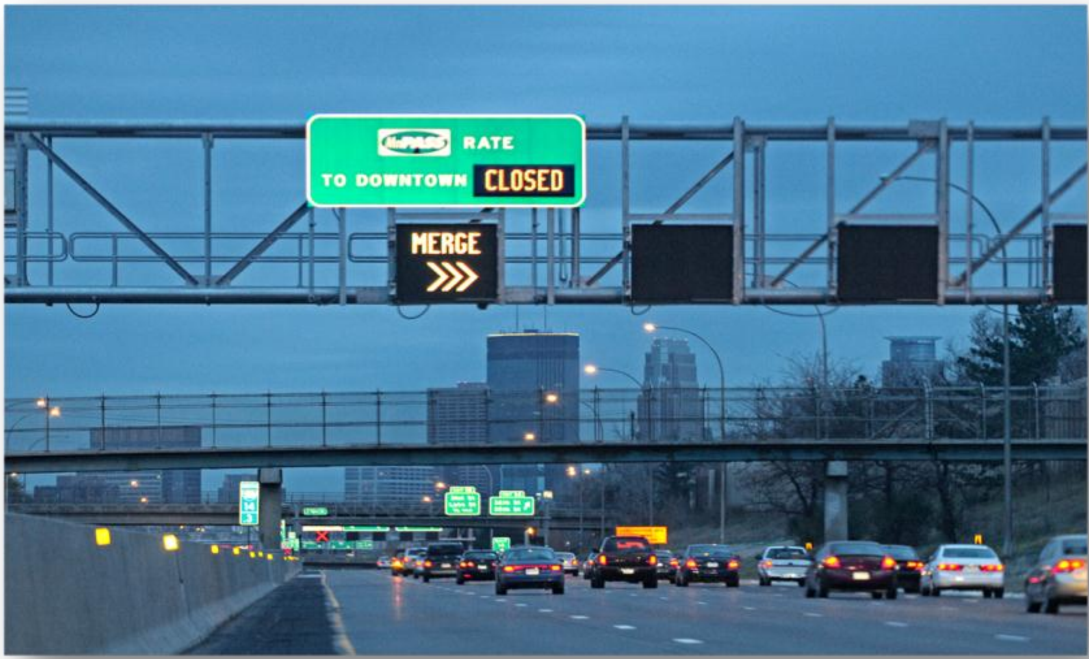

Figure 9. I-35W MnPASS and ATM signage (Source: Mn/DOT).

Dynamic Junction Control

Dynamic junction control is a way to change how lanes are used at an interchange or ramp. It uses electronic message signs, dynamic pavement markings, and/or lane use control signs to shift traffic to specific lanes (main travel lanes or ramp) based on traffic demand. The idea is to manage traffic flow by using the available capacity more effectively.

Using dynamic junction control, also known as dynamic merge control, agencies can modify access based on traffic demand from two entering roadways, improving the operation of roads that have more lanes entering than leaving the merge. It takes advantage of available capacity to smooth the merge. A diagram illustrating the concept is shown in Figure 10. A photo of dynamic pavement markings used at an entrance ramp is shown in Figure 11.
The following highlight where dynamic junction control can be used:

- Freeways or roads with frequent congestion and major merging volumes;
- Facilities with available capacity on main travel lanes before an interchange; and
- Roads where traffic volumes on two connecting roads peak at different times.

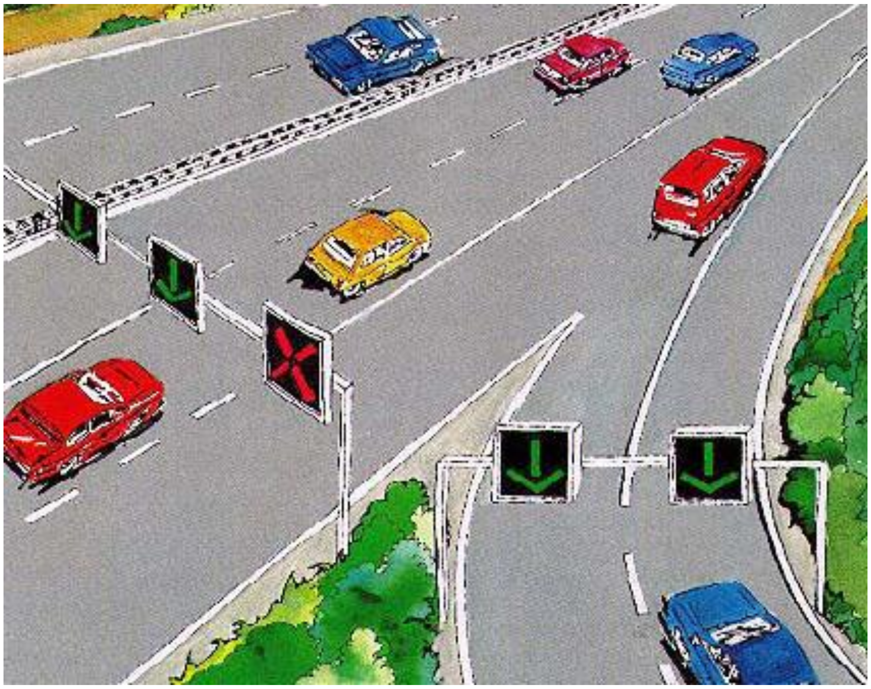

Figure 10. Dynamic Junction Control Schematic (Source: BASt, Germany).

Figure 11. Dynamic Pavement Markings (Source: Ministry of Transport, The Netherlands).

Dynamic junction control is not widely used in the U.S., but some states are planning to open projects in the near future. A recent application has been implemented in Los Angeles on the northbound SR-110 to northbound Route-5 Connector (Figure 12). In this location, pavement

Figure 12. Dynamic junction control on NB SR-110, Los Angeles, California (Source: Caltrans).

lighting and changeable message signs are used to convert the shoulder on SR-110 into a part-time optional exit lane to northbound Route-5 during peak travel times. Currently, operating as a time of day measure, Caltrans is looking at more dynamic uses of the system based on measured and predicted traffic demand.

Integrated Corridor Management

The Integrated Corridor Management (ICM) Program is one of the major efforts within the U.S Department of Transportation (U.S. DOT) to promote active and integrated management of transportation corridors across modes and agencies. While technically not under the ATM umbrella, ICM expands the idea of effective facility management to include the entire corridor – not just a single facility. The intent of ICM is to reduce congestion, improve network performance, and increase travel reliability. Urban corridors often contain several parallel routes and modes that, today, are managed as separate systems by different agencies. In everyday operations and during unplanned events, there is a need to manage all capacity across the entire corridor to maximize person and vehicle throughput while providing reliable travel options. Ideally, ATM would operate on various facilities and be coordinated within an ICM project. Through increased awareness, decision-support, and coordination, ICM systems strive to move from a traditional reactive way of managing traffic to a proactive approach. With ICM, system operators take action before corridor performance degrades and, in cases where degradation has already occurred, take action to restore normal conditions.

The Dallas ICM Pioneer Site covers the US-75 corridor from downtown Dallas to SH 121 with the North Dallas Toll Way to the west and various arterials to the east as their corridor. The various ICM strategies that are being evaluated include route diversions, mode diversions, smart parking at light rail transit facilities, and the management of the HOV/HOT lanes in the corridor. The demonstration, which is now active, includes the following:

- Real-time traveler information about traffic and travel times, public transit, and parking availability to facilitate traveler decision making;
- Detectors that collect information on the current travel conditions on freeways, frontage roads, arterial streets, light-rail Red Line, Red Line park-and-ride lots, and High-Occupancy Vehicle (HOV) lanes in the corridor; and
- A decision support system (DSS) to help operators select the appropriate combination of ICM strategies to apply to different operational conditions.

Technology Implications of Innovative Transportation Management

One primary factor links all of these innovative transportation management strategies together: technology. Each of these approaches requires significant investment in field- based technologies that provide data into a traffic management center. Those centers serve as the hub of transportation operations for a region and are a critical part of the use of these strategies. Needed data include traffic volumes, travel speeds, incident presence and location, shoulder availability, weather conditions, and pavement conditions related to weather. All of this data is currently provided by field equipment, which needs to be maintained for effective operations. The rapid growth in private sector data may play a role in these strategies. Agencies need to explore how public data can be fused with private sector data and used in a collaborative way to meet the data needs of these strategies and all travelers.

Furthermore, as connected vehicle and automated vehicle data begins to become part of the data stream, field devices need to be able to capture that data and also send it to the TMC. All of this data can then be used in the traffic management center to deploy operational strategies as needed and based on real-time conditions. Without robust and reliable field equipment that can collect available data, an agency cannot effectively use innovative operational approaches to address the growing congestion challenges in their region.

Policy Implications of Innovative Transportation Management

The following sections summarize how innovative transportation management may have policy implications in Texas.

Legislative Authority

One of the major hurdles to implementing some of the innovative transportation management strategies is legislative authority. While many of these strategies currently fall within the roles and responsibilities of TxDOT and other operating agencies, two primary strategies do not: dynamic speed limits and dynamic shoulder use.

The current authority for TxDOT to implement a variable speed limit pilot program is temporary. HB 2204 expires February 1, 2015, as does the section in the Texas Administrative Code (TAC). The bill and subsequent TAC rule are limited in scope and do not provide TxDOT with the broad legislative authority to deploy VSL across the state in regions where it has the potential to benefit operations in congested corridors. The results of the VSL pilot studies underway in Texas can be used to inform policymakers on further action regarding statutory authority for VSL in the future.

Dynamic shoulder use, whether for transit vehicles or all vehicles, is also not legal in Texas. Two previous legislative attempts to allow transit vehicles to use shoulders to bypass traffic (SB 434 – 2009, HB 2327 – 2011), were passed by the Texas Legislature and vetoed by the Governor. Concerns cited in the Governor's veto proclamation were that allowing highway shoulders to be used by transit buses would leave no emergency lane, confuse drivers as to the purpose of highway shoulders and endanger motorists, emergency personnel and transit bus passengers. Additionally, the previous pieces of legislation did not account for the authority to automatically deploy these strategies with operator intervention when appropriate which has optimized effectiveness as these operational approaches have developed and matured.

Agency Capabilities

In addition to the legislative authority barriers to these innovative strategies, agencies may need to change the way they do business to be able to successfully use these strategies to manage congestion. A variety of larger agency policies and methods may need updating. These dimensions of business include business processes, systems and technology, agency culture, organization and workforce capabilities, performance measurement, and collaboration. An agency's capability across these dimensions can spell success and enable both current and future innovative traffic management at the regional level.

The Role of Transportation Operations in Reducing Congestion

As discussed previously, technology is essential to the successful deployment and operation of innovative transportation management strategies. Thus, if these strategies are to be advanced, transportation operations need to be a priority in the planning, programming, and funding processes for roadway infrastructure. To be successful, the operation of the existing system must be considered as important as the more traditional expansion activities, and be seen as critical to realizing the benefits of investment in the transportation infrastructure. If appropriate, legislative authority and agency policies should support this shift in how operations is managed and funded. For example, many metropolitan planning organizations have management and operations strategies included in their metropolitan transportation plans, and many have these strategies included in their transportation improvement plans.

Legislation, policy, and financial resources are critical to the long-term success of active traffic management. Such resources help maintain and operate the system in a more efficient manner and ensure it adapts to new technologies to better serve customers. Thus, the successful deployment of these strategies requires that transportation agencies make the commitment to operations a priority.

Human Factors

A challenge related to the use of these advanced technologies and strategies is the way in which all of the relevant information is given to the driver. If more than one strategy is operating at a time, it is possible that a driver will become overloaded with information and become confused or not respond properly. In recent years, some limited human factors studies have been conducted to see what messages are easily understood for specific ATM strategies. However, it is unknown what impacts all of these strategies have together. Until automated vehicles become commonplace, it may be necessary to consider policies that ensure only the most critical information is given to drivers to limit overload. Also, including these strategies in driver education materials is important to ensure all drivers understand them. Public outreach campaigns are also essential for the same reason.

The Importance of Enforcement

Enforcement plays a key role in the overall success of these innovative transportation management strategies. The manual enforcement of VSL can be difficult and a challenge to defend in court. To address these challenges, automated enforcement plays a role in successful operations in Europe. While not popular in the U.S., some agencies use automated enforcement in work zones (Maryland), in areas (parks and schools) with high numbers of child pedestrians (City of Chicago, Maryland), and at intersections (Washington, D.C.). In all of these locations, the automated enforcement is attributed to better speed compliance. Automated enforcement may be the key to effective operations until such time that automated vehicles make up a majority of the vehicle fleet and automatically follow the operational approaches deployed unless overridden by the driver.

Future Vehicle Technologies

One final challenge lies in the transition from these innovative strategies to a vehicle stream with fully automated vehicles. Before that distant future arrives, vehicles will begin to be equipped with technologies that take infrastructure and traffic information and provide directions to the driver. It is highly likely that an in-vehicle device could provide information that conflict with dynamic information coming from the infrastructure (e.g., external VSL does not match the speed limit provided to the driver). In this scenario, policies may be needed to identify the priority information that is enforceable. A vision of the distant future includes one in which the vehicles - using data gathered through sensors and directly from infrastructure operators – will themselves be able to adjust speeds automatically and eliminate the congestion “shock waves” that agencies are working to mitigate through current ATM strategies.

APPENDIX – ATM Strategies Defined

Active Traffic Management Strategies (Source: FHWA).

ATM Operational Strategy	Description	Sample of Current U.S. Deployments
Adaptive Ramp Metering	The deployment of traffic signal(s) on ramps to dynamically control the rate at which vehicles enter a freeway facility. Can utilize traffic responsive or adaptive algorithms, dynamic bottleneck identification, automated incident detection, and integration with adjacent arterial traffic signal operations.	Los Angeles (CA), Portland (OR)
Adaptive Traffic Signal Control	The continuous monitoring of arterial traffic conditions and queuing at intersections and the dynamic adjustment of signal timing to optimize one or more operational objectives (such as minimize overall delays).	New York (NY)
Advanced Traveler Information	The delivery of real-time information about roadway, traffic, and travel mode conditions, either pre-trip and/or en-route, to influence driver behavior.	Various
Dynamic Junction Control	Dynamically allocating lane access on mainline and ramp lanes in interchange areas where high traffic volumes are present and the relative demand on the mainline and ramps change throughout the day.	Los Angeles (CA)
Dynamic / Contraflow Lane Reversal	The reversal of lanes to dynamically allocate the capacity of congested roads, thereby allowing capacity to better match traffic demand throughout the day.	Various
Dynamic Lane Use Control	Dynamically closing or opening of individual traffic lanes as warranted and providing advance warning of the closure(s) (typically through dynamic lane control signs) to safely merge traffic into adjoining lanes.	Minneapolis (MN), Seattle (WA),
Dynamic Merge Control	Dynamically managing the entry of vehicles into merge areas with a series of advisory messages (e.g., displayed on a dynamic message sign [DMS] or lane control sign) approaching the merge point that prepare motorists for an upcoming merge and encouraging or directing a consistent merging behavior.	Northern Virginia
Dynamic Shoulder Use	The use of the shoulder as a travel lane(s) based on congestion levels during peak periods and in response to incidents or other conditions as warranted during non-peak periods.	Minneapolis (MN), Chicago (IL)
Dynamic Speed Limits	The adjustment of speed limits based on real-time traffic, roadway, and/or weather conditions. Dynamic speed limits can either be enforceable (regulatory) speed limits or recommended speed advisories, and they can be applied to an entire roadway segment or individual lanes.	Seattle (WA), Minneapolis (MN), Texas
Queue Warning	The real-time display of warning messages (typically on dynamic message signs and possibly coupled with flashing lights) along a roadway to alert motorists that queues or significant slowdowns are ahead, thus reducing rear-end crashes and improving safety.	Seattle (WA), Northern Virginia
Transit Signal Priority	The management of traffic signals by using sensors or probe vehicle technology to detect when a bus nears a signal controlled intersection, turning the traffic signals to green sooner or extending the green phase, thereby allowing the bus to pass through more quickly.	Various