



NATIONAL CENTER FOR TRANSPORTATION SYSTEMS PRODUCTIVITY AND MANAGEMENT

# Traffic Management Centers: Challenges, Best Practices, and Future Plans

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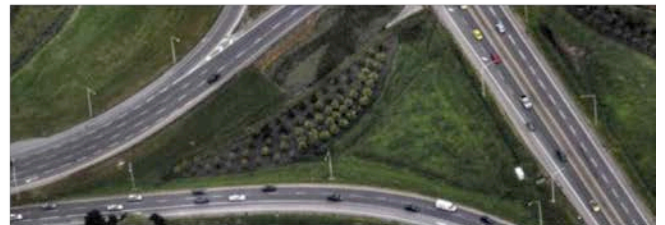
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# TRAFFIC MANAGEMENT CENTERS: CHALLENGES, BEST PRACTICES, AND FUTURE PLANS

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National Center for Transportation System Productivity and  
Management

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## I. EXECUTIVE SUMMARY

Transportation management centers serve as the technical and institutional hubs that facilitate interagency coordination and integrate a wide range of traffic management strategies to achieve the collective goal of providing safe, efficient and sustainable transportation infrastructure. This report presents a study aiming at providing a nationwide scan on best practices in TMCs with a focus on ITS in terms of innovative tools, technologies, methods, and policies.

A web-based survey was conducted focusing on current applications as well as new methods and tools in various aspects of TMC operations and services. The survey covers five major areas of interest - current tools and applications used in TMC operations, practices in data collection and information sharing, potential enhancements with new technologies, staffing and skill needs, and incident management performance measures. The questionnaire consists of both fact-finding and opinion-seeking questions. The former helps to shed light on the state-of-the-practices, while the latter provides a channel to understand the preferences and attitudes toward the implementation of emerging technologies and tools in TMC operations. The survey was conducted during March and April 2014. Initial recruit emails with link to the survey website were sent to over 80 TMC contacts around the nation. A total of 42 responses from twenty-five different states were received and analyzed.

In terms of current applications by function area, 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. 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 integrated corridor management, and connected vehicle. Data gathering through external or alternative data sources shows potential for future growth, and many agencies indicated the desire to obtain data from other agencies such as arterial traffic conditions, transit information, parking availability information, etc. Regarding the trend and potential of advanced technologies, various applications in automation tools and advanced wireless technologies are being considered very useful to TMC operations. The most important strategies for facilitating the application of advanced technologies are documentation on all systems, fostering an embracing agency culture, and following system engineering processes. The results provide valuable insights for policy makers and developers in understanding the potentials of the various applications and how to best incorporate them to enhance TMC operations.

## II. INTRODUCTION

Traffic management centers (TMCs) are the brains for most freeway and arterial management systems.<sup>1</sup> 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 research is to review the state-of-the-practice in TMC operations in order to increase the understanding of what are the common features that have led to their success. This benchmarking process will help in establishing 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.<sup>2</sup> As computer and information technologies have evolved tremendously in the past decade, many ITS technologies have emerged and changed the ways of traffic management and information provision. During the same period, our cities have experienced rapidly growing travel demand and increasing concerns in congestion, safety, and sustainability. This research will update the knowledge in TMC practices in terms of the latest technologies, tools and strategies in addressing the new challenges faced by urban traffic management agencies. In addition, the TMC Pooled Fund Study sponsored by the FHWA has provided a series of guidelines and handbooks in system planning, operational strategies, system design, and maintenance with regard to TMC operations.<sup>3</sup>

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<sup>1</sup> FHWA website [http://www.ops.fhwa.dot.gov/freewaymgmt/trans\\_mgmnt.htm](http://www.ops.fhwa.dot.gov/freewaymgmt/trans_mgmnt.htm)

<sup>2</sup> Metropolitan Transportation Management Center Concepts of Operation A Cross-Cutting Study. FHWA-JPO-99-020.

<sup>3</sup> TMC Pooled Fund Study with FHWA  
[http://tmcdfs.ops.fhwa.dot.gov/cfprojects/new\\_search.cfm?new=2](http://tmcdfs.ops.fhwa.dot.gov/cfprojects/new_search.cfm?new=2)

The goal of this research is to draw a typology of best practices in transportation management centers with a focus on ITS in terms of innovative tools, technologies, methods, and policies being employed. The proposed approach is to conduct an expert panel survey of TMCs in the nation. The study is intended to accomplish the following objectives:

- a) Identify key components that play critical roles in TMC operations as the major focuses for this study, for examples, data archiving and warehousing, communications and information provision, etc.
- b) Conduct a nationwide survey on current applications and future potentials of technologies and tools in advancing TMC practices.
- c) Synthesize the best practices and the lessons learned toward the identified key components, which could be generalized with broader applicability to provide some insights to other interested agencies.

This research will add 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, improve the performance and services of the centers, and eventually contribute to the efficient management of the transportation network and effective implementation of technologies in responding to traffic conditions and emergencies (such as incidents, special events, and other recurring and non-recurring delays).

### **III. BACKGROUND**

Table 1 below presents a brief 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 processes in TMC development. Later studies targeted various aspects related to TMC operations, including business planning, performance measurement, technology advancement and data capture.



**Table 1 A timeline of studies on Traffic Management Centers**

<b>Major Study</b>	<b>Year</b>	<b>Description</b>
Transportation Management Center Concepts of Operation Implementation Guide <sup>4</sup>	1999	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.
Metropolitan TMC Concepts of Operation (A Cross Cutting Study) <sup>5</sup>	1999	Eight TMCs from US and Canada were studied. In-depth reviews were conducted, and documented the plan, design and deployment of ITS in TMCs.
An Annotated Outline for a TMC Operation Manual <sup>6</sup>	2000	This “checklist” modeled manual provided a reference for agencies in writing/updating their operations manuals.
Configuration Management for Transportation Management System <sup>7</sup>	2003	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.
Handbook for Developing a TMC Operations Manual <sup>8</sup>	2005	Provided the basic guidelines for the development of a concept of operation on the planning, designing, and implementing of the policies and plans to operate the TMCs.

<sup>4</sup> Christine M. Johnson and Edward L. Thomas. Transportation Management Center Concepts of Operation --- Implementation Guide. Publication FHWA-OP-99-029. FHWA, U.S. Department of Transportation, 1999.

<sup>5</sup> Christine M. Johnson and Edward L. Thomas. Metropolitan Transportation Management Center Concepts of Operation - A Cross-Cutting Study. Publication FHWA-JPO-99-020. FHWA, U.S. Department of Transportation, 1999.

<sup>6</sup> An Annotated Outline for a Traffic Management Center Operations Manual. Management and Operations Committee of the ITS Council, 2000.

<sup>7</sup> Brian Smith. Configuration Management for Transportation Management System. FHWA-OP-04-013. FHWA, U.S. Department of Transportation, 2003.

<sup>8</sup> Edward J. Seymour, James D. Carvell, Jr., Jodi L. Carson, Robert E. Brydia. Handbook for Developing A TMC Operations manual. Publication FHWA-HOP-06-015. FHWA, U.S. Department of Transportation, 2005.



Major Study	Year	Description
Transportation Management Center Business Planning and Plans Handbook <sup>9</sup>	2005	Provided TMC managers and transportation agency executives with key tools and strategies that can be applied to the business planning development and the plan preparation process.
TMC Performance Monitoring, Evaluation and Reporting Handbook <sup>10</sup>	2005	A handbook that provided guidance and recommended practices for initiating, maintaining, and utilizing information derived from TMS performance monitoring, evaluation, and reporting
Scan Tour <sup>11</sup>	2006	Visited five European nations to study how freeway congestion was addressed using dynamic or actively managed traffic management techniques, from national, state and local perspectives.
Transportation Incident Management Handbook <sup>12</sup>	2010	Included the latest advances in TIM programs and offered practitioners insights on the latest innovations in TIM tools and technologies.
Impacts of technology Advancements on transportation management Center Operations <sup>13</sup>	2013	Identified and analyzed the potential impacts on TMC operations of technology advancements in the next ten years.
Transportation Management Center - Data Capture for Performance and Mobility Measures Reference Manual <sup>14</sup>	2013	This guide provided technical guidance and recommended practices regarding concepts methods, techniques, and procedures for data management. It also documented the benefits of TMC activities for a variety of stakeholders.

<sup>9</sup> Pretorius, P. Transportation Management Center Business Planning and Plans Handbook. In ITE 2004 Annual Meeting and Exhibit, Institute of Transportation Engineers, lake Buena Vista, FL, 2005.

<sup>10</sup> Byungkyu Park. Transportation Management System Performance Monitoring, Evaluation, and Reporting - A Technical Handbook. Publication FHWA-HOP-07-124. FHWA, U.S. Department of Transportation, 2005.

<sup>11</sup> Chuck Fuhs. Synthesis of Active Traffic Management Experiences in Europe and the United States. Publication FHWA-HOP-10-031. FHWA, U.S. Department of Transportation, 2010.

<sup>12</sup> Owens, N., A. Armstrong, P. Sullivan, C. Mitchell, D. Newton, R. Brewster, and T. Trego. Traffic Incident Management Handbook. FHWA-HOP-10-013. FHWA, U.S. Department of Transportation, 2010.

<sup>13</sup> Arianne M., Kathleen S., Les J. and Steve K. Impacts of technology Advancements on transportation management Center Operations. Publication FHWA-HOP-13-008. FHWA, U.S. Department of Transportation, 2013.

<sup>14</sup> Conklin, Clifford A., Bahler, and Stephen J. Transportation Management Center Data Capture for Performance and Mobility Measures Reference manual. Publication FHWA-JPO-13-055. FHWA, U.S. Department of Transportation, 2013.

## IV. NEW TECHNOLOGIES IN TMCS

Several recent studies have focused on new methods and tools in various aspects of TMC operations and services, from GIS-based approach for traffic enforcement resource optimization to dynamic speed display, and from a decision support tool based on area wide traffic management scenarios to large scale ITS data archiving<sup>15,16,17,18</sup>. The New York City Department of Transportation (DOT) developed a standard methodology for traffic information management, which facilitates the identification, collection, validation and analysis of traffic data from multiple sources<sup>19</sup>. Katwijk and Koningsbruggen developed an automatic coordination concept among traffic control tools by considering each tool as an intelligent agent and relieving the traffic operator from controlling different scenarios<sup>20</sup>.

In light of the latest advancements in new technologies, many opportunities have emerged that could greatly enhance TMC operations. Autonomous vehicle technologies hold the potential to improve safety, and enhance vehicle throughput for both highway and transit<sup>21</sup>. The study suggested that TMC safety operations would benefit from the technology with the associated features (autonomous emergency breaking, blind spot alert, cross traffic alert, driver fatigue alert, lane keeping assistance etc.). At the same time TMC would find less difficulty in congestion management, as the vehicle throughput could be improved with the application of “cooperative adaptive cruise control” by reducing the separation between vehicles; buses could run in platoons with

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<sup>15</sup> Carrick, G., Bejleri, I., and Ouyang, Y. A Methodological Approach to Spatiotemporal Optimization of Rural Freeway Enforcement in Florida. In Transportation Research Board 93ed Annual Meeting, Transportation Research Board, Washington, D.C., 2014.

<sup>16</sup> John D. Bullough, Jennifer A. Brons, and Nicholas P. Skinner. Preliminary Evaluation of Dynamic Speed Displays with Conditional Messaging. In Transportation Research Board 93ed Annual Meeting, Transportation Research Board, Washington, D.C., 2014.

<sup>17</sup> Henk J. van Zuylen, Lu Shoufeng, Li Jie, and Yusen Chen. The Development of Area Wide Traffic Management Scenarios. In Transportation Research Board 93ed Annual Meeting, Transportation Research Board, Washington, D.C., 2014.

<sup>18</sup> Qu, T., Parker, T. S., Cheng, Y., Ran, B., and Noyce A. D. Large Scale Intelligent Transportation System Traffic Detector Data Archiving. In Transportation Research Board 93ed Annual Meeting, Transportation Research Board, Washington, D.C., 2014.

<sup>19</sup> Rahman, A., Marsico, M., and Howard, K. New York City Department of transportation Traffic Information Management System (TIMS). In Transportation Research Board 93ed Annual Meeting, Transportation Research Board, Washington, D.C., 2014.

<sup>20</sup> Ronald van Katwijk and Paul van Koningsbruggen. Coordination of Traffic Management Instruments Using Agent Technology. In Transportation Research Part C: Emerging Technologies Volume 10, Issues 5-6. Oct-Dec 2002, pp. 455–471.

<sup>21</sup> Jerome M. Lutin and Alain L. Kornhauser. Application of Autonomous Driving Technology to Transit – Functional Capabilities for Safety and Capacity. In Transportation Research Board 93ed Annual Meeting, Transportation Research Board, Washington, D.C., 2014.

the help of vehicle to vehicle communications. From data and information perspective, the key benefits of connected vehicle technology include incident detection, faster and more accurate data on network conditions, improved automation of data exchanges, which eventually lead to improved efficiency for decision making and strategy implementation<sup>22</sup>. Others focused on improving the communication systems by proposing a Hybrid Technology Networking (HTN) which utilizes Wi-Fi technologies<sup>23</sup>. The effectiveness of using social media as a travel information dissemination media has also been explored; the advantages include quick penetration to large number of travelers, more direct control over the information contents than traditional broadcast media or text alert, control over timing of the message, market segmentation of transit user group based on their age and experience<sup>24</sup>.

A recent FHWA report provided a comprehensive overview of the impacts of technology advancements on TMC operations in the next ten years<sup>25</sup>. The report identified eight top trends and issues, including: 1) service-oriented program mindset and organizational structure, 2) active transportation and demand management (ATDM) concept and toolkit, 3) tolling and other pricing operations, 4) performance monitoring and management, 5) automation and related tools to increase efficiency, 6) third-party data and information, 7) mobile communications and wireless networks, and 8) social media for traveler information and crowdsourcing. Various strategies to address these trends were also presented in the report.

With all the above development in mind, this study intends to update the knowledge in TMC practices in terms of the latest technologies, tools and strategies. A web-based survey is conducted to gather information from TMCs around the nation, regarding their views and attitudes toward these new trends and technologies. Given the potential technological enhancement, there are also additional needs in terms of staffing and skills to take full advantage of those advancements and incorporate them into TMC daily operations. Therefore, another focus of the survey is on the preparedness of TMCs

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<sup>22</sup> Kimley-Horn and Associates, Inc. Traffic Management Centers in a Connected Vehicle Environment - Review of Connected Vehicle Program Activities in Relation to Traffic management Center Operations. CTS Pooled Fund Study, University of Virginia. Jun 2013.

<sup>23</sup> Shrestha, L. P., Hemple, M., Rakshit, M. S., and Rezaei, F. Hybrid Technology Networking: A Complete Solution for Wireless Communications for Real-Time Monitoring of Cars on Freight Trains. In Transportation Research Board 93ed Annual Meeting, Transportation Research Board, Washington, D.C., 2014.

<sup>24</sup> Chan, R. and J. L. Schofer. The Role of Social media in Communicating Transit Disruptions. In Transportation Research Board 93ed Annual Meeting, Transportation Research Board, Washington, D.C., 2014.

<sup>25</sup> Arianne M., Kathleen S., Les J. and Steve K. Impacts of technology Advancements on transportation management Center Operations. Report #FHEA-HOP-13-008, Jan 2013.

in terms of staff training, staff development strategies, and additional skill needs, etc. This paper presents major findings from the survey, which may provide some insights for policy makers and developers in terms of the TMCs' perspective on the potential of applying new technologies and tools in TMC operations.

## V. SURVEY DESIGN

The purpose of the survey is to help 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 has five sections, each represent a major area of interest:

- 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, ICM strategies, cloud computing, etc.
- Potential enhancements with new technologies – this section intends to shed light on the potential and readiness of deploying new technologies in TMC operations, such as automation tools, advanced wireless technologies, and social media tools.
- Staffing and Skill Needs – this section focuses on staffing needs and training strategies in light of the emerging technology and information applications.
- Traffic Incident Management (TIM) performance measures – focusing on TIM performance measures, this section intends to provide a general overview on TIM program performance through commonly used quantitative indicators.

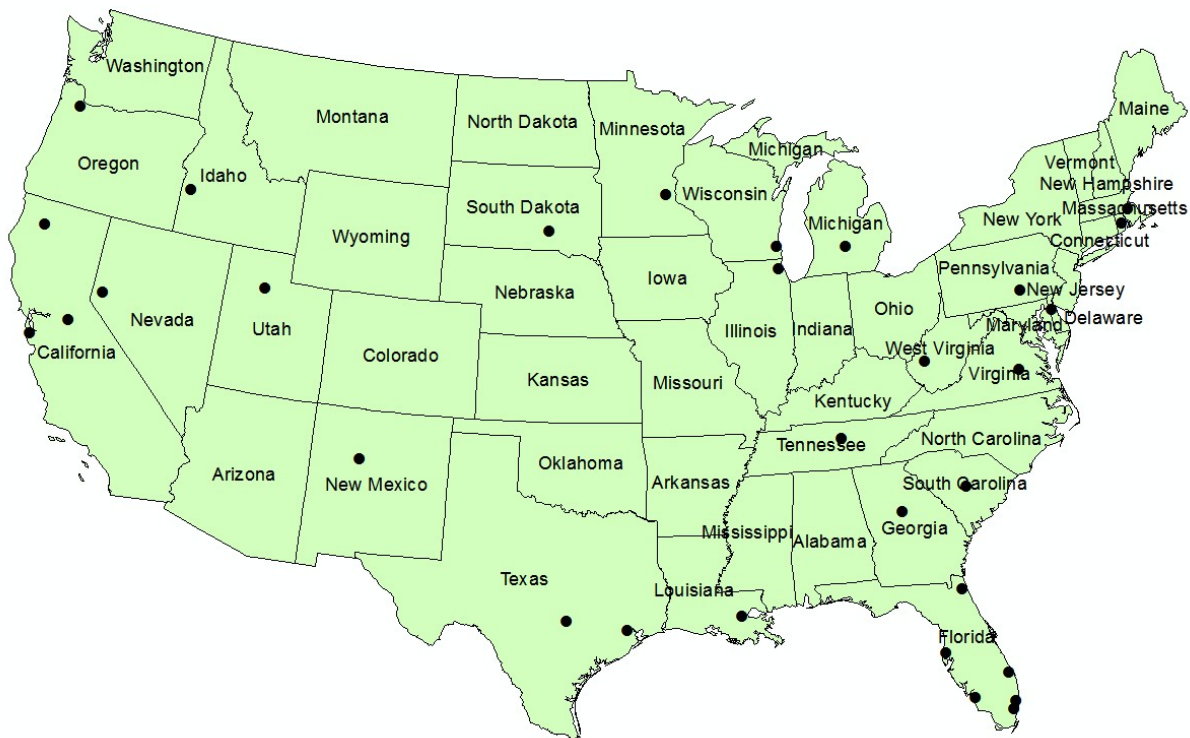
The questionnaire consists of both fact-finding and opinion-seeking questions. The former helps to provide a summary of the state-of-the-practices, while the latter provides a channel to understand the preferences and attitudes toward the implementation of emerging technologies and tools in TMC operations. It is intended that this survey be completed by a TMC manager and/or someone who is familiar with the TMC activities. A complete survey questionnaire is presented in Appendix A.

The survey was administered through web-based approach. Google Forms was used as the platform for survey implementation. Several advantages were found using this tool: 1) it provides a user-friendly environment for questionnaire design, editing, and revisions, 2) all responses will be automatically connected with a spreadsheet reducing potential human input errors, and 3) it has no cost and is easy to manage, and can be easily shared with others through Google Docs.

One unexpected issue is that the survey site is blocked by many agencies' (especially DOTs') firewall due to security concerns, since the web address is associated with Google Docs. Realizing the potential effects on response rate, follow-up emails and phone calls were carried out to explain the issue and recruit respondents. A number of respondents went the extra step and completed the survey using personal computers or devices. As a result, the survey responses covered twenty-five states around the country.

## VI. SURVEY RESULTS ANALYSIS

The survey was conducted during March and April 2014. Initial recruit emails with link to the survey site were sent to over 80 TMC contacts around the nation. Follow-up emails and phone-calls were carried out to enhance response rate. Alternative contacts were identified when invalid email addresses were detected.



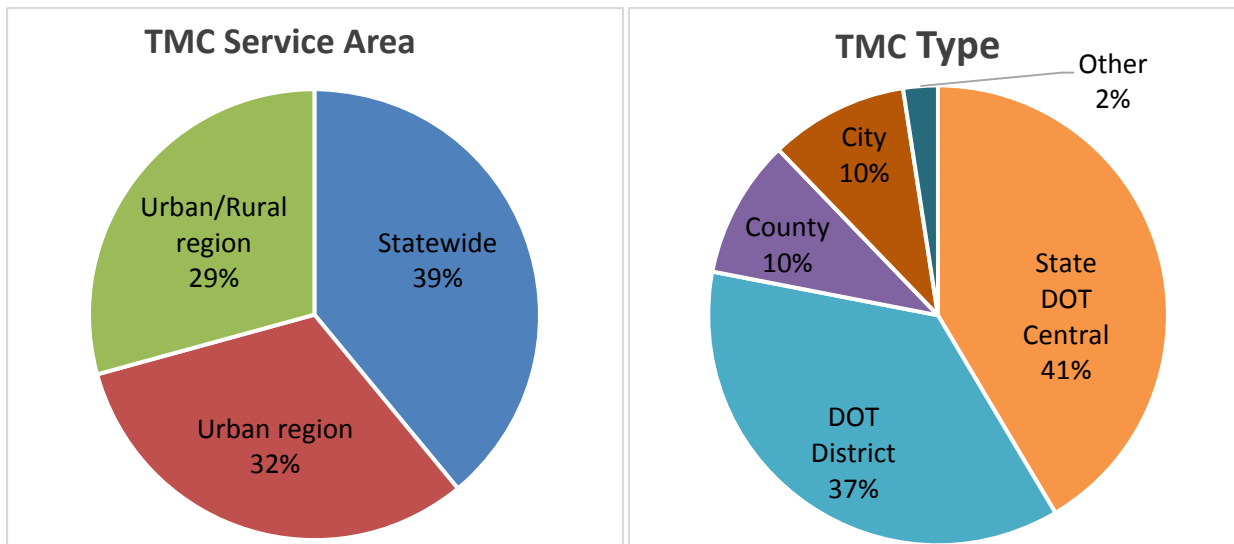
**Figure 1** Survey response coverage map.

A total of 42 responses from twenty-five different States were received and analyzed. Figure 1 shows the geographic coverage of survey responses. A list of TMC participants and their contact information is presented in Appendix B.

**A. 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.

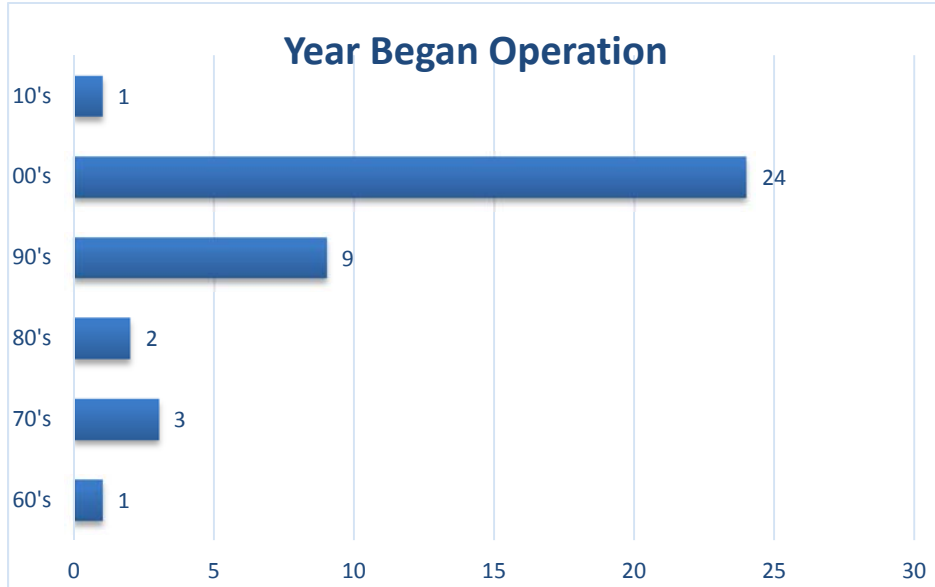
Figure 2 presents two charts describing the service area and the type of the surveyed TMCs. As shown in the figure, the survey captured comparable number of TMCs in all three categories of service area: statewide, urban, and urban/rural. In regards to the institutional nature, a majority of the surveyed TMCs are part of the DOT, either the DOT central office (41%), or the district office (37%). TMCs under County or City government are also represented in the survey; each takes about 10% share of the sample. One TMC sits in the “Other” category, which is part of the Florida Turnpike that covers the south and central Florida areas.



**Figure 2 TMC service area and type for the surveyed TMCs.**

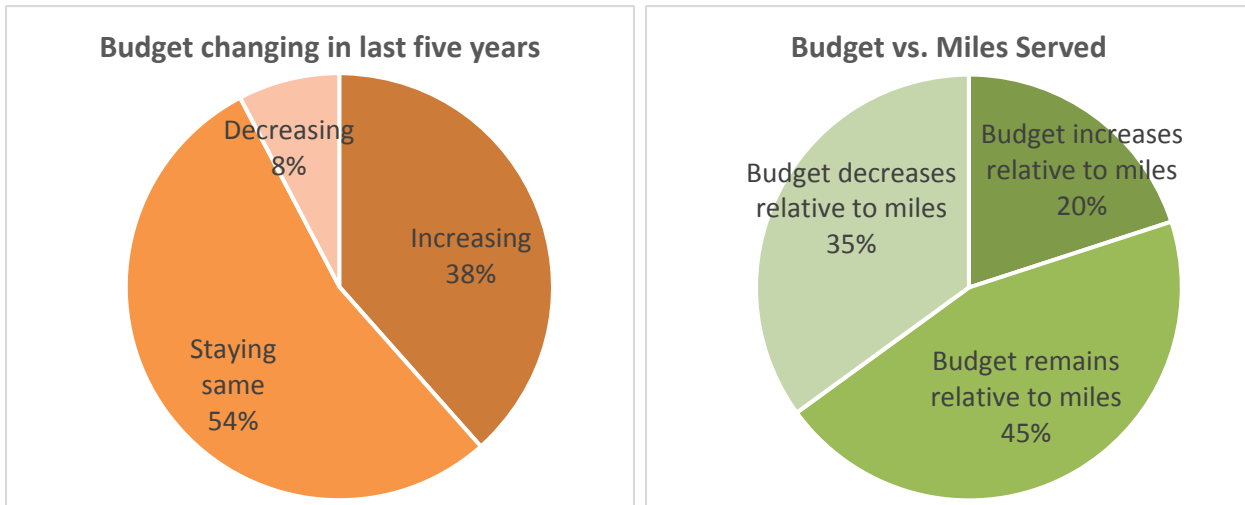
Figure 3 shows the proportion of TMCs by year that it began operation. A vast majority of the surveyed TMCs began operation during the 1990’s (22.5%) and the 2000’s (60%). One TMC was established in the 60’s, and one fairly recent in year 2010.





**Figure 3** Year began operation for the surveyed TMCs.

Figure 4 below presents a summary on annual budget and centerline mile changes over the past five years. More than half TMCs have stable budget level, about 38% received increasing budget, while 8% experienced decreasing budget. However, when compared with changes in their centerline miles served, about 35% TMCs have experienced decreasing budget, which means either their budgets remain the same while centerline miles increased, or their budgets decreased when miles served remain the same.



**Figure 4** Annual budget and centerline mile changes in the past five years.

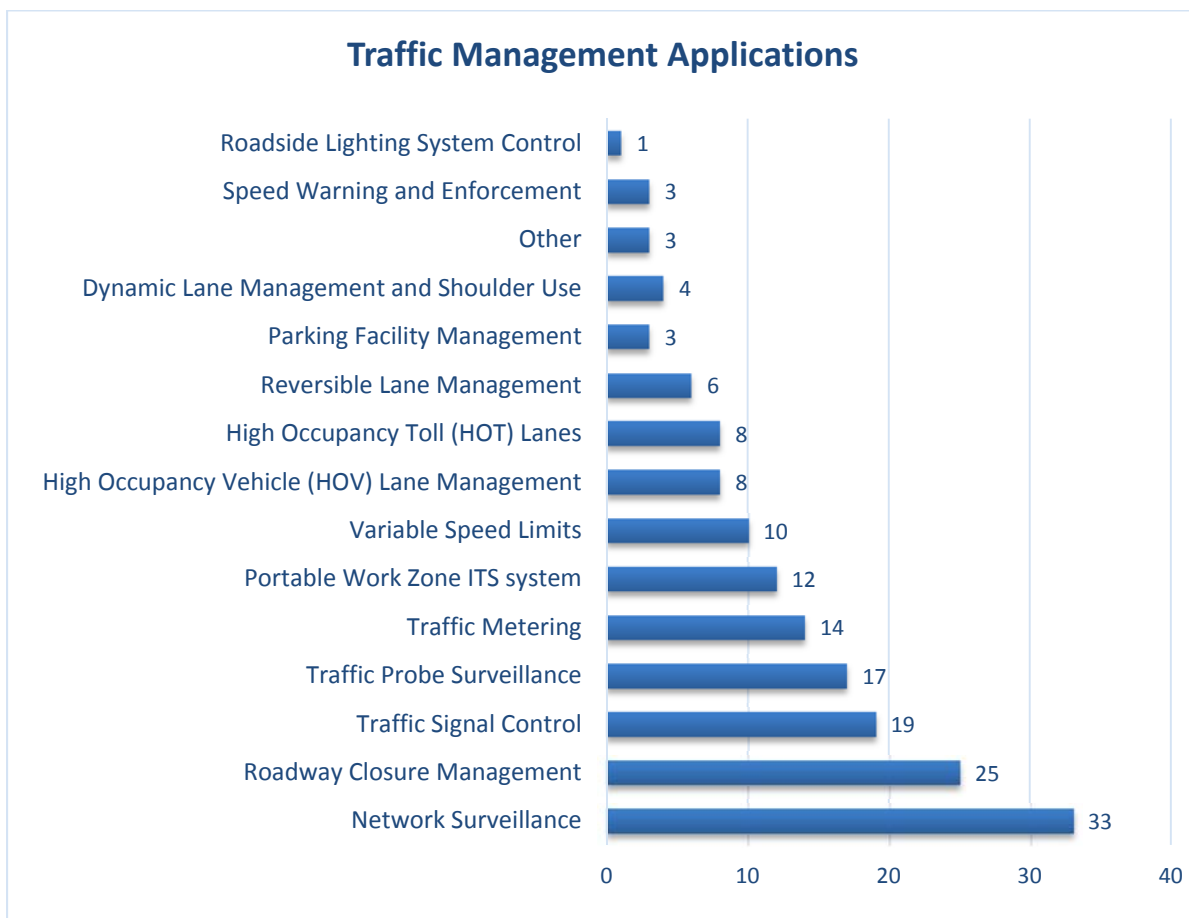
A closer look at the budget situation indicates that, in general, most (7 out of 8) TMCs supported by local governments experienced budget decrease, while less than 20% of DOT TMCs have gone through budget decrease relative to miles served.



## B. Current Applications

This section focuses on tools, programs, policies, and strategies that are being applied at TMCs. The first five choice questions target the five major TMC function areas, namely traffic management, incident management, traveler information, maintenance and construction, and performance monitoring and evaluation. The choice set for each function area are developed based on the ITS architecture<sup>26</sup>. The last question is an open-ended question that provides an opportunity to capture innovative practices.

Q1. Please select the applications in Traffic Management that are being used at your TMC (choose all that apply).



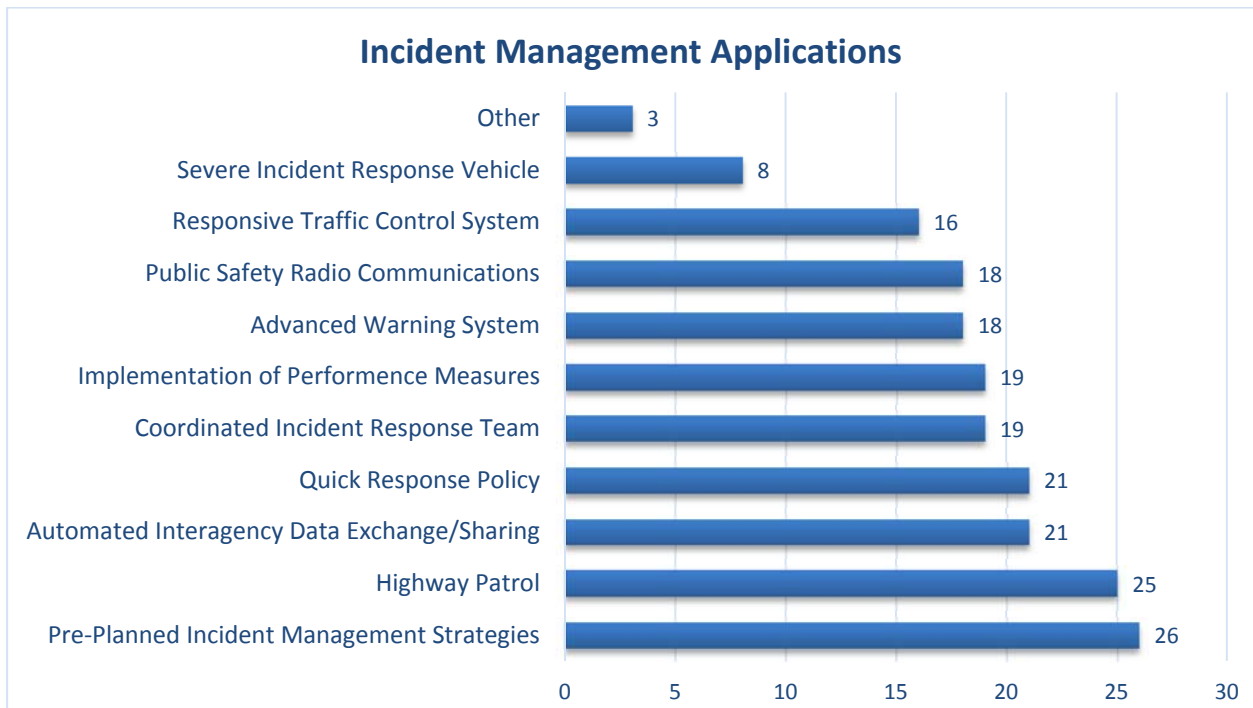
**Figure 5 Usage of applications in traffic management.**

Question 1 aims to identify the traffic management applications/tools currently being used by TMCs, as presented in Figure 5. The applications/tools are listed in the Y-axis, while the length of the bars represent the number of TMCs that selected this

<sup>26</sup> The National ITS Architecture. <http://www.iteris.com/itsarch/html/mp/mpindex.htm>.

application/tool. Network Surveillance is the most popular application, followed by Roadway Closure Management, Traffic Signal Control, and Traffic Probe Surveillance, all were chosen by more than half of the surveyed TMCs. Less than 20% of the TMCs are using land management related strategies (HOV, HOT, reversible lane, etc.) Roadside Lighting System Control, Speed Warning and Enforcement, and Parking Facility Management show the least application. In addition to the provided selection set, Toll Truck Dispatching is mentioned by the TMC from the Bay Area District of the Caltrans.

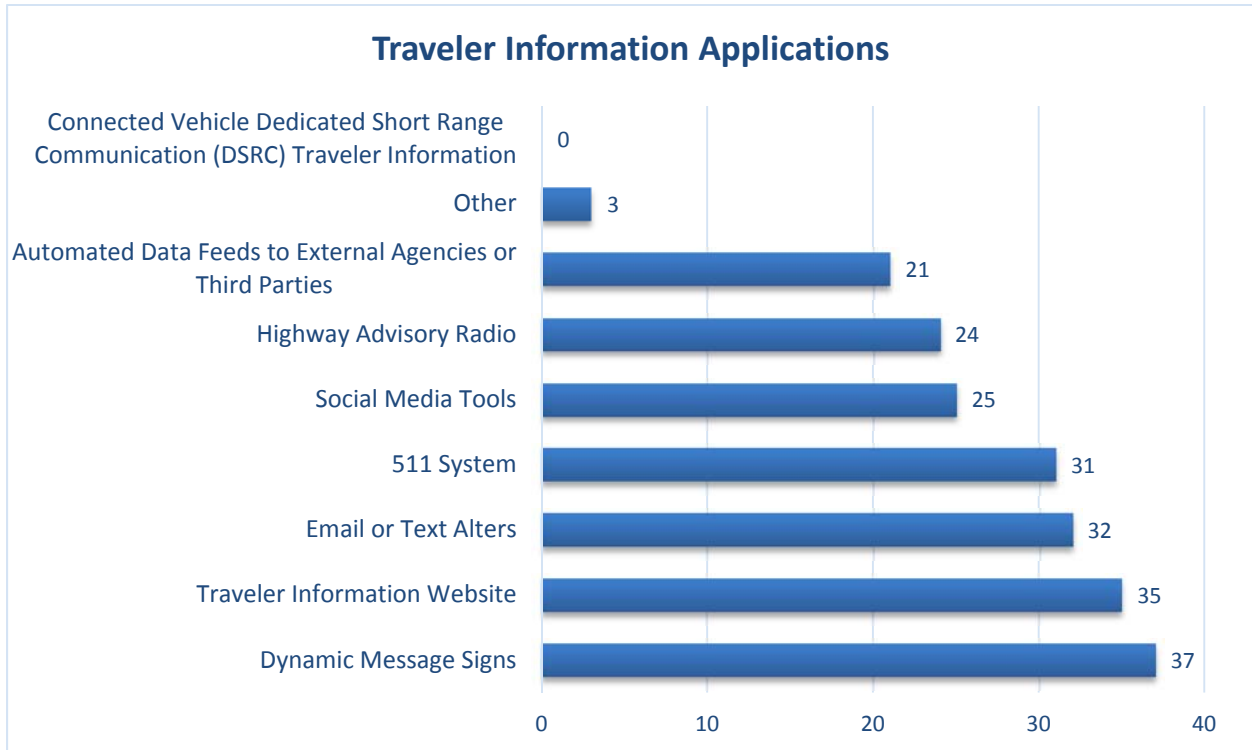
Q2. Please select the applications in Incident Management that are being used at your TMC (choose all that apply).



**Figure 6 Usage of applications in incident management.**

Figure 6 presents the usage of incident management applications. The pattern indicates a relatively comparable usage of those tools in general. The most popular applications are Pre-Planned Incident Management Strategies and Highway Patrol. The least implemented application is 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).

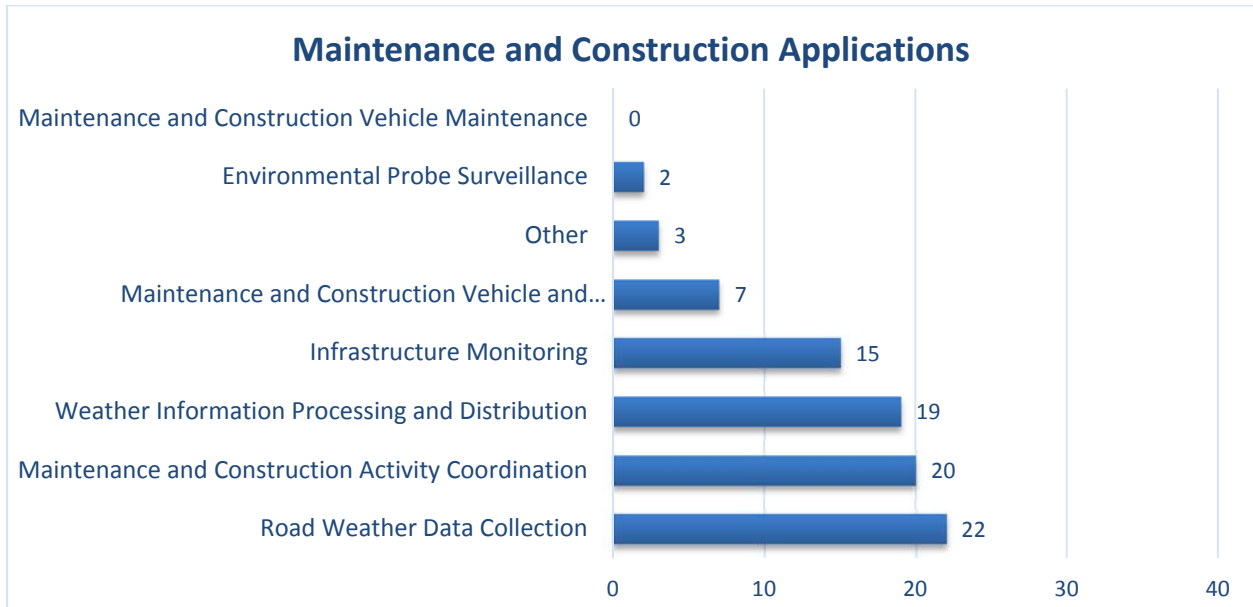


**Figure 7 Usage of applications in traveler information.**

Question 3 concerns the usage of applications in traveler information as shown in Figure 7. In general, traveler information applications have been widely implemented, as most of these applications are being used by more than 50% of the TMCs. The two most common applications are Dynamic Message Sign and Traveler information Website. Connected vehicle DSRC communication system was provided in the choice list, but has 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.

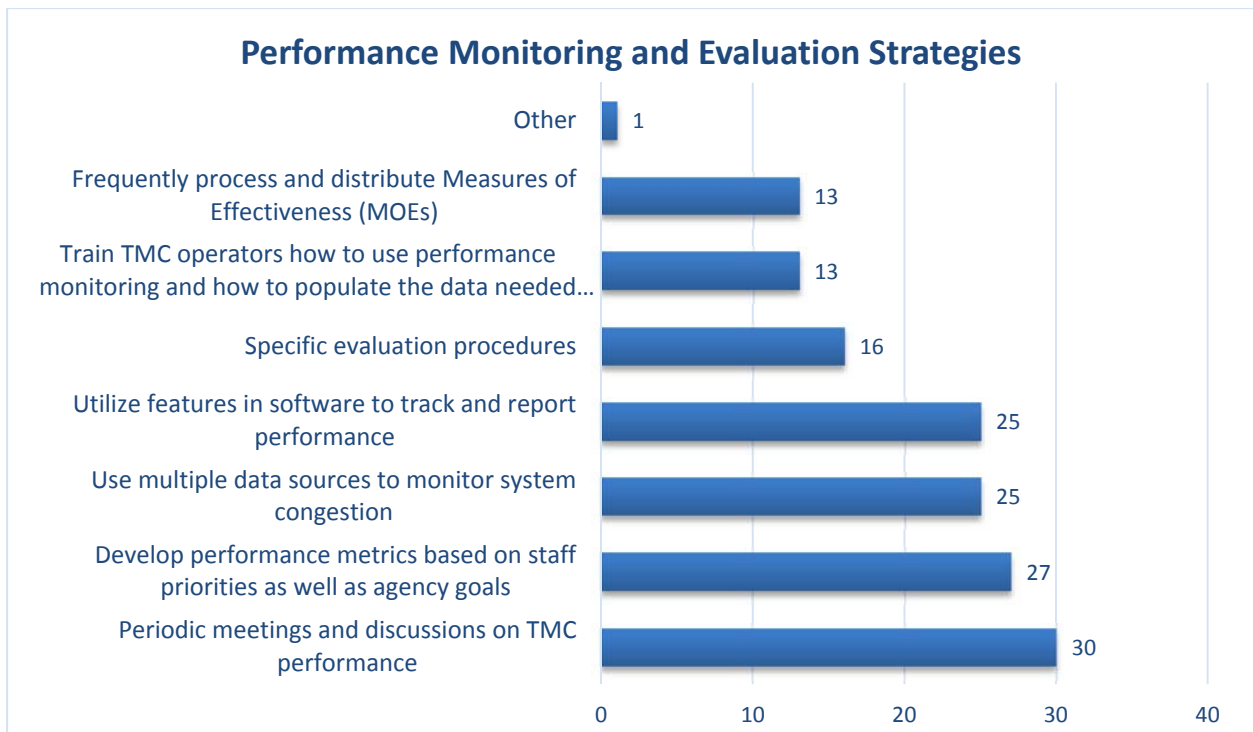
Question 4 focuses on the usage of applications in maintenance and construction as shown in Figure 8. This area sees relatively less usage of applications, compared with previous TMC functional areas. Road weather Data Collection, Maintenance and Construction Activity Coordination, and Weather Information Processing and Distribution are the most widely implemented applications, while Environmental Probe Surveillance shows 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.

Q4. Please select the applications in Maintenance and Construction that are being used at your TMC (choose all that apply).



**Figure 8 Usage of maintenance and construction applications.**

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



**Figure 9 Usage of performance monitoring and evaluation strategies.**

In terms of performance monitoring and evaluation strategies, Figure 9 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 have specific evaluation procedures, have 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 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.

- The Intelligent Roadway Information System (IRIS) Advanced Traffic Management System (ATMS) developed by the Minnesota DOT. As an open source FMS software, it 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.
- The Smartphone Application for Service Patrol (Road Rangers) to populate SunGuide Software, from Florida DOT District 2.
- The Emergency Traffic Operations Repository Web site, developed by the Wisconsin Statewide Traffic Operation Center (STOC) in house, provides multiple channels within the DOT, county and city government and first responders to easily get contacts, training, tools, maps, and guidelines, etc.
- The Freeway Service Team Program Web site, developed by the Wisconsin STOC, enables service contractors (private and local sheriff departments) to login and enter shift data, keep track of operator training, and generate reports. FST performance measures are generated from this site. The Traffic Incident Alert Web site, used by Wisconsin State Patrol and the STOC Control Room operators, sends emails out to other government entities and media outlets to alert of higher severity incidents.

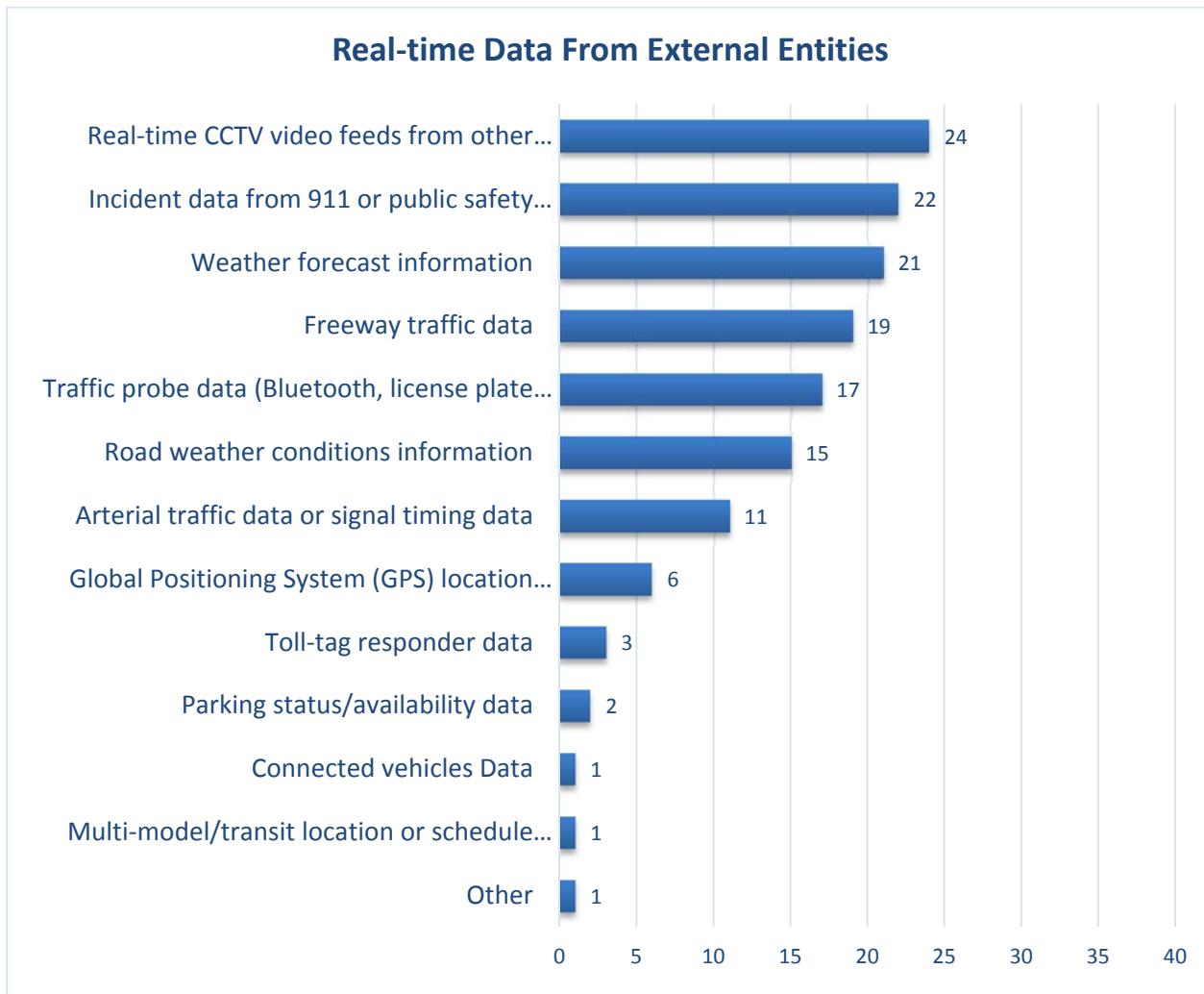
- The ATMS software developed by IBI Group to control all ITS devices and to input real-time incidents on freeway and arterial roadways, at the Ada County Highway District, Idaho. The software also allows automated e-mails to subscribers.
- The Safety Barrier Cable System (SBCS) implemented by the Florida DOT. The Symprx Software communicates with the barriers. The Data Proxy server talks to SunGuide, which alerts operations when vehicles break a barrier along the roadway. The safety barrier alerts can be produced into the system messages and these alerts can be used to generate events similar to the Florida Highway Patrol computer-aided dispatch(FHP-CAD) alerts and TSS alerts.
- The Texas DOT Austin District established policy and agreements for information sharing on facility planning, design, construction, and operation.
- The 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.
- The Georgia DOT developed the NaviGator, which is an Advanced Traffic Management System. Most of the Georgia's NaviGator system is installed in metro Atlanta, 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 the TMC. Information from the system is distributed to the public through a variety of outlets. GDOT administers two website, and operates a 511 telephone information service.
- The consolidated schema for regional GIS database by New Mexico DOT.

### **C. Data and Information Sharing**

This section focuses on emerging technologies and opportunities in data and information sharing activities at TMCs. Beside 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.

Question 7 identifies the types of real-time data that TMCs currently obtain from external entities. The result is presented in Figure 10. There are three types of real-time data that are most frequently used/obtained by the TMCs from external sources, which are 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, have received some application, but have not been widely incorporated into TMC practices.

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).



**Figure 10 Real-time data obtained from external entities.**



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, RWIS)
- Software and procedures (more robust and flexible freeway management software, and documented and repeatable transition plan to upgrade field network communication)

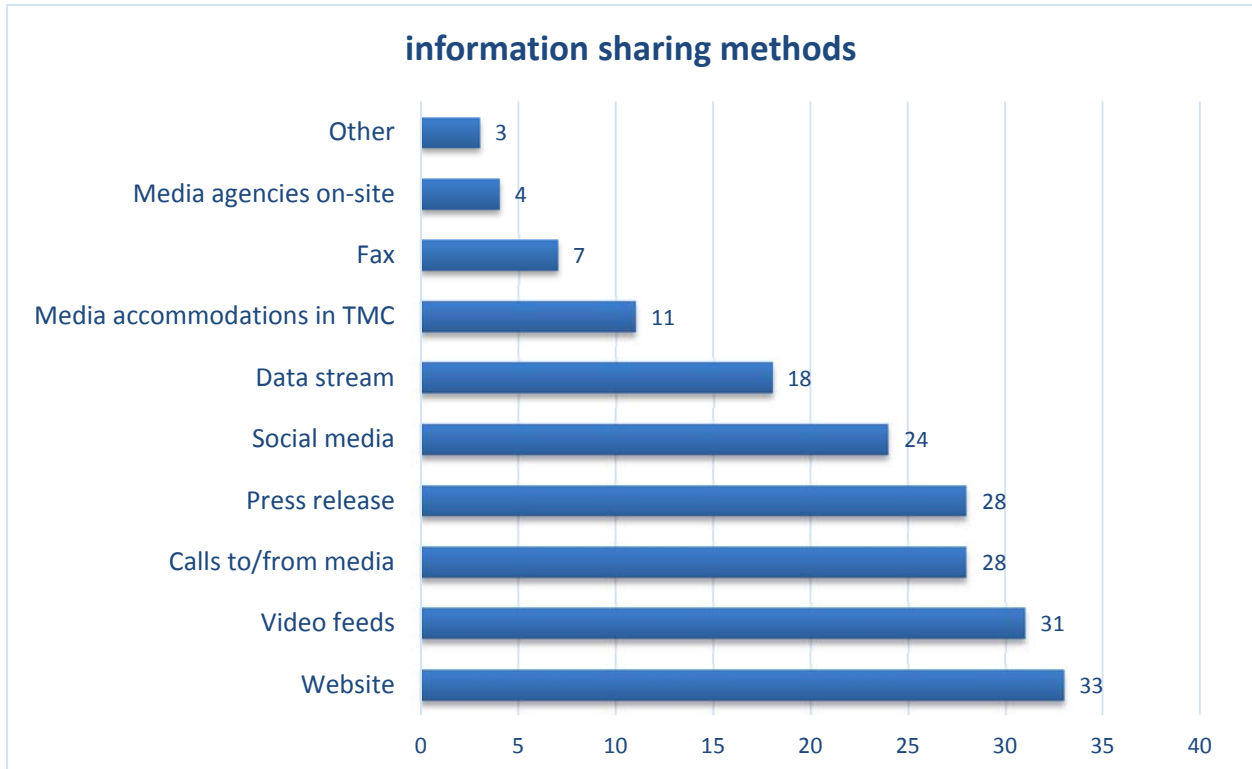
Q9. Please specify what types of data you are sharing with other agencies.

While question 7 identifies data import from external agencies, this question focuses on TMC data exportation that could benefit other agencies. The top-shared data are:

- 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)

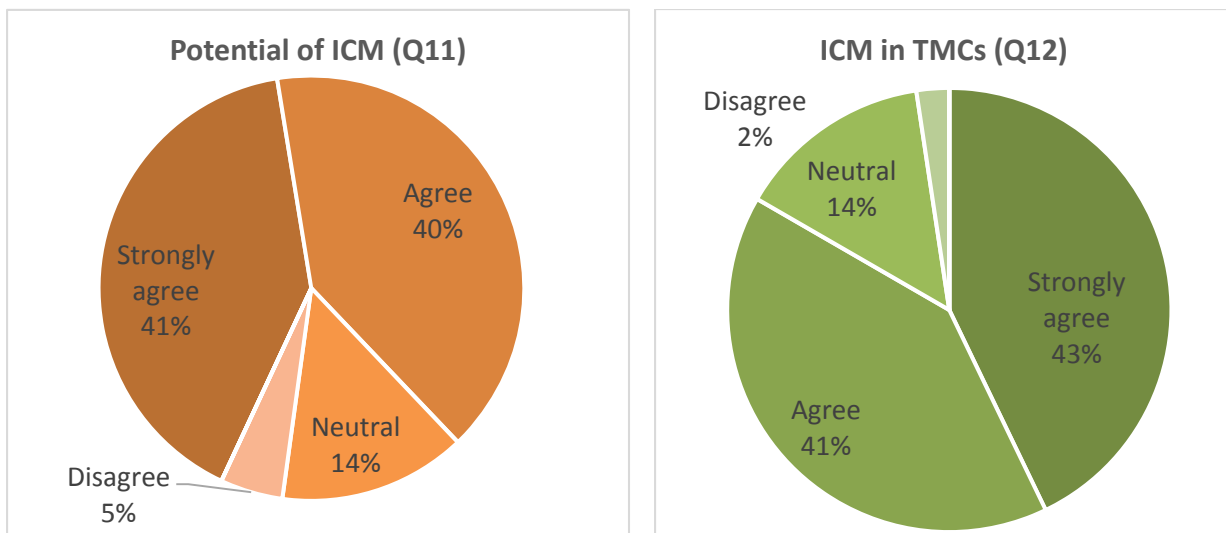
Q10. Which of the following information sharing methods your TMC uses for media interface (choose all that apply).

Question 10 focuses on media interface methods. As shown in Figure 11, the most widely applied methods are Website (33), followed by Video Feeds (31), Calls to/from Media (28) and Press Release (28). Social media as a platform for media interface has gained popularity, and used by 60% of the TMCs. Over a third of the TMCs have media accommodations onsite or media agencies onsite directly. The "other" methods mentioned by the respondents include radio link, in-house software, and public information officer.



**Figure 11 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).



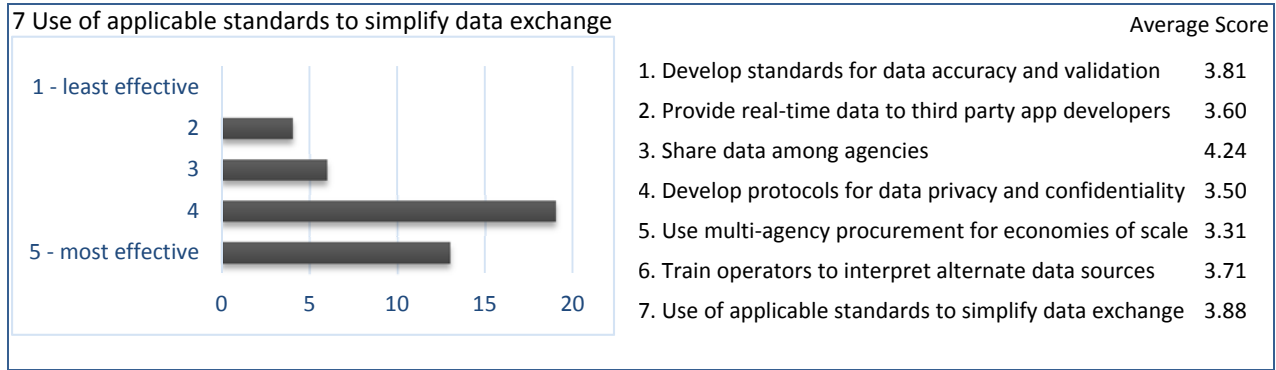
**Figure 12 Attitudes towards ICM initiatives.**

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 aims at gauging the potential of integrating ICM initiatives with TMC operations. As presented in Figure 11, a majority of the TMCs either agree or strongly agree 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 disagree 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 indicates generally consistent attitudes toward the two statements.

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





**Figure 13 Effectiveness of data collection/ integration strategies.**

Question 13 aims at seeking opinions from TMCs in terms of the effectiveness of data collection and integration strategies. As shown in Figure 13, “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 indicate 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 indicates a general reluctance in multi-agency data collection efforts, which may be due to the challenges in inter-agency collaboration and data ownership issues.

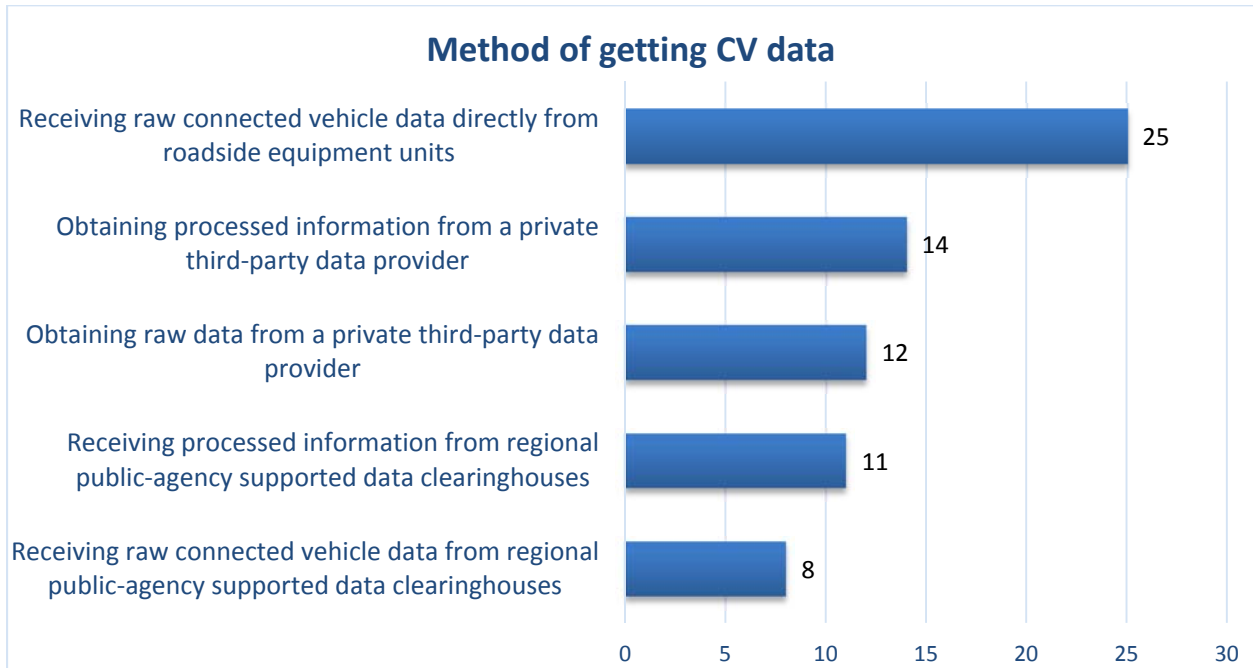
Q14. Integrating connected vehicle data (i.e., incident, speed, road weather, etc.) has the potential to greatly enhance your TMC’s operations (please choose only one).

86% of the respondents agree (among which 24% strongly agree) that connected vehicle data has the potential to contribute to TMC operations. While one TMC disagrees, 5 remain neutral. This indicates 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)?

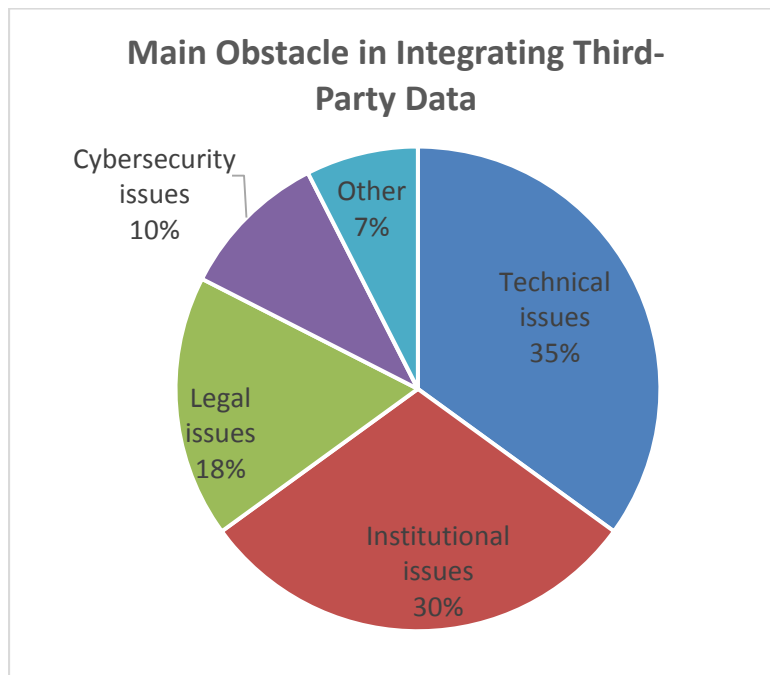
In terms of how to obtain connected vehicle data if desired to, most TMCs prefer to receive raw data directly from roadside equipment units, as shown in Figure 14. If the TMCs were to receive data from other entities, such as third-party data provider, or regional data clearinghouses, processed data were preferred over raw data. Among

external entities, more TMCs prefer to receive data from third-parties over regional clearinghouses.



**Figure 14 Method of obtaining connected vehicle data.**

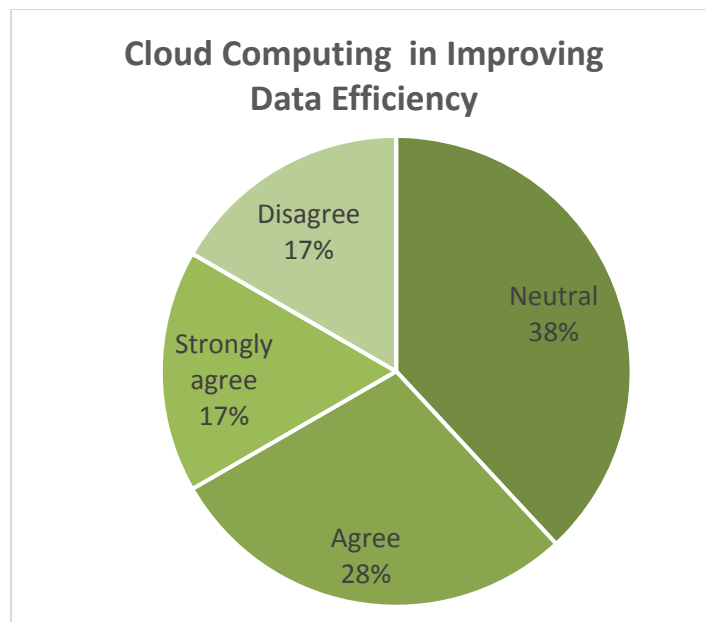
Q16. What do you foresee to be the main obstacle in integrating third-party data within your TMC operations (please choose only one)?



**Figure 15 Main obstacles in integrating third-party data.**

Question 16 intends to gain some understanding of the obstacles encountered when obtaining third-party data. As shown in Figure 15, when asked to choose only one, over one-third of the TMCs (35%) chose technical issue, followed by institutional (30%) and legal issues (18%). Four TMCs indicated cybersecurity issues as the main obstacles in integrating third-party data. Financial and reliability issues were also mentioned as the main issues.

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



**Figure 16** Cloud computing in improving data management efficiency.

A relatively new technology in the transportation industry, cloud computing has not received wide application yet. Figure 16 shows that while 45% of the TMCs agree with the potential of cloud computing, about 17% disagree and the rest 38% remain neutral.

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

The responses indicate 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 include collaboration with local university and regional MPO that archives/manages the data.

### D. Potential Enhancement with New Technologies

This section mainly focuses on the application and attitude towards the potential of emerging technologies in enhancing and supporting TMC operations. The technologies and tools that are of interest to this survey include automation tools, advanced wireless technologies, and social media tools.

Q19. Please rank the following applications in automation tools based on their usefulness in supporting your TMCs.

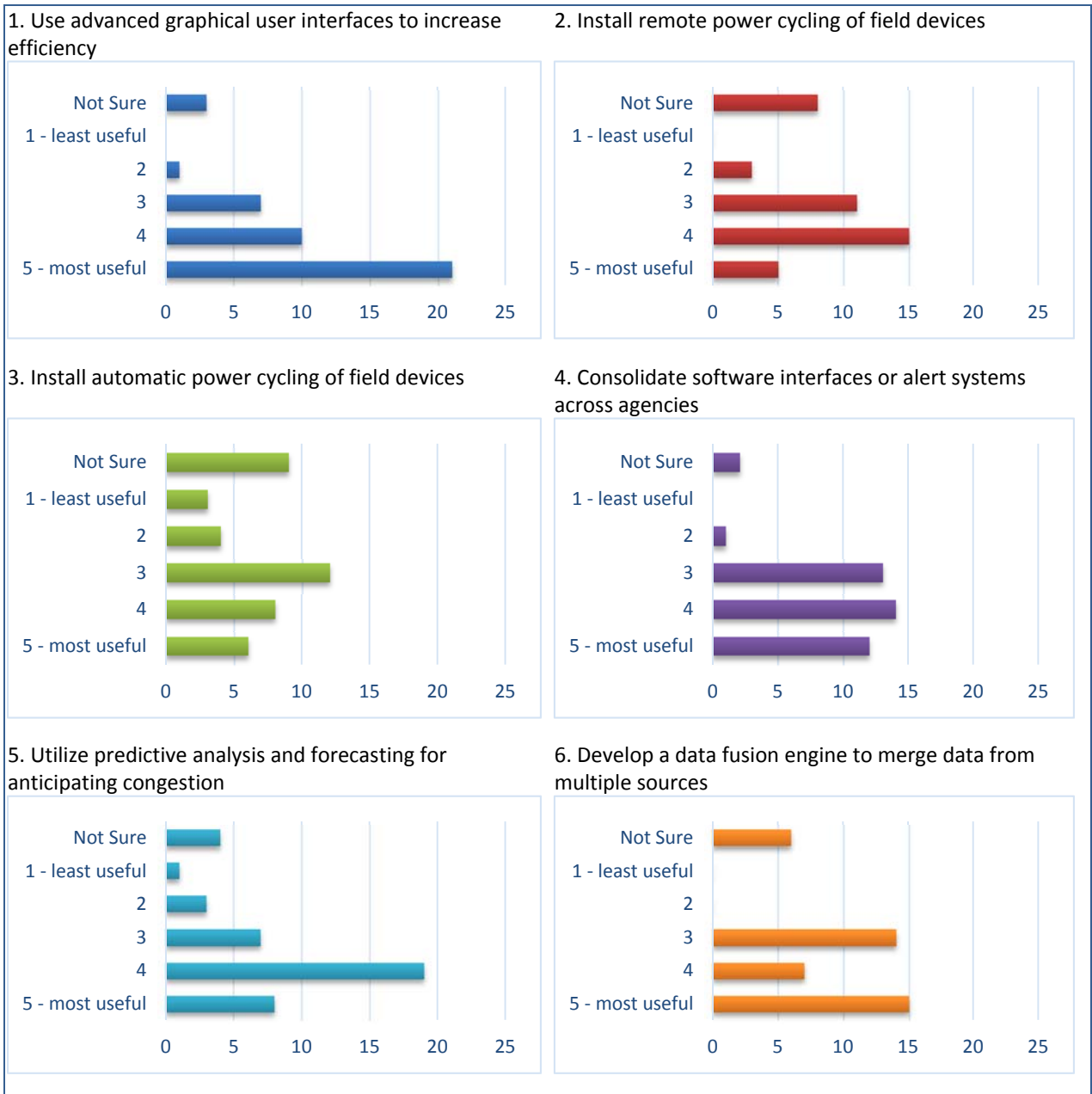
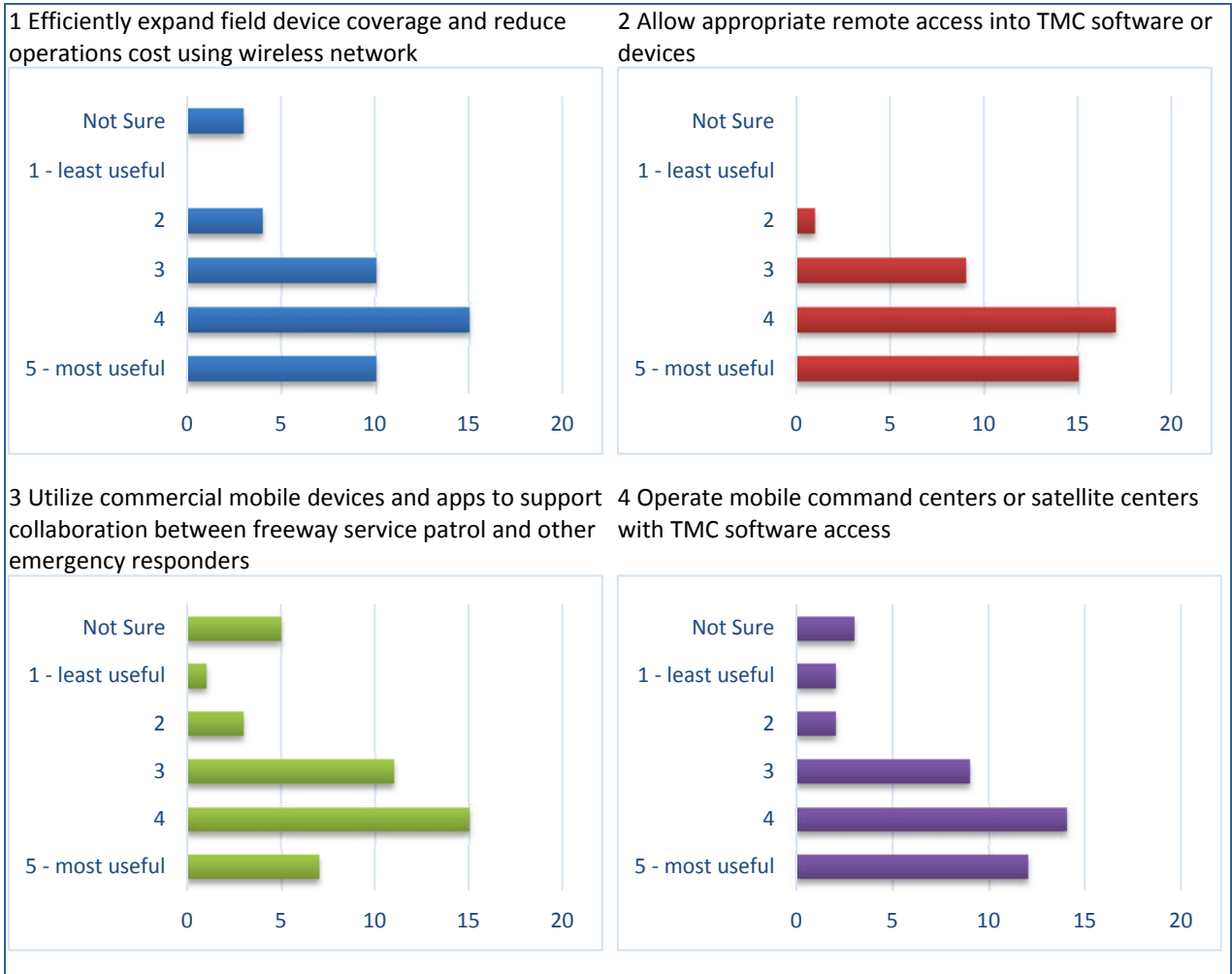


Figure 17 Usefulness of automation tools in supporting TMC operations.



As Figure 17 presents, among the six listed automation tools in data and analysis, advanced graphical user interface was selected as the most useful tools. Data fusion engine to merge data from multiple sources, consolidated software interfaces or alert systems across agencies, and predictive analysis and forecasting tools are also considered very useful in supporting TMC operations.

Q20. Please rank the following applications in advanced wireless technologies based on their usefulness to your TMC’s operations.

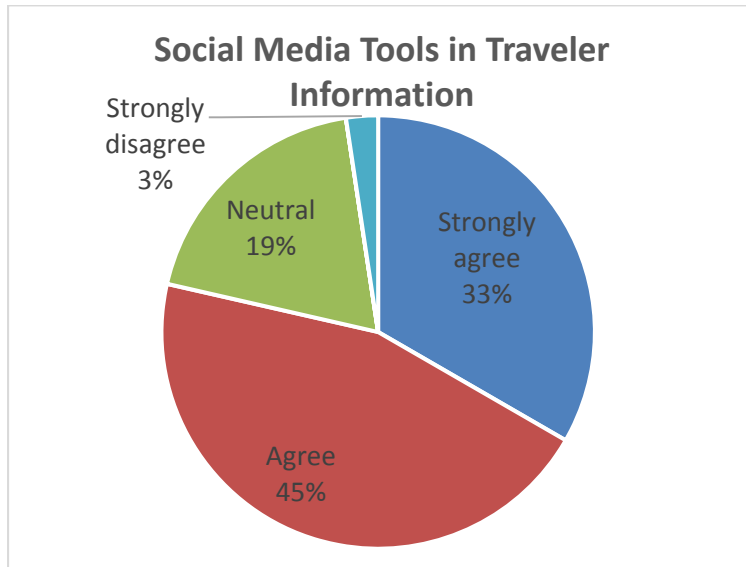


**Figure 18 Usefulness of advanced wireless technologies.**

As technologies in wireless communications advances, Question 20 intends to shed light on how TMCs view these technologies in terms of the usefulness to operations. Among the four proposed applications, “Allow appropriate remote access into TMC software or devices” was considered as either the most useful or useful by 32 respondents. 25 TMCs indicated that incorporating wireless network for field devices

were useful (with value 4 or 5). Although the other two applications received relatively less favorable considerations, more than half TMCs considered them as useful – 26 for “Operate mobile command centers or satellite centers with TMC software access”, and 22 for “Utilize commercial mobile devices and app to support collaboration between freeway service patrol and other emergency responders”.

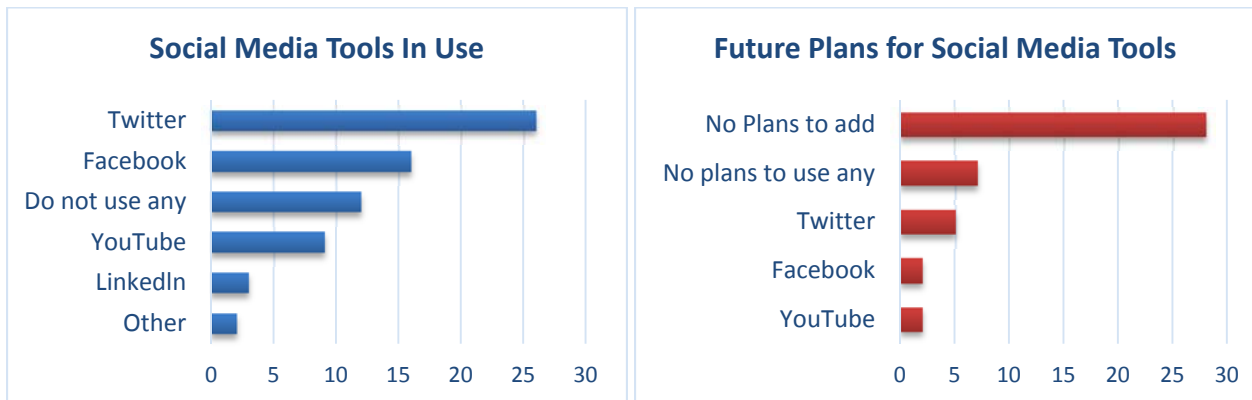
Q21. Social media tools have the potential to greatly enhance TMC’s operations in traveler information dissemination and crowdsourcing (please choose only one).



**Figure 19** The potential of social media tools in traveler information.

Q23. Please select the social media tools your TMC currently uses (choose all that apply).

Q24. Please check the social media tools your TMC plan to use in the near future (choose all that apply).



**Figure 20** Usage of social media tools.

Question 23 and Question 24 look at current usage of social media tools and future plans of using them, respectively. As shown in Figure 20, Twitter is the most popular social media tool used by TMCs (26), followed by Facebook (16), and YouTube (9). 3 TMCs indicated the engagement with LinkedIn. 12 TMCs currently do not use any social media tools. The “other” tools mentioned by the respondents include WAZE, and customized apps.

Among the 12 TMCs that has not engaged in any social media tools, 7 TMCs had no plan to use them in the near future, 5 TMCs indicated the plan to use Twitter, among which 2 TMCs also plan to use Facebook. 2 TMCs that are already engaged with social media tools indicated the plan to use YouTube in the near future.

**Q22. Please rank the following strategies in applying social media tools based on their usefulness to your TMC’s operations.**

Question 22 describes six strategies in applying social media tools in TMC practices. The respondents were asked to rank the strategies in terms of their usefulness. As shown in Figure 21, the top strategies that considered most useful are “Provide traveler information focusing on pre-trip planning”, “Foster relationships among agency public relations groups”, and “Develop procedures and protocols for use of social media”. Most TMCs also welcomed the idea of “Utilize crowdsourcing for traffic and incident information, and user feedbacks”, since only 5 TMCs considered it not useful (value 2 or below).

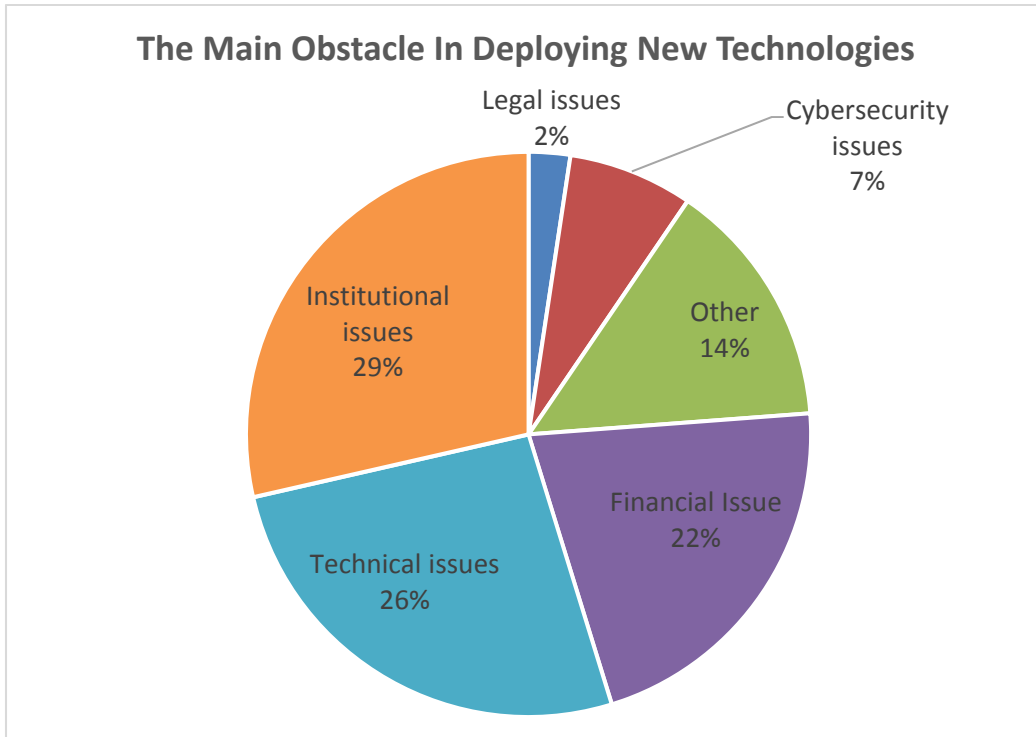
Notably, the other two strategies received mixed comments. With 18 TMCs consider “Designate a larger or statewide TMC to take responsibility for social media alters” useful, 10 other TMCs think otherwise. Similarly, 8 TMCs do not take “Partner with private sector to facilitate social media outlets and realize cost efficiencies” as very useful to their operations.



**Figure 21 Usefulness of social media strategies.**

Q25. What do you foresee to be the main obstacle in deploying new technologies for your TMC (please choose only one)?

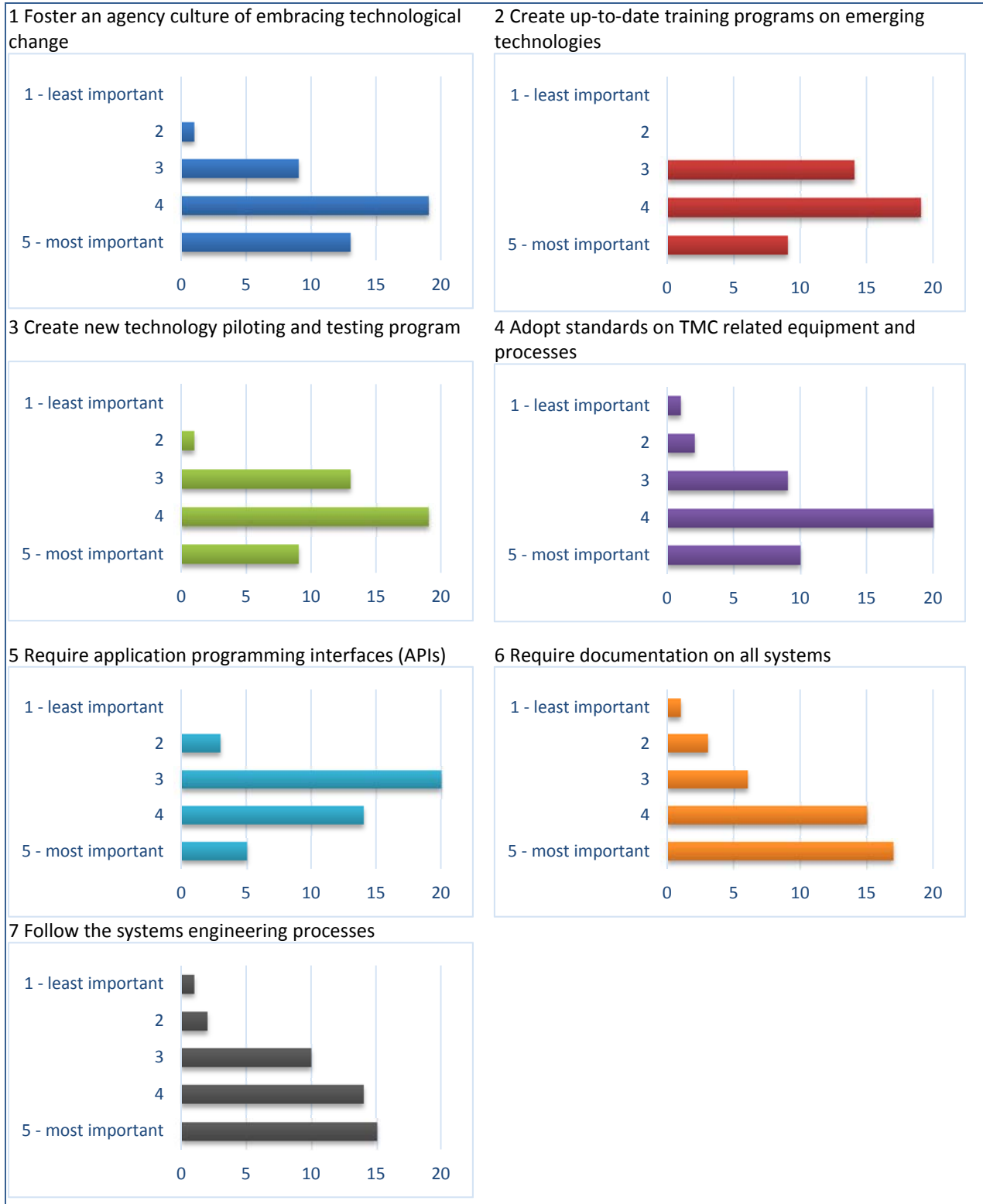
As Figure 22 presents, comparable number of TMCs consider the main obstacle in deploying new technologies as institutional, technical and financial issues respectively. Three TMCs chose cybersecurity as the main issue, while one TMC considers legal issues as the main obstacle. Staffing was indicated by several TMCs as the main issue.



**Figure 22** The main obstacle in deploying new technologies.

Q26. Please rank the following strategies in terms of their importance in facilitating the adoption of new technologies at your TMC.

Question 26 asks the respondents to evaluate seven strategies in terms of the importance in facilitating the adoption of new technologies. As shown in Figure 23, documentation, agency culture, and following system engineering process are considered as the most important factors contributing to technology adoption. Training, pilot testing, and adoption standards are also identified as important elements.



**Figure 23** Evaluation of strategies in the adoption of new technologies.

## **E. Staffing and Skill Needs**

In light of the rapid development in new technologies and tools, TMCs may face additional challenges in acquire staff with capable skills to handle and take advantage of the latest advancements in traffic management and information technologies. This section intends to understand TMCs' views, in terms of additional data needs, training programs, and staff development, etc.

Q27. What additional types of staff resources (or staff knowledge and skills) are needed to support your TMC's missions in light of the emerging technology and information applications?

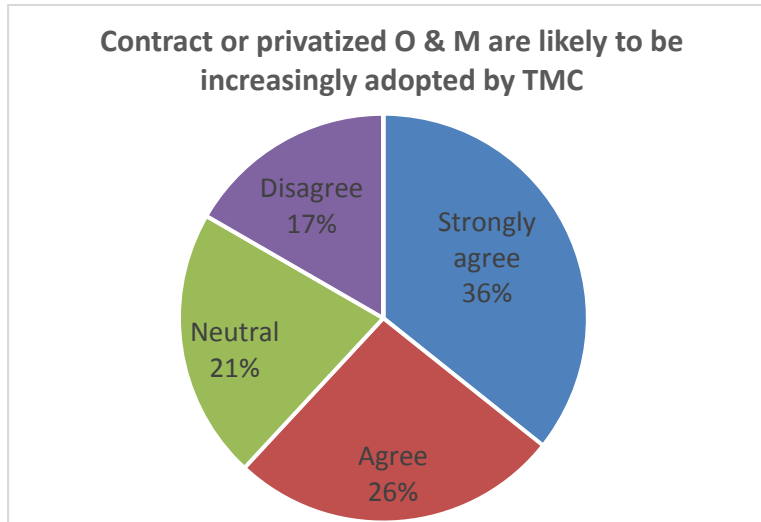
Question 27 asks each agency on the expected staff and skill needs in supporting TMC operations from new technology and tools perspective. The common needs identified by the TMCs include:

- IT related skills, such as network/database management
- System engineering, in system integration, maintenance and operations
- ITS design and traffic engineering
- Additional staff for more coverage/capacity
- Training and continuing education, including, new technology training, network hardware training, systems training from vendors
- Funding

Q28. Contract or privatized operations and maintenance are likely to be increasingly adopted by TMCs, as it relieves the needs to acquire and maintain staff with the required skills (please choose only one).

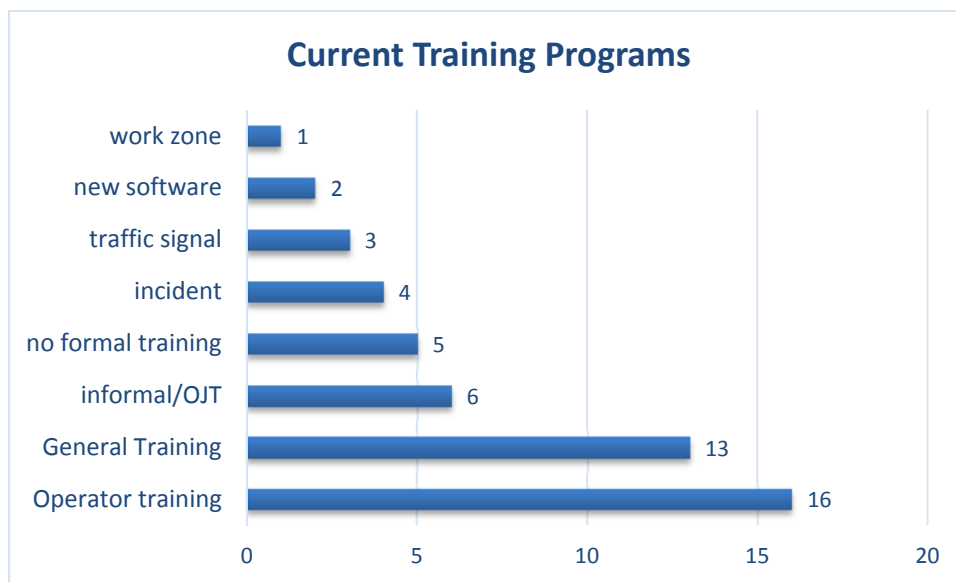
When it comes to contracting/privatizing operations and maintenance activities, 36% of the TMCs strongly agree that it is likely to be increasingly adopted. An additional 26% of TMCs agree with the trend, 17% disagree, and none of the TMCs strongly disagree.





**Figure 24 Attitude towards contract or privatized operations and maintenance.**

Q29. What types of training programs (formal or informal) does your TMC provide?



**Figure 25 Training programs provided at TMCs.**

Question 29 is an open-ended question that identifies what types of training programs that TMCs provide to their staff. The most common training mentioned is operator training, provided at 16 TMCs. A number of TMCs did not mention specific types of the training program, which is categorized together with other types of training (leadership training, quarterly staff meeting, TMC Academy, etc.) as general training. 6 TMCs indicated that informal or on the job training (OJT) were provided, and 5 TMCs do not

have formal training program. The other types of trainings mentioned include traffic signal training, training for new software release, and work zone training.

Q30. Please rank the following strategies based on their importance to your TMC's training program.

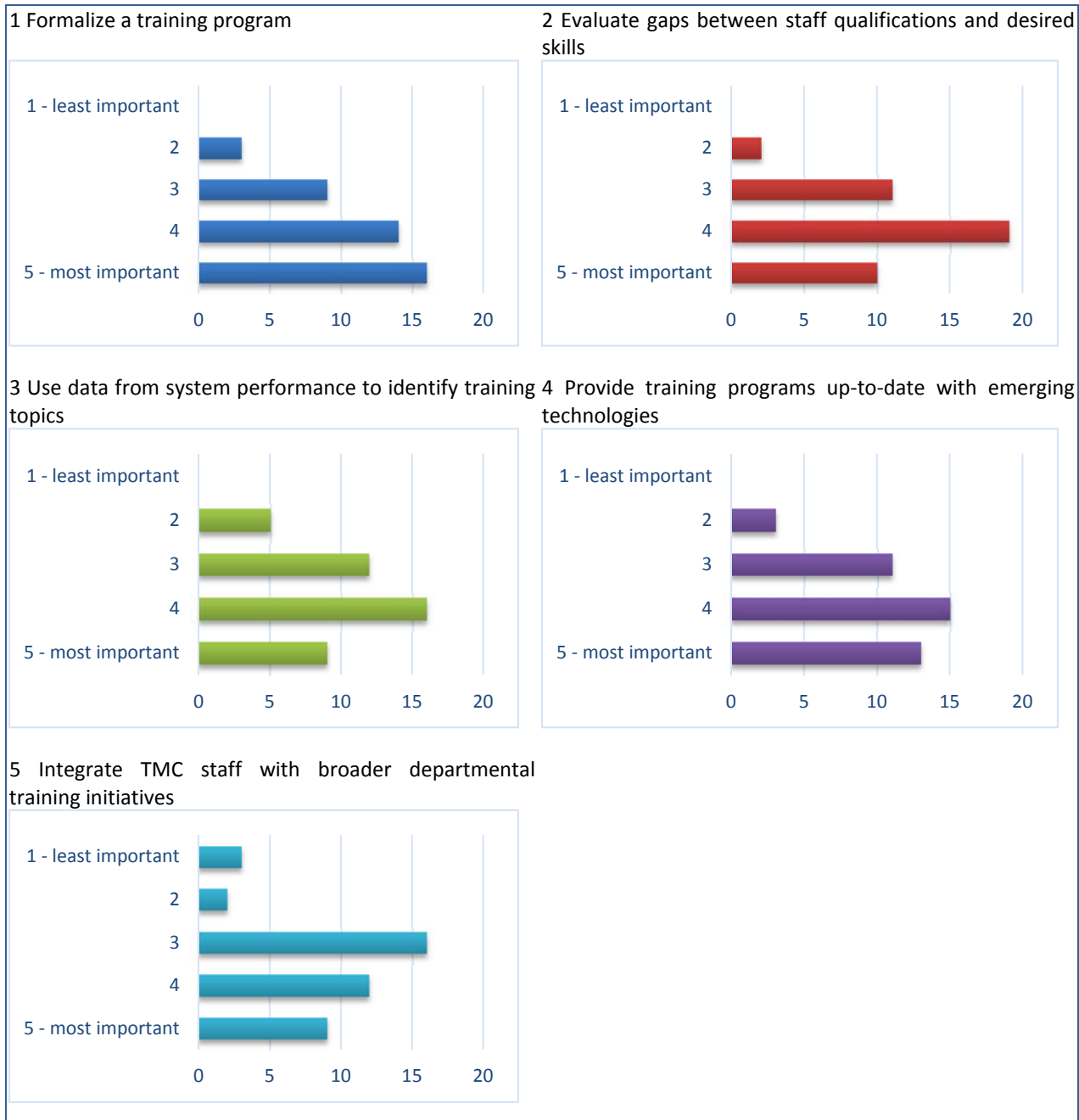
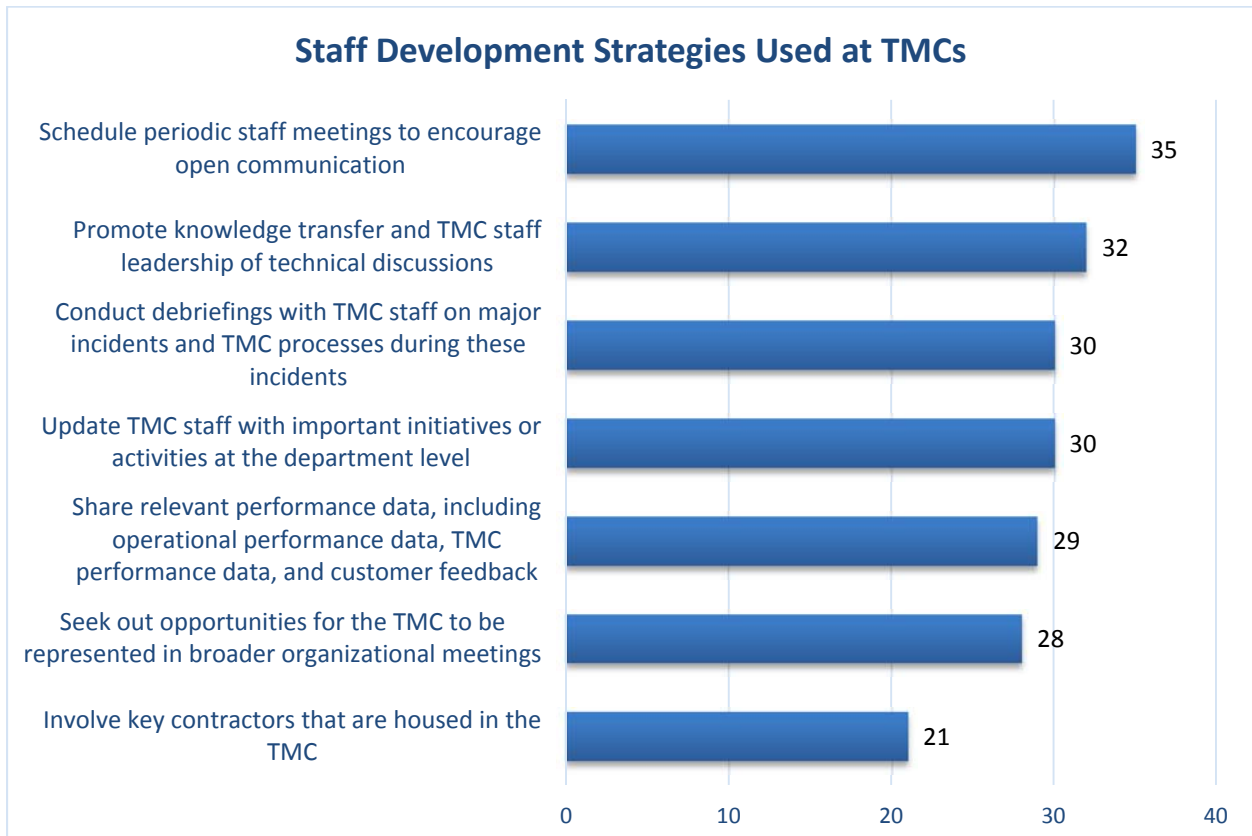


Figure 26 Importance of TMC training program strategies.

As shown in Figure 26, in general, most of the strategies were deemed important by most agencies, except for the last one. The most important ones are formalization of the training program, evaluation of gaps and identify training needs, and up-to-date program with emerging technologies.

Q31. Please select the strategies in staff development (beyond training programs) that are being used at your TMC (choose all that apply).

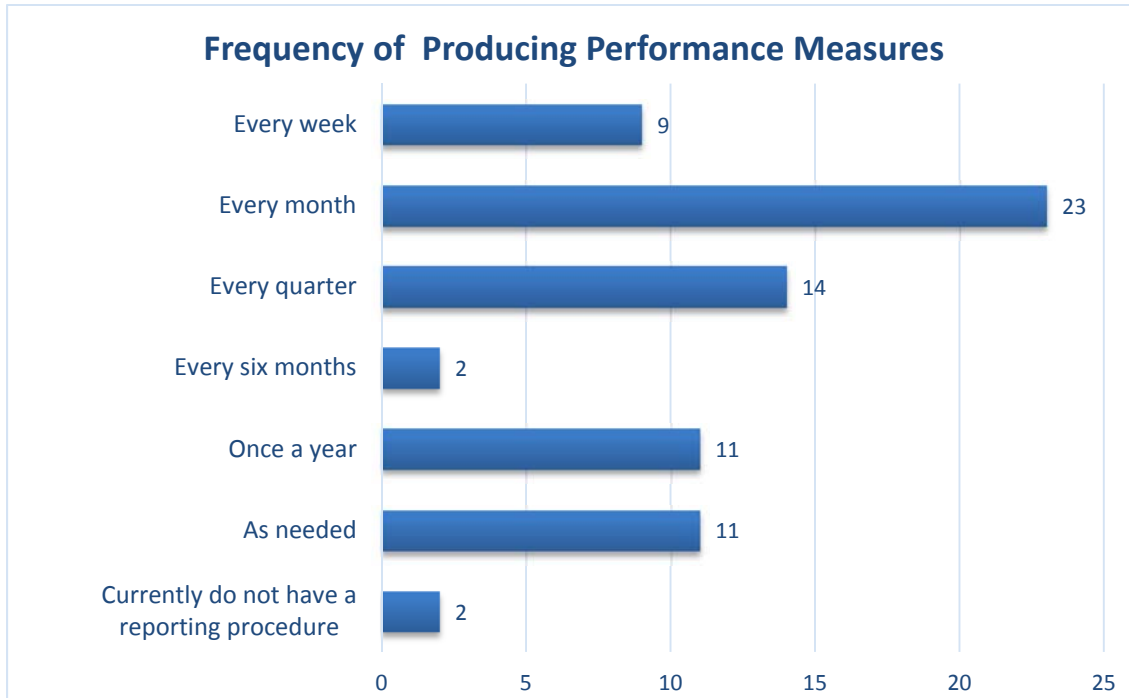


**Figure 27 Strategies in staff development used at TMCs.**

Beyond training programs, Figure 27 shows staff development strategies that TMCs are using. All strategies (except one) have very high application rate, deployed by at least 70% of the TMCs.

Q32. How often do you produce performance measures report (choose all that apply)?

Figure 28 presents a chart that summarizes how often TMCs produce performance reports. Most agencies produce performance measures on a monthly basis.



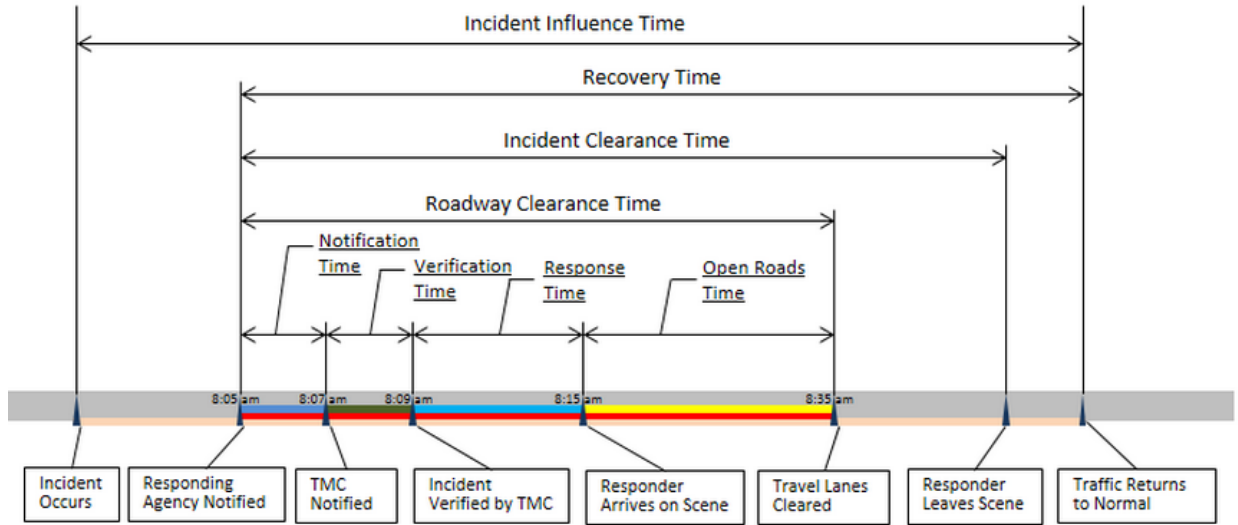
**Figure 28** Frequency of producing performance measures report.

## F. TIM Performance Measures

Since TIM is one of the most critical functional programs for most TMCs, this section aims to provide a quick overview of the current state-of-the-practice on their TIM program performance.

The responders were asked to provide the performance over a few quantitative measures that are commonly monitored and reported by TMCs. The respondents were asked to report in the following categories based on latest available data:

- Detection Duration (in minutes)
- Verification Duration (in minutes)
- Response Duration (in minutes)
- Roadway Clearance Duration (in minutes)
- Incident Clearance Duration (in minutes)
- Field Responder Safety (number of injuries and number of fatalities per year)
- Whether track secondary incidents



Source: Florida DOT

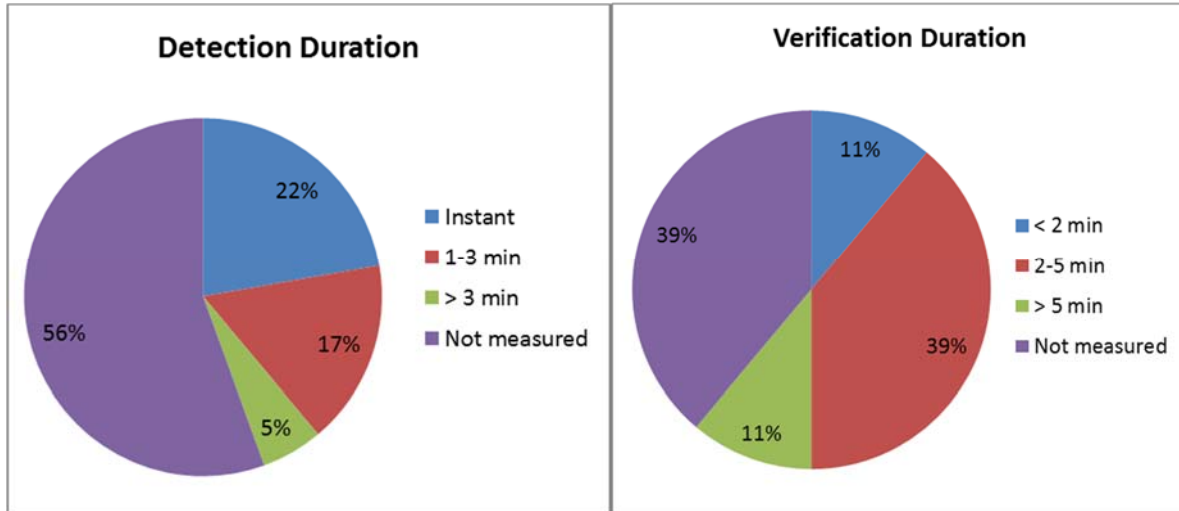
**Figure 29 Traffic incident management timeline.**

A chart (shown in Figure 29) was provided in the survey to avoid any potential confusion on the definitions of the measures. A total of 42 TMC participated in the survey, of which 18 provided answers to at least one of the above measurements. Most respondents indicated that their performance measures reports use similar definitions. All responses were based on data reported in late 2013, or early 2014, or 2013 yearly average. Table 2 below presents a summary of the survey results.

**Table 2 TIM Performance Summary from Survey (in minutes)**

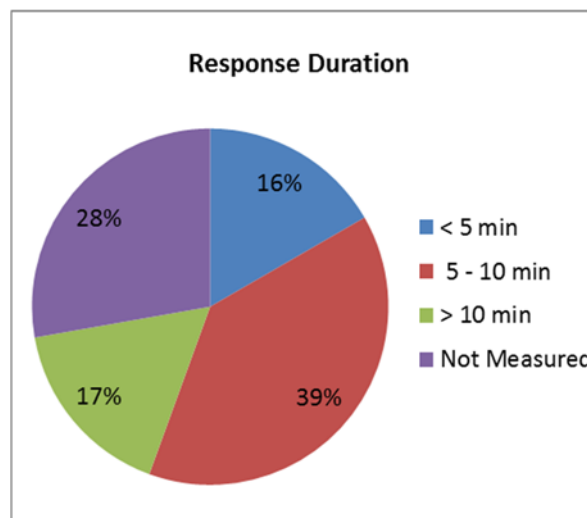
	Detection Duration	Verification Duration	Response Duration	Roadway Clearance Duration	Incident Clearance Duration
<b>Minimum</b>	0	1	2.6	12.8	20.8
<b>Maximum</b>	33	15	20	90	100
<b>Average</b>	5.03	4.15	8.97	36.77	46.01
<b>Median</b>	0.6	3.3	8	29.4	36
<b>Count</b>	8	11	13	17	17

As shown in Figure 30, the survey indicates that a significant portion of agencies (56%) does not consider detection duration as a performance measure. For those that do keep record of detection duration, a vast majority of them are able to detect the incident within 3 minutes. Similarly, most agencies shown verification duration within 5 minutes.



**Figure 30 Survey summaries – detection duration & verification duration.**

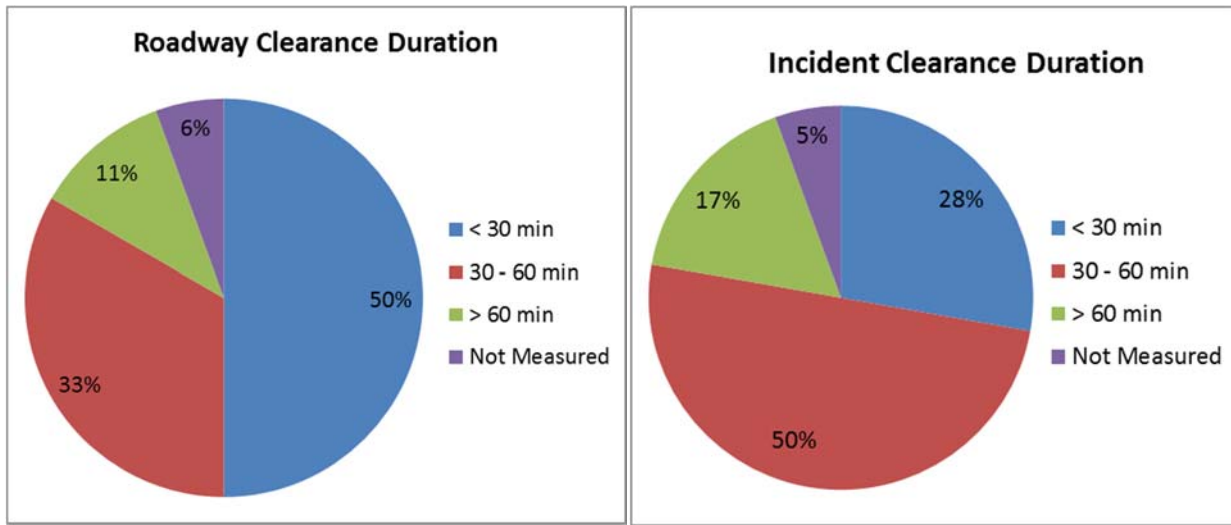
Response duration measures the time it takes from the incident being verified till the first responder arrives on scene. The average response time falls between 5 and 10 minutes. Figure 31 below shows the percentage of agencies within each response duration category. 16% agencies were able to respond within 5 minutes, 39% between 5 to 10 minutes, while 17% showed response time larger than 10 minutes. Average response time falls between 5 and 10 minutes.



**Figure 31 Survey summaries – response duration.**

Roadway clearance duration measures the time between the notification of an incident and clearance of the travel lane(s), while incident clearance duration refers to the time from notification of an incident till the responding agency leaves the scene. As shown in Figure 32, half of the agencies are able to clear travel lanes in 30 minutes, and more

than three quarters of the agency manages to keep their average incident clearance times within 60 minutes.



**Figure 32 Survey summaries - roadway clearance and incident clearance duration.**

Responder safety has been recognized as one of the three national unified goals (NUG) for traffic incident management<sup>27</sup>. The survey asked the respondents to report number of responder injuries and fatalities per year. Only 5 out of the 42 agencies reported these measures. Although only three respondents explicitly indicated that these two indicators were not measured by the agency, it is reasonable to expect that the actual share of agency that do not measure responder safety would be much higher.

Secondary incident tracking is also a relatively new performance measure that is gaining more attentions for implementation in practice. Based on the responses, 18 out of the 42 respondents (43%) are reporting secondary incidents, 12 agencies did not track secondary incidents, and the rest of the 12 agencies did not respond. One barrier to secondary incident tracking could be the lack of clear definition to identify/differentiate secondary incidents.

## VII. CONCLUSIONS

As computer and information technologies have evolved tremendously since the past decade, many Intelligent Transportation System (ITS) technologies have emerged and changed the ways of traffic management and information provision. This study intends

<sup>27</sup> National Unified Goal for Traffic Incident Management - Detailed Explanation. National Traffic Incident Management Coalition. American Association of State Highway and Transportation Officials, 2007.



to update the knowledge in traffic management center (TMC) current practices as well as future plans in terms of the potentials in applying latest technologies, tools and strategies. A web-based survey is conducted to gather information from TMCs around the nation, regarding their views and attitudes toward these new trends and technologies. Additional staff and skill needs in light of the technology advancements are also being explored as part of the survey.

In terms of current applications by function area, 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; some strategies are widely applied and others still await more attentions. Tools in Maintenance and Construction show plenty of room for further implementation, as do those tools in Traffic Management, especially the emerging strategies such as lane management strategies, speed warning and enforcement, parking facilities, etc. 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. Data gathering through external or alternative data sources shows potential for future growth, and many agencies indicated the desire to obtain data from other agencies such as arterial traffic conditions, transit information, parking availability information, etc.

Regarding the trend and potential of advanced technologies, a few inferences can be drawn from the survey results. Various applications in automation tools and advanced wireless technologies are being considered very useful to TMC operations. Of these advanced graphical user interface and remote access to TMC software and devices are the most useful applications. A vast majority of the TMCs hold positive attitude towards using social media tools for traveler information, and more than 70% of the TMCs are already using social media applications. In terms of strategies for applying social media tools, the most useful one is minimizing driver distractions by focusing on providing pre-planning information. Institutional, technical, and financial issues are the biggest obstacles to applying advanced technologies. The most important strategies for facilitating the application of advanced technologies are documentation on all systems, fostering an embracing agency culture, and following system engineering processes. In terms of additional needs in staff resources, IT professionals, system engineers, ITS and traffic engineers, and training and continuing education are identified by the TMCs. The results provide valuable insights for policy makers and developers in

understanding the potentials of the various applications and how to best incorporate them to enhance TMC operations.

This study provides a comprehensive scan on current applications and tools in key TMC function areas, which 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. In light of innovative technologies and tools, this study contributes to the body of knowledge by providing an overview from the TMC perspective in terms of their views and attitudes toward emerging trends, which provides some insights for policy makers and developers in terms of the potentials of the various applications in advanced technologies and the most suitable strategies to incorporate them to enhance TMC operations.

## **VIII. ACKNOWLEDGMENTS**

Funding for this study is provided by the National Center for Transportation System Productivity and Management (NCTSPM). Special gratitude goes to Dr. Michael Hunters, Director of the NCTSPM, and Audrey F. Leous for their continuous support and coordination throughout the course of the project. The authors would also like to thank all the survey participants for their time, support and inspiration, without which this study would not have been possible.

## **IX. APPENDIX A SURVEY QUESTIONNAIRE**

# Survey of Traffic Management Center (TMC) Practices



## Thank you for participating in the survey!

This survey is being conducted by the Florida International University (FIU) as part of a project sponsored by the National Center for Transportation Systems Productivity and Management (NCTSPM), a National University Transportation Center (UTC) funded by the Research and Innovative Technology Administration (RITA) of the U.S. DOT. The purpose is to help 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 includes questions addressing each of the following five areas of interest:

1. Current tools used in TMC operations
2. Practices in data and information sharing
3. Potential enhancements with new technologies
4. Staffing and Skill Needs
5. Traffic Incident Management (TIM) performance measures

The questionnaire consists of both fact-finding and opinion-seeking questions. It is intended that this survey be completed by a TMC manager and/or someone who is familiar with the TMC activities. The survey results will be shared with all participants after they are compiled and summarized. It is the goal of this survey to identify best practices and future plans in applying technologies and tools in TMC operations.

We estimate that it will take you approximately 30 minutes to complete the survey. Your participation and contribution are highly appreciated. Please complete the survey by **Friday, April 4, 2014**. If you have any questions or comments please do not hesitate to contact us.

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## General Information

Please provide the following general information:

Name: [Click here to enter text.](#)

Position Title: [Click here to enter text.](#)

Phone (optional): [Click here to enter text.](#)

Email: [Click here to enter text.](#)

Agency Name: [Click here to enter text.](#)

Service Area: [Click here to enter text.](#)

**1. How would you characterize the service area covered by your TMC?**

- Statewide
- Urban region
- Urban/Rural region
- Other: [Click here to enter text.](#)

**2. Your TMC is part of a (please choose only one)**

- State DOT Central Office
- DOT District
- County Government
- City Government
- Other: [Click here to enter text.](#)

**3. Please list the agencies (e.g., highway patrol, transit agency, etc.), if any, that are on-site or co-located in your TMC.**

**4. In which year did your TMC begin operation?** [Click here to enter text.](#)

**5. What are the approximate centerline miles served by your TMC?**

**Freeways:** [Click here to enter text.](#)

**Arterials:** [Click here to enter text.](#)

6. **Over the past five years, the number of centerline miles your TMC serves has been (please choose only one).**

- Increasing
- Staying about the same
- Decreasing
- Other: [Click here to enter text.](#)

7. **What is your TMC's current annual budget?** [Click here to enter text.](#)

8. **Over the past five years, your annual TMC budget has generally been (please choose only one).**

- Increasing
- Staying about the same
- Decreasing
- Other: [Click here to enter text.](#)

## Current Applications by Functional Areas

**Q1. Please select the applications in Traffic Management that are being used at your TMC (choose all that apply).**

- Network Surveillance
- Traffic Probe Surveillance
- Traffic Signal Control
- Traffic Metering
- High Occupancy Vehicle (HOV) Lane Management
- High Occupancy Toll (HOT) Lanes
- Roadside Lighting System Control
- Portable Work Zone ITS System
- Parking Facility Management
- Reversible Lane Management
- Speed Warning and Enforcement
- Roadway Closure Management
- Variable Speed Limits
- Dynamic Lane Management and Shoulder Use
- Other: [Click here to enter text.](#)

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

- Automated Interagency Data Exchange/Sharing
- Pre-Planned Incident Management Strategies
- Coordinated Incident Response Team
- Highway Patrol
- Severe Incident Response Vehicle
- Quick Response Policy
- Advanced Warning System
- Responsive Traffic Control System
- Public Safety Radio Communications
- Implementation of Performance Measures
- Other: [Click here to enter text.](#)



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

- 511 System
- Traveler Information Website
- Dynamic Message Signs
- Highway Advisory Radio
- Email or Text Alerts
- Social Media Tools
- Connected Vehicle Dedicated Short Range Communication (DSRC) Traveler Information
- Automated Data Feeds to External Agencies or Third Parties
- Other: [Click here to enter text.](#)

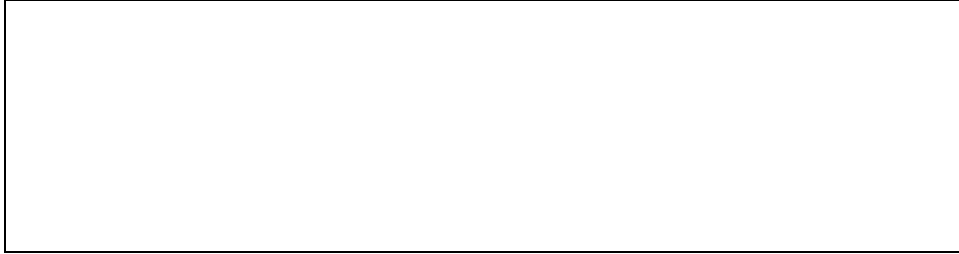
**Q4. Please select the applications in Maintenance and Construction that are being used at your TMC (choose all that apply).**

- Maintenance and Construction Vehicle and Equipment Tracking
- Maintenance and Construction Vehicle Maintenance
- Maintenance and Construction Activity Coordination
- Road Weather Data Collection
- Weather Information Processing and Distribution
- Environmental Probe Surveillance
- Infrastructure Monitoring
- Other: [Click here to enter text.](#)

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

- Develop performance metrics based on staff priorities as well as agency goals
- Frequently process and distribute Measures of Effectiveness (MOEs)
- Use multiple data sources to monitor system congestion
- Utilize features in software to track and report performance
- Periodic meetings and discussions on TMC performance
- Specific evaluation procedures
- Train TMC operators how to use performance monitoring and how to populate the data needed for performance monitoring
- Other: [Click here to enter text.](#)

**Q6. Please briefly describe any tools, systems, or procedures your TMC has developed, if you would like to share your experience with other TMCs.**

A large, empty rectangular box with a thin black border, intended for the respondent to provide a detailed answer to the question above. The box is currently blank.

## Data and Information Sharing

**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).**

- Arterial traffic data or signal timing data
- Freeway traffic data
- Incident data from 911 or public safety computer-aided dispatch systems
- Toll-tag responder data
- Real-time CCTV video feeds from other agencies
- Road weather conditions information
- Weather forecast information
- Multi-modal/transit location or schedule adherence information
- Global Positioning System (GPS) location data (taxi, trucks, smart phones, etc.)
- Traffic probe data (Bluetooth, license plate matching, floating car, etc.)
- Parking status/availability data
- Connected vehicles Data
- Other: [Click here to enter text.](#)

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

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

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

- Data stream
- Video feeds
- Website
- Calls to/from media
- Fax

- Press release
- Media accommodations in TMC
- Media agencies on-site
- Social media
- Other: [Click here to enter text.](#)

**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).**

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

**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).**

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

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

	1 - least effective	2	3	4	5 - most effective
Develop standards for data accuracy and validation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Provide real-time data to third party app developers	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Develop protocols for data privacy and confidentiality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Share data among agencies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use multi-agency procurement for economies of scale	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Train operators on how to interpret alternate data sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use of applicable standards to simplify data exchange	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**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).**

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

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

- Receiving raw connected vehicle data directly from roadside equipment units and integrated into the TMCs Advanced Management System (ATMS)
- Obtaining raw data from a private third-parity data provider
- Obtaining processed information from a private third-parity data provider
- Receiving raw connected vehicle data from regional public-agency supported data clearinghouses
- Receiving processed information from regional public-agency supported data clearinghouses
- Other: [Click here to enter text.](#)

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

- Legal issues
- Institutional issues
- Technical issues
- Cybersecurity issues
- Other: [Click here to enter text.](#)

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

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

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

## Potential Enhancements with New Technologies

**Q19. Please rank the following applications in automation tools based on their usefulness in supporting your TMS's**

	1-least helpful	2	3	4	5-most helpful	Not Sure
Use advanced graphical user interfaces to increase efficiency	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Install remote power cycling of field devices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Install automatic power cycling of field devices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Consolidate software interfaces or alert systems across agencies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Utilize predictive analysis and forecasting for anticipating congestion	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Develop a data fusion engine to merge data from multiple sources	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Q20. Please rank the following applications in advanced wireless technologies based on their usefulness to your TMC's operations.**

	1-least helpful	2	3	4	5-most helpful	Not Sure
Efficiently expand field device coverage and reduce operations cost using wireless network	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Allow appropriate remote access into TMC software or devices	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Utilize commercial mobile devices and apps to support collaboration between freeway service patrol and other emergency responders	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Operate mobile command centers or satellite centers with TMC software access	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Q21. Social media tools have the potential to greatly enhance TMC's operations in traveler information dissemination and crowdsourcing (please choose only one).**

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

**Q22. Please rank the following strategies in applying social media tools based on their usefulness to your TMC's operations.**

	1-least helpful	2	3	4	5—most helpful	Not Sure
Develop procedures and protocols for use of social media	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Foster relationships among agency public relations groups	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Designate a larger or statewide TMC to take responsibility for social media alerts	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Provide traveler information focusing on pre-trip planning to minimize driver distraction	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Utilize crowdsourcing for traffic and incident information, and user feedbacks	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Partner with private sector to facilitate social media outlets and realize cost efficiencies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Q23. Please select the social media tools your TMC currently uses (choose all that apply).**

- Do not use any
- Facebook
- Twitter
- YouTube
- LinkedIn
- Other: [Click here to enter text.](#)

**Q24. Please check the social media tools your TMC plan to use in the near future (choose all that apply).**

- Already use some of these tools
- Do not plan to use
- Facebook
- Twitter
- YouTube
- LinkedIn
- Other: [Click here to enter text.](#)

**Q25. What do you foresee to be the main obstacle in deploying new technologies for your TMC (please choose only one)?**

- Legal issues
- Institutional issues
- Technical issues
- Cybersecurity issues
- Other: [Click here to enter text.](#)



**Q26. Please rank the following strategies in terms of their importance in facilitating the adoption of new technologies at your TMC.**

	1 - least important	2	3	4	5 - most important
Foster an agency culture of embracing technological change	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Create up-to-date training programs on emerging technologies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Create new technology piloting and testing program	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Adopt standards on TMC related equipment and processes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Require application programming interfaces (APIs)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Require documentation on all systems	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Follow the systems engineering processes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

## Staff and Skill Needs

**Q27. What additional types of staff resources (or staff knowledge and skills) are needed to support your TMC's missions in light of the emerging technology and information applications?**

**Q28. Contract or privatized operations and maintenance are likely to be increasingly adopted by TMCs, as it relieves the needs to acquire and maintain staff with the required skills (please choose only one).**

- Strongly agree
- Agree
- Neither agree nor disagree
- Disagree
- Strongly disagree

**Q29. What types of training programs (formal or informal) does your TMC provide?**

**Q30. Please rank the following strategies based on their importance to your TMC's training program.**

	1 - least important	2	3	4	5 - most important
Formalize a training program	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Evaluate gaps between staff qualifications and desired skills	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Use data from system performance to identify training topics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Provide training programs up-to-date with emerging technologies	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Integrate TMC staff with broader departmental training initiatives	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

**Q31. Please select the strategies in staff development (beyond training programs) that are being used at your TMC (choose all that apply).**

- Schedule periodic staff meetings to encourage open communication
- Promote knowledge transfer and TMC staff leadership of technical discussions
- Share relevant performance data, including operational performance data, TMC performance data, and customer feedback

- Conduct debriefings with TMC staff on major incidents and TMC processes during these incidents
- Involve key contractors that are housed in the TMC
- Seek out opportunities for the TMC to be represented in broader organizational meetings
- Update TMC staff with important initiatives or activities at the department level

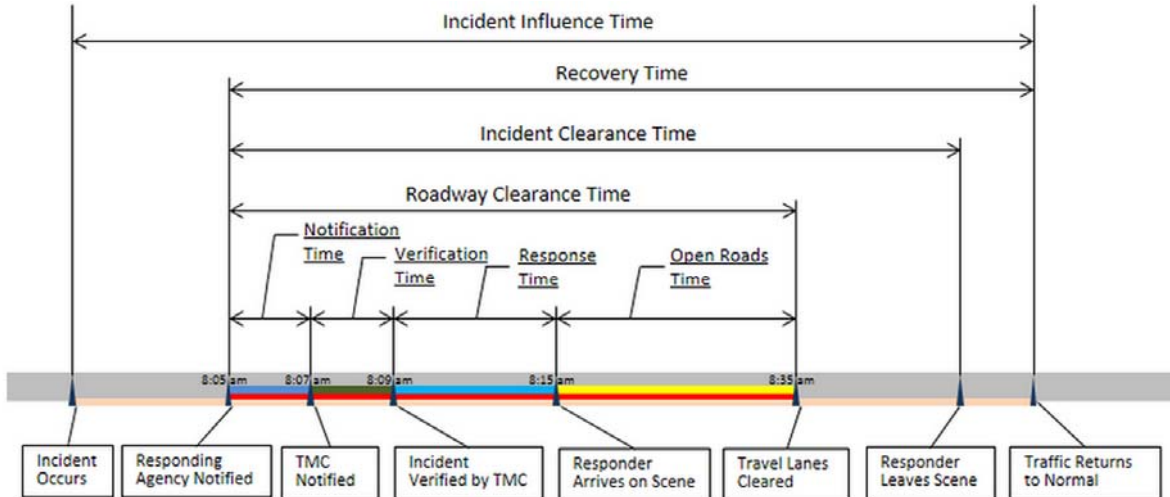
**Q32. How often do you produce performance measures report (choose all that apply)?**

- Currently do not have a reporting procedure
- Every week
- Every month
- Every quarter
- Every six months
- Once a year
- As needed
- Other: [Click here to enter text.](#)

## Traffic Incident Management (TIM) Performance Measures

Please use the latest available information to fill in the following TIM performance measures at your TMC. (Please skip these questions if your TMC does not report TIM performance measures.)

Please refer to the timeline below for definitions of the durations.



Source: Florida DOT

If you use different definitions for the durations, please indicate how they are different.

The reporting period for the performance measures is (e.g. 1st quarter 2014, or February 2014):

[Click here to enter text.](#)

Detection duration (in minutes): [Click here to enter text.](#)

Verification duration (in minutes): [Click here to enter text.](#)

Response duration (in minutes): [Click here to enter text.](#)

Roadway clearance duration (in minutes): [Click here to enter text.](#)

Incident clearance duration (in minutes): [Click here to enter text.](#)

Responder safety -number of injuries per year: [Click here to enter text.](#)

-number of fatalities per year: [Click here to enter text.](#)

Do you track/report secondary incident?  Yes  No

**Please use the space below to provide any additional information or comments you may have.**

## X. APPENDIX B CONTACT LIST

Name	Position Title	Phone	Email	Agency	Metro Area
J. Michael Wreh	Manager	401-222-5826	michael.wreh@dot.ri.gov	RIDOT	YES
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Emmanuel Posadas	Traffic Operations Engineer		eposadas@myboca.us	City of Boca Raton	N/A
Robbie Brown	ITS Operations Manager	239-225-1901	Robbie.Brown@dot.state.fl.us	Florida Dept. of Transportation	SWFL
Chad	TMC Operations	404-635-2810	chendon@dot.ga.gov	GDOT	Atlanta

Traffic Management Centers: Challenges, Best Practices, and Future Plans

Name	Position Title	Phone	Email	Agency	Metro Area
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