Potential for Applying Advanced Technologies at TMCs – Results from a Nationwide Survey

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ABSTRACT

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 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 towards 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. This paper presents major findings from the survey, 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.
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. During the same period, our cities have experienced rapidly growing travel demand and increasing concerns in congestion, safety, and sustainability. Today’s traffic management centers (TMCs) are faced with both challenges and opportunities. This study intends to 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.

Several 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 delay, and from a decision support tool based on area wide traffic management scenarios to large scale ITS data archiving (1-4). 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 (5). KatwijK and Koningsbruggen developed an automatic coordination concept among traffic control tools by considering each tool as an intelligent agent and relieve the traffic operator from controlling different scenarios (6).

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 (7). The study suggest 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 and the buses could run in platoons with 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 (8). Others focused on improving the communication systems by proposing a Hybrid Technology Networking (HTN) which utilizes Wi-Fi technologies (9). 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 traveler, direct control over the information contents than traditional broadcast media or text alert, control over timing of the message, marker segmentation of transit user group based on their age and experience (10).

A recent FHWA report provided a comprehensive overview of the impacts of technology advancements on TMC operations in the next ten years (11). 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 are 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 towards 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. So another focus of the survey is on the preparedness of TMCs 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.

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 entire survey has 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 second half of the survey, while current applications are presented in another paper. The two major sections concerning this paper are:

- 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.

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 can be found in the project final report (12).
The survey was administered through web-based approach. Google Forms (13) 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. Contact information for the respondents can be found in the project final report, and their contributions and time are deeply appreciated.

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. A total of 42 responses from twenty-five different states were received and analyzed. Figure 1 below shows the geographic coverage of survey responses.

![Map showing survey response coverage](image)

**Figure 1** Survey response coverage map.
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.

![TMC Service Area](image)

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

![Years Began Operation](image)

**Figure 3** Years began operation for the surveyed TMCs.
Figure 3 shows the proportion of TMCs by year that the operation began. 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.

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% showed increasing budget, while 8% experienced decreasing budget, as shown in the chart on the left side. However, when compared with changes in their centerline miles served (shown in the chart on the right side), about 35% TMCs has 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 has gone through budget decrease relative to miles served.

![Budget changing in last five years](image1.png)

![Budget vs. Miles Served](image2.png)

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

### 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 TMS’s operations.
1. Use advanced graphical user interfaces to increase efficiency
2. Install remote power cycling of field devices
3. Install automatic power cycling of field devices
4. Consolidate software interfaces or alert systems across agencies
5. Utilize predictive analysis and forecasting for anticipating congestion
6. Develop a data fusion engine to merge data from multiple sources

**Figure 5** Usefulness of automation tools in supporting TMC operations.

As Figure 5 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.

1. Efficiently expand field device coverage and reduce operations cost using wireless network

2. Allow appropriate remote access into TMC software or devices

3. Utilize commercial mobile devices and apps to support collaboration between freeway service patrol and other emergency responders

4. Operate mobile command centers or satellite centers with TMC software access

**Figure 6** 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 apps 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 7 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 8 Usage of social media tools.

Question 23 and 24 look at current usage of social media tools and future plans of using them, respectively. As shown in Figure 8, 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 have 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.

1. Develop procedures and protocols for use of social media
2. Foster relationships among agency public relations groups
3. Designate a larger or statewide TMC to take responsibility for social media alerts
4. Provide traveler information focusing on pre-trip planning to minimize driver distraction
5. Utilize crowdsourcing for traffic and incident information, and user feedbacks
6. Partner with private sector to facilitate social media outlets and realize cost efficiencies

Figure 9 Usefulness of social media strategies.
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 9, 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”, given that 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.

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

![The Main Obstacle In Deploying New Technologies](image)

**Figure 10** The main obstacle in deploying new technologies.

As Figure 10 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 thinks legal issue as the main obstacle. Staffing was indicated by several TMCs as the main issue.

Q26. Please rank the following strategies in terms of their importance in facilitating the adoption of new technologies at your TMC.
1 Foster an agency culture of embracing technological change

2 Create up-to-date training programs on emerging technologies

3 Create new technology piloting and testing program

4 Adopt standards on TMC related equipment and processes

5 Require application programming interfaces (APIs)

6 Require documentation on all systems

7 Follow the systems engineering processes

Figure 11  Evaluation of strategies in the adoption of new technologies.
Question 26 asks the respondents to evaluate seven strategies in terms of the importance in facilitating the adoption of new technologies. 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 being identified as important elements.

**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’ view of this issue, in terms of additional skill 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. Additional 26% of TMCs agree with the trend, only 17% disagree, and none of the TMCs strongly disagree.
Q29. What types of training programs (formal or informal) does your TMC provide?

Figure 12  Attitude towards contract or privatized operations and maintenance.

Figure 13  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, provided at 13 TMCs. 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.

1. Formalize a training program
2. Evaluate gaps between staff qualifications and desired skills
3. Use data from system performance to identify training topics
4. Provide training programs up-to-date with emerging technologies
5. Integrate TMC staff with broader departmental training initiatives

As shown in Figure 14, 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.

Figure 14 Importance of TMC training program strategies.
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).

![Staff Development Strategies Used at TMCs]

**Figure 15** Strategies in staff development used at TMCs.

Beyond training programs, figure 15 shows staff development strategies that TMCs are using. All strategies (except the last one) showed very high application rate, deployed by at least 70% of the TMCs.

**CONCLUSION**

This paper presents a study on the potential of applying advanced technologies in TMCs, as part of a nationwide survey focusing on innovative tools, technologies, methods and policies. As several studies have examined the features and potential impacts on TMC operations of various emerging technologies, this study contributes to the body of knowledge by providing an overview from the TMC perspective in terms of their views and attitudes towards emerging trends. 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
operation, with advanced graphical user interface and remote access to TMC software and devices 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 in 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 trop obstacles in applying advanced technologies, and the most important strategies in facilitating the application of advanced technologies are documentation on all systems, fostering an embracing agency culture, and following system engineering process. In terms of additional needs in staff resources, IT professionals, system engineers, ITS and traffic engineers, and training and continuing education are identified. The results provide valuable insights for policy makers and developers in understanding what are the potentials of the various applications and how to best incorporate them to enhance TMC operations.

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