Traffic Management Centers

IN A CONNECTED VEHICLE ENVIRONMENT

Final

Task 1 - Review of Connected Vehicle Program Activities in Relation to Traffic Management Center Operations – TMC Survey Results

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1 Introduction

The members of the Connected Vehicle Pooled Fund Study (PFS) recognize that the role of the TMC and TMC operations will be impacted or influenced by a future connected vehicle environment. To better prepare for the potential impacts, and to identify operational activities, resource and system needs, the PFS initiated this project to identify how a connected vehicle environment will shape the role and function of TMCs. The project examines operational, technical, and policy impacts of a new TMC environment, and informs the Connected Vehicle PFS members about priority needs and gaps that would need to be addressed relative to TMCs in a future connected vehicle environment.

Task 1, Review of Connected Vehicle Program Activities in Relation to Traffic Management Center Operations, provides an important foundation for the project. This task aggregates and summarizes key operational functions performed by TMCs and begins to assess the readiness of TMCs to integrate new processes, functions, and data in a connected vehicle environment. This task will summarize and aggregate current (and anticipated future) efforts within TMCs to provide a baseline for assessing potential impacts and operational issues or readiness for a connected vehicle environment. To obtain this information, the PFS team developed an electronic survey instrument to distribute to a select list of TMCs. The electronic survey was distributed to TMCs in April 2013.

This Technical Paper summarizes the feedback and results from this survey, as well as outlines some initial recommendations on potential priorities and focus areas for the follow-on tasks within this study. Information obtained from the survey responses will inform more detailed interviews with a select number of TMCs, concepts for expected changes in TMCs as a result of connected vehicles and associated enabling data, as well as recommendations, action items, and potential future focus areas or additional research needs for the CTS Pooled Fund group.

2 Approach and Methodology

The objective of the survey was to obtain information from a broad range of TMCs about current connected vehicle activities and which activities may have the most impact on TMCs, what TMC functions or activities could most benefit from integrating with connected vehicle activities and initiatives, and the overall “readiness” of TMCs to adapt to a connected vehicle environment.

The study team developed a candidate list of TMCs in the United States (and included three international TMCs) to contact for feedback. Recognizing the diversity of operations programs supported by TMCs, these survey candidates were identified to provide a broad cross-section of operating models, geographic distribution, and represented a range of characteristics and attributes, including:

- Urban areas with a focus on freeway management (and potentially traffic signal management);
- Rural or statewide focus;

- Collocated operations of multiple agencies;
- Early adopters of connected vehicle research or pilot tests;
- Road management during hazardous weather (winter, hurricane evacuations);
- Staffing models (agency staff vs. contracted operations); and
- Users of third-party probe data to support TMC operations.

A total of 34 TMCs were identified to receive the survey. The list was reviewed and updated by the CTS PFS group. There were a total of 16 completed surveys, with 19 initiating the survey.

Questions were developed to ascertain:

- Current awareness of connected vehicle research activities among TMCs;
- Current TMC functions and focus areas;
- Multi-source data currently being used to support TMC operations or being shared by TMCs with other operating partners;
- Operating functions that TMCs felt would be enhanced by connected vehicle capabilities;
- Potential benefits or impacts to TMC processes, operations or services;
- Staffing and skill set needs within the TMC to support connected vehicle capabilities; and
- Policy and legal considerations.

A copy of the survey questions is included as **Attachment A.**

3 Survey Responses

The survey included questions about the respondents' current TMC operating environment and operations model, current TMC functions and responsibilities, and posed a series of questions to gauge potential interest in or perceived benefits of specific connected vehicle applications. Respondents also were asked about their current familiarity with connected vehicle research. All respondents indicated they were either very familiar or somewhat familiar; none indicated they had no familiarity with connected vehicle research.

The responses to the survey are presented in this section, and they are grouped into the following areas:

- 3.1 Current TMC Functions and Operating Environments
- 3.2 Potential Connected Vehicle Focus/Priorities
- 3.3 Potential Benefits and Impacts of Connected Vehicles for TMCs

3.1 Current TMC Functions and Operating Environments

A series of questions asked about the geographical coverage of the TMC, operating environment (agency vs. contracted operations, single vs. multiple agencies) as well as current TMC functionality. Responses indicated a good cross-section of geographic operations coverage of responding TMCs, as shown in Figure 1. Similarly, a range of operating environments, including agency-staffed, contracted operations, single and multi-agency operating models also were represented, as shown in Figure 2.

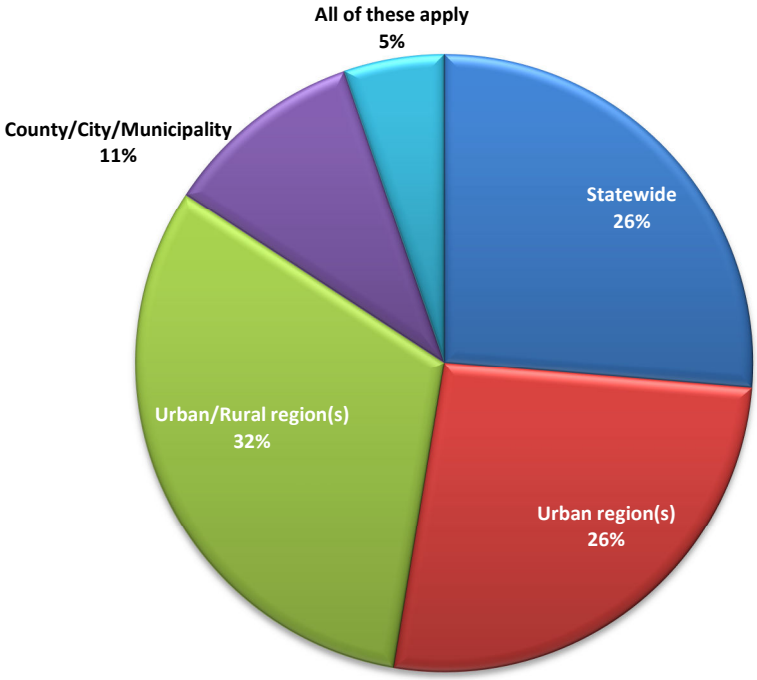

Figure 1 – Geographic Operations Coverage of Responding TMCs

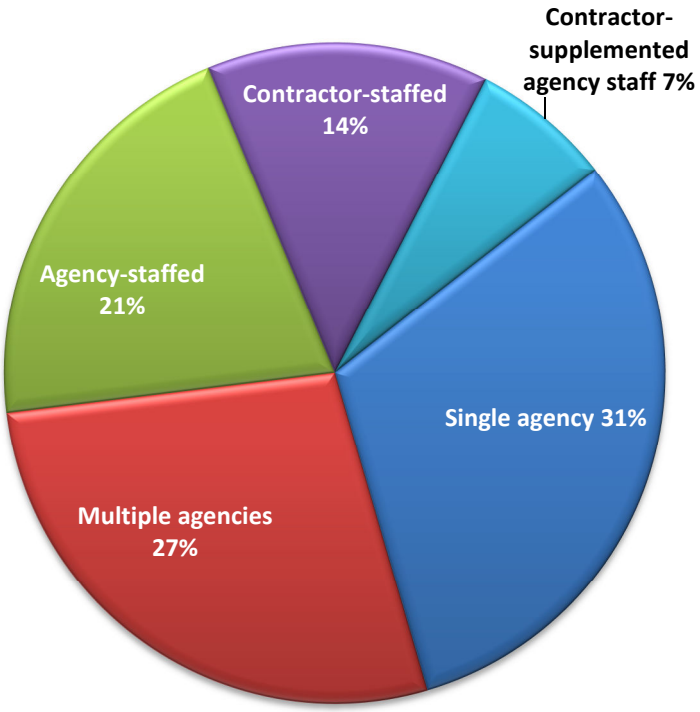

Figure 2 – Operating Environment of Responding TMCs

Respondents were asked to select from several different functions that best represent their TMC. Based on the number of times a function was selected, they were grouped into three areas, which are presented below.

Responses showed that the majority of TMCs that responded to the survey focus on traditional functions of monitoring road and travel conditions through CCTV and detectors, and a very strong focus on traveler information, including roadside infrastructure, phone and web-based systems, as well as mobile platforms or applications. The highest ranking incident management function (based on number of responses) was to implement pre-planned response strategies. The list of eleven functions below represents the most frequently selected TMC functions (the number of responses is indicated in parentheses):

- Freeway Management and Operations - CCTV monitoring and control (17)
- Freeway Management and Operations - Detection (vol/occ/speed) (14)
- Traveler Information - Dynamic message signs (16)
- Traveler Information - Traveler information web site (16)
- Traveler Information - Automated travel time generation (12)
- Traveler Information - Automated data feeds to external agencies/entities to share road and traffic conditions information (12)
- Traveler Information - 511 phone system (12)

- Traveler Information - Central/regional road conditions reporting system (11)
- Traveler Information - Traveler information mobile capabilities (mobile platform or application) (11)
- Traveler Information - Email/Text Alerts (11)
- Incident Management - Pre-planned incident management strategies (14)

The second grouping represents a selection frequency of six to ten, which represents approximately half of the respondents to the survey. Within this category are the road weather management functions, as well as some responsibility or role in asset management and coordination with maintenance resources or teams.

- Freeway Management and Operations - Freeway metering (9)
- Arterial Management and Operations - Traffic signal operations and management (10)
- Arterial Management and Operations - Arterial CCTV (8)
- Incident Management - Coordinate/request incident response teams (10)
- Incident Management - Automated TMC/public safety interface for data exchange (8)
- Traveler Information - Social media tools (10)
- Traveler Information - Highway Advisory Radio (8)
- Road Weather Management - Automated weather data sent to TMC from other sources (i.e., National Weather Service, other agency ESS) (10)
- Road Weather Management - Dissemination of weather-related data (9)
- Road Weather Management - Road condition information from field crews, law enforcement or the public (9)
- Road Weather Management - Monitoring of environmental sensor stations (ESS) (8)
- Road Weather Management - Coordinate/request of maintenance response to weather or winter operations teams (8)
- Maintenance and Construction Operations - Temporary work zone field equipment monitoring and/or control (8)
- Maintenance and Construction Operations - Coordinate/request maintenance resources or teams (8)
- Asset Management - Automated alerts for field equipment status or malfunctions (8)
- Asset Management - Monitoring capability for telecommunications network status (7)

The third grouping represents more complex functions, and a fewer number of responses (five or fewer). Included with this group are those functions related to active management, Integrated Corridor Management and managed lanes, among others. The number of responses aligns with the emergence of such programs throughout the country.

- Freeway Management and Operations - Managed lanes (e.g. HOV and HOT lanes) (5)
- Freeway Management and Operations - Integrated Corridor Management (5)
- Arterial Management and Operations - Arterial Detection Systems (5)
- Incident Management - Public safety radio communications (5)

- Maintenance and Construction Operations - Real-time location data of maintenance fleet vehicles (5)
- Other operational attributes of your TMC not captured above (4)
- Freeway Management and Operations - Active Traffic Demand Management (ATDM) (3)
- Freeway Management and Operations - Variable speed limits (3)
- Freeway Management and Operations - Shoulder Running (3)
- Freeway Management and Operations – Tolling (2)

The final question related to TMC functions focused on real-time data being collected by the TMC from other entities through an automated interface. This is an important consideration in a multi-source data environment, and in particular for a future connected vehicle data environment. Figure 3 below shows a significant number of TMCs responding they collect or receive real-time video, speed and weather forecast information. Items in the "other" category included other sources of incident data (non-CAD), such as alerts, texts or pages.

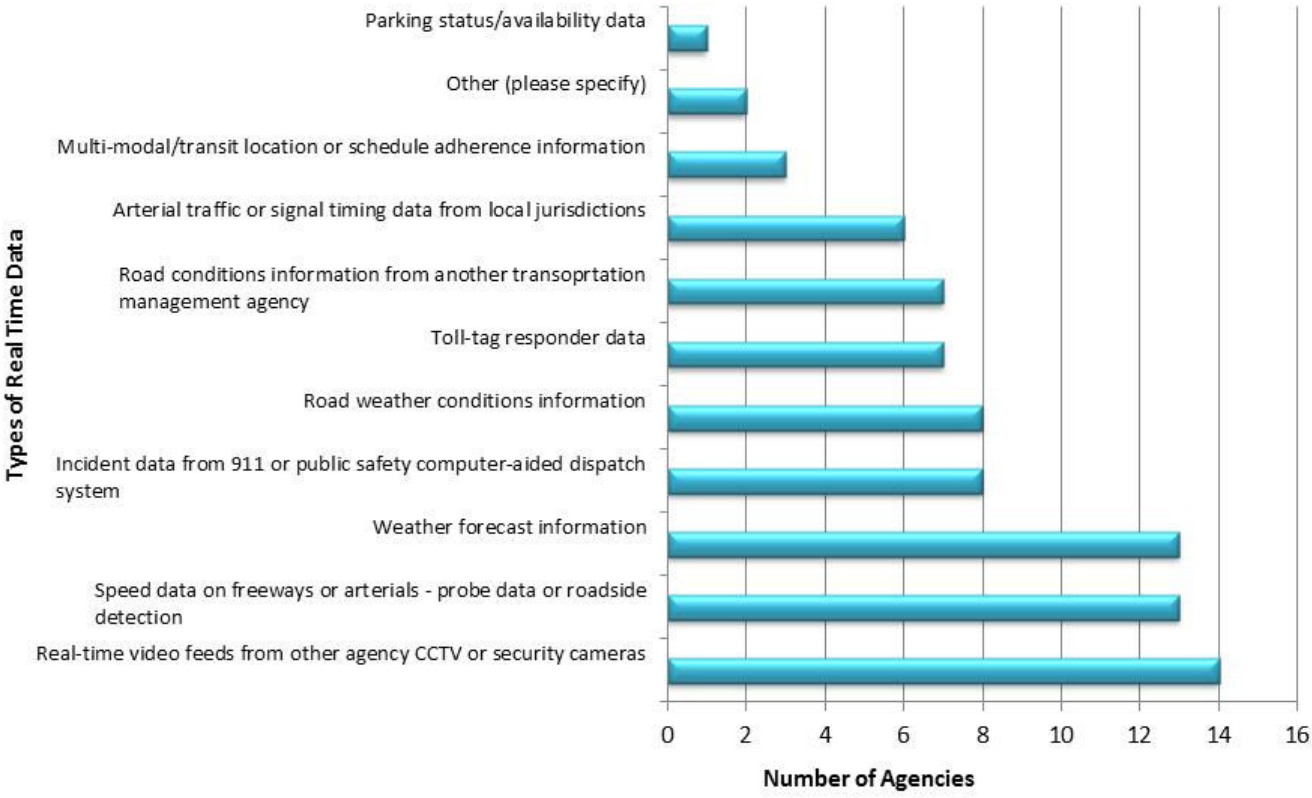

Figure 3 – Real-Time Data Collected by TMCs from Other Entities

3.2 Potential Connected Vehicle Focus/Priorities

An important objective of this survey was to obtain TMC perspectives on what they perceive as potential benefits of a connected vehicle environment, what that environment could enable (relative to TMC functionality), and what TMC processes or services they envision could be enhanced or expanded as a result of connected vehicle capabilities.

Several respondents noted expansion of coverage area for road and travel conditions information, in particular arterials (which is a gap for real-time conditions information for many agencies). Improved traveler information through more real-time data and more situation/traveler specific information also were identified by several respondents, which speak to enhancements of existing 'core' TMC functions. Several saw connected vehicle capabilities enabling more dynamic and active management, including routing assistance and transportation demand management. Improving safety also was identified as an important enabler of connected vehicle capabilities. Overall, respondents saw these capabilities as providing an enhanced level of TMC situational awareness for the transportation network.

Respondents were presented with 37 connected vehicle application areas and were asked to select up to five that they felt would have the most impact on their TMC operations. The most frequently selected applications represented those focused largely on situational awareness at the network/corridor level:

- Incident Detection (11)
- Probe Data Collection - Vehicle position, speed, and heading (10)
- Arterial Management - Advanced Traffic Signal Systems (e.g. leveraging connected vehicle data to support traffic signal operations including adaptive traffic signal systems) (8)
- Traveler Information - Traffic Conditions (7)

The second grouping of applications received three to four selections. These included:

- Traveler Information - Travel Times (4)
- Traveler Information – Incidents (4)
- Safety Applications/Cooperative Intersection Collision Avoidance Systems (CICAS) - Signal/Stop Sign Violation Warnings (4)
- Arterial Management - Applications that broadcast signal phase and time (SPaT) messages that are received by OBE units to support eco-driving and provide mobility improvements (3)
- Freeway Management - Queue Warning (3)
- Freeway Management - Variable Speed Limits (3)
- Road Weather Management - Road Weather Conditions Monitoring (3)
- Safety Applications/Speed Warnings - Speed Limit Reductions (3)
- Safety Applications/Cooperative Intersection Collision Avoidance Systems (CICAS) - Gap Assist at Signals and Stop Signs (3)

More than half of the applications on the survey received two or fewer responses. In the case of multimodal applications, the target audience for the survey likely has a very limited role in multimodal operations or coordination. For applications related to other road weather management, infrequently selected applications including road weather conditions warning, monitoring snow plow operations, and emissions/air quality monitoring may not be representative of many TMC's current responsibilities. The infrequency of selecting safety application/speed warnings (such as work zones, school zones, highway-rail crossings, and curve speeds) could be indicative of the location-specific nature of these warnings. The limited selections by TMCs does not indicate they are not important applications, but rather they might not fit within the broader network, regional or statewide focus for a TMC to implement a specific strategy to address in real-time.

Respondents also were asked to identify how they envision receiving real-time data from connected vehicle applications or connected vehicle-enabled technologies. Figure 4 below shows the distribution of responses, with preference indicated toward receiving data from either an agency-deployed RSE (integrated into the ATMS) or from an agency-supported data clearinghouse. Further inquiry would be needed to ascertain why this was the overwhelming preference. Twenty-one percent indicated a preference toward processed information from a third party provider, which is a similar mechanism to the current practice of obtaining speed probe data from the private sector.

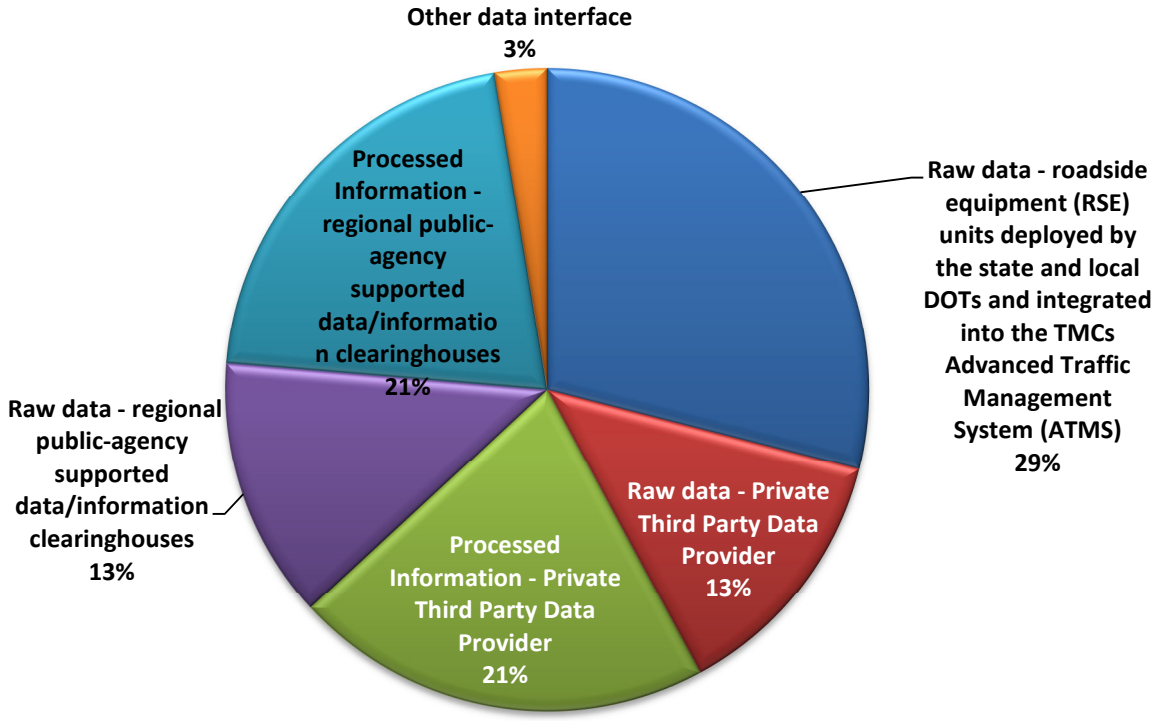

Figure 4 – Methods for TMCs Obtaining Connected Vehicle Data

The next question related to agency deployment of enabling infrastructure asked about timeframe for agencies to deploy RSEs, if the National Highway Traffic Safety Administration mandates vehicle-to-vehicle communications to support cooperative active safety. The majority of respondents indicated they would be likely to deploy within a one to five year timeframe, as shown in Figure 5. (Note: 20% of respondents did not respond to this question).

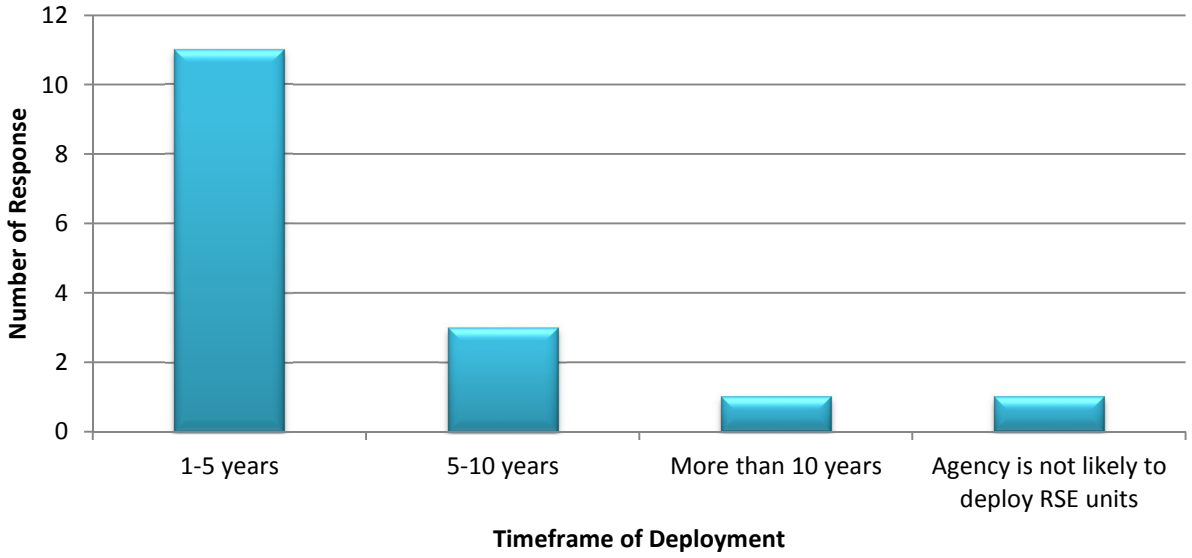

Figure 5 – Agency Timeframe (post NHTSA decision) on Deploying Roadside Equipment

3.3 Potential Benefits and Impacts of Connected Vehicles

The final series of questions were free-form, and intended to obtain specific insights, perceived benefits, or perceived challenges and constraints from TMC managers about a future connected vehicle environment and the effect on TMC processes and functions. Questions also focused on potential impacts or needs in terms of staffing or skill sets, as well as any policy or legal issues TMC managers felt would need to be addressed when integrating connected vehicle capabilities into the TMC operating environment.

3.3.1 TMC Operations and Management

- More information/data for making better decisions, improved data availability and quality;
- Increased situational awareness, travel info, incident management, safety, reduction in secondary crashes;
- Faster and more reliable information, faster identification of issues;
- Increased capabilities to deliver high quality and needed services to the travelling public;
- Better decision making capability on highway throughput;
- Will need to update to incorporate new data/ information;

- Faster response to incidents. More effective and efficient management of capacity / demand;
- Stepwise increase in staff, change in focus from ATIS to ATMS; and
- It would enhance our ability to perform our function by giving us information we already get in a more timely fashion. It will give us information we don't get now which can be used to better perform our job and add new functionality based on the new data that will be available.

3.3.2 Communications Network

- Wider network coverage;
- Improved communication capabilities assuming network is built properly and funded appropriately;
- Will use a portion of communications assets such as fiber;
- Reduced need for TMC owned communications facilities - increased reliance on public networks and shift to wireless;
- Need to upgrade to higher speeds;
- Demand for bandwidth might require some data be process locally, some function or intelligence might be decentralized;
- Separate networks and communication; and
- Would use some of our existing fiber backbone and require that we have sufficient bandwidth/equipment to handle the increased data flow efficiently and reliably.

3.3.3 TMC Data Management

- More complex;
- New processes may be required;
- Additional data sources;
- Faster and more reliable information;
- Will trade off the burden of processing raw data with the burden of processing data from a much broader area of coverage;
- Addition of databases, bigger servers and SANS;
- More data to manage, data management and information processing will be monumental; and
- Hopefully TMDD standards will be followed for easy integration into existing ATMS/ATIS Systems.

3.3.4 Central Operation Systems

- More complex;
- Will need to be significantly modified to focus more on analytics and response, and less on raw data processing from the street;
- More coordinated and advanced system;
- Comprehensive situation awareness of system's performance;
- New modules to handle data;
- Hopefully TMDD Standards will be followed for easy integration into existing ATMS/ATIS Systems.

3.3.5 Current Partnerships for Operations and Data

- Improved information to share;
- Will significantly enhance our ability to work cooperatively and perhaps integrated with other jurisdictions;
- New partners can be brought in such as county Police and EMS services, expand data partnerships to include local agencies;
- Enhance integrated corridor management with local partners; and
- Explosion of data requests, ATIS by private entities;

3.3.6 Efficiency Changes in TMC Processes in a Connected Vehicle Environment

Several respondents identified that processes in a future TMC in a connected vehicle environment would be more efficient, citing automation as contributing to that efficiency. Some noted that processes, although more efficient, also will be more complex. Decision processes will become more complex over an expanded TMC control/area of coverage, or initially processes will be more complex but will become more efficient over time. One response noted that efficiency needs to occur in the way TMCs manage and mine data in order to be able to effectively operate in a data-intensive connected vehicle environment.

3.3.7 TMC Staffing Resources or Knowledge/Skill Needs

Some respondents indicated no change to current operations staff, while others identified the need to add new staff to support operations and in particular IT and data management functions. The following summarizes the envisioned staffing impacts and needs identified:

- New procedures will need to be developed, more training provided, staff will need to learn skills required to maintain RSEs and back-office systems, and a larger staff needed, especially during peak travel times;
- Knowledge/understanding the use of the data and how it will translate to drivers;
- Additional operations staff to handle new functions, additional training and training as operators turn over;
- Staffing will shift to deemphasize design/construction of field equipment to collect data and provide VMS - and will emphasize analytics, traffic/transportation engineering and operations/emergency response;
- More IT skills such as network administration, data processing, and data management, Might need 24/7 IT/database administrator support on-site;
- Additional ITS device maintenance staff; and
- Improvements to system graphical user interface will limit training needs.

3.3.8 Policy and Legal Considerations

When asked about potential policy and legal considerations with integrating connected vehicle data into TMC systems and processes, several respondents noted concerns over privacy. Some responses by early adopters did not indicate that privacy represented a significant issue (note: data may have already had provisions in place to address privacy concerns), and one noted that the concept of integrating

connected vehicle data would be similar to integrating anonymous toll tag data to support travel times. The following represents a summary of the responses received to this question:

- Any personal information should be removed from the data before being received by any public agency; as long as the processed information is purchased by an agency the responsibility will be on the information provider to provide correct information
- Privacy concerns and the freedom of information process.
- Standard operating procedures would need modified to include direction
- We have connected vehicle data already in our TMC and did not need to address this.
- The connected vehicle will provide us with more information capable of supporting a more active transportation management environment. As such, we need to investigate the implications of moving from a passive condition information distribution environment to one in which we actively try to influence traveler behavior and choice.
- I envision significant new state legislation before connected vehicle enabled capabilities are fully operational
- External data agreements and use of said data
- General purchasing procedures will need to be simplified. Our ability to reach agreement will need to happen faster and be more flexible. Our legislative authority to work outside of transportation will likely need to be addressed.
- Don't foresee anything different than integrating toll tag information for travel times

4 Summary

TMC managers provided some important insights for this initial task. Responses indicate that connected vehicles is viewed as potentially expanding and enhancing current core functions and responsibilities (including incident response and traveler information), and making TMCs more effective and efficient. High impact applications were identified that aligned with traditional TMC roles and functions (detecting incidents, travel speed monitoring, traffic conditions information, arterial management). Respondents indicated the key benefits would be faster and more accurate data on network conditions, improved automation of data exchanges, improved efficiency for decision making and strategy implementation, as well as connected vehicles filling a gap in data to provide situational information on corridors not instrumented with agency detection systems, such as rural highways or arterials.

There was a high degree of consistency in the responses related to potential impacts on data management and central operating systems, as well as the need for additional IT staff to support the expanded data environment with connected vehicles. Respondents also were somewhat consistent in identifying the need for additional training for operations staff to be able to interpret and act upon the expanded situational awareness information being provided to the TMC.

Attachment A – Survey Questions

Traffic Management Centers in a Connected Vehicle Environment

The Cooperative Transportation Systems (CTS) Pooled Fund Study has initiated a study to examine readiness of Traffic Management Centers (TMCs) and potential impacts and benefits to TMCs in a future Connected Vehicle environment. Your feedback is being sought to provide input to the study team about:

- Current level of connected vehicle activities within TMCs
- Types of data and capabilities that you envision could be integrated to support TMC and system operations
- Challenges and benefits that you perceive about your TMC operations in a connected vehicle environment

We are asking for responses by April 26. Please contact the principal investigator, Lisa Burgess, if you have any questions. Lisa.Burgess@kimley-horn.com.

Connected Vehicles Background

Connected vehicles have the potential to transform the way we travel through the use of a reliable, interoperable wireless data communications network—a system that allows cars, buses, trucks, trains, traffic signals, cell phones, and other devices to automatically communicate with one another. Connected vehicle research combines leading edge technologies – advanced wireless communications, on-board computer processing, advanced vehicle-sensors, Global Positioning System (GPS) navigation, smart infrastructure, and others – to provide the capability for vehicles to identify threats, hazards, and delays on the roadway and to communicate this information over wireless networks to provide drivers with alerts, warnings, and real time road network information.

At its foundation is a communications network that supports vehicle-to-vehicle (V2V) two-way communications, vehicle-to-infrastructure (V2I[1]) one- and two-way communications, and vehicle or infrastructure-to-device[2] (X2D) one- and two-way communications to support cooperative system capability. Onboard equipment (OBE) units consist of connected vehicle equipment installed in the vehicle capable of broadcasting and receiving wireless messages. Roadside equipment (RSE) units consist of roadside equipment capable of broadcasting and receiving wireless messages from vehicles.

Connected vehicles are envisioned to enable a surface transportation system in which crashes are significantly reduced and roadway operators and travelers have the information they need about travel conditions to operate more effectively. Connected vehicle research will establish an information backbone for the surface transportation system that will support applications to enhance safety and mobility and, ultimately, an information-rich surface transportation system. Connected vehicle research also supports applications to enhance livable communities, environmental stewardship, and traveler convenience and choices.

[1] Although two-way communications between vehicles and infrastructure is usually called "V2I", one-way communication is generally distinguished by designating the initiator of the communications first. Thus, one-way infrastructure-to-vehicle communications is called "I2V" and one-way vehicle-to infrastructure communications uses the more common "V2I" designation.

[2] In this context, the term "device" refers only to devices that are "carry-in" devices, i.e., devices that can be temporarily installed in vehicles and are not connected to in-vehicle information systems. These devices include ones (e.g., smart phones) that could also be carried by pedestrians or other users of the roadways (e.g., cyclists).

The ability to identify, collect, process, exchange, and transmit real-time data provides drivers with an opportunity for greater situational awareness of the events, potential threats, and imminent hazards within the vehicle's environment. When combined with technologies that intuitively and clearly present alerts, advice, and warnings, drivers can make better and safer driving decisions. Additionally, when further combined with automated vehicle-safety applications, connected vehicle technology enables the vehicle to respond and react in a timely fashion when the driver either cannot or does not react quickly enough. Vehicle safety systems, because of the need for frequently broadcasted real-time data, are expected to use dedicated short range communications (DSRC) technology for active safety applications. Many of the other envisioned applications could use other technologies, such as third or fourth generation (3G/4G) cellular or other Wireless Fidelity (Wi-Fi) communications, as well as DSRC.

2013 NHTSA Agency Decision and 2014 Heavy-Vehicle Decision

Because of the substantial impact that V2V and V2I technology could have on safety, the National Highway Traffic Safety Administration (NHTSA) believes that this technology warrants consideration for possible regulatory action. NHTSA has stated their intent to make an agency decision on V2V and V2I safety communications systems by 2013. NHTSA's agency decision could include one of several options, such as:

- Future regulatory action;
- Inclusion in the New Car Assessment Program (NCAP); or
- Additional research and development.

If justified, a regulatory approach would require manufacturers to include equipment to support V2V and V2I safety applications in new cars by a future date; the consumer information approach through NCAP would enable manufacturers to earn higher government safety ratings for vehicles that support the V2V and V2I safety applications. A similar milestone has been set in 2014 for a decision regarding V2V and V2I safety technology on heavy vehicles.

For More Information

For more information about the USDOT Connected Vehicle program and research areas, please visit: http://www.its.dot.gov/connected_vehicle/connected_vehicle.htm.

For more information about the Cooperative Transportation Systems Pooled Fund Study and its focus areas, please visit: http://cts.virginia.edu/CTSPFS_1.html.

1. **Responding Agency Information**
   - Name: _____
   - Title: _____
   - Agency: _____
   - Email contact: _____
   - Phone contact: _____

2. **How familiar are you with Connected Vehicle Research?**
   - Very Familiar
   - Somewhat Familiar
   - Not Too Familiar
   - Not Familiar at All

3. **Information about your TMC**
   - Name/identifier _____
   - Geographic coverage/area served or area of responsibility
     - Statewide
     - Multi-state
     - Urban region(s)
     - Urban/Rural region(s)
     - County/City/Municipality
     - All of these apply

4. **Describe your TMC's operating environment (select all that apply):**
   - Single agency
   - Multiple agencies
   - Agency-staffed
   - Contractor-staffed
   - Contractor-supplemented agency staff

5. **Describe your TMC's current functionality:**

   Freeway Management and Operations
   - Detection (vol/occ/speed)
   - CCTV monitoring and control
   - Freeway metering
   - Managed lanes (e.g., HOV and HOT Lanes)
   - Active Traffic Demand Management (ATDM)
   - Variable speed limits
   - Integrated Corridor Management
   - Shoulder Running
   - Tolling
   - Other: _____

   Arterial Management and Operations
   - Traffic signal operations and management
   - Arterial Detection Systems
   - Arterial CCTV
   - Other: _____

Traveler Information

- ☐ Central/regional road condition reporting system
- ☐ 511 phone system
- ☐ Traveler information web site
- ☐ Traveler information mobile capabilities (mobile platform or application)
- ☐ Automated travel time generation
- ☐ Dynamic message signs
- ☐ Highway Advisory Radio
- ☐ Email/Text Alerts
- ☐ Social media tools
- ☐ Automated data feeds to external agencies/entities to share road and traffic conditions information
- ☐ Other: _____

Incident Management

- ☐ Automated TMC/public safety interface for data exchange
- ☐ Pre-planned incident management strategies
- ☐ Coordinate/request incident response teams
- ☐ Public safety radio communications
- ☐ Other: _____

Road Weather Management

- ☐ Monitoring of environmental sensor stations (ESS)
- ☐ Automated weather data sent to TMC from other sources (i.e., National Weather Service, other agency ESS)
- ☐ Coordinate/request of maintenance response to weather or winter operations teams
- ☐ Dissemination of weather-related data
- ☐ Road condition information from field crews, law enforcement or the public
- ☐ Other: _____

Maintenance and Construction Operations

- ☐ Temporary work zone field equipment monitoring and/or control
- ☐ Real-time location data of maintenance fleet vehicles
- ☐ Coordinate/request maintenance resources or teams
- ☐ Other: _____

Asset Management

- ☐ Automated alerts for field equipment status or malfunctions
- ☐ Monitoring capability for telecommunications network status
- ☐ Other: _____

Other operational attributes of your TMC not captured above:

6. **TMCs manage, share and obtain a wide range of real-time data to support its operations functions. Please identify which types of real-time data your TMC currently receives from external entities (such as other agencies, third party providers, universities) via an automated interface.**
   - ☐ Arterial traffic data or signal timing data from local jurisdictions
   - ☐ Speed data on freeways or arterials (such as probe data or roadside detectors installed by other agencies or third party vendors)
   - ☐ Incident data from 911 or public safety computer-aided dispatch systems
   - ☐ Toll-tag responder data
   - ☐ Real-time video feeds from other agency CCTV or security cameras
   - ☐ Road conditions information from another transportation management agency
   - ☐ Road weather conditions information
   - ☐ Weather forecast information
   - ☐ Multi-modal/transit location or schedule adherence information
   - ☐ Parking status/availability data
   - ☐ Other: _____

7. **Connected vehicle research is focused on providing mobility, safety, and environmental improvements. With regards to potential effects or enablers for service delivery, in which area do you foresee your TMC potentially providing a substantial increase in service delivery as a result of connected vehicle capabilities, and why?**

8. **Connected vehicles technology is expected to turn vehicles on the road into real-time probes. These probes could potentially provide anonymous data on vehicle locations, speeds, accelerations, throttle setting, engine rpm and torque, weather-related vehicle data (e.g., lights status, wiper status, temperature, air pressure), and other event-driven vehicle data such as brake activation and traction control system activation. Given this expected potential:**
   - ☐ What existing TMC functionality do you envision your TMC enhancing through the use of these data? *(free form response)*
   - ☐ What new TMC functionality would you like to have at your TMC if connected vehicle data were available? *(free form response)*

9. **Select up to five connected vehicle applications that you think would have the <u>most impact/highest value</u> added to your TMC operations:**

<u>Probe Data Collection</u>

- ☐ Probe Data Collection (e.g., vehicle position, speed, and heading)

<u>Incident Detection / Mayday Messages</u>

- ☐ Incident Detection
- ☐ Mayday Alerts and Relays

<u>Arterial Management</u>

- ☐ Advanced Traffic Signal Systems (e.g., leveraging connected vehicle data to support traffic signal operations including adaptive traffic signal systems)
- ☐ Traffic Signal Priority
- ☐ Traffic Signal Pre-Emption for Emergency Vehicles
- ☐ Applications that broadcast signal phase and timing (SPaT) messages that are received by OBE units to support eco-driving and provide mobility improvements

Freeway Management

- ☐ Ramp Metering
- ☐ Queue Warning
- ☐ Variable Speed Limits

Traveler Information

- ☐ Traveler Information / In-Vehicle Signage
  - Traffic Conditions
  - Travel Times
  - Incidents
  - Work Zones

Road Weather Management

- ☐ Road Weather Conditions Monitoring
- ☐ Emissions / Air Quality Monitoring
- ☐ Road Weather Conditions Warnings (e.g., slippery pavement, icy bridge)
- ☐ Monitoring of Snow Plow Activities

Multimodal Applications

- ☐ Transit Vehicle Probe Data (including location of transit vehicles, passenger data, and schedule adherence)
- ☐ Transit Connection Protection
- ☐ Dynamic Ridesharing and Dispatching
- ☐ Multi-modal Traveler Information

Fee Collection

- ☐ Toll Collection
- ☐ Parking Payment

Asset Management

- ☐ DOT Vehicle Location Tracking (e.g., maintenance vehicles, Safety Service Patrols)
- ☐ Pot Hole Detection / Pavement Conditions Monitoring

Safety Applications

- ☐ Road Geometry Warnings
  - Truck Rollover Warning
  - Over-Height/Over-Width Warning
- ☐ Speed Warnings
  - Speed Limit Reductions
  - Curve Speed Warning
  - School Zone Speed Warning
  - Work Zone Speed Warning
- ☐ Cooperative Intersection Collision Avoidance Systems (CICAS)
  - Signal/Stop Sign Violation Warnings
  - Gap Assist at Signals and Stop Signs
- ☐ Highway Rail Intersection (HRI) Warning
- ☐ Work Zone Intrusion Detection

Other

- ☐ Parking Management / Information
- ☐ Other (please specify): _____

10. Why do you think the applications you selected in question 9, will add value to your TMC operations?

11. In the near term (i.e., next 10 years), with limited market penetration of connected vehicles in the United States, what types of applications listed in questions 9 is your TMC most likely to deploy using connected vehicle technologies?

- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____
- ☐ _____

12. Until relatively recently, most TMCs received traffic data almost exclusively through government-owned roadside sensors. Now public agencies are beginning to receive traffic data from private third party data providers or other non-agency sources. Connected vehicles may offer opportunities for yet another paradigm shift, with a large percentage of vehicles providing data through a common interface and in a common format.

How do you foresee your TMC obtaining connected vehicle data? (Note: you may check multiple boxes if you foresee TMCs receiving data from multiple sources or in multiple forms)

- ☐ Receiving raw connected vehicle data directly from roadside equipment (RSE) units deployed by the state and local DOTs and integrated into the TMCs Advanced Traffic Management System (ATMS)
- ☐ Obtaining raw data from a private third party data provider
- ☐ Obtaining processed information from a private third party data provider
- ☐ Receiving raw connected vehicle data from regional public-agency supported data/information clearinghouses
- ☐ Receiving processed information from regional public-agency supported data/information clearinghouses
- ☐ Other data interface (describe): _____

13. If NHTSA announces in 2013 that it intends to mandate vehicle-to-vehicle (V2V) communications to support cooperative, active safety, in what timeframe would your agency begin deploying roadside equipment (RSE) units assuming there is a qualified product list (QPL) for RSE units?

- ☐ 1-5 years
- ☐ 5-10 years
- ☐ More than 10 years
- ☐ Agency is not likely to deploy RSE units

14. **What potential benefits or impacts do you foresee a connected vehicle environment having on:**
    - ☐ TMC operations and management: _____
    - ☐ Communications network: _____
    - ☐ TMC data management: _____
    - ☐ Central operating systems: _____
    - ☐ Current partnerships for operations and data: _____
    - ☐ Other: _____

15. **From your perspective, what changes in working processes do you envision may occur at a TMC in a connected vehicle environment? Will a connected vehicle environment make particular TMC (decision) processes more complex, easier, more efficient, or less efficient?**

16. **What types of additional staff resources (or staff knowledge and skills) will be required for your TMC in a connected vehicle environment?**

17. **What policy or legal implications do you foresee needing to address in order to be able to integrate connected vehicle data or connected vehicle-enabled capabilities within your TMC operations?**

18. **Please provide any additional information or perspective that you would like to share with the study team about future TMC considerations in a connected vehicle environment.**

19. **The study team will evaluate responses and will select TMCs for a more detailed interview. Are you willing to participate in an interview?**
    - ☐ **Yes**
    - ☐ **No**