An Overview of TMC Practices– Results from a Nationwide Survey

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ABSTRACT

The goal of this paper is to draw a typology of best practices in TMCs with a focus on current applications and tools in key TMC function areas, and practices in data collection and information sharing. A web-based survey was conducted to collect information from TMCs around the country. Both fact-finding and opinion-seeking questions were included in the questionnaire. This study presents an overview of TMC practices, and provides an opportunity for information exchange and sharing among agencies. It also reveals some agencies’ experience as best-practices or innovative applications that could be useful to other agencies and lead to improved performances and services. The survey also provides some perspectives in terms of what applications are yet to receive more attentions, and which technology or data may have the potential to be incorporated in TMC operations.
INTRODUCTION

Traffic management centers (TMCs) are the brains for most freeway and arterial management systems. TMCs monitor and manage the traffic flow and the transportation network, as well as provide traveler information through the deployment of various Intelligent Transportation System (ITS) technologies and proactive management strategies. A TMC also functions as the technical and institutional hub that facilitates interagency coordination and integrates a wide range of traffic management strategies to achieve the collective goal of providing safer, more efficient, and sustainable transportation infrastructure to meet the mobility needs.

The success of a TMC directly influences the efficiency of the transportation network, the economic competitiveness of a region in moving people and goods, and the quality of life for the communities. The intent of this study is to review the state-of-the-practice in TMC operations, establish a general standard in TMC performance, and provide the opportunity for information exchange and sharing among the agencies that will lead to improved performances and services.

The last study of this nature regarding TMC operations was conducted in 1999 charged by the FHWA, which investigated and documented the operations of eight TMCs around the country (1).

To accomplish this goal, a nationwide survey was conducted with TMCs around the nation. The survey focused on current applications and potentials of technologies and tools in advancing TMC practices. This paper presents first part of major findings from the survey results, including current tools used for each TMC function, and practices in data and information. This paper adds to the literature by providing an updated and comprehensive scan of current practices in TMC operations. The results of this study will help agencies to assess their practices, learn from others’ experiences, and improve the performance and services of the centers.

BACKGROUND

Table 1 below presents a quick summary of significant events in TMC development. Following significant advances in computer and communication technologies, a series of major efforts were initiated during late 1990s and early 2000s, with a general emphasis on applying systems engineering process in TMC development. Later studies then focused on various aspects related to TMC operations, including business planning, performance measurement, technology advancement, and data capture.

Table 1: A Timeline of Major Studies on Traffic Management Centers

<table>
<thead>
<tr>
<th>Major Study</th>
<th>Year</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metropolitan TMC Concepts of Operation (A Cross Cutting Study) (1)</td>
<td>1999</td>
<td>Eight TMCs from US and Canada were studied. In-depth reviews were conducted, and documented the plan, design, and deployment of ITS in TMCs.</td>
</tr>
<tr>
<td>Major Study</td>
<td>Year</td>
<td>Description</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>------</td>
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</tr>
<tr>
<td>Transportation Management Center Concepts of Operation Implementation Guide (2)</td>
<td>1999</td>
<td>Presented an extensive list of reference materials on TMC concept of operations. Examples were given to highlight ideas about planning, designing, implementing, operating, and maintaining TMCs.</td>
</tr>
<tr>
<td>An Annotated Outline for a TMC Operation Manual (3)</td>
<td>2000</td>
<td>This “checklist” modeled manual provided a reference for agencies in writing/updating their operations manuals.</td>
</tr>
<tr>
<td>Configuration Management for Transportation Management System (4)</td>
<td>2003</td>
<td>Described a series of processes and procedures developed in the information technology community to establish and maintain system integrity. Provided guidance on improving transportation management systems.</td>
</tr>
<tr>
<td>Handbook for Developing a TMC Operations Manual (5)</td>
<td>2005</td>
<td>Provided the basic guidelines for the development of a concept of operation that provides the ideas of planning, designing, and implementing the policies and plans to run the TMCs.</td>
</tr>
<tr>
<td>Transportation Management Center Business Planning and Plans Handbook (6)</td>
<td>2005</td>
<td>Provided TMC managers and transportation agency executives with key tools and strategies that they can apply to business plan development and plan preparation process.</td>
</tr>
<tr>
<td>TMC Performance Monitoring, Evaluation and Reporting Handbook (7)</td>
<td>2005</td>
<td>A handbook that provides guidance and recommended practices for initiating, maintaining, and utilizing information derived from TMC performance monitoring, evaluation, and reporting</td>
</tr>
<tr>
<td>Scan Tour (8)</td>
<td>2006</td>
<td>Visited five European nations to study how they were addressing freeway congestion using dynamic or actively managed traffic management techniques; from national, state, and local perspectives.</td>
</tr>
<tr>
<td>Traffic Incident Management Handbook (9)</td>
<td>2010</td>
<td>Included the latest advances in TIM programs and offers practitioners insights into the latest innovations in TIM tools and technologies.</td>
</tr>
<tr>
<td>Impacts of technology Advancements on transportation management Center Operations (10)</td>
<td>2013</td>
<td>Identified and analyzed the potential impacts of technology advancements on TMC operations in the next ten years.</td>
</tr>
<tr>
<td>Transportation Management Center –Data Capture for Performance and Mobility Measures Reference Manual (11)</td>
<td>2013</td>
<td>Provided technical guidance and recommended practices regarding concepts, methods, techniques, and procedures for collecting, analyzing, and archiving TMC operations data to develop measures of roadway and TMC performance.</td>
</tr>
</tbody>
</table>
SURVEY DESIGN

The survey was designed to provide a nationwide scan of current TMC practices, as well as future plans in terms of the latest technologies and tools in traffic management and information applications. The survey had five major sections: current tools used in TMC operations, practices in data and information sharing, potential enhancements with new technologies, staffing skill needs, and traffic incident management (TIM) performance.

Considering the length limitation, this paper focuses on the first two sections concerning current applications, as well as practices in data and information sharing. The other sections will be presented in a separate paper focusing on the potential of applying latest technologies and tools.

- Current tools used in TMC operations – this section aims at gaining an understanding of the existing tools/applications/programs that are being used for each TMC function area (including traffic management, incident management, traveler information, maintenance and construction, and performance monitoring and evaluation).

- Practices in data and information sharing – this section focuses on the application and preference of emerging data collection and information sharing methods, such as external or third-party data, integrated corridor management (ICM) strategies, cloud computing, etc.

The questionnaire had a mix of choice questions and open-end questions that seek the respondents’ direct inputs or opinions. The survey targeted TMC managers and those who are familiar with the TMC activities. A complete survey questionnaire can be found in the project final report (12).

The survey was implemented online through Google Forms, which provide a user-friendly and flexible platform for survey design and administration.

SURVEY RESULTS ANALYSIS

The survey was conducted during March and April 2014. The survey link was sent to over 80 TMC contacts, supplemented by follow-up emails and phone-calls to enhance response rate. A total of 42 responses from twenty-five different states were received and analyzed.

The survey results are summarized and presented in the following sub-sections: basic background information regarding the TMCs, current applications in each of the five TMC functional areas, and practices in data and information sharing.

Basic Information

To understand the representativeness of the sample, some basic information was collected from the TMCs, including the service area of the TMC, years of operation, size of the TMC as in centerline miles served, and annual budget.
Figure 1 presents two charts describing the service area and the type of the surveyed TMCs. As shown in the chart on the left, the survey captured comparable number of TMCs in all three categories of service area: statewide, urban, and urban/rural. In regards to the institutional nature as shown in the chart on the right, a majority of the surveyed TMCs were part of the DOT, either the DOT central office (41%), or the district office (37%). TMCs under County or City government were also represented in the survey, each takes about 10% share of the sample.

Figure 1 TMC service area and type for the surveyed TMCs.

A vast majority of the surveyed TMCs began operation during the 90’s (22.5%) and the 00’s (60%). One TMC was established in the 60’s, and one fairly recent in year 2010.

In terms of annual budget and centerline mile changes over the past five years, more than half TMCs had stable budget level, about 38% showed increasing budget, while 8% experienced decreasing budget. However, when compared with changes in their centerline miles served, about 35% TMCs had experienced decreasing budget, which means either their budget remain the same while centerline miles increased, or their budget decreased when miles served remain the same. A closer look at the budget situation indicates that, in general, most (7 out of 8) TMCs supported by local governments experienced budget decrease, as less than 20% of DOT TMCs had gone through budget decrease relative to miles served.

Current Applications

This section focuses on tools, programs, policies, and strategies that are being applied at TMCs. The first five choice questions target at the five major TMC function areas, namely traffic management, incident management, traveler information, maintenance and construction, and performance monitoring and evaluation. The national ITS architecture (13) provides some reference for the tools and applications in the choice set.
Q1. Please select the applications in Traffic Management that are being used at your TMC (choose all that apply).

<table>
<thead>
<tr>
<th>Traffic Management Applications</th>
<th>Number of TMCs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Network Surveillance</td>
<td>33</td>
</tr>
<tr>
<td>Roadway Closure Management</td>
<td>25</td>
</tr>
<tr>
<td>Traffic Signal Control</td>
<td>19</td>
</tr>
<tr>
<td>Traffic Probe Surveillance</td>
<td>17</td>
</tr>
<tr>
<td>Traffic Metering</td>
<td>14</td>
</tr>
<tr>
<td>Portable Work Zone ITS system</td>
<td>12</td>
</tr>
<tr>
<td>Variable Speed Limits</td>
<td>10</td>
</tr>
<tr>
<td>High Occupancy Toll (HOT) Lanes</td>
<td>8</td>
</tr>
<tr>
<td>High Occupancy Vehicle (HOV) Lane Management</td>
<td>8</td>
</tr>
<tr>
<td>Reversible Lane Management</td>
<td>6</td>
</tr>
<tr>
<td>Dynamic Lane Management and Shoulder Use</td>
<td>4</td>
</tr>
<tr>
<td>Parking Facility Management</td>
<td>3</td>
</tr>
<tr>
<td>Speed Warning and Enforcement</td>
<td>3</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
</tr>
<tr>
<td>Roadside Lighting System Control</td>
<td>1</td>
</tr>
</tbody>
</table>

**Figure 2 Usage of applications in traffic management.**

This question aims to identify the traffic management applications/tools currently being used by TMCs. Selection choices are listed in Figure 2 in the Y-axis, while the length of the bars represent the number of TMCs that selected this application/tool. Network Surveillance was the most popular application, followed by Roadway Closure Management, Traffic Signal Control, and Traffic Probe Surveillance, which were chosen by approximately half of the surveyed TMCs. Less than 20% of the TMCs were using lane management related strategies (HOV, HOT, reversible lane, etc.). Roadside Lighting System Control, Speed Warning and Enforcement, and Parking Facility Management showed the least application among the surveyed TMCs. In addition to the provided selection set, Toll Truck Dispatching was mentioned by the TMC from the Bay Area District of the Caltrans.

Q2. Please select the applications in Incident Management that are being used at your TMC (choose all that apply).

Corresponding Questions 2, Figure 3 presents the usage of incident management applications. The pattern indicates a relatively homogenous usage of those tools in general.
**Figure 3** Usage of applications in incident management.

The most popular applications were Pre-Planned Incident Management Strategies and Highway Patrol. The least implemented application was Severe Incident Response Vehicle. The “other” incident management applications mentioned by respondents include: Unplanned Event from Rode Island DOT, and Regional Incident Management Team from City of Orlando, FL.

Q3. Please select the applications in Traveler Information that are being used at your TMC (choose all that apply).

Question 3 concerns about the usage of applications in traveler information as shown in Figure 4. In general, traveler information applications had been widely implemented, as most of these applications were being used by more than 50% of the TMCs. The two most common applications were Dynamic Message Sign and Traveler information Website. Half of the TMCs implemented automated data feeds to external agencies or third-parties. Connected vehicle DSRC communication system was provided in the choice list, but had not been implemented by any TMCs. The “other” traveler information applications mentioned by respondents include: Smartphone APP from Delaware DOT and New Orleans District, and One Stop Shop for traveler information from Caltrans District 2.
Q4. Please select the applications in Maintenance and Construction that are being used at your TMC (choose all that apply).
Question 4 focuses on the usage of applications in maintenance and construction as shown in Figure 5. This area sees relatively less usage of applications, compared with previous TMC functional areas. Road weather Data Collection, Maintenance and Construction Activity Coordination, and Weather Information Processing and Distribution were the most widely implemented applications, while Environmental Probe Surveillance showed the least application. About three respondents indicated that none of these applications were implemented at their TMCs. One respondent from the Delaware DOT provided an additional application that was used at their agency, which is Hydrological Monitoring System during the design phase.

Q5. Please select the strategies in Performance Monitoring and Evaluation that are being used at your TMC (choose all that apply).

<table>
<thead>
<tr>
<th>Performance Monitoring and Evaluation Strategies</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Periodic meetings and discussions on TMC performance</td>
<td>30</td>
</tr>
<tr>
<td>Develop performance metrics based on staff priorities as well as agency goals</td>
<td>27</td>
</tr>
<tr>
<td>Utilize features in software to track and report performance</td>
<td>25</td>
</tr>
<tr>
<td>Use multiple data sources to monitor system congestion</td>
<td>25</td>
</tr>
<tr>
<td>Specific evaluation procedures</td>
<td>16</td>
</tr>
<tr>
<td>Frequently process and distribute Measures of Effectiveness (MOEs)</td>
<td>13</td>
</tr>
<tr>
<td>Train TMC operators how to use performance monitoring</td>
<td>13</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
</tbody>
</table>

Figure 6  Usage of performance monitoring and evaluation strategies.

In terms of performance monitoring and evaluation strategies, Figure 6 shows that more than 70% of the TMCs hold periodic meetings and discussions on TMC performance, while more than 60% of the TMCs developed performance metrics and utilized multiple data sources and software to monitor and report performance. About one-third of the TMCs had specific evaluation procedures, performance monitoring related trainings, and frequently process and distribute MOEs.

Q6. Please briefly describe any tools, systems, or procedures your TMC has developed, if you would like to share your experience with other TMCs.
In addition to the above choice questions, the respondents were also being asked to provide information on any tools, or procedures that they would like to share. This information can be seen as best-practices or innovative applications that could be useful to other agencies. The responses are summarized below.

- Minnesota DOT developed an Advanced Traffic Management System (ATMS), called Intelligent Roadway Information System (IRIS). The system has been deployed at four Caltrans TMCs in addition to the deployment at the MnDOT Metro RTMC and the Duluth and Rochester TMCs. The IRIS enables transportation agencies to monitor and control dynamic message signs, traffic cameras, streaming video, adaptive ramp metering, lane controls, dynamic shoulder lane, reversible gate arm controls, etc. and provides access to congestion information for freeways and local arterials.

- Florida DOT District 2 developed smartphone application for Service Patrol (Road Rangers) to populate SunGuide program, which is also an application of ATMS.

- Emergency Traffic Operations Repository Web site developed by the Wisconsin Statewide Traffic Operation Center (STOC) in house, which provide multiple channels within the DOT, county and city government and first responders to easily get contacts, training, tools, maps, and guidelines, etc.

- Freeway Service Team (FST) Program Web site developed by the Wisconsin STOC, which service contractors (private and local sheriff departments) can login and enter shift data, keep track of operator training and generate reports. FST performance measures are generated from this site. Traffic Incident Alert Web site that either the Wisconsin State Patrol or the STOC Control Room operators use to send emails out to other government entities and media outlets to alert of higher severity incidents.

- Ada County Highway District of Idaho developed ATMS application to control all ITS devices and to input real-time incidents on freeway and arterial roadways. The ATMS application also allows automated e-mails to subscribers.

- Florida DOT implemented Safety Barrier Cable System (SBCS). The communication system alerts TMC operators when vehicle breaks barrier along roadway. Safety barrier alerts can be produced into the system messages and that these alerts can be used to generate events similar to the Florida Highway Patrol computer-aided dispatch (FHP-CAD) alerts and traffic sensor subsystem (TSS) alerts.

- Texas DOT Austin District established policy and agreements for information sharing on facility planning, design, construction, and operation.

- Georgia DOT tracks the Travel Time Index (TTI) on 35 specific corridors in the metro Atlanta area to monitor traffic trends on a monthly basis. They also post dashboard
gauges related to traffic flow and incident response times on the GDOT website. GDOT developed an ATMS, called the NaviGAtor, which includes traffic cameras, changeable message signs, ramp meters and a traffic speed sensor system. All devices are links to GDOT’s command center at TMC. Information is distributed to the public through a variety of outlets.

Data and Information Sharing

This section focuses on emerging technologies and opportunities in data and information sharing activities at TMCs. Besides fact-finding questions that identify current practices in data collection and information sharing, attitudinal questions were also developed to gather information on preferences and perspectives regarding emerging initiatives and applications that involve data and information sharing; such as integrated corridor management (ICM), social media, third-party data, and connected vehicle data, etc.

Q7. Please select the types of real-time data your TMC currently obtains from external entities, such as other agencies and third parties, etc., (choose all that apply).

![Real-time Data From External Entities](image)

Figure 7 Real-time data obtained from external entities.
Question 7 identifies the types of real-time data that TMCs currently obtain from external entities. The result is presented in Figure 7. Three types of real-time data were most frequently used/obtained by the TMCs from external sources, including Real-time CCTV Video Feeds from Other Agencies, Incident Data from 911 or Public Safety Computer-aided Dispatch Systems, and Weather Forecast Information. A few potential data sources identified in the choice set, such as GPS data, toll-tag data, parking data, connected vehicle data, and transit data, received some application, but had not been widely incorporated into TMC practices.

Q8. What additional data (internal and external) you believe could better support your TMC’s operations?

This question intends to identify additional data needs from the TMC perspective. Of the ten TMCs that responded to this question, most of them indicated the needs to coordinate with other agencies for data. The top desired data include:

- Arterial traffic conditions (incident detection, signal timing, travel times, etc.)
- Additional computer aided dispatch (CAD) information from other entities (other TIM team members, adjacent jurisdictions, additional public safety agencies, etc.)
- Traffic probe data (Bluetooth)
- Other data (transit schedule adherence information, parking availability, road weather data)
- Software and procedures (more robust and flexible freeway management software, and documented and repeatable transition plan to upgrade field network communication)

Q9. Please specify what types of data you are sharing with other agencies.

Corresponding to question 7 that identifies data import from external agencies, this question focuses on TMC data export that could benefit other agencies. The most shared data were:

- CCTV data (22)
- Traffic condition data (travel time, speed, volume, occupancy) (9)
- Incident information (8)
- Traveler information (VMS, DMS, 511) (6)
- Roadway condition (weather, construction, etc.) (8)

Q10. Which of the following information sharing methods your TMC uses for media interface (choose all that apply).

Question 10 focuses on media interface methods. As shown in Figure 8, the most widely applied methods were Website (33), followed by Video Feeds (31), Calls to/from Media (28) and Press Release (28). Social media as a platform for media interface gained popularity, and used by 60% of the TMCs. Over a third of the TMCs accommodated media agencies onsite directly. The
“other” methods mentioned by the respondents included radio link, own software, and public information officer.

Figure 8  Media interface methods.

Q11. Integrated Corridor Management (ICM) (i.e., the integration of freeway and arterial control, and coordination between highway and multimodal transit operations) holds the promise to achieve the full benefits of transportation management (please choose only one).

Figure 9  Attitudes towards ICM initiatives.
Q12. TMCs are in the best position to support ICM initiatives in terms of data integration, data sharing, integrated control and management, and information dissemination (please choose only one).

Question 11 and 12 aim at gauging the potential of integrating ICM initiatives with TMC operations. As presented in Figure 9, a majority of the TMCs either agreed or strongly agreed that ICM holds the potential to enhance transportation management, and that TMCs are in the best position to support ICM initiatives. As 5% and 2% of the TMCs disagreed with the above two statements respectively, no one indicated strong disagreement. A closer look at the responses for the two questions from the same TMC indicated a general consistency attitude towards the two statements.

Q13. Please rank the following strategies based on their effectiveness in enhancing the data collection/integration activities at your TMC.

1. Develop standards for data accuracy and validation
2. Provide real-time data to third party app developers
3. Share data among agencies
4. Develop protocols for data privacy and confidentiality
5. Use multi-agency procurement for economies of scale
6. Train operators to interpret alternate data sources
Question 13 aims at seeking opinions from TMCs in terms of the effectiveness of data collection and integration strategies. As shown in Figure 10, “Share data among agencies” received the highest score among all strategies, followed by “Use of application standards to simplify data exchange”, and “Develop standards for data accuracy and validation”. These indicated an emphasis on data sharing, as well as standard procedures and protocols to facilitate the data sharing activities. Operator training on the interpretation of various data sources was also identified as a highly effective strategy in data collection and integration practices. Noticeably, third-party app application and data privacy protocols gained positive views from the TMCs. Multi-agency procurement received the lowest score, despite the potential benefits of economies of scale. This indicated a general reluctance in multi-agency data collection efforts, which may due to the challenges in inter-agency collaboration and data ownership issues.

Q14. Integrating connected vehicle data (i.e., incident, speed, road weather, etc.) has the potential to greatly enhance your TMC’s operations (please choose only one).

86% of the respondents agreed (24% strongly agreed) that connected vehicle data has the potential to contribute to TMC operations. While one TMC disagreed, 5 remained neutral. This indicated a favorable attitude towards connected vehicle technology in general.

Q15. If you agency plans to use connected vehicle data, how do you foresee your TMC obtaining these data (choose all that apply)?

In terms of how to obtain connected vehicle data if desired to, most TMCs preferred to receive raw data directly from roadside equipment units, as shown in Figure 11. If the TMCs were to receive data from other entities, such as third-party data provider, or regional data clearinghouses, processed data were preferred over raw data. Among external entities, more TMCs preferred to receive data from third-parties over regional clearinghouses.
Figure 11  Method of obtaining connected vehicle data.

Q16. What do you foresee to be the main obstacle in integrating third-party data within your TMC operations (please choose only one)?

Figure 12  Main obstacle in integrating third-party data.
Question 16 intends to gain some understanding on the obstacles of obtaining third-party data. As shown in Figure 12, when asked to choose only one, over one-third of the TMCs (35%) chose technical issue, followed by institutional (30%) and legal issues (18%). Cybersecurity issue was indicated as the main obstacle of integrating third-party data for 4 TMCs. Financial and reliability issues were also mentioned as main issues.

Q17. Cloud computing is worth considering by your TMC to improve data management efficiency (please choose only one).

Figure 13  Cloud computing in improving data management efficiency.

A relatively new technology in the transportation industry, cloud computing has not received wide application yet. Figure 13 shows that while 45% of the TMCs agreed with the potential of cloud computing, about 17% disagreed and the rest 38% remained neutral.

Q18. What methods or system does your TMC currently use for data archiving and management?

The responses indicated that a vast majority of the TMCs utilize some sort of software packages, and database servers for data archiving and management. Alternative methods mentioned by the TMCs included collaboration with local university and regional MPO that archives/manages the data.

DISCUSSIONS

In terms of current applications by function area, Table 2 below summarizes the common applications – applied by at least half of the TMCs, and potential tools that could be considered for future implementation. The survey results indicate that TIM and Traveler Information are the two areas that are well developed where most of the tools received wide applications among the
TMCs. Performance Monitoring and Evaluation has been well implemented, where some strategies are widely applied and others still await more attentions, such as specific evaluation procedures, periodic processing and distribution of MOEs. Tools in Maintenance and Construction still show plenty of potential for further implementation, so as those in Traffic Management, especially the emerging strategies such as lane management strategies, speed warning and enforcement, and parking facilities, etc.

Table 2 Summary List - Current Tools Used in TMC Operations

<table>
<thead>
<tr>
<th>TMC Function Area</th>
<th>Most Common Applications</th>
<th>Potential Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traffic Management</td>
<td>- Network surveillance&lt;br&gt;- Roadway closure management</td>
<td>- Variable speed limits&lt;br&gt;- HOT lanes&lt;br&gt;- Lane management (HOV, reversible, etc.)&lt;br&gt;- Parking facility management&lt;br&gt;- Speed warning and enforcement&lt;br&gt;- Roadside lighting system control</td>
</tr>
<tr>
<td>Incident Management</td>
<td>- Pre-planned incident management strategies&lt;br&gt;- Highway patrol&lt;br&gt;- Automated interagency data exchange/sharing&lt;br&gt;- Quick response policy</td>
<td></td>
</tr>
<tr>
<td>Traveler Information</td>
<td>- Dynamic Message Signs (DMS)&lt;br&gt;- Traveler information website&lt;br&gt;- Email or text alerts&lt;br&gt;- 511 system&lt;br&gt;- Social media tools&lt;br&gt;- Highway Advisory Radio (HAR)&lt;br&gt;- Automated data feeds to external agencies or third parties</td>
<td></td>
</tr>
<tr>
<td>Maintenance &amp; Construction</td>
<td>- Road weather data collection&lt;br&gt;- Maintenance and construction activity coordination</td>
<td>- Vehicle and equipment tracking&lt;br&gt;- Environmental probe surveillance&lt;br&gt;- Vehicle maintenance</td>
</tr>
<tr>
<td>Performance Monitoring and Evaluation Strategies</td>
<td>- Periodic meetings and discussions on TMC performance&lt;br&gt;- Performance metrics based on staff priorities as well as agency goals&lt;br&gt;- System monitoring with multiple data sources&lt;br&gt;- Utilize features in software to track and report performance</td>
<td>- Specific evaluation procedures&lt;br&gt;- Frequent processing and distribution of MOEs&lt;br&gt;- Operator training on performance monitoring</td>
</tr>
</tbody>
</table>
In terms of practices in data and information sharing, a majority of the agencies exhibit positive attitude towards emerging methods and technologies and the associated applications in TMC services, such as ICM, and connected vehicle technology. Cloud computing, however, has not received as favorable attentions.

Data collection and integration showed large room for future growth, and many agencies indicated the desire to obtain data from multiple sources and/or other agencies, such as

- Traffic probe data (Bluetooth, license plate matching, etc.)
- Arterial traffic data
- GPS data (taxi, trucks, smart phones, etc.)
- Toll-tag responder data
- Parking availability data
- Transit location or schedule adherence information

CONCLUSIONS

This paper provides an overview on current applications and tools implemented at TMCs based on the results of a web-based survey covering TMCs around the country. It helps TMCs understand their status comparing to other agencies, while also provides lists of tools, applications, and innovative practices that could be considered for future implementation. The paper also reveals TMCs’ perceptions and preferences on key issues related to data and information sharing activities. There is an indication of the desire/needs to obtain additional data from alternative sources, which points to the needs for data collection and exchange standards and enhanced software capabilities and procedures to support/automate data integration and information sharing. This further confirms the critical role of TMCs as the technical and institutional hub to facilitate the implementation of advanced policies, applications, and tools for traffic management and data integration.

REFERENCES


