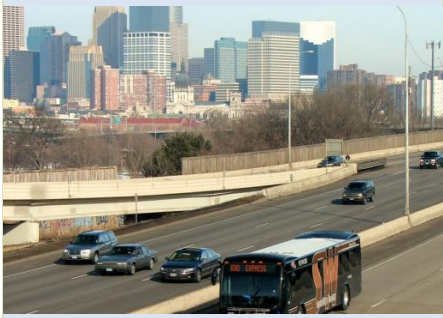
Intelligent Transportation Systems (ITS)
Concept of Operations for
Freeway Traffic Management



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FINAL

June 30, 2010

Contents

1.0 Executive Summary

This document presents a Concept of Operations (ConOps) for freeway traffic management. The emphasis of this document is on defining the use of ITS tools to manage traffic on the Minnesota Department of Transportation (Mn/DOT) operated freeways. More specifically, 'who' uses the tools, 'why' are the tools used, and 'how' are the tools used. Examples of ITS 'Tools' include Dynamic Message Signs (DMS), Closed Circuit Television (CCTV) cameras, and Traffic Management Center (TMC) Software.

Freeway traffic management is typically defined as a combination of traffic control strategies (e.g. metering the rates of vehicle on-ramps and reversible lanes) and traveler information strategies (e.g. en-route information sharing through DMS, personal communications using computers, cellular phones or other mobile devices, or mass media dissemination.) Together, the combination of informing travelers of the current situation and controlling the traffic using physical controllers can effectively manage the traffic in metropolitan areas where demand is nearing the level of capacity.

Mn/DOT has managed freeway traffic in the metropolitan areas of Minneapolis and St. Paul for decades, using tools such as ramp meters and dynamic message signs. Freeway traffic management also occurs in other metropolitan areas throughout the state, and with traffic technologies expanding in deployment, freeway traffic management will most likely continue to expand throughout the state of Minnesota. This document describes the current strategies and tools for freeway traffic management, with the intention of supporting efforts to continue to expand freeway traffic management to new areas of the state.

2.0 Background

2.1 Intended Use of this Document

The intended uses of this ConOps are:

- To guide future Intelligent Transportation System (ITS) deployments on freeways throughout Minnesota; and
- To be a resource for the operations, maintenance, expansion and enhancements to existing ITS tools used today for freeway traffic management.

To accomplish these uses, the ConOps first introduces the needs for effective traffic management. The ConOps then introduces a number of ITS Tools that are used to satisfy the traffic management needs. Each tool is then addressed in detail, describing 'who' uses the tool, 'why' the tool is used, and 'how' the tool is used.

Consider the following example:

Deployment of freeway travel times on DMS is a popular use of an ITS Tool to address the need travelers have for congestion or travel time notification. A common question asked at ITS conferences after a presentation on DMS travel time displays is, "How much did it cost your agency to implement travel times on DMS"? Often, the incremental step a metropolitan area (such as the Twin Cities) took to achieve travel times on existing (or new) DMS was relatively small and inexpensive. However, the true answer to this question is actually much more complex:

- There is the need for detectors located and spaced appropriately, recording data frequently enough, and communicating the data in real-time to a central location;
- There is the need for automated algorithms to access the detector data, calculate travel times and determine the appropriate message for each DMS;
- There is the need for operating procedures that allow for automated message generation for the DMS, and to prioritize these messages with manually entered messages; and
- Finally, there is the need for DMS located in meaningful locations such that the travel time displays are effective for the travelers.

Similarly, if a metro area wished to deploy ramp meters, there is the need for appropriated located detectors, the need for a ramp meter algorithm, the need for a software system to operate the ramp meter algorithm to process detector data, the need for communication to the ramp meters, and the need for the ramp meter devices.

What these examples illustrate is that each tool (for example: traffic detectors) has multiple potential uses for multiple applications (in this example traffic detectors are used for both ramp metering and travel times), and therefore the requirements must reflect these so they can be considered during the design phase. What this also illustrates is that each use of an ITS Tool (e.g. travel times on DMS) may involve multiple other ITS Tools.

The ultimate success of this document will be if future deployments of ITS Tools in Minnesota (new deployments or enhancements) use this document to consider all the likely uses and users of ITS Tools during the design and development phase. Ideally this will optimize the value and efficiency of ITS Tool deployment.

2.2 Structure of this Document

Following this brief introductory section, the remainder of the document is dedicated to the freeway traffic management ConOps.

Section 3 presents a synopsis of the current Mn/DOT freeway conditions.

Section 4 describes the needs that are addressed by freeway traffic management. Each need is assigned a unique ID number that traces through the document.

Section 5 presents the overall concept for freeway traffic management, including the role of ITS Tools in freeway traffic management. Section 5 includes a table that maps the needs introduced in Section 4 to the ITS Tools described in the remainder of the document.

Sections 6 – 10 present the concepts of operations for the ITS Tools. The ITS Tools are arranged by the traffic operations actions they most contribute towards. In Sections 6 – 10, a series of tables are used to describe the ITS Tools.

- Interdependencies of Needs Tables describe how actions (e.g. Observation and Detection) are linked to the needs (e.g. incident/event verification)
- Operation and Maintenance Responsibility Tables describe the groups typically responsible for performing operations and maintenance of the ITS tools.
- Operational Concept Tables describe why the tool is used, who uses the tool, how the tool is used, and high level requirements.
- Constraints Tables describe high level constraints that should be considered during design and deployment.
- Role of ITS Architecture Tables describe how each ITS Tool relates to the Minnesota Regional ITS Architecture and National ITS Architecture.

3.0 Current Conditions

The Freeway Network

The Mn/DOT statewide freeway network is defined as limited access roads (without signalized intersections) operating any configuration ranging from two lanes per direction to five lanes per direction. The Minneapolis-St. Paul Metro Area (Twin Cities) operates the most complex network of freeways in the state. Two major Interstate highways (I-35 and I-94) converge in the Twin Cities, I-35 splits in to I-35W and I-35E as it passes through Minneapolis and St. Paul respectively, rejoining later as I-35. I-94 passes through Minneapolis and St. Paul, and splits in to two loop roads (I-694 and I-494) as well as a spur road (I-394). In addition, other freeways contribute to the overall network. In summary, the Twin Cities freeway network is used by through traffic heading North/South or East/West, as well as local commuters, leisure travelers, and commercial vehicles.

Outstate Minnesota is served by three major Interstates (I-35, I-94, and I-90), as well as other limited access freeways. Some outstate cities (including Duluth, St. Cloud, Rochester, and Moorhead) experience the freeway passing through (or nearby) the city. Otherwise, the majority of outstate freeway travel is rural freeway travel. Figure 1 depicts the Minnesota Freeway System.

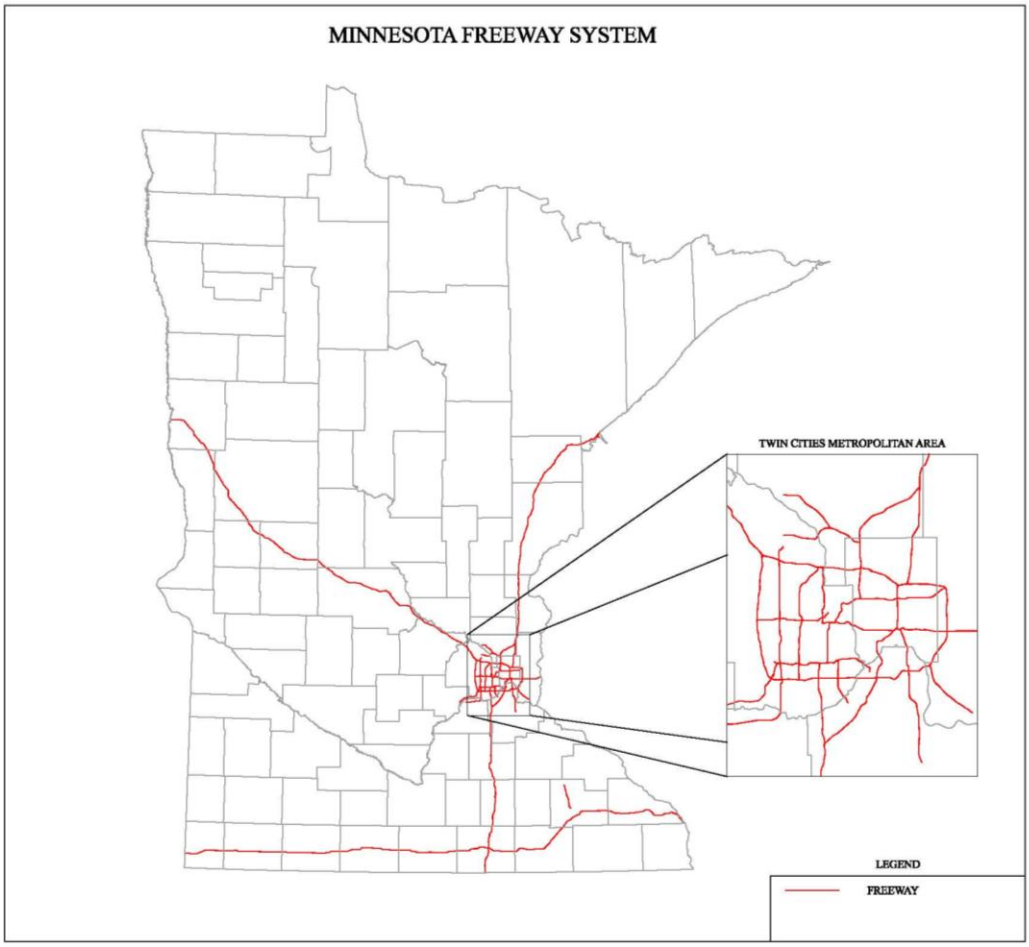

Figure 1: Minnesota Freeway System

Current Traffic Management

Under the current conditions, traffic management actions are most often performed during peak travel hours in the metro areas, and during inclement weather or difficult driving conditions statewide. Traffic management includes restricting vehicle access, informing travelers about conditions, providing alternate routes, and responding to incidents.

Intelligent Transportation Systems

Mn/DOT has operated transportation technologies (ITS) since the 1970's. The current use of ITS Tools ranges from very dense coverage of ITS systems in the Twin Cities, to moderate density of coverage in smaller outstate metropolitan areas, to limited ITS Tools in the rural portions of the state freeway network.

Mn/DOT has a statewide ITS architecture, updated in 2009. The ITS architecture provides a roadmap for how the ITS systems and subsystems interface with each other.

Mn/DOT is developing an ITS Design Manual. The design manual includes best practices, sample design documents, and captures the experiences and lessons learned from designing ITS in Minnesota as a resource for other deployments.

4.0 The Need for Freeway Traffic Management

4.1 Stakeholder Identification

For purposes of this document, stakeholders are defined as any individual, group of individuals, or agency that has a need for traffic management, or the actions related to traffic management. There are essentially two classifications of stakeholders:

1. **Primary Stakeholders** are those stakeholders that Mn/DOT addresses directly through traffic management. The primary stakeholders include:

    - Commuters to the metro areas;
    - Commercial vehicle operators traveling within or through Minnesota;
    - Leisure travelers within Minnesota;
    - Other state agencies; and
    - Other public sector transportation agencies (e.g. county, city, neighboring states) that benefit from traffic management.

2. **Secondary Stakeholders** are those stakeholders that have needs and benefit from the traffic management actions of Mn/DOT. However, these stakeholders are typically not the primary purpose for performing specific traffic management actions. Although they are secondary benefactors their needs are still respected and addressed to the extent possible when designing ITS systems. Secondary Stakeholders include:

    - Information service providers (e.g. private media) that will use outputs of Mn/DOT systems to perform travel information; and
    - Researchers (public and private) that use traffic management data and information to research many aspects of transportation or the use of technologies.

4.2 Operational and Stakeholder Needs

The challenges that face travelers and operators on freeways have been assessed and a set of problem statements have been prepared based on the input received from Mn/DOT. These problem statements, and the related needs, are summarized in the table below.

Table 1: Freeway Traffic Management Needs

Problem	Needs (As a Result of the Problem)
Incidents and events significantly reduce freeway capacity and cause operational problems.	***Need 1: Incident/event verification*** There is a need to verify the existence and impacts of incidents and events in real-time.
Heavy traffic volumes can create freeway Levels of Service that impede traffic flow and limit capacity.	***Need 2: Traffic and transportation infrastructure monitoring*** There is a need to monitor traffic volumes, congestion levels, and transportation infrastructure in-real time.
Current and future weather conditions (primarily precipitation) and the resulting driving conditions impact traffic flow and the likelihood of incidents.	***Need 3: Weather and driving condition monitoring*** There is a need to understand and monitor the current and impending weather conditions in real-time.
Travelers unaware of congestion or delays miss opportunities to divert to alternate routes and encounter delays.	***Need 4: Real-time travel time/congestion notification*** There is a need to inform travelers en-route and pre-trip of travel times and congestion.
Travelers unaware of incidents, isolated inclement weather conditions (e.g. spots of black ice, flooding, drifting snow, fog) encounter unexpected stopped traffic and delays without the option to divert or enter the conditions at unsafe speeds.	***Need 5: Real-time unplanned event notification*** There is a need to inform travelers en-route and pre-trip of active unplanned events (e.g. crashes, unusual driving conditions, Amber Alerts, special events, weather condition alerts).
Construction, maintenance, or special planned events activities can cause delays to travelers.	***Need 6: Real-time planned event notification*** There is a need to alert travelers en-route and pre-trip of planned events (e.g. special events, roadwork)
Numerous factors must be considered when formulating traffic management responses to operational problems.	***Need 7: Freeway operational analysis*** There is a need for short-term analysis of multiple data sources and long term performance measurement analyses.
Traffic lane changes (or lack of lane changes) at some static locations (e.g. tunnels) and near active incidents/congestion creates unsafe conditions and impedes traffic flow.	***Need 8: Individual lane control*** There is a need to alert travelers en-route of the status (e.g. open, closed, speed limit) of individual lanes on the freeway.
Traffic platoons entering freeways at or near capacity can create significant bottlenecks, delays and contribute to crashes.	***Need 9: Zonal or isolated freeway access control*** There is a need to control access to freeways.

Problem	Needs (As a Result of the Problem)
Numerous factors must be considered when planning traffic management adjustments and improvements to operational problems.	***Need 10: Freeway data storage, archive and access*** There is a need to store, archive, and share freeway traffic data.
Many incidents and events are not automatically detected and reported, but are known by some member of the operations team.	***Need 11: Manual Event Reporting*** There is a need for manual incident and event reporting.
There are times when vehicles must be restricted from specific lanes in order to maintain desired flows.	***Need 12: Lane access management*** There is a need to restrict or allow vehicles in specific lanes in order to maintain desired traffic flows.
Traffic management devices in the field must be controlled by operators without requiring operators to be local to the device.	***Need 13: Manual device control*** There is a need to manually control freeway management devices remotely.
Operators are not available to perform all device control.	***Need 14: Automated device control*** There is a need to control freeway management devices without operator intervention.
Operators having to manually determine all traffic management strategies can cause delay and inconsistencies in providing real-time traveler information.	***Need 15: Automated algorithm execution*** There is a need to automatically compute travel times, activate ramp meters, and compute meter rates.
Travelers unaware of unsafe roads due to weather/traffic conditions can create unsafe driving situations.	***Need 16: Automated/manual road closure*** There is a need to close a road due to unsafe weather/traffic conditions.
Inconsistent information can impede incident response and congestion management.	***Need 17: Center-to-Center communications*** There is a need for voice, data, and video sharing between public agencies.
Operators unaware of the location of response vehicles can cause delays. Operators unaware of pavement conditions can cause delays or inefficiencies when treating roadways.	***Need 18: Vehicle Tracking*** There is a need for tracking the geographic location of vehicles and pavement conditions.
Manual information sharing between public agencies can delay response and information dissemination	***Need 19: Inter-agency incident information sharing*** There is a need to share event information in real-time between public agencies.

5.0 Overall Concept for Freeway Traffic Management

Mn/DOT manages the traffic flowing on freeways throughout the state of Minnesota to promote mobility and safety. Freeways are defined (for the purposes of this document) as all Mn/DOT maintained roads that are accessed controlled and do not include at-grade intersections.

5.1 Traffic Management Actions

Freeway traffic management is accomplished by a series of actions; these actions are performed by Mn/DOT staff as well as public (city and county) and private partners. The actions include:

- Observation and detection;
- Data processing and response formulation;
- Information sharing (to other agencies and the traveling public); and
- Traffic control.

Figure 2, illustrates the freeway traffic management actions.

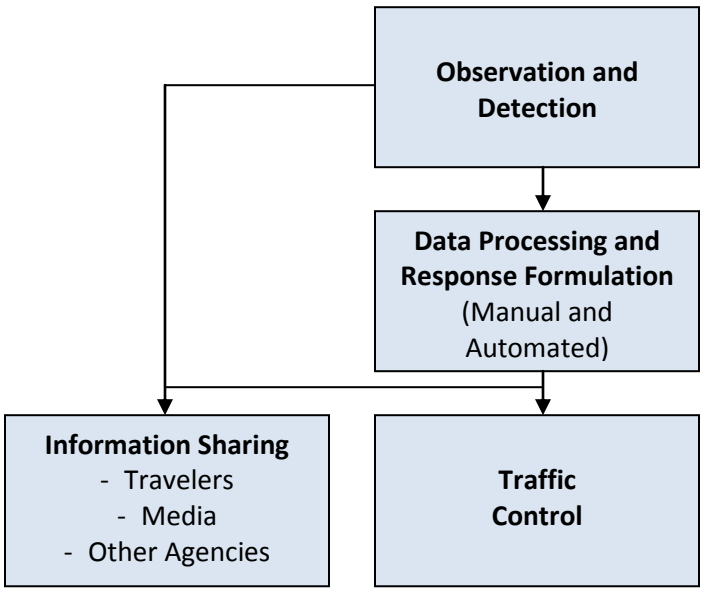

Figure 2: High Level Summary of Freeway Traffic Management Actions

5.2 ITS Tools that Support Traffic Management Actions

Intelligent Transportation Systems are technology systems, devices, and applications that work together as 'Tools' to support the actions of freeway traffic management. Each ITS Tool supports one or more of the actions performed for traffic management. Examples of ITS 'Tools' include DMS, CCTV cameras, and ramp meters.

Figure 3 below, illustrates the 'Tools' that support each of the four traffic management actions.

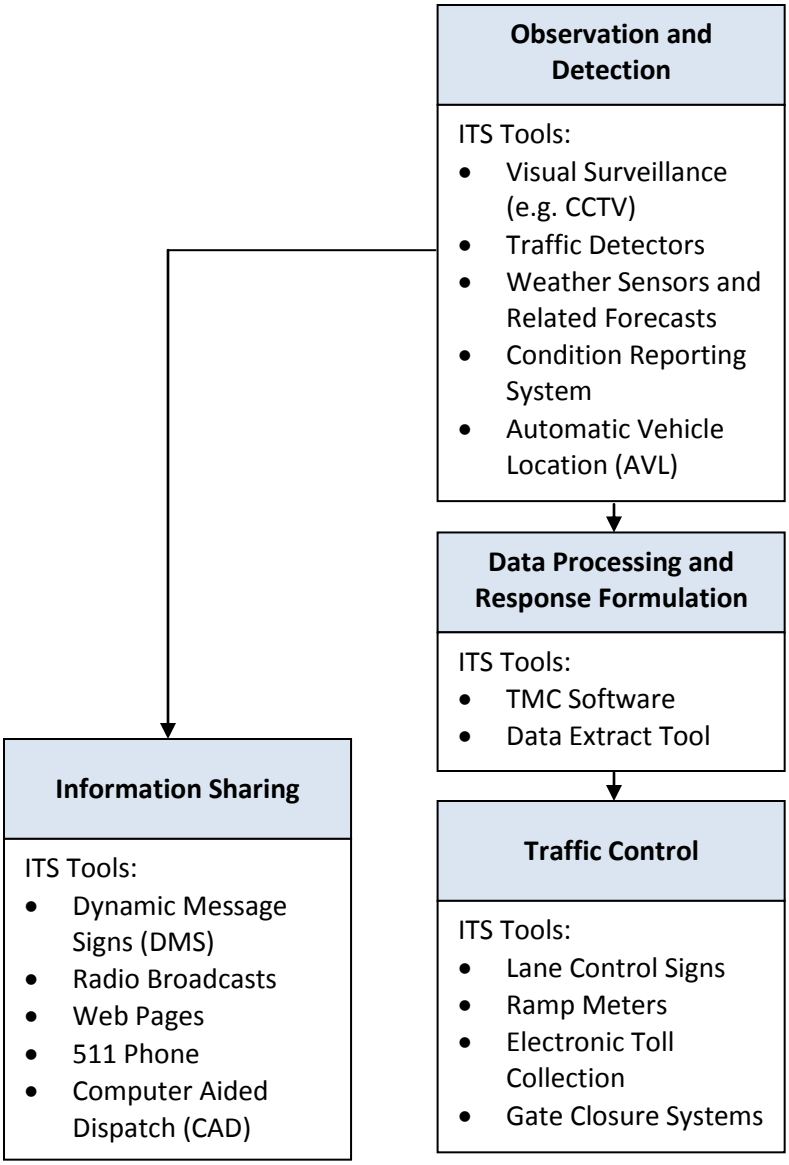

Figure 3: Illustration of ITS Tools that Support Traffic Management

5.3 Mapping of ITS Tools to Needs

Table 2, on the following page, maps the needs presented in Section 4 to the ITS Tools introduced in this section. By mapping the needs to the ITS Tools, the intent is to illustrate, at a high level:

- The roles of each ITS Tool (i.e. what needs the tool addresses); and
- The approaches for meeting each need (i.e. what tools support each need).

However, the table goes one step further to illustrate constraints (in addition to the primary mapping of ITS Tools to needs). For example, Need 4: Real-time travel time/congestion notification is primarily addressed by three ITS Tools (DMS, 511, and radio broadcasts). In isolation, these ITS Tools can not address the need; other ITS Tools are needed, (e.g. Traffic Detectors). For these relationships, a 'C' is placed in the cell to illustrate that the ITS Tool and the need are constrained to each other, even if the ITS Tool is not a primary tool addressing the need.

Table 2: Map of ITS Tools to Freeway Traffic Management Needs

Need	ITS Tools															
	Observation and detection					Information Sharing					Data Processing & Response Formulation		Traffic Control			
	Visual Surveillance	Traffic Detectors	Weather Sensors & Related Forecasts	Condition Reporting System	AVL	DMS	Radio Broadcasts	Web Display	511 Phone	CAD	TMC Software	Data Extract Tool	Lane Control Signs	Ramp Meters	Electronic Toll Collection	Gate Closure
Need 1: Incident/event verification	P															
Need 2: Traffic & transportation infrastructure monitoring	P	P														
Need 3: Weather and driving condition monitoring	P		P													
Need 4: Real-time travel time/congestion notification		C				P	P	P	P		C					
Need 5: Real-time unplanned event notification	C			C		P	P	P	P							
Need 6: Real-time planned event notification				C		P	P	P	P							
Need 7: Freeway operational analysis	C	C		C							P					
Need 8: Individual lane control	C	C									C		P			
Need 9: Zonal or isolated freeway access control		C												P		
Need 10: Freeway data storage, archive and access		C									C	P				
Need 11: Manual event reporting	C	C		P												
Need 12: Lane access management		C													P	
Need 13: Manual device control											P					
Need 14: Automated device control		C									P					
Need 15: Automated algorithm execution		C									P					
Need 16: Automated/manual road closure	C															P
Need 17: Center-to-Center communications								P								
Need 18: Vehicle Tracking					P											
Need 19: Inter-agency incident information sharing										P						

P = Primary Relationship Between Need and ITS Tool ***C= Constraint Between Need and ITS Tool***

5.4 Supporting Infrastructure Tools

In addition to the ITS Tools that support traffic management, there is a set of supporting infrastructure that is needed to allow the ITS tools to work effectively. These supporting infrastructures include such things as:

- Land line field communications (e.g. fiber-optic and coaxial cable);
- The Internet;
- Wireless infrastructure such as AM radio and 800 MHz radio; and
- Electrical power.

5.4.1 Supporting Infrastructure Tool #1: Land-line Communications

Land-line communications tools (e.g. fiber optic and coaxial cable) provide for high-speed communications of large volumes of data. Traffic management tools described in this document (especially such tools as surveillance devices, traffic detectors, and DMS) require reliable, fast communications capabilities. The criticality of these devices often mandates redundant communications to allow connectivity during those times when land-line communications may be lost (e.g. during construction or an accidental cut of the line).

The functionality of the traffic management tools described in this document relies upon land-line communications. Therefore, there is a dependency of many of the needs to land-line communications, and land-line communications' deployments shall be considered critical.

5.4.2 Supporting Infrastructure Tool #2: The Internet

The Internet plays a critical role in traffic management by allowing software to be accessed through Internet connectivity, and by allowing information (such as camera images) to be shared with agencies and individuals who are not connected to the Mn/DOT Local Area Network (LAN). In addition, the commercial Internet allows traffic management personnel to access non-Mn/DOT resources (e.g. the WeatherChannel.com).

The functionality of several tools described in this document relies upon the Internet.

5.4.3 Supporting Infrastructure Tool #3: Wireless Communications

Wireless communications are used to communicate with individuals while mobile (e.g. FIRST vehicle operators, RTMC operators, managers and other responders) while in the field. In addition, wireless communications are used to communicate to mobile devices, where land-line communications are not practical or possible.

5.4.4 Supporting Infrastructure Tool #4: Power Supply

Each traffic management tool that is located in the field requires some power source. The most common power supply is land-line power, however alternate power sources such as solar or wind energy are used in remote locations where power sources are not located nearby. The functionality of the devices, and therefore their ability to address the needs relies upon the power sources.

5.5 Structure of the Remaining Sections

The emphasis of this document is on the ITS Tools that support freeway traffic management. Each of the remaining sections is dedicated to one of the freeway traffic management 'Actions' illustrated in Figure 3, as follows:

- Section 6 describes Observation and Detection;
- Section 7 describes Information Processing and Response Formulation;
- Section 8 describes Information Sharing; and
- Section 9 describes Traffic Control.

To accomplish the intent of each section, a combination of text and tables are used. For brevity, descriptions of each table are described here and not repeated in each section.

5.5.1 Interdependencies of Needs Tables

Subsections 6.1, 7.1, 8.1 and 9.1 describes the operational concept for the each 'Action'. These sections include bulleted lists of needs addressed by the action. For example, the Action presented in Section 7 (Freeway Operational Analysis) addresses Need #10: *Freeway Data Storage, Archive, and Access.* However, in order for this Action to meet this need, Need #2: *Traffic and Transportation Infrastructure Monitoring* must be met by the 'Action' described in Section 6 (Observation and Detection). Therefore,

there are interdependencies between these 'Actions' that are linked by the needs. This set of tables present these interdependencies, when appropriate.

Table 3: EXAMPLE Interdependencies of Needs Table

In Order for Action (e.g. Observation and Detection) to Meet This Need	This Need Must Be Met (The Dependency)	Action Responsible for Meeting Dependency

5.5.2 Operations and Maintenance Tables

Subsections 6.2, 7.2, 8.2 and 9.2 present the ITS Tools. The first table included in the ITS Tool description describes the Operations and Maintenance roles and responsibilities for each tool. The responsibilities are broken out by either 'Metro' or 'Outstate'.

Table 4: EXAMPLE Operations and Maintenance Responsibilities Table

Operations & Maintenance Activities	Metro Area Responsibility	Outstate Responsibility

5.5.3 Description of Use Tables

The second set of tables in Section 6.2, 7.2, 8.2 and 9.2 describes the following for each ITS Tool:

- 'Why' the ITS Tool is used - A direct correlation to the needs identified in Section 4;
- 'Who' Uses the ITS Tool for each purpose;
- 'How' each specific user group uses the ITS tool; and
- High level requirements for the ITS Tool based upon this use case scenario, including only those requirements that can be derived from the information in the Description of Use table.

Table 5: EXAMPLE Operational Concept Table

Why is the ITS Tool Used?	Who Uses the ITS Tool?	How is the ITS Tool Used?	Requirements

5.5.4 Constraints Table

The third table in each ITS Tool subsection defines constraints. Three types of constraints are included:

- General constraints – External factors that could constrain the use of the ITS Tool, such as power, communications, location;
- Constraints to other Actions or ITS Tools – Descriptions of the aspects of other traffic management 'Actions' that this ITS Tool is constrained to. In other words, something that if it were to cease operating would prevent this ITS Tool from performing it's function; and
- Constraints by other Actions or ITS Tools – Descriptions of those aspects of other actions or ITS Tools that place a constraint on this ITS Tool. In other words, a description of the things that if this ITS Tool were to cease performing would prevent other ITS Tools from performing their functions.

Table 6: EXAMPLE Constraints Table

Constraint	Description of Constraint

5.5.5 ITS Architecture Table

The final table in each ITS Tool section indicates the role of a specific ITS Tool as it relates to the Minnesota Regional ITS Architecture and National ITS Architecture.

Table 7: EXAMPLE ITS Architecture Table

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package

6.0 Observation and Detection

6.1 Concept of Operations for Observation and Detection

6.1.1 Role in Freeway Traffic Management

Observation and detection describes the action of observing conditions, detecting events or incidents, and assembling information through manual or automated processes. This is a key action in freeway traffic management as it provides freeway operations staff with information and visual verification of conditions and events, thereby enabling them to perform analyses of situations and respond by managing traffic or responding to incident emergencies. Data is collected and shared with partner agencies and the traveling public in the observation and detection action. Finally, data acquired by this action is used for long-term analysis of needed infrastructure changes to better manage traffic.

Therefore, nearly every freeway traffic management strategy implemented to address nearly every need identified in previous chapters traces back and is dependent upon observation and detection in some way. The dependency of the other activities upon observation and detection are described in the following subsections.

6.1.2 Needs Addressed by Observation and Detection

Based upon research and feedback, freeway traffic management personnel have identified that the following needs are addressed by the Observation and Detection action.

- Need 1: Incident/event verification;
- Need 2: Traffic and transportation infrastructure monitoring;
- Need 3: Weather and driving conditions monitoring;
- Need 11: Manual Event Reporting; and
- Need 18: Vehicle Tracking.

6.1.3 ITS Tools for Observation and Detection

The ITS Tools used to perform traffic observation and detection, and therefore address the stated needs include:

- ***Visual Surveillance*** (most common as CCTV cameras and related viewing mechanisms);
- ***Traffic detectors***;
- ***Weather sensors and related forecasting;***
- ***Condition Reporting Systems***; and
- ***Automatic Vehicle Location.***

6.1.4 Interdependencies of Needs

There are not any interdependencies between the Observation and Detection action and the needs addressed by Observation and Detection as shown in the following table.

Table 8: Observation and Detection Interdependencies of Needs

In Order for Observation and Detection to Meet This Need	This Need Must Be Met (The Dependency)	Action Responsible for Meeting Dependency
Need 1: Incident/event verification	N/A	*There are no interdependencies for the needs addressed by Observation and Detection*
Need 2: Traffic and transportation infrastructure monitoring		
Need 3: Weather and driving conditions monitoring		
Need 11: Manual Event Reporting		
Need 18: Vehicle Tracking		

The remaining Subsections to 6.0 present the ITS Tools associated with Observation and Detection.

6.2 Visual Surveillance (e.g. CCTV)

Visual Surveillance (most commonly CCTV cameras) tools provide a mechanism for traffic operations staff, travelers, information service providers, and law enforcement personnel to view video or static images of events on the roadways. Images are relayed to a central monitoring location where the images are projected onto a video monitor, television screen, internet display, or other related viewing mechanisms.

6.2.1 Scenarios for the use of Visual Surveillance

There are eleven distinct use case scenarios for visual surveillance:

1. Mn/DOT Metro Freeway Operations Perspective

- Metro Freeway Operations uses real-time video to verify incidents and to observe traffic and road conditions by positioning the camera and zoom lens on specific events. In the metro area, near complete coverage of the freeways allows most every incident to be observed, and all major traffic congestion can be viewed.

  Freeway Operations also may view video of past events by either viewing video buffered for short-term durations, or long term storage of selected incidents/events. Potential uses of buffered video by Freeway Operations includes training, performance management, incident debriefing, and to contribute insight to designers to develop safety improvements to the infrastructure. It is important to note that all incidents can be buffered due to the viewing angle of the camera. The aftermath of an incident (secondary incidents) is usually viewable once Freeway Operations is alerted of an incident and the camera angle is moved.

2. Mn/DOT Metro Maintenance Dispatch Perspective

- In the metro area, freeway traffic management includes the clearing of snow and ice from roadways to maintain as much capacity as possible. Metro Area Maintenance Dispatchers use video to observe road conditions as part of their decision making process for dispatching crews for road maintenance (e.g. removal of snow, debris, removal, pre-treatment of roads), and to assess when incidents will last longer than one hour and require traffic control from Metro Area Maintenance. Buffered and stored video of events (e.g. crashes related to winter storms) can be viewed by Maintenance Dispatchers and used for training or procedure development.

3. Mn/DOT Outstate District Perspective

- Mn/DOT Outstate Districts that have visual surveillance use the video to verify incidents and to observe traffic and road conditions by positioning the camera and zoom lens on specific events. Video is also used to address public complaints.

4. Mn/DOT Planning and Roadway Design Perspective

- Buffered and stored video capturing daily traffic trends, incidents, or severe congestion can be used by Mn/DOT designers (much in the way crash reports are used but with more details) to develop safety improvements to the infrastructure.

5. Mn/DOT Public Affairs Perspective

- Buffered and stored video can be used by Mn/DOT Public Affairs to market Mn/DOT's efforts and to perform public awareness outreach.

6. Television Information Service Providers / Media Outlets' Perspective

- Local television news media observe camera video when preparing traffic reports and display video on television broadcasts.

- Television media outlets do not have control over any camera. They may however, select the camera feed to view and/or display on their broadcast (display only one at a time).

7. Non-television Information Service Providers / Media Outlets' Perspective

- Non-television news media outlets observe camera video to prepare traffic reports. This includes local media, radio broadcasts, and private information service providers.

- Non-television new media also may provide links to still image camera snapshots produced by visual surveillance.

8. Minnesota State Patrol Perspective

- The Minnesota State Patrol (MSP) views and controls camera video at operations centers throughout the state to assess the incident/event and dispatch emergency management response appropriately and to enter reports into reporting systems.

9. Emergency Management Agencies Perspective

- Emergency management responders observe camera video to assist in emergency management response.

10. Other Public Agencies' (e.g. cities, counties, Wisconsin DOT, University of Minnesota) Perspective

- Local County Traffic Operations groups observe camera video and traffic conditions to assist in prioritizing traffic signal repairs or upgrades (to non-freeway controllers).

- Transit agencies observe camera views to assist in rerouting buses.

- Public agencies observe freeway conditions to assist in traffic control to minimize impacts.

11. Traveling Public Perspective

- The traveling public observes static camera images through traveler information websites and local TV news outlets. The images provide sufficient information about traffic congestion, weather, and pavement conditions to assist pre-trip decision making.

6.2.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities of visual surveillance devices (e.g. CCTV cameras) are shown in the table below.

Table 9: Visual Surveillance Operations and Maintenance Responsibilities

Visual Surveillance Operations & Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Overall maintenance of cameras and other field devices	• Mn/DOT Metro Area Freeway Management Systems (FMS) Maintenance	• Mn/DOT District Information Technology (IT) Maintenance • Mn/DOT Electrical Servics Section (ESS)
Overall maintenance of video switches (HW and SW) operated within the operations centers	• Mn/DOT Metro Area FMS Maintenance • Mn/DOT Metro Area FMS Integration	• Mn/DOT District IT Maintenance • Mn/DOT ESS
Overall operations • Camera control • Video buffering	• Mn/DOT Metro Area Freeway Operations • Minnesota State Patrol	• Mn/DOT District Traffic Operations • Minnesota Outstate State Patrol

6.2.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why visual surveillance is used (the purposes it performs);
- Who uses visual surveillance (for each purpose);
- How they use visual surveillance; and
- High level requirement considerations based on the use of visual surveillance.

Table 10: Observation and Detection Operational Concept: Visual Surveillance

Traffic Management Action: Observation and Detection **ITS Tool:** Visual Surveillance			
Why is Visual Surveillance Used?	**Who Uses Visual Surveillance?**	**How is Visual Surveillance Used?**	**Visual Surveillance Requirements**
Need 1: Incident/ Event Verification	Mn/DOT Metro Freeway Operations	• Video is viewed at operators' workstations, on the RTMC viewing wall, managers offices, and Incident Response Room. • During incidents or events, camera views are selected to appear on the incident management wall of the RTMC, causing the video to be buffered. • Camera controls allow operators to zoom to the event and view surrounding areas. • Video is used to verify and assess the expected impacts of incidents/events, determine which traffic control to implement, activate DMS, activate lane control signs, and to create traveler information descriptions for 511 and the web. • Operators clarify lane closures, debris, and monitor the response actions. • Operators can select to buffer the video for later viewing.	VS1: Mn/DOT Metro Freeway Operators shall have the capability to control cameras from the operations center. VS2: Mn/DOT Metro Freeway Operators shall have the capability to zoom cameras to enough detail to observe debris and lane blockages through the cameras. VS3: Mn/DOT Metro Freeway Operators shall have access to real-time full motion video. VS4: Mn/DOT Metro Freeway Operators shall have the capability to buffer video.

Traffic Management Action: Observation and Detection **ITS Tool:** Visual Surveillance			
Why is Visual Surveillance Used?	**Who Uses Visual Surveillance?**	**How is Visual Surveillance Used?**	**Visual Surveillance Requirements**

	Mn/DOT Metro Maintenance Dispatch	• Video is used to assess whether Metro Maintenance will be needed to provide traffic control and clean up (incidents/events lasting longer than 1 hour).
		• Mn/DOT Metro Maintenance Dispatch assumes the responsibilities of the RTMC Operators when not staffed.
		  ○ Video is viewed at operators' workstations, on the RTMC viewing wall, managers offices, and Incident Response Room.
		  ○ During incidents or events, camera views are selected to appear on the incident management wall of the RTMC, causing the video to be buffered.
		  ○ Camera controls allow operators to zoom to the event and view surrounding areas.
		  ○ Video is used to verify and assess the expected impacts of incidents/events, determine which traffic control to implement, activate DMS, activate lane control signs, and to create traveler information descriptions for 511 and the web.
		  ○ Operators clarify lane closures, debris, and monitor the response actions.
		  ○ Operators can select to buffer the video for later viewing.
			VS5: Mn/DOT Metro Maintenance Dispatch shall have the capability to control cameras remotely.
			VS6: Mn/DOT Metro Dispatch shall have the capability to zoom cameras to enough detail to observe debris and lane blockages through the cameras.
			VS7: Mn/DOT Metro Dispatch shall have access to real-time full motion video.
			VS8: Mn/DOT Metro Dispatch shall have the capability to buffer video.

Traffic Management Action: Observation and Detection **ITS Tool:** Visual Surveillance			
Why is Visual Surveillance Used?	**Who Uses Visual Surveillance?**	**How is Visual Surveillance Used?**	**Visual Surveillance Requirements**
	Mn/DOT Outstate Districts	• Camera coverage is less complete outstate. If crashes occur near cameras, the incident site (or the extent of the backup) is observed. • Temporary cameras are sometimes used in freeway construction zones to allow Mn/DOT Traffic, State Patrol, and Mn/DOT Distict Maintenance to view flow through the work zone and watch for incidents. • Video is not buffered or stored currently, but this is a requested feature. • Cameras are typically viewed by Transportation Operations Center (TOC) operators (MSP or traffic operations).	VS9: Mn/DOT Outstate District Traffic Operators shall have the capability to control cameras remotely. VS10: Mn/DOT Outstate District Traffic Operators shall have the capability to buffer video. VS11: Communications for outstate cameras shall provide a mechanism for temporary (portable) cameras to be viewed remotely.
	Minnesota State Patrol	• Video is viewed at operators' workstations or on the RTMC viewing wall (in the Metro Area). • Video is used to assess the incident/event and dispatch emergency management response appropriately. • Camera controls allow operators to zoom to the event and view surrounding areas. • Video is used to verify and assess the expected impacts of incidents/events create event descriptions. • Operators clarify lane closures, debris, and monitor the response actions.	VS12: State Patrol Operators shall have the capability to control cameras remotely. VS13: State Patrol Operators shall have the capability to control cameras from the operations center. VS14: State Patrol Operators shall have the capability to zoom cameras to enough detail to observe debris and lane blockages through the cameras. VS15: State Patrol shall have access to real-time full motion video.

Traffic Management Action: Observation and Detection **ITS Tool:** Visual Surveillance			
Why is Visual Surveillance Used?	**Who Uses Visual Surveillance?**	**How is Visual Surveillance Used?**	**Visual Surveillance Requirements**
	Emergency Management Agencies	• Video is viewed at operators' workstations. • Video is used to assess the incident/event and dispatch emergency management response appropriately.	VS16: Emergency Management Agencies shall have access to real-time streaming video.
	RTMC Radio Contractor Announcer	• The RTMC Radio Contractor Announcer in the metro area view incidents on the RTMC video wall when creating content for traffic announcements.	VS17: RTMC Radio Contractor shall have access to real-time full motion video.
Need 2: Traffic and Transporta-tion Infrastructure Monitoring	Mn/DOT Metro Freeway Operations	• Video is viewed at operators' workstations, on the RTMC viewing wall, managers offices, and Incident Response room. • Operators use video to monitor field devices (e.g. signs) to ensure they have activated properly. • Operators use video to observe traffic and detect variations from typical patterns (e.g. heavy traffic during peak periods or events), monitor the ramp metering system (extent of mainline and ramp queues), and use the information to adjust ramp metering, and to create messages for DMS, 511, and the web. • Video can be buffered for later review.	VS1: Mn/DOT Metro Freeway Operators shall have the capability to control cameras remotely. VS2: Mn/DOT Metro Freeway Operators shall have the zoom capability to allow observation of debris and lane blockages. VS3: Mn/DOT Metro Freeway Operators shall have access to real-time full motion video. VS4: Mn/DOT Metro Freeway Operators shall have the capability to buffer video.

Traffic Management Action: Observation and Detection **ITS Tool:** Visual Surveillance			
Why is Visual Surveillance Used?	**Who Uses Visual Surveillance?**	**How is Visual Surveillance Used?**	**Visual Surveillance Requirements**
	Mn/DOT Outstate Districts	• Freeway traffic is observed for unusual backups or causes of delay. • In Districts using gate closure systems, cameras are viewed to confirm closure of the gate(s). • Mn/DOT Maintenance views video to assess weather and driving conditions or to determine if traffic control is needed. • Operators use video to determine traveler information descriptions for 511 and the web. • In metro areas (e.g. Duluth, St. Cloud, Rochester), camera control allow operators to observe traffic and detect variations from typical patterns. • Video is used to monitor device (e.g. DMS) functionality. • In areas near state borders (e.g. Fargo/Moorhead) camera control across state boundaries is planned.	VS9: Mn/DOT Outstate District Traffic Operators shall have the capability to control cameras remotely. VS10: Mn/DOT Outstate District Traffic Operators shall have the capability to buffer camera images -. VS11: Communications for outstate cameras shall provide a mechanism for temporary (portable) cameras to be viewed remotely.

Traffic Management Action: Observation and Detection **ITS Tool:** Visual Surveillance			
Why is Visual Surveillance Used?	**Who Uses Visual Surveillance?**	**How is Visual Surveillance Used?**	**Visual Surveillance Requirements**
	Minnesota State Patrol	• Video is viewed at operators' workstations or on the RTMC viewing wall (in the Metro Area). • Camera controls allow operators to zoom to the event and view surrounding areas. • Video is used to create event descriptions for CAD. • Video is used to create messages for 511 and the web in Outstate Districts.	VS12: State Patrol Operators shall have the capability to control cameras remotely. VS13: State Patrol Operators shall have the capability to control cameras from the operations center. VS14: State Patrol Operators shall have the capability to zoom cameras to enough detail to observe debris and lane blockages through the cameras. VS15: State Patrol shall have access to real-time full motion video.
	Other Agencies	• Video is used by some Twin Cities counties to observe traffic patterns in order to prioritize signal timing projects (retiming, repairs, or upgrades) on county highways. • Video is used to observe freeway conditions to assist in traffic control to minimize impacts. • Video is used by Metro Transit to observe freeway conditions to reroute transit vehicles.	VS18: Public agencies shall have access to real-time streaming video. VS19: Metro Transit shall have a direct fiber connection to view video.

Traffic Management Action: Observation and Detection **ITS Tool:** Visual Surveillance			
Why is Visual Surveillance Used?	**Who Uses Visual Surveillance?**	**How is Visual Surveillance Used?**	**Visual Surveillance Requirements**
	Information Service Providers	• Television and Non-television media outlets observe video to assess speeds, congestion locations, and prepare traffic reports. • Television media outlets display video on television broadcasts. • RTMC Radio Contractor views camera images on the RTMC viewing wall to create content for broadcasts.	VS20: Television broadcasters shall have a mechanism to receive and broadcast camera feeds from all metro area cameras (one simultaneous operating feed). VS21: Metro Area Television broadcasters shall receive real-time, full motion video. VS22: Information service providers (non-Television) shall have a mechanism to view still images from camera feeds.
	Public	• Still images are viewed via traveler information websites. • Images on websites allow travelers to view congestion and driving conditions assisting in pre-trip decision making.	VS23: Public shall have a mechanism to view real-time still images from camera feeds.

Traffic Management Action: Observation and Detection **ITS Tool:** Visual Surveillance			
Why is Visual Surveillance Used?	**Who Uses Visual Surveillance?**	**How is Visual Surveillance Used?**	**Visual Surveillance Requirements**
Need 3: Weather and Driving Condition Monitoring	Mn/DOT Metro Freeway Operations	• Video is used to observe precipitation and ice/snow on the roadway and assess the expected impacts to prepare traffic management strategies. • Video is used to identify flooding locations or snow buildup (e.g. freeway shoulders).	VS1: Mn/DOT Metro Freeway Operators shall have the capability to control cameras remotely. VS2: Mn/DOT Metro Freeway Operators shall have the zoom capability to allow observation of debris and lane blockages. VS3: Mn/DOT Metro Freeway Operators shall have access to real-time full motion video. VS4: Mn/DOT Metro Freeway Operators shall have the capability to buffer video.
	Mn/DOT Metro Maintenance	• Video is used to observe precipitation and pavement conditions in order to estimate efforts to maintain capacity of the highway and manage field personnel (e.g. split shifts if needed, schedule additional maintenance staff).	VS5: Mn/DOT Metro Maintenance Dispatch shall have the capability to control cameras remotely. VS6: Mn/DOT Metro Dispatch shall have the capability to zoom cameras to enough detail to observe debris and lane blockages through the cameras. VS7: Mn/DOT Metro Dispatch shall have access to real-time full motion video. VS8: Mn/DOT Metro Dispatch shall have the capability to buffer video.

Traffic Management Action: Observation and Detection **ITS Tool:** Visual Surveillance			
Why is Visual Surveillance Used?	**Who Uses Visual Surveillance?**	**How is Visual Surveillance Used?**	**Visual Surveillance Requirements**
	Mn/DOT Outstate Districts	• Video is used to observe precipitation and driving conditions and assess the expected impacts to prepare traffic management strategies.	VS9: Mn/DOT Outstate District Traffic Operators shall have the capability to control cameras remotely. VS10: Mn/DOT Outstate District Traffic Operators shall have the capability to buffer camera images. VS11: Communications for outstate cameras shall provide a mechanism for temporary (portable) cameras to be viewed remotely.
	Minnesota State Patrol	• Video is used to observe precipitation and driving conditions and assess the expected impacts to prepare traffic management strategies.	VS12: State Patrol Operators shall have the capability to control cameras remotely. VS13: State Patrol Operators shall have the capability to control cameras from the operations center. VS14: State Patrol Operators shall have the capability to zoom cameras to enough detail to observe debris and lane blockages through the cameras. VS15: State Patrol shall have access to real-time full motion video.
	Public	• Still images are viewed via traveler information websites. • Images on websites allow travelers to view weather conditions assisting in pre-trip decision making.	VS23: Public shall have a mechanism to view real-time still images from camera feeds.

6.2.4 External Constraints of Visual Surveillance

External constraints involving visual surveillance are summarized in the following table.

Table 11: Visual Surveillance Constraints

Constraint	Description of Constraint
Camera Locations	• Camera location and spacing between cameras is a factor on the usefulness of the device. • The role of each user and use case scenario should be considered when deploying cameras. • Other factors such as morning and evening glare, natural and man-made obstructions, should also be considered.
Camera Power Source	• The proximity of the power source for camera deployment is critical
Communications with Camera	• Individual use case scenarios for each camera should be considered when designing communications (whether redundant communications, full-time video connection, or download of snapshots is required)
Constraint to Freeway Operational Analysis	• The control of visual surveillance devices may either be performed by the TMC Software, or by a vendor specific video switch associated with the cameras. This ConOps does not discuss 'how' control is performed. However, if camera control is by the TMC Software there is a constraint to the TMC Software (within the Freeway Operational Analysis 'Action').
Constraint to Information Sharing	• Other agencies and travelers must be able to view video or still images captured by visual surveillance devices. Currently, this is defined as a function of the Information Sharing Action.
Constraint by Information Sharing	• RTMC Radio Contractor need to view visual observations (cameras) in creating radio reports.

6.2.5 Role of Visual Surveillance in ITS Architecture

Visual Surveillance was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for Advanced Transportation Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS) as shown in the table below.

Table 12: Role of Visual Surveillance in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS 01 Network Surveillance • ATIS01 Broadcast Traveler Information	• TM04 Provide cameras at locations with high incidents and areas of high importance for incident identification and verification • TM09 Share surveillance video data, and other information with PSAPs • TM25 Operate CCTV cameras which corresponds with National ITS Architecture Market Package • TM36 Implement Integrated Corridor Management (ICM) • TI15 Make camera images available to travelers	• ATMS 01 Network Surveillance • ATMS 08 Traffic Incident Management System

6.3 Traffic Detection

Traffic detection refers to a system for indicating the presence or passage of vehicles. The detector data provides input to accurately measure freeway conditions.

6.3.1 Scenarios for the use of Traffic Detection

There are six distinct use case scenarios for real-time traffic detection:

1. ***Mn/DOT Freeway Operations Perspective***

   - Metro Area Freeway Operations operates traffic detectors at half mile intervals throughout the majority of the metro area. The detectors measure volume and occupancy. TMC Software functions to receive, process, and store data from the traffic detectors. The detector data is used in real-time to control ramp meters, determine Mn/PASS rates, and calculate travel time. The freeway detector data is also used to examine conditions and trends by viewing past data.

2. Mn/DOT Outstate District Perspective

   - Many of Mn/DOT's Outstate Districts do not have traffic detectors on the freeways. District 6 has freeway loop detector data to identify vehicle speed, occupancy and vehicle classification. Data is also collected in various districts from Automatic Traffic Recorder (ATR) throughout the state. Detection will be required as outstate districts consider traffic management strategies such as ramp metering and travel time reporting.

3. Mn/DOT Planning Perspective

   - The Mn/DOT Planning section uses traffic detector data to understand and study freeway conditions for planning purposes.

4. Television Information Service Providers / Media Outlets' Perspective

   - Local television news media use real-time traffic detector data when preparing traffic reports. Information service providers download traffic detector data in real-time to populate traffic maps.

5. Non-television Information Service Providers / Media Outlets' Perspective

   - Non-television news media outlets use real-time traffic detector data to prepare traffic reports. This includes local media, radio broadcasters, internet-based traffic information services, and private information service providers.

6. Other Public Agencies' (e.g. cities, counties) Perspective

   - Public agencies use traffic detector data to understand freeway conditions in real-time.

6.3.2 Operations and Maintenance Responsibility

Operations and maintenance of traffic detection are detailed in the table below.

Table 13: Traffic Detection Operations and Maintenance Responsibilities

Traffic Detection Operations & Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Validating detector data Periodic validation that detectors are still functioning properly and reporting accurate data.	• Mn/DOT Metro Area Freeway Operations	• Mn/DOT District Traffic
Monitoring detector functionality and performance Report any detectors that are not functional, or beginning to show signs of functional issues. These may include issues at the detector location, functionality of the detector or related communications.	• Mn/DOT Metro Area Freeway Operations	• Mn/DOT District Traffic
Repair or replacement of non-functioning detectors	• Mn/DOT Metro Area FMS Maintenance	• Mn/DOT District Maintenance • Mn/DOT District Traffic • Mn/DOT ESS
Repair communication with non-functioning detectors	• Mn/DOT Metro Area FMS Maintenance	• Mn/DOT District Maintenance • Mn/DOT District IT • Mn/DOT ESS

6.3.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why traffic detection is used (the purposes it performs);
- Who uses traffic detection (for each purpose);
- How they use traffic detection; and
- High level requirement considerations based on the use of traffic detection.

Table 14: Observation and Detection Operation Concept: Traffic Detection

Traffic Management Action: Observation and Detection **ITS Tool:** Traffic Detection			
Why is Traffic Detection Used?	**Who Uses Traffic Detection?**	**How is Traffic Detection Used?**	**Traffic Detection Requirements**
Need 2: Traffic and transportation infrastructure monitoring	Mn/DOT Metro Freeway Operations	• Traffic detector data is collected in the field, communicated to the RTMC, and read by TMC Control Software. The TMC Control Software system allows real-time viewing of the data. The data archive allows viewing of past data. • Metro Freeway Operations dispatchers view traffic data using the TMC Software and experienced operators can detect incidents or traffic situations from pattern changes in the displayed data (incidents are then verified using cameras). • Traffic detector data is used by Ramp Meter algorithms to determine ramp metering rates. • Traffic data is used by the Mn/PASS System to automatically determine the lane pricing based on conditions in the High Occupancy Toll (HOT) lane. • Traffic data is used by a Travel Time algorithm to automatically calculate travel times on key segments. • Traffic data is observed through the TMC Software display to assist RTMC operators in selecting response activities.	TD1: Detectors shall be spaced at a maximum of ½ mile in locations where corridor-wide ramp metering or freeway travel time calculation is operational. TD2: Traffic detectors shall record volume and occupancy in each lane for both mainline and ramps. TD3: Traffic detector data shall be communicated to a central location for storage and algorithm processing.
	Mn/DOT Planning	• Traffic detector data will be used to understand and study freeway conditions to assist in planning.	TD4: Traffic detector data shall be archived for later retrieval and analysis.
	Mn/DOT Outstate Districts	• Traffic detector data is available to operators in locations where the TMC Software is operational.	

Traffic Management Action: Observation and Detection **ITS Tool:** Traffic Detection			
Why is Traffic Detection Used?	**Who Uses Traffic Detection?**	**How is Traffic Detection Used?**	**Traffic Detection Requirements**
	Information Service Providers (ISPs)	• Volume and occupancy data (as detected by freeway detectors) is available as an RSS / XML feed. • Television and Non-television media outlets use traffic detector data to assess/calculate speeds and travel times, congestion locations, and prepare traffic reports. • Some ISPs operate systems that produce color coded freeway maps depict traffic slowdowns, either on Television broadcasts or on websites.	TD5: Traffic detector data shall be posted to an Internet accessible location (external to the Mn/DOT firewall) for outside agencies to access.
	Other Public Agencies	• Transit agencies may ingest detector data into operational decision support systems to compare freeway parameters against thresholds used to determine if bus diversions are enacted.	TD5: Traffic detector data shall be posted to an Internet accessible location (external to the Mn/DOT firewall) for outside agencies to access.

6.3.4 External Constraints of Traffic Detection

External constraints for traffic detectors are summarized in the following table.

Table 15: Traffic Detection Constraints

Constraint	Description of Constraint
Communications with Detector	• Individual use case scenarios for each detector location should be considered when designing communications (whether redundant communications is required and whether full-time connection or dial-up is required) • Location in the freeway network (e.g. proximity to bridges or utilities) may impact the availability and cost feasibility of communications.
Constraint to Information Sharing	• Detector data needs to reach organizations and agencies outside Mn/DOT.
Constraint by Data Processing and Response Formulation	• The action 'Data processing and response formulation' places a constraint on Traffic Detectors. 'Data processing and response formulation' relies on the outputs of traffic detectors, and therefore the role of this action should be considered before implementing any changes to traffic detectors.

6.3.5 Role of Traffic Detectors in ITS Architecture

Traffic Detection was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 16: Role of Traffic Detectors in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS 09 Traffic Forecast and Demand Management	• TM03 Use archived data for traffic management strategy development and long range planning	• AD1 Data Mart • AD2 Data Warehouse

6.4 Weather Sensors and Related Forecasting

Weather Sensors and Related Forecasting provide current and predicted weather conditions. The National Oceanic and Atmospheric Administration's (NOAA) National Weather Service provides weather, hydrologic, and climate forecasts and warnings for the United States, its territories, adjacent waters and ocean areas.

Providers of value-added sector specific meteorological services utilize National Weather Service data and predictions, road condition information, and local environmental data to provide weather observations and forecasts. Examples include the Data Transmission Network (DTN).

6.4.1 Scenarios for the use of Weather Sensors and Related Forecasting

There are three distinct use case scenarios for weather sensors and related forecasting:

1. Mn/DOT Metro Freeway Operations Perspective

- Metro Area Freeway Operations uses radar and internet based commercial (free of charge) weather prediction and reporting systems to assist in traffic control planning during rush hour.

2. Mn/DOT Metro Maintenance Dispatch Perspective

- Metro Area Maintenance Dispatchers use weather sensors and related forecasting to assist the decision process for scheduling and dispatching crews (e.g. during snowstorms).

3. Mn/DOT Outstate District Perspective

- Mn/DOT Outstate Maintenance use weather sensors (such as RWIS) and related forecasting (internet service providers) to assist in planning and maintaining roads.

6.4.2 Operations and Maintenance Responsibilities

Operations and maintenance of weather sensors and related forecasting are detailed in the table below.

Table 17: Weather Sensors and Related Forecasting Operations and Maintenance Responsibilities

Weather Sensors and Related Forecasting Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Non Mn/DOT Weather Source Operation Many weather sources are accessed over the Internet and Mn/DOT plays no role in the operation of the systems.	N/A	N/A
Operations and maintenance of Mn/DOT owned Road Weather Information Systems (RWIS) detectors and systems.	• Mn/DOT Metro Area Maintenance	• Mn/DOT District Maintenance

6.4.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why weather sensors and related forecasting is used (the purposes it performs);
- Who uses weather sensors and related forecasting (for each purpose);
- How they use weather sensors and related forecasting; and
- High level requirement considerations based on the use of weather sensors and related forecasting.

Table 18: Observation and Detection Operational Concept: Weather Sensors and Related Forecasting

Traffic Management Action: Observation and Detection **ITS Tool:** Weather Sensors and Related Forecasting			
Why is the Tool Used?	**Who Uses the Tool?**	**How are Weather Sensors and Related Forecasting Used?**	**Requirements**
Need 3: Weather Monitoring	Mn/DOT Metro Freeway Operations	• Freeway Operations staff members view radar images and Internet weather reports from their workstation. Maintenance staff members have access to RWIS and value added weather services and can verbally relay information in the RTMC. • Weather forecasts and current condition reports are used to verify and assess the expected impacts of weather during peak periods. During inclement weather, operators may manually adjust ramp metering rates, adjust FIRST Vehicle strategies, and call in additional dispatch staff members to accommodate the unusual traffic patterns expected. • For rare situations where operators feel that unexpected localized weather should be relayed to motorists (e.g. isolated snow drifting of a small section, black ice caused by a local event), operators may post messages to DMS, 511 phone, or 511 web describing the local weather or driving condition. However, DMS is not used to describe overall driving or weather conditions (that could be observed by travelers).	WS1: Mn/DOT Metro Freeway Operators shall have Internet access to outside weather sites (public and private).
	Mn/DOT Metro Maintenance	• On-line weather resources and value added weather services are accessible to maintenance dispatcher's workstations. • Weather sensors and related forecasting is used to plan pre-treatment and removal of snow and ice. • Speed data is used by Mn/DOT Metro Maintenance to determine when 'bare pavement' is achieved.	WS2: Mn/DOT Metro Maintenance Operators shall have Internet access to outside weather sites (public and private). WS3: Mn/DOT Metro Maintenance Operators shall have access to RWIS information.

Traffic Management Action: Observation and Detection **ITS Tool:** Weather Sensors and Related Forecasting			
Why is the Tool Used?	**Who Uses the Tool?**	**How are Weather Sensors and Related Forecasting Used?**	**Requirements**
	Mn/DOT Outstate District Maintenance	• On-line weather resources and value added weather services are accessible to maintenance dispatchers' workstations. • Weather sensors and related forecasting is used to plan pre-treatment and removal of snow and ice.	WS4: Mn/DOT Outstate Maintenance Operators shall have Internet access to outside weather sites (public and private). WS5: Mn/DOT Outstate Maintenance Operators shall have access to RWIS information.

6.4.4 External Constraints of Weather Sensors and Related Forecasting

External constraints involving weather sensors and related forecasting are summarized in the following table.

Table 19: Weather Sensors and Related Forecasting Constraints

Constraint	Description of Constraint
External weather sources	Mn/DOT staff use external weather sources (e.g. weather.com) which are low cost tools. However, these tools are not under any control by Mn/DOT and may be discontinued at any time requiring a substitute data source.

6.4.5 Role of Weather Sensors and Related Forecasting in ITS Architecture

Weather Sensors and Related Forecasting was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATIS as shown in the table below.

Table 20: Role of Weather Sensors and Related Forecasting in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATIS 01 Broadcast Traveler Information	• TI04 Provide current and forecast road and weather condition information	• ATIS 02 Interactive Traveler Information

6.5 Condition Reporting System

A Condition Reporting System supports the manual creation and assembly of current and planned events to be used to populate traveler information systems.

6.5.1 Scenarios for the use of the Condition Reporting System

There are five distinct use case scenarios for the Condition Reporting System:

1. Mn/DOT Metro Freeway Operations Perspective

- Metro Freeway Operations manually enters crashes and other real-time incidents impacting the metro area freeways into the reporting system.

2. Mn/DOT Metro Maintenance Dispatch Perspective

- Metro Maintenance Dispatchers input road condition information into the condition reporting system.
- Metro Maintenance enters planned maintenance into the condition reporting system that will impact travelers, such as lane or road closures.

3. Mn/DOT Outstate District Perspective

- Mn/DOT Outstate Districts work with the State Patrol to input road condition reports into the condition reporting system.
- Mn/DOT Maintenance and Construction enter roadwork activities that will impact travelers.

4. Mn/DOT Construction Perspective

- Mn/DOT Construction enters planned construction and roadwork activities.

5. Mn/DOT Public Affairs Perspective

- Mn/DOT Public Affairs enters Amber Alerts in the Condition Reporting System.

6.5.2 Operations and Maintenance Responsibilities

Operations and maintenance of Condition Reporting Systems are detailed in the table below.

Table 21: Condition Reporting System Operations and Maintenance Responsibilities

Condition Reporting System Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
24X7 hosting and Operations of Condition Reporting System.	• Vendor / Contractor	• Vendor / Contractor
Manual Entry, Edit, and Removal of Events	• Mn/DOT Metro Area Freeway Operations • Mn/DOT Metro Area Construction • Mn/DOT Metro Area Maintenance	• Mn/DOT District Construction • Mn/DOT District Maintenance • Minnesota State Patrol
System management: • User account creation • System Governance • Contractor management • Upgrades and enhancement prioritization	• Mn/DOT Public Affairs	• Mn/DOT Public Affairs

6.5.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why the Condition Reporting System is used (the purposes it performs);
- Who uses the Condition Reporting System (for each purpose);
- How they use the Condition Reporting System; and
- High level requirement considerations based on the use of the Condition Reporting System.

Table 22: Observation and Detection Operational Concept: Condition Reporting System

Traffic Management Action: Observation and Detection **ITS Tool:** Condition Reporting System (CRS)			
Why is CRS Used?	**Who Uses CRS?**	**How is the Condition Reporting System Used?**	**Condition Reporting System Requirements**
Need 11: Manual Event Reporting	Mn/DOT Metro Freeway Operations Mn/DOT Metro Maintenance Mn/DOT Outstate Districts Mn/DOT Outstate State Patrol Mn/DOT Construction	• Condition Reporting System is available to any authorized user through Internet access • Unplanned events (driving conditions, crashes, closures, Amber Alerts) are entered by authorized users from any Internet accessible location. • Planned events (e.g. roadwork, planned closures) are entered into the system and automatically feed the traveler information systems. • All events are entered with an expiration time (time the event automatically is removed from the system) and an operator can delete the event at any time. • Event locations are described by specifying the highway and the start/end locations on the highway; or an entire county. • An automated connection to the Minnesota State Patrol CAD system allows for incident information to be transferred to the CRS. • Loop data is another source of data input to the CRS that has been used in several test applications.	CRS1: Mn/DOT Freeway Operators, Mn/DOT Metro Maintenance, Mn/DOT Outstate Traffic, Outstate State Patrol, and Mn/DOT Construction shall have access via the internet to the Condition Reporting System CRS2: The Condition Reporting System shall allow for event entry of current events or future planned events. CRS3: The Condition Reporting System shall require that all events include a start time/date, end time/date, highway the event occurs on, location along the highway, and at least one standardized phrase describing the event/incident. CRS4: Events entered in to Condition Reporting System (and all data about the events) shall be communicated to Information Sharing ITS Tools (e.g. web pages, 511 phone) automatically.
	Mn/DOT Public Affairs	• Authorized Mn/DOT Public Affairs Staff enters Amber Alerts into the Condition Reporting System.	CRS5: The Condition Reporting System shall provide a mechanism for operators to enter Amber Alerts.

6.5.4 External Constraints of the Condition Reporting System

External constraints involving the Condition Reporting System are summarized in the following table.

Table 23: Condition Reporting System Constraints

Constraint	Description of Constraint
Participation in a multi-state effort	• Mn/DOT currently participates in a multi-state program developing and operating the condition reporting system. This may impact the flexibility of the program or the delivery of services.

6.5.5 Role of the Condition Reporting System in ITS Architecture

The Condition Reporting System was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS and ATIS as shown in the table below.

Table 24: Role of Condition Reporting Systems in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS06 Traffic Information Dissemination • ATIS01 Broadcast Traveler Information	• TM05 Provide incident and congestion information to travelers • TI01 Provide incident information on freeways and major arterials • TI03 Provide traffic flow maps showing recurring or predicted freeway congestion levels • TI05 Provide information on roadway construction and maintenance activities • TI07 Provide information on tollways • TI 08 Provide information on seasonal weight restrictions • TI09 Provide information on CVO permit restrictions • TI10 Operate a statewide web-based and telephone 511 system	• ATIS01 Broadcast Traveler Information • ATIS02 Interactive Traveler Information • ATMS06 Traffic Information Dissemination

6.6 Automatic Vehicle Location (AVL)

Automatic Vehicle Location (AVL) is a means for determining the geographic location of a vehicle and transmitting the information.

6.5.1 Scenarios for the use of the AVL

There are four distinct use case scenarios for AVL:

1. Mn/DOT Metro Freeway Operations Perspective

- The Freeway Incident Response Team (FIRST) vehicles are equipped with AVL. Mn/DOT Metro Freeway Operations utilizes the AVL on FIRST vehicles to track vehicle location and to effectively dispatch the nearest vehicle to an incident.

2. Mn/DOT Metro Maintenance Dispatch Perspective

- Metro Maintenance vehicles are equipped with AVL. AVL provides Metro Area Maintenance dispatchers with an understanding of vehicle positions. Also, demonstrations and operational tests are underway to test 'mobile platforms' that are able to monitor pavement and atmospheric conditions and report these conditions (coupled with the vehicle location) to a central location.

3. Mn/DOT Outstate District Perspective

- Some of the Mn/DOT Outstate Districts have equipped maintenance vehicles with AVL to assist in managing the fleet, and ultimately monitoring conditions and materials deployed.

4. Minnesota State Patrol Perspective

- Minnesota State Patrol vehicles are equipped with AVL to assist in incident response.

6.5.2 Operations and Maintenance Responsibilities

Operations and maintenance of AVL are detailed in the table below.

Table 25: AVL Operations and Maintenance Responsibilities

Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Operate and maintain in-vehicle devices	• Mn/DOT Metro Area FMS Maintenance (FIRST vehicles) • Mn/DOT Metro Area Maintenance (Maintenance vehicles)	• Mn/DOT District Maintenance
Operate and maintain central software and display system	• Mn/DOT Metro Area FMS Maintenance (FIRST vehicles) • Mn/DOT Metro Area Maintenance (Maintenance vehicles)	• Mn/DOT District Maintenance
Operate and maintain wireless communications network	TBD	• Mn/DOT District IT

6.5.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why AVL is used (the purposes it performs);
- Who uses AVL (for each purpose);
- How they use AVL; and
- High level requirement considerations based on the use of AVL.

Table 26: Observation and Detection Operational Concept: AVL

Traffic Management Action: Observation and Detection **ITS Tool:** Automatic Vehicle Location (AVL)			
Why is AVL Used?	**Who Uses AVL?**	**How is AVL Used?**	**AVL Requirements**
Need 18: Vehicle Tracking	Mn/DOT Metro Freeway Operations	• Mn/DOT Metro Freeway Operations utilizes AVL on FIRST vehicles when responding to incidents or vehicle breakdowns. The Freeway Operators are able to determine which FIRST vehicle is in the closest proximity to the incident in order to provide the most efficient response.	AVL1: Mn/DOT Metro Freeway Operations shall have access to FIRST vehicle AVL data.
	Mn/DOT Metro Maintenance	• Metro Area Maintenance dispatchers currently use AVL to track maintenance vehicles when clearing the freeways.	AVL2: Mn/DOT Metro Maintenance shall have access to maintenance vehicle AVL data.
	Mn/DOT Outstate Districts	• Mn/DOT Outstate Districts vehicles with AVL are used to manage fleets of vehicles and provide the most efficient response to an incident.	AVL3 : Mn/DOT Outstate Districts shall have access to District AVL data.
	Minnesota State Patrol	• Minnesota State Patrol vehicles are equipped with AVL to assist in incident response.	AVL4 : Mn/DOT State Patrol shall have access to State Patrol vehicle AVL data.

6.5.4 External Constraints of AVL

External constraints involving AVL are summarized in the following table.

Table 27: AVL Constraints

Constraint	Description of Constraint
Communications medium	• Real-time operations of AVL is constrained by a functioning wireless data communications medium. The AVL needs should be considered before any changes are made to the wireless data communication medium.

6.5.5 Role of AVL in ITS Architecture

AVL was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 28: Role of AVL in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• MC01Maintenance and Construction Vehicle and Equipment Tracking • EM01 Emergency Call-taking and Dispatch	• WZ01 Track locations of maintenance fleet and personnel and usage of materials • E06 Provide AVL to emergency vehicles	• MC06 Winter Maintenance • EM02 Emergency Routing

7.0 Data Processing and Response Formulation

7.1 Operational Concept for Data Processing and Response Formulation

7.1.1 Role in Freeway Traffic Management

Data Processing and Response Formulation consists of automated and manual processes that are performed to determine or create specific approaches to traffic management. In other words, the Observation and Detection action (described in Chapter 6) assembles data, and the data processing and response action uses the data to create the management approaches (manual or automated) that are performed by the information sharing and traffic management actions.

7.1.2 Needs Addressed by Data Processing and Response Formulation

Based upon research and feedback, the following needs are addressed primarily by Data Processing and Response Formulation:

- Need 7: Freeway operational analysis;
- Need 10: Freeway data storage, archive, and access;
- Need 13: Manual device control;
- Need 14: Automated device control; and
- Need 15: Automated algorithm execution.

7.1.3 ITS Tools for Data Processing and Response Formulation

The ITS Tools used to perform data process and response formulation, and therefore address the stated needs include:

- ***Traffic Management Center (TMC) Software***; and
- ***Data Extract Tool***.

The remaining subsections of 7.0 provide a detailed concept of operations for the use of these ITS devices.

7.1.4 Interdependencies of Needs

There are interdependencies between the Data Processing and Response Formulation action and the needs addressed by Data Processing and Response Formulation as shown in the following table.

Table 29: Data Processing and Response Formulation Interdependencies of Needs

In order for Data Processing and Response Formulation to Meet This Need	This Need Must Be Met (The Dependency)	Action Responsible for Meeting Dependency
Need 10: Freeway data storage, archive, and access	Need 2: Traffic and Transportation Infrastructure monitoring	Observation and Detection
Need 13: Manual Device Control	N/A	N/A
Need 14: Automated Device Control	N/A	N/A
Need 15: Automated algorithm execution.	Need 2: Traffic and Transportation Infrastructure monitoring	Observation and Detection

7.2 Traffic Management Center Software (TMC Software)

Traffic Management Center Software is a term used to represent the system or systems operating in either a traffic management center or a virtual traffic management center where operations personnel control ITS devices in order to manage traffic. The ITS tool described in this ConOps is not specific to any one software, but rather refers to a collection of software systems that allow operators or automated algorithms to determine activities for devices such as DMS, CCTV cameras, and Intelligent Lange Control Signs (ILCS). For example, a TMC may use one software (or hardware/software combination) to control cameras, and different software to control DMS. For the sake of this ConOps, this collection of different software solutions is collectively referred to as TMC Software.

7.2.1 Scenarios for the use of TMC Software

There are three distinct use case scenarios for TMC Software:

1. ***Mn/DOT Metro Freeway Operations Perspective***

    - *Automated Traffic Controls* - Metro Freeway Operations uses TMC Software to operate a set of algorithms that control ramp meters, calculate Travel Times on selected routes and post the Travel Times on DMS and to a website, trigger suggested actions for managed corridors (I-35W and soon I-94), and to calculate Mn/PASS HOT lane rates.

    - *Manual Traffic Controls* - Metro Freeway Operations uses TMC Software to perform a variety of manual traffic management controls. The TMC Software allows operators to view information about the freeways including volume, occupancy, and status of ITS devices. The software also allows operators to control field devices such as: controlling the pan/tilt/zoom of cameras, viewing the camera images at workstations and on the wall display, posting lane control signals at the entry point to the Lowry Tunnel, posting messages to the DMS signs, and deliver data to Mn/Pass HOT lanes.

2. Mn/DOT Metro Maintenance Dispatch Perspective

    - Metro Area Maintenance Dispatchers use TMC Software to post messages to DMS at times when Freeway Operations personnel are not on-duty (typically evenings and weekends). Maintenance dispatchers also use the software to position cameras to observe pavement and/or weather conditions.

3. Mn/DOT Outstate District Perspective

    - Mn/DOT Outstate Districts that have TMC Software systems use the software to post messages to DMS signs describing construction, crashes, or other events.

4. Information Service Providers Perspective

- Information service providers will benefit from the TMC Software algorithms and the outputs of these algorithms through Mn/DOT's website. Private information service providers will disseminate the information they receive.

- The RTMC Radio Contractor accesses information through the TMC Software and use the information to build announcements for the broadcast.

7.2.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities of TMC Software are shown in the table below.

Table 30: TMC Software Operations and Maintenance Responsibilities

Operational Activities	Metro Area Responsibility	Outstate Responsibility
Overall operations of software to keep the TMC software running	• Mn/DOT Metro Area Freeway Operations	• Mn/DOT Metro Freeway Operations • Mn/DOT District Traffic Office • Mn/DOT ESS • Mn/DOT Metro Arterial Operation • Mn/DOT District Traffic Office • Software Vendor
Operate and maintain communications with field devices and server systems	• Mn/DOT Metro Area FMS Maintenance • Mn/DOT Metro Area IT	• Mn/DOT District IT • Mn/DOT Maintenance • Mn/DOT ESS
Maintain, support, and update the TMC Software Code	• Mn/DOT Metro Area Freeway Operations • Mn/DOT Metro Area IT	• Mn/DOT Freeway Operations • Software Vendor

7.2.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why visual TMC Software is used (the purposes it performs);
- Who uses TMC Software (for each purpose);
- How they use TMC Software; and
- High level requirement considerations based on the use of TMC Software.

Table 31: Data Processing and Response Formulation Operational Concept: TMC Software

Traffic Management Action: Data Processing and Response Formulation **ITS Tool:** TMC Software			
Why is TMC Software Used?	**Who Uses TMC Software?**	**How is TMC Software Used?**	**TMC Software Requirements**
Need 7: Freeway operational analysis	Mn/DOT Metro Freeway Operations	• Metro Freeway Operations view detector data, event reports, roadwork reports, and other information displayed by the TMC Software to determine the current status of the freeway. Experienced operators can detect incidents by detector value changes. • Freeway operational analysis is a combination of observing conditions, viewing options for response (e.g. pre-defined DMS messages) and selecting the most appropriate response.	

<table>
<tr><td colspan="4">Traffic Management Action: Data Processing and Response Formulation
ITS Tool: TMC Software</td></tr>
<tr><th>Why is TMC Software Used?</th><th>Who Uses TMC Software?</th><th>How is TMC Software Used?</th><th>TMC Software Requirements</th></tr>
<tr><td rowspan="2">Need 13: Manual Device Control (Operator based)</td><td>Mn/DOT Metro Freeway Operations</td><td>TMC Software is the tool that allows operators to view camera images and detector data; and to create commands for field devices that are then relayed to the devices (e.g. controlling cameras, posting messages to DMS, activating lane control signs).
Operators use available data and information (volume, occupancy, camera views) to determine the most appropriate DMS messages to display. DMS messages are selected from pre-defined message options stored in the TMC software (only managers can create text for DMS) and posted to the sign.
Operators can manually override the automated ramp meter algorithm if deemed necessary.
Operators can change the status of the lane control signs (arrow to ‘X’).
Operators use the TMC software to control signs on the managed corridors.
Operators use the TMC software to monitor status of field devices.</td><td rowspan="2">TMC 1: The TMC Software shall communicate with detectors, DMS, CCTV, Ramp Meters and ILCS.
TMC2: The TMC Software shall present operators with a view of current traffic detector data through color coded maps.
TMC3: The TMC Software shall provide a mechanism for operators to select a DMS, Lane Control Sign, or ILCS to view current messages displayed and select messages from pre-defined message lists or symbol lists.
TMC4: The TMC Software shall prioritize DMS message displays according to rules and procedures stored in the TMC Software.
TMC5: The TMC Software shall provide operators a mechanism to control cameras.
TMC6: The TMC Software shall report status of field devices connected to the TMC Software.</td></tr>
<tr><td>Mn/DOT Metro Maintenance</td><td>Operators control freeway management devices (DMS and cameras) from their workstations when critical events occur and Freeway Operations staff are not on duty</td></tr>
</table>

Traffic Management Action: Data Processing and Response Formulation **ITS Tool:** TMC Software			
Why is TMC Software Used?	**Who Uses TMC Software?**	**How is TMC Software Used?**	**TMC Software Requirements**
	Mn/DOT Outstate Districts	• State Patrol dispatchers are usually first alerted to crashes or incidents. MSP dispatchers will post messages to be displayed on DMS	TMC7: The TMC Software shall be accessible to Mn/DOT and MSP operators at any location connected to the Mn/DOT Local Area Network (LAN). TMC8: MSP shall have full entry authority to TMC Software.
Need 15: Automated Algorithm Execution	Mn/DOT Metro Freeway Operations	• An algorithm runs regularly using current detector data to compute Travel Times for pre-defined stretches of road. Stretches of road are not necessarily from intersection to intersection, often they are from a DMS location to a known landmark. <Once computed, the Travel Time is sent to the DMS as a message, and posted on the website for travelers to view>. • An algorithm automatically determines that ramp meters are to be activated based upon time of day. Then meter rates are determined by the algorithm based upon detector data and an internal algorithm. <The TMC software communicates these rates to the ramp meter devices in the field. Manual intervention from operators overrides the automated rates>. • An algorithm automatically determines congestion pricing for the MnPASS lanes. • An algorithm compares detector data on managed corridors and determines messages to be presented to operators based upon thresholds being met.	TMC9: The TMC Software shall operate algorithms that execute calculations using data ingested, and control devices automatically based upon the algorithm rules (e.g. calculate freeway travel times and post travel times to DMS automatically). The current algorithms include: Freeway Travel Times, Ramp Meter Rates, managed corridor messages. TMC10: The TMC Software shall provide a mechanism for operators to override automated algorithms by performing manual controls.

Traffic Management Action: Data Processing and Response Formulation **ITS Tool:** TMC Software			
Why is TMC Software Used?	**Who Uses TMC Software?**	**How is TMC Software Used?**	**TMC Software Requirements**
	Information Service Providers	• Information service providers operate automated systems to access the data outputs of the TMC Software (e.g. travel times calculated and posted on the Mn/DOT website).	TMC11: The TMC Software shall provide a mechanism to post algorithm calculations to external Internet accessible locations to allow outside agencies to view the information.
Need 14: Automated Device Control	Mn/DOT Metro Freeway Operations	• The Travel Times <computed by automated algorithms> are sent to the appropriate DMS as a message, and posted on the website for travelers to view by the TMC software. • When the ramp meter algorithm determines ramp meters should be operational, and determines rates, the TMC software communicates these rates to the ramp meter devices in the field. Manual intervention from operators overrides the automated rates. • The TMC software displays recommended messages to operators for the managed corridors.	TMC 12: The TMC Software shall send control commands to field devices that cause the field devices to perform actions (e.g. display message, display red/green ramp meters) either from manual commands or automated algorithm outcomes.

7.2.4 External Constraints of TMC Software

External constraints involving TMC Software are summarized in the following table.

Table 32: TMC Software Constraints

Constraint	Description of Constraint
Open Source Software	• Mn/DOT Metro Freeway operations are not constrained by any proprietary software (as the metro area TMC Software was developed in-house). The Open source nature allows other agencies to contribute to the software. This may benefit Mn/DOT and should be considered when enhancements are requested (possible sharing of resources with other states). Some outstate districts also use the software.
Proprietary control software	• Some outstate districts deployed vendor software for device control. These might constrain future changes to the system.
Constraint to Observation and Detection	• TMC Software places a constraint on Observation and Detection ITS Tools. In order for TMC Software to perform properly, Observation and Detection must continue to operate, performing traffic detection.
Constraint by Information Sharing (DMS)	• The functionalities and requirements of Information Sharing place a constraint on TMC Software. Changes to TMC Software may impact the ability of Information Sharing ITS Tools (e.g. DMS) to function properly.

7.2.5 Role of TMC Software in ITS Architecture

TMC Software was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for Advanced ATMS as shown in the table below.

Table 33: Role of TMC Software in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS01 Network Surveillance • ATMS04 Freeway Control	• TM20 Operate dynamic shoulders • TM22 Provide a system-coordinated response for incidents • TM23 Operate ramp meters • TM24 Operate freeway/expressway DMS, • TM25 Operate CCTV cameras, and • TM26 Operate MnPASS HOT lanes • TM36 Implement Integrated Corridor Management (ICM) strategies	• ATMS04 Freeway Control • ATMS05 HOV Lane Management • ATMS07 Regional Traffic Management • ATMS10 Electronic Toll Collection • ATMS18 Reversible Lane Management

7.3 Data Extract Tool

Beyond the real-time use of detector data, the detector data for freeways is very valuable for research, planning, and training purposes. Data Extract is a tool for extracting any detector data that is ingested into the TMC software. Data Extract allows any user to access and download data reports over the Internet.

A data extract tool is primarily used for Freeway Operational Analysis. However, there are a variety of users and a variety of reasons why freeway operational analysis is performed.

7.3.1 Scenarios for the use of the Data Extract Tool

The following are distinct use case scenarios for the Data Extract Tool:

1. Mn/DOT Metro Freeway Operations Perspective

- The Metro Area Freeway Operations Group uses the data extract tool to analyze data from freeway segments and make data driven decisions for changes to traffic management, or needs for infrastructure improvements and adjustments.

2. Mn/DOT Metro Planning Perspective

- The Mn/DOT Metro Planning Group uses the data extract tool to analyze detector data to support long term transportation planning.

3. Mn/DOT Outstate Districts Perspective

- Mn/DOT Outstate Districts using the same TMC Software as the RTMC have the capability to analyze data from detected freeway segments.

4. Research Organizations Perspective

- Public and private sector research organizations (e.g. Universities, consultants) use the data extract tool to examine current and historic data for the available freeways.

7.3.2 Operations and Maintenance Responsibility

Operations and maintenance of the Data Extract Tool are detailed in the table below.

Table 34: Data Extract Tool Operations and Maintenance Responsibilities

Data Extract Tool Operation and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Software and servers operations and maintenance	• Mn/DOT Metro Area Freeway Operations	• Mn/DOT Metro Area Freeway Operations • Mn/DOT District Traffic Office • Mn/DOT ESS • Mn/DOT District Traffic Office • Software vendor

7.3.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why the Data Extra Tool is used (the purposes it performs);
- Who uses the Data Extract Tool (for each purpose);
- How they use the Data Extract Tool; and
- High level requirement considerations based on the use of the Data Extract Tool.

Table 35: Data Processing and Response Formulation Operational Concept: Data Extract Tool

Traffic Management Action: Data Processing and Response Formulation **ITS Tool:** Data Extract Tool			
Why is the Data Extract Tool Used?	**Who Uses the Data Extract Tool?**	**How is the Data Extract Tool Used?**	**Data Extract Tool Requirements**
Need 10: Freeway data storage, archive, and access	Mn/DOT Metro Freeway Operations	• The data extract is accessed over the internet, reports are downloaded as spreadsheets. • Data Extract Tool is used to request and receive reports from any combination of detectors on the freeways for any time periods (pending availability of data). • Volume and occupancy data for mainline and ramps are viewed to study trends, analyze driver reactions to incidents or events, or to understand current traffic patterns.	DET1: The Data Extract Tool shall be accessible to any agency using Internet connectivity. DET2: The Data Extract Tool shall allow downloading of past data that includes any and all data stored in the system.
	Mn/DOT Metro Planning	• Data Extract Tool is used to access actual traffic data to be used as inputs to the long term modeling and planning.	DET1: The Data Extract Tool shall be accessible to any agency using Internet connectivity.
	Mn/DOT Outstate Districts	• The data extract is accessed over the internet, reports are downloaded as spreadsheets. • Data Extract Tool is used to request and receive reports from any combination of detectors on the freeways for any time periods (pending availability of data). • Volume and occupancy data are viewed to study trends, analyze driver reactions to incidents or events, or to understand current traffic patterns.	DET1: The Data Extract Tool shall be accessible to any agency using Internet connectivity. DET2: The Data Extract Tool shall allow downloading of past data that includes any and all data stored in the system.
	Other Agencies	• Data Extract Tool allows any user to access historical volume and occupancy data throughout the metro freeway networks. Research agencies and consulting firms can use this to develop algorithms, examine data trends, and understand the impacts of incidents or events.	DET1: The Data Extract Tool shall be accessible to any agency using Internet connectivity.

7.3.4 External Constraints of the Data Extract Tool

External constraints involving the Data Extract Tool are summarized in the following table.

Table 36: Data Extract Tool Constraints

Constraint	Description of Constraint
Uses outside Traffic Management	• There are a number of uses for the Data Extract Tool outside traffic. Some examples are short and long term planning, and research. These uses should be considered before any significant changes to the service are made.
Constraint to Traffic Detectors	• The Data Extract Tool works with existing traffic detectors and detector formats. Any changes to traffic detectors or additions of new types of detectors may require modifications to the data extract tool to maintain compatibility.

7.3.5 Role of the Data Extract Tool in ITS Architecture

The Data Extract tool was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 37: Role of the Data Extract Tool in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS09 Traffic Forecast and Demand Management	• TM03 Use archived data for traffic management strategy development and long range planning	• AD1 Data Mart • AD2 Data Warehouse

8.0 Information Sharing

8.1 Operational Concept for Information Sharing

8.1.1 Role in Freeway Traffic Management

In the overall picture of traffic management, once data, visual observations, and manual event reports are gathered (in the Observation and Detection 'Action'), and the data are processed and traffic management responses are formulated, there are two real-time traffic management actions that are performed by traffic management personnel:

- Information is shared with travelers and other agencies; and
- Traffic controls are implemented to restrict or allow movement of vehicles.

The emphasis of this section is on information sharing. Information sharing describes the sharing of data and information with agencies outside Mn/DOT, with the traveling public, and with other sections within Mn/DOT. The overall role in freeway traffic management is to share real-time and historic data and information to assist travelers' decision making, and to share information with other transportation professionals to support manual and automated traffic control.

8.1.2 Needs Addressed by Information Sharing

Based upon research and feedback, the following needs are primarily addressed by Information Sharing:

- Need #4: En-route travel time/congestion notification;
- Need #5: En-route unplanned event notification;
- Need #6: En-route planned event notification;
- Need #17: Center-to-Center communication; and
- Need #19: Computer Aided Dispatch (CAD).

8.1.3 ITS Tools for Information Sharing

The ITS Tools used to perform information sharing, and therefore address the stated needs include:

- ***Dynamic Message Signs (DMS);***
- ***Radio Broadcasts;***
- ***Web Pages (including RSS feeds);***
- ***511 Phone systems: and***
- ***Computer Aided Dispatch.***

8.1.4 Interdependencies of Needs

There are interdependencies between the Action of Information Sharing and the needs addressed by Information Sharing as shown in the following table.

Table 38: Information Sharing Interdependencies of Needs

In Order for Information Sharing to Meet This Need	This Need Must Be Met (The Dependency)	Action Responsible for Meeting Dependency
Need 4: En-route travel time/congestion notification Need 5: En-route unplanned event notification	Need 6: Freeway Operational Analysis Need 13: Manual Device Control Need 14: Automated Device Control Need 15: Automated Algorithm Execution	Data Processing and Response Formulation
	Need 1: Incident/Event verification Need 2: Traffic and transportation infrastructure monitoring	Observation and Detection
Need 6: En-route planned event notification	Need 11: Manual Event Reporting	
	Need 6: Freeway Operational Analysis Need 13: Manual Device Control	Data Processing and Response Formulation
Need #17: Center-to-Center communication	No Dependencies	N/A

8.2 Dynamic Message Signs

DMS are either fixed or portable signs capable of displaying text messages (or text and graphics) selected for display by an operator (either locally or through remote access).

8.2.1 Scenarios for the use of Dynamic Message Signs

There are four distinct use case scenarios for DMS:

1. ***Mn/DOT Metro Freeway Operations Perspective***

- Travel times or related congestion descriptions are displayed on DMS to provide travelers with information that may allow them to divert their travel, or to simply inform travelers of expected conditions. Because of the dynamic nature of these alerts, the messages are generated automatically. The current approach is to calculate messages using algorithms that utilize real-time detector data as described in the Data Processing and Response Formulation section. However, other sources (including private sector service providers) could be utilized.

- DMS is used to inform travelers of unplanned events and incidents, including such things as crashes, lane closures, Amber Alerts, or obstructions in the roadway.

- DMS is used to inform travelers of planned events and incidents, including such things as roadwork or planned closures. In these instances, alert messages may be posted before the event occurs.

- There is a hierarchy of messages to be displayed with an associated level of priority. For example, Travel Times are displayed automatically during peak periods. Higher priority messages will override Travel Time messages. When Travel Times are not reported and there are no current incidents, the signs may be used for information describing construction, public safety messages, and Amber Alerts.

2. Mn/DOT Metro Maintenance Dispatch Perspective

- Metro Area Maintenance Dispatchers post messages to the metro area DMS to notify travelers about roadwork activities during nights and weekends. Some examples of this are when they close a lane during off-peak hours and feel it is critical to alert travelers to the lane closure in advance of the closure. Because maintenance personnel are on duty 24 hours a day/7 days a week, they post messages to the DMS during periods when Freeway Operations dispatchers are not staffed. These messages may include descriptions of crashes or other events.

3. Mn/DOT Outstate Districts Perspective

- Mn/DOT Outstate Districts use DMS to describe events such as roadwork, lane closures, or major weather events. When possible, descriptions of crashes or other incidents are posted on the DMS. DMS messages are either posted by traffic operations staff or by Minnesota State Patrol dispatchers (who are on duty 24/7) working in local TOCs.

4. Traveling Public Perspective

- The traveling public uses information provided on the DMS to make travel decisions. The messages provide sufficient information about current conditions to assist en-route decision making.

5. Local Cities and Counties Perspective

- When incidents and event impact local roads (county or city), there may be situations where messages are broadcast on Mn/DOT DMS on the freeways to inform travelers who may be exiting to the local roads about the situation.

8.2.2 Operations and Maintenance Responsibility

Operations and maintenance responsibilities for DMS are shown in the table below.

Table 39: DMS Operations and Maintenance Responsibilities

Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Content selection for DMS display Real-time decisions about the information to be disseminated to travelers (e.g. is there roadwork to report? Is a crash impacting the freeway?)	• Mn/DOT Metro Freeway Operations	• State Patrol • Mn/DOT District Traffic
Controlling and Activating DMS	• Mn/DOT Metro Freeway Operations	• State Patrol • Mn/DOT District Traffic • Mn/DOT District Construction • Mn/DOT District Maintenance • Construction Contractor
Maintain existing DMS	• Mn/DOT Metro FMS Maintenance	• Mn/DOT District Maintenance • Mn/DOT District IT Maintenance • Mn/DOT District Traffic • Mn/DOT District ESS
Maintain communications with DMS	• Mn/DOT Metro FMS Maintenance	• Mn/DOT District ESS

8.2.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why DMS is used (the purposes it performs);
- Who uses DMS (for each purpose);
- How they use DMS; and
- High level requirement considerations based on the use of DMS.

Table 40: Information Sharing Operational Concept: Dynamic Message Signs

Traffic Management Action: Information Sharing **ITS Tool:** Dynamic Message Sign			
Why are DMS Used?	**Who Uses DMS?**	**How is DMS Used?**	**DMS Requirements**
Need 4: En-route travel time/ congestion notification	Mn/DOT Metro Freeway Operations	• Automated calculations of travel times will generate messages describing freeway travel times to key landmarks, and messages will automatically be sent to the appropriate DMS based upon the algorithm rules (role of Data Processing and Response Formulation) . • Travel Time message are posted only during peak periods and follow standard RTMC protocols for message priority. • Freeway Operations is responsible for configuring which DMS display Travel Time messages and which landmarks are used to describe Travel Times. • Manually created messages describing unplanned congestion (not travel times) are entered by operators when observed through visual surveillance or analysis of detector data. Congestion reports may be entered in the Condition Reporting System and/or entered for posting to DMS signs. • Manually created messages are either entered with an expiration time/date, or are manually removed by operators.	DMS1: Freeway DMS shall receive communications from TMC Software describing messages to be displayed on the sign. DMS2: Freeway DMS shall confirm successful receipt of the communications from TMC Software. DMS3: Freeway DMS shall communicate to the TMC Software the current messages displayed on the DMS.
	Traveling public (Freeway commuters)	• Travelers will view DMS message and select whether to use an alternate route or continue on the current route. • Travelers benefit from understanding the extent of the travel delays (Travel Times) or the cause of the congestion (e.g. 'crash ahead expect delays').	DMS4: Freeway DMS shall be located strategically to support decision points for travelers. DMS6: DMS displays shall be appropriate for viewing at freeway speeds.

Traffic Management Action: Information Sharing **ITS Tool:** Dynamic Message Sign			
Why are DMS Used?	**Who Uses DMS?**	**How is DMS Used?**	**DMS Requirements**
Need 5: En-route unplanned event notification	Mn/DOT Metro Freeway Operations	• When incidents are observed on cameras or reported through cellular 911 (via Minnesota State Patrol), or other delay causing events are observed, Freeway Operations dispatchers will post messages to freeway DMS informing travelers of conditions. • Freeway Operations dispatchers will use the TMC software to enter events.	DMS1: Freeway DMS shall receive communications from TMC Software describing messages to be displayed on the sign. DMS2: Freeway DMS shall confirm successful receipt of the communications from TMC Software. DMS3: Freeway DMS shall communicate to the TMC Software the current messages displayed on the DMS. DMS5: Freeway DMS shall be capable of displaying all possible messages pre-defined in the TMC Software.

Traffic Management Action: Information Sharing **ITS Tool:** Dynamic Message Sign			
Why are DMS Used?	**Who Uses DMS?**	**How is DMS Used?**	**DMS Requirements**
	Mn/DOT Outstate Districts	• State Patrol dispatchers are usually first alerted to crashes or incidents. MSP dispatchers primarily will post messages to be displayed on DMS. Mn/DOT Traffic personnel also have the capability to post messages.	DMS1: Freeway DMS shall receive communications from TMC Software describing messages to be displayed on the sign. DMS2: Freeway DMS shall confirm successful receipt of the communications from TMC Software. DMS3: Freeway DMS shall communicate to the TMC Software the current messages displayed on the DMS. DMS5: Freeway DMS shall be capable of displaying all possible messages pre-defined in the TMC Software.
	Local Cities & Counties	• Local cities or counties may call the RTMC to request messages posted on the freeway DMS advising travelers of incidents on local roads that impact freeway driving.	
	Traveling Public	• View incident notifications on DMS to assist in selecting routes.	DMS4: Freeway DMS shall be located strategically to support decision points for travelers. DMS6: DMS displays shall be appropriate for viewing at freeway speeds.

Traffic Management Action: Information Sharing **ITS Tool:** Dynamic Message Sign			
Why are DMS Used?	**Who Uses DMS?**	**How is DMS Used?**	**DMS Requirements**
Need 6: En-route planned event notification	Mn/DOT Metro Freeway Operations	• Freeway Operations will make a decision of when to post descriptions of roadwork activities (based upon other events occurring). Events such as lane closures that result from short-term construction and maintenance are typically posted.	DMS1: Freeway DMS shall receive communications from TMC Software describing messages to be displayed on the sign. DMS2: Freeway DMS shall confirm successful receipt of the communications from TMC Software. DMS3: Freeway DMS shall communicate to the TMC Software the current messages displayed on the DMS.
	Mn/DOT Maintenance	• Post maintenance and roadwork messages during times when Freeway operations are not on duty.	
	Traveling Public	• View event information to follow a path to an event or to avoid the route during construction/maintenance.	DMS4: Freeway DMS shall be located strategically to support decision points for travelers. DMS6: DMS displays shall be appropriate for viewing at freeway speeds.

8.2.4 External Constraints of Dynamic Message Signs

External constraints involving dynamic message signs are summarized in the following table.

Table 41: Dynamic Message Signs Constraints

Constraint	Description of Constraint
DMS Location	• The location and spacing of DMS is critical to the messages posted on the DMS (e.g. key decision points). • The role of each user and use case scenario should be considered when identifying the location of a DMS. • Other factors such as morning and evening glare, natural and man-made obstructions, should also be considered.
DMS Power Source	• The location of the power source for the DMS should be considered
Communications with DMS	• Individual use case scenarios should be considered when designing communications for a DMS (e.g. whether redundant communications is required)
Constraint to Data Processing and Response Formulation	• The ITS Tool DMS places a constraint on data processing and response formulation, as the functionality of DMS is dependent upon the actions performed by data processing and response formulation.

8.2.5 Role of Dynamic Message Signs in ITS Architecture

Dynamic Message Signs were identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 42: Role of the DMS in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS06 Traffic Information Dissemination	• TM24 Operate Freeway/Expressway DMS	• ATMS 06 Traffic Information Dissemination

8.3 Radio Broadcasts

Radio broadcasts refer to those tools that broadcast information over a radio frequency to radio receivers owned and operated by travelers. These tools offer extremely low cost options for travelers to hear traffic and weather information. In Minnesota, radio broadcasts may include either public radio systems (e.g. low bandwidth Highway Advisory Radio (HAR) systems using limited frequency ranges) or private sector commercial radio broadcasts that combine traffic reports with news, entertainment and music.

8.3.1 Scenarios for the use of Radio Broadcasts

There are four distinct use case scenarios for radio broadcasts:

1. Mn/DOT Metro Freeway Operations Perspective

- Mn/DOT Freeway Operations provides a workstation to a Radio Announcer for peak period traffic reports. The workstation allows on-air talent to view camera images and interact with Freeway Operations dispatchers to learn about major events.

- Mn/DOT provides a real-time RSS data feed that private sector radio media outlets may access for traffic data. Mn/DOT also provides video access to media outlets. Beyond providing data and video, Mn/DOT has no additional role in private media delivery.

2. Mn/DOT Public Affairs (Metro and Outstate) Perspective

- Mn/DOT Public Affairs and public information officers issue press releases and notices about major events to the media outlets. These announcements may include long-term roadwork expected to impact travel, traffic management changes, or other newsworthy announcements.

3. Media Outlets' (Information Service Providers) Perspective

- A radio announcer provides traffic reports during peak times from the Mn/DOT Regional Transportation Management Center. This is in a unique partnership with Mn/DOT.

- Other news media outlets access data (from Mn/DOT and other sources) and view video reports to generate traffic announcements.

4. Traveling public Perspective

- The traveling public listens to traveler information messages from information service providers through radio broadcasts which typically occur during morning and evening commute times, or during inclement weather. The messages are typically broadcast at regular intervals (e.g. every 10 minutes or every 30 minutes) to allow travelers to tune in for regular reports.

8.3.2 Operations and Maintenance Responsibility

Operation responsibilities for Radio Broadcasts are shown in the table below.

Table 43: Radio Broadcasts Operations Responsibilities

Radio Broadcasts Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Operations of RTMC Radio Broadcasts, and related maintenance	• RTMC Radio Contractor • Mn/DOT Freeway Operations provides workstation and access to camera and data views	N/A
Operating a continuous real-time RSS data feed for all media outlets to access	• Mn/DOT Freeway Operations	N/A

8.3.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why radio broadcasts are used (the purposes it performs);
- Who uses radio broadcasts (for each purpose);
- How they use radio broadcasts; and
- High level requirement considerations based on the use of radio broadcasts.

Table 44: Information Sharing Operational Concept: Radio Broadcasts

Traffic Management Action: Information Sharing **ITS Tool:** Radio Broadcasts			
Why is the Tool Used?	**Who Uses the Tool?**	**How is are Radio Broadcasts Used?**	**Radio Broadcast Requirements**
Need 5: En-route unplanned event notification Need 6: En-route planned event notification	Mn/DOT Metro Freeway Operations	• Freeway Operations dispatchers and managers can utilize the RTMC radio broadcasts to alert travelers to major traffic situations by relaying messages to the announcer. • During incidents (e.g. weather or major traffic incidents) the RTMC radio announcer can operate in continuous traffic reporting mode.	RB1: RTMC Radio Contractor broadcasts shall have metro wide coverage. RB2: RTMC Radio Contractor broadcasters shall have access to camera images. RB3: Metro Freeway Operators shall have a mechanism to communicate directly to the RTMC Radio Contractor announcers.
	Mn/DOT Public Affairs (Metro & Outstate)	• Private media outlets are used as a tool to reach travelers with non real-time messages issued as press releases. There is little or no control over how the media outlets use the information.	RB4: Mn/DOT shall operate a mechanism to post press releases describing traffic events, incidents, or changes in traffic management strategies.
	Information Service Providers	• Media outlets prepare and disseminate traffic reports via the radio • Media outlets utilize Mn/DOT's 800 Mhz system to assist in preparing traffic reports	RB5: Information service providers shall have access to Mn/DOT's 800 MHz system.
	Public	• Travelers listen to traffic reports via the radio en-route and pre-trip	RB5: The Traveling Public shall have a mechanism to listen to radio broadcasts.

8.3.4 External Constraints of Radio Broadcasts

External constraints involving radio broadcasts are summarized in the following table.

Table 45: Radio Broadcasts Constraints

Constraint	Description of Constraint
External traveler information source	Mn/DOT Metro Area Freeway Operations staff utilizes the RTMC Radio Contractor to alert travelers to traffic situations since they are collocated at the RTMC. The RTMC Radio Announcer is a useful tool for Mn/DOT, however the service is on a contract basis.
Constraint to Visual Observations	The RTMC radio broadcasts rely on Visual Observations (cameras).

8.3.5 Role of Radio Broadcasts in ITS Architecture

Radio broadcasts were identified in the Minnesota Statewide Regional Architecture as a need/potential solution for Advanced Transportation Information Systems (ATIS) as shown in the table below.

Table 46: Role of the Radio Broadcasts in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
ATIS01 Broadcast Traveler Information	• TI01 Provide incident information on freeways and major arterials (via KBEM and media), • TI04 Provide current and forecast weather condition information, and • TI05 Provide information on roadway.	• ATIS01 Broadcast Traveler Information • ATIS 02 Interactive Traveler Information • ATMS 06 Traffic Information Dissemination

8.4 Web Pages

Internet web pages refer to websites that allow travelers to view travel information using such strategies as camera image displays, color coded maps, or text descriptions. Web pages that display travel information are operated by Mn/DOT as well as a variety of other public and private agencies and companies. For example, information service providers operate web pages, and commercial media outlets operate web pages.

8.4.1 Scenarios for the use of Web Pages

There are four distinct use case scenarios for web pages:

1. Mn/DOT Statewide Real-time Traveler Information Website Perspective

- Mn/DOT operates a statewide travel information website (http://511mn.org). Information consists of road conditions, camera links, roadwork, crashes, and travel weather information as well as broadcasting AMBER Alerts.

- The statewide website delivers pre-trip and en-route information to travelers about planned roadwork, driving conditions, and real-time crashes and other incidents.

2. Mn/DOT Metro Freeway Operations Perspective

- Freeway Operations operates a website with a traffic flow map, camera images, travel times, and incidents/events.

3. Mn/DOT Outstate Districts Perspective

- Some Mn/DOT Districts operate local web pages as part of the overall Mn/DOT website (http://www.dot.state.mn.us). Local web pages contain links to project (construction) pages and may include information about projects (e.g. maps, diagrams, budget and schedule). Local information is used to educate and inform local residents about the plans for construction (budget, schedule, impact to traffic). Local sites may link to camera images and include real-time event information to assist in planning trips.

4. Media Outlets / Information Service Providers' Perspective

- Numerous private sector information service providers operate websites displaying much of the same information displayed on the Mn/DOT real-time travel information websites. The private providers' access data through the live Mn/DOT RSS data feed.

8.4.2 Operations and Maintenance Responsibility

Operations and maintenance responsibilities for Web Pages are shown in the table below.

Table 47: Web Pages Operations Responsibilities

Operational Activities	Metro Area Responsibility	Outstate Responsibility
Information content creation Content for the Mn/DOT websites is provided by the traffic detectors, Condition Reporting System, and visual observation (as described in the 'Observation and Data Gathering' section)	• Mn/DOT Metro Area Freeway Operations • Mn/DOT Metro Area Maintenance • Mn/DOT Metro Area Construction	• State Patrol • Mn/DOT District Traffic • Mn/DOT District Construction • Mn/DOT District Maintenance
Overall Operations and Maintenance of Websites	• Mn/DOT Metro Area Freeway Operations (Mn/DOT site) • Vendor/contractor (statewide site)	• Vendor Contractor
24/7 operations, including monitoring and support to correct system outages	• Mn/DOT Metro Area Freeway Operations • 511 Contractor	• 511 Contractor
Monitor bandwidth	• Mn/DOT Metro Area Freeway Operations • 511 Contractor	• Mn/DOT IT Maintenance • 511 Contractor

8.4.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why web pages are used (the purposes it performs);
- Who uses web pages (for each purpose);
- How they use web pages; and
- High level requirement considerations based on the use of web pages.

Table 48: Information Sharing Operational Concept: Web Pages

Traffic Management Action: Information Sharing **ITS Tool:** Web Pages			
Why are Web Pages Used?	**Who Uses Web Pages?**	**How are Web Pages Used?**	**Web Pages Requirements**
Need 5: En-route unplanned event notification Need 6: En-route planned event notification Need #17: Center-to-Center communica-tion	Mn/DOT Freeway Operations	• All information describing events that is displayed on the website is either automated (i.e. assembled from detectors and displayed on maps automatically) or entered in to the Condition Reporting System. • Camera images are displayed on the web site as a mechanism for sharing camera views with the traveling public and other transportation agencies.	WP1: Mn/DOT web pages shall receive data and information describing events, incidents, traffic, and driving conditions. WP2: Mn/DOT web pages shall format data and information and display content using a combination of map and text based displays. WP3: Mn/DOT web pages shall present camera images and allow web page users to view the location of the camera, as well as the image.
	Mn/DOT Outstate Districts	• Descriptions about roadwork projects are created by District Staff, and updated as appropriate.	WP4: Mn/DOT web pages shall allow for District specific 'pages' to display local content entered locally.
	Public	• Travelers view traveler information via web pages pre-trip • Travelers view travel information via web pages using mobile devices such as iPhones and Blackberries.	WP5: Mn/DOT web pages shall load quickly using typical Internet connections. WP6: Mn/DOT web pages shall provide mobile device specific views.
	Information Service Providers	• Private information service providers may capture data and information from Mn/DOT websites to rebroadcast on the private website.	WP3: Mn/DOT web pages shall present camera images and allow web page users to view the location of the camera, as well as the image.

8.4.4 External Constraints of Web Pages

External constraints involving web pages are summarized in the following table.

Table 49: Web Pages Constraints

Constraint	Description of Constraint
Participation in a multi-state effort	• Mn/DOT participates in a multi-state program developing and operating the condition reporting system which provides the data for the 511 web display. This may impact the flexibility of the program or the delivery of services.
Traffic Detectors	• The Mn/DOT Metro Area utilizes traffic detector data to post travel times on the Twin Cities Metro Traffic Map web display. Available traffic detector data may impact the ability to provide travel times.
Cameras	• The Mn/DOT Metro Area displays camera images on the Twin Cities Metro Traffic Map web display. Communication to the metro area cameras may impact the ability to provide camera images.
Constraint to Data Processing and Response Formulation	• The ITS Tool 'Web pages' places a constraint on data processing and response formulation as the functionality of web pages are dependent upon the actions performed by data processing and response formulation.

8.4.5 Role of Web Pages in ITS Architecture

Web Pages were identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 50: Role of Web Pages in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS06 Traffic Information Dissemination • ATMS01 Network Surveillance	• TM05 Provide incident and congestion information to travelers • TM09 Share surveillance video data, and other information with PSAPs	• ATIS01 Broadcast Traveler Information • ATIS02 Interactive Traveler Information • ATMS06 Traffic Information Dissemination • ATMS08 Traffic Incident Management

8.5 511 Phone

The FCC has designated 511 as the universal three digit telephone number for travel information. Minnesota operates a 511 phone system as an ITS Tool for dissemination of travel information.

8.5.1 Scenarios for the use of 511 Phone

The following are distinct use case scenarios for 511 Phone:

1. Mn/DOT Statewide Perspective

- Mn/DOT provides real-time travel information on Mn/DOT's 511 Phone. Information consists of road conditions, travel times, construction detours, road congestion, and travel weather information as well as broadcasting AMBER alerts.

- All information on the 511 phone system is populated automatically from the Condition Reporting System.

2. Traveling public Perspective

- The traveling public hears traveler information messages through the Mn/DOT 511 Phone System. The phone messages provide sufficient information about current conditions to assist pre-trip route decision making.

8.5.2 Operations and Maintenance Responsibility

Maintenance and operations responsibilities for the 511 Phone system are outlined in the following table.

Table 51: 511 Phone Operations and Maintenance Responsibilities

511 Phone Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
24/7 Operations of the Phone system Information for the 511 phone system is pulled from the Condition Reporting System, and therefore requires no manual intervention. However, operations of the servers and connections to CARS must be maintained.	• Mn/DOT Public Affairs • 511 Contractor	• Mn/DOT Public Affairs • 511 Contractor
Maintenance of the 511 Phone System	• Mn/DOT Public Affairs • 511 Contractor	• Mn/DOT Public Affairs • 511 Contractor

8.5.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why 511 Phone is used (the purposes it performs);
- Who uses 511 Phone (for each purpose);
- How they use 511 Phone; and
- High level requirement considerations based on the use of the 511 Phone.

Table 52: Information Sharing Operational Concept: 511 Phone

Traffic Management Action: Information Sharing **ITS Tool:** 511 Phone			
Why is 511 Phone Used?	**Who Uses 511 Phone?**	**How is 511 Phone Used?**	**511 Phone Requirements**
Need 5: En-route Unplanned Event Notification Need 6: En-route Planned Event Notification	Mn/DOT Public Affairs	• Content for the 511 phone system is automatically generated from events in the Condition Reporting System • Amber Alerts may be recorded as a "floodgate message" played at the onset of the call by authorized Mn/DOT representatives. • The "floodgate message" feature – an announcement played at the onset of the call could allow for manually recorded announcements (e.g. recorded by the RTMC Radio operator).	511P1: The 511 Phone shall automatically create messages to play to callers based upon stored incidents and event descriptions. 511P2: The 511 Phone shall provide a mechanism for manually recorded 'floodgate' messages to be recorded one time and then played each time a caller calls the system.
	Traveling Public	• Travelers call 511 for real-time traffic reports, and receive route based reports of the conditions they can expect currently on the highway.	511P3: The Traveling Public shall have a mechanism to access the 511 Phone.

8.5.4 External Constraints of 511 Phone

External constraints involving 511 Phone are summarized in the following table.

Table 53: 511 Phone Constraints

Constraint	Description of Constraint
Participation in a multi-state effort	Mn/DOT participates in a multi-state program developing and operating the condition reporting system which provides the information for the 511 Phone. This may impact the flexibility of the program or the delivery of services.
Constraint to Data Processing and Response Formulation	The ITS Tool 511 Phone places a constraint on data processing and response formulation, as the functionality of 511 Phone is dependent upon the actions performed by data processing and response formulation.

8.5.5 Role of 511 Phone in ITS Architecture

511 Phone was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 54: Role of 511 Phone in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS06 Traffic Information Dissemination	• TM05 Provide incident and congestion information to travelers.	• ATIS01 Broadcast Traveler Information • ATIS02 Interactive Traveler Information • ATMS06 Traffic Information Dissemination

8.6 Computer Aided Dispatch (CAD)

Computer Aided Dispatch (CAD) refers to software systems that promote efficiency in dispatching field personnel (e.g. maintenance personnel, emergency responders). Operators typically enter incidents or events in to CAD systems and dispatch personnel appropriately. CAD systems are therefore, good sources of information about current incidents or events.

8.5.1 Scenarios for the use of Computer Aided Dispatch

The following are distinct use case scenarios for CAD:

1. ***Mn/DOT Freeway Operations use of CAD***

    - Mn/DOT Freeway Operations use CAD to receive incident information from MSP, and to share incident information with MSP.

    - Mn/DOT Freeway Operations has an semi-automated link between CAD and the Condition Reporting System, allowing the CRS to be populated with CAD events to be shared with the traveling public.

2. ***Minnesota State Patrol Perspective***

    - Minnesota State Patrol uses CAD for dispatching and responding to incidents. Mn/DOT Freeway Operations has access to view CAD events. Therefore, it is an information sharing tool to Mn/DOT and ultimately the traveling public.

8.5.2 Operations and Maintenance Responsibility

Maintenance and operations responsibilities for CAD are outlined in the following table.

Table 55: CAD Operations and Maintenance Responsibilities

Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
CAD system operations	• Minnesota State Patrol	• Minnesota State Patrol
Operations of the automated link to Mn/DOT Condition Reporting System	• Mn/DOT Metro Area Freeway Operations	• Mn/DOT Metro Area Freeway Operations

8.5.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why CAD is used (the purposes it performs);
- Who uses CAD (for each purpose);
- How they use CAD; and
- High level requirement considerations based on the use of CAD.

Table 56: Information Sharing Operational Concept: CAD

Traffic Management Action: Information Sharing **ITS Tool:** Computer Aided Dispatch (CAD)			
Why is CAD Used?	**Who Uses CAD?**	**How is CAD Used?**	**CAD Requirements**
Need #19 Inter-agency incident information sharing	Mn/DOT Freeway Operations	• Mn/DOT Freeway Operations personnel have a 'view only' access monitor to view incidents in the MSP CAD system. • Freeway operators use CAD to understand the impacts and the response actions being performed for active incidents and respond by posting messages to DMS, altering ramp meter rates, or other traffic management response processes. • Freeway operators use the automated link between CAD and the CRS to populate the CRS with incidents in real-time to include as many incidents as possible in the traveler information dissemination.	CAD-1: The CAD system shall publish incident data to an Internet accessible location. CAD-2: The CAD system shall remove any sensitive or restricted information before publishing incident information.
	Minnesota State Patrol	• Minnesota State Patrol dispatchers enter incident in the CAD system for their purposes of responding to incidents. • MSP operators use CAD as a mechanism to inform Mn/DOT of the incident and response actions.	CAD-1: The CAD system shall publish incident data to an Internet accessible location. CAD-2: The CAD system shall remove any sensitive or restricted information before publishing incident information.

8.5.4 External Constraints of CAD

External constraints involving CAD are summarized in the following table.

Table 57: CAD Constraints

Constraint	Description of Constraint
MSP CAD Operations	Mn/DOT's use of CAD for information gathering is constrained by MSP operating the CAD system and allowing Mn/DOT access to the information.
CAD-CARS Integration	The semi-automated CARS ingest of CAD data is constrained by MSP pushing data out of the CAD system, and by MSP ensuring that any 'restricted' information is stripped from the data feed before Mn/DOT has access to the feed.

8.5.5 Role of CAD in ITS Architecture

CAD was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATIS and ATMS as shown in the table below.

Table 58: Role of the CAD in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATIS06 Transportation Operations Data Sharing • ATMS06 Traffic Information Dissemination • EM01 Emergency Call-taking and Dispatch	• TI12 Share/integrate public safety CAD data with CARS • TM13 Provide incident information to emergency management agencies • E01 Provide CAD to CAD integration for multi-agency coordination at major incidents • E05 Operate and enhance CAD system	• ATMS08 Traffic Incident Management System

9.0 Traffic Control

9.1 Operational Concept for Traffic Control

9.1.1 Role in Freeway Traffic Management

Traffic control describes the action of regulating or guiding traffic on the freeway based upon the data and information gathered and the calculations and assessments performed. Controlling traffic on the freeway is a key component to maintaining traffic flow for the traveling public and is closely related to Information Sharing as a tool to maintain efficient and effective traffic flows.

9.1.2 Needs Addressed by Traffic Control

Based upon research and feedback, the following needs are primarily addressed by Traffic Control:

- Need 8: Individual lane control;
- Need 9: Zonal or isolated freeway access;
- Need 12: Lane access management; and
- Need 16: Automated/manual road closure.

9.1.3 ITS Tools for Traffic Control

The ITS Tools used to perform traffic observation and detection, and therefore address the stated needs include:

- ***Lane Control Signs***;
- ***Ramp Meters***;
- ***Electronic Toll Collection***; and
- ***Gate Closure Systems***.

9.1.4 Interdependencies of Needs

There are interdependencies between the Action of Traffic Control and the needs addressed by Traffic Control as shown in the following table.

Table 59: Traffic Control Interdependencies of Needs

In Order for Traffic Control to Meet This Need	This Need Must Be Met (The Dependency)	Action Responsible for Meeting Dependency
Need 8: Individual lane control	Need 2: Traffic and transportation monitoring	Observation and detection
	Need 1: Incident/event verification	Observation and detection
	Need 11: Manual Event Reporting	Data Processing and Response Formulation
	Need 15: Automated Algorithm Execution	Data Processing and Response Formulation
	Need 13: Manual Device Control	Data Processing and Response Formulation
	Need 14: Automated Device Control	Observation and detection
Need 9: Zonal or isolated freeway access	Need 2: Traffic and transportation monitoring	Observation and detection
	Need 15: Automated Algorithm Execution	Data Processing and Response Formulation
	Need 13: Manual Device Control	Data Processing and Response Formulation
	Need 14: Automated Device Control	Data Processing and Response Formulation
Need 12: Lane access management	Need 2: Traffic and transportation monitoring	Observation and detection
	Need 15: Automated Algorithm Execution	Data Processing and Response Formulation
	Need 14: Automated Device Control	Data Processing and Response Formulation
Need 16: Automated/manual road closure	Need 13: Manual Device Control	Data Processing and Response Formulation
	Need 2: Traffic and Transportation Infrastructure monitoring	Observation and detection

9.2 Lane Control Signs

Lane Control signs are directional signs which clearly display lane usage (cross and arrow) and advisory speeds as well as text messages.

9.2.1 Scenarios for the use of Lane Control Signs

There are two distinct use case scenarios for lane control signs:

1. ***Mn/DOT Metro Freeway Operations Perspective***

- The Metro Freeway Operations Group uses lane control signs for incident management, designation of lane or shoulder status (i.e. open/closed), and advisory speeds.
- Lane control signs are used to operate Dynamic Shoulders by designating the lane as a shoulder when needed (e.g. during a stall or crash) and allowing traffic movement at other times.
- Lane control signs are used to present advisory speed limits to help smooth traffic and gradually slow traffic during incidents.
- Lane control signs are used to advise travelers about lane closures or vehicle restrictions in lanes and recommend alternate lanes.

2. Traveling public Perspective

- The traveling public observes lane control signs en-route to make informed lane choice decisions or to decide to alter their speed in anticipation of upcoming conditions.

9.2.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for lane control signs are shown in the table below.

Table 60: Lane Control Signs Operations and Maintenance Responsibilities

Lane Control Signs Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Operations of Lane Control Signs	• Mn/DOT Metro Freeway Operations	N/A
Maintenance of Lane Control Signs and Communications to Signs	• Mn/DOT Metro FMS Maintenance	N/A

9.2.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why lane control signs are used (the purposes it performs);
- Who uses lane control signs (for each purpose);
- How they use lane control signs; and
- High level requirement considerations based on the use of lane control signs.

Table 61: Traffic Control Operational Concept: Lane Control Signs

Traffic Management Action: Traffic Control **ITS Tool:** Lane Control Signs (LCS)			
Why are LCS Used?	**Who Uses LCS?**	**How are Lane Control Signs Used?**	**Lane Control Signs Requirements**
Need #8: Individual Lane Control	Mn/DOT Metro Freeway Operations	• Operators remotely activate Lane Control Signs from their workstation using TMC Software to: ○ Warn motorists of events downstream; and ○ Notify motorists if a lane is open or closed (dynamically assigning traffic to a lane). • Some decision trees and algorithms are programmed such that as incident locations are entered, a series of sign recommendations are presented to the operator for approval and eventually sent to the lane control signs.	LCS1: Lane control signs shall receive communications from TMC software and display appropriate messages or graphics based upon the communications received. LCS2: Lane control signs shall communicate the current message/display and report diagnostics of the signs to the TMC Software.
	Public	• Travelers view messages on Lane Control Signs en-route	LCS3: Lane control signs shall be visible to travelers and present messages that are understandable to travelers at freeway speeds.

9.2.4 External Constraints of Lane Control Signs

External constraints involving lane control signs are summarized in the following table.

Table 62: Lane Control Signs Constraints

Constraint	Description of Constraint
Lane Control Signs Location	• Lane Control Sign location and spacing is a factor for the usefulness of the device. • The Lane Control Sign should be mounted in a manner that allows maintenance personnel unobstructed access with minimal impact to traffic below. • The role of each user and use case scenario should be considered when deploying lane control signs. • Other factors such as morning and evening glare, and natural and man-made obstructions should also be considered.
Lane Control Signs Power Source	• The location of the power source for lane control sign deployment should be considered.
Communications with Lane Control Signs	• Individual use case scenarios for each lane control sign should be considered when designing communications (e.g. whether redundant communication is required).
Constraint to Data Processing and Response Formulation	• Lane control signs place a constraint on data processing and response formulation, as the functionality of the sign is dependent upon the actions performed by data processing and response formulation.

9.2.5 Role of Lane Control Signs in ITS Architecture

Lane Control Signs were identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 63: Role of the Lane Control Signs in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS04 Freeway Control	• TM07 Provide lane and shoulder control	• ATMS04 Freeway Control

9.3 Ramp Meters

Ramp Meters control the flow of traffic entering a freeway facility in order to maintain a steady state flow and spread platoons of vehicles to prevent them from entering the freeway as a group.

9.3.1 Scenarios for the use of Ramp Meters

There are two distinct use case scenarios for ramp meters:

1. Mn/DOT Freeway Operations Perspective

Metro Area Freeway Operations operates ramp meters to maintain freeway travel speeds and to reduce crashes near the gore point of entrance ramps.

2. Traveling Public Perspective

The traveling public must adhere to green and red lights at ramp meters as they would any traffic signal.

9.3.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for ramp meters are shown in the table below.

Table 64: Ramp Meters Operations and Maintenance Responsibilities

Ramp Meters Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Operations of Ramp Meters	• Mn/DOT Metro Area Freeway Operations	N/A
Maintenance of Ramp Meters and Communications to Meters	• Mn/DOT Metro Area FMS Maintenance	N/A

9.3.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why ramp meters are used (the purposes it performs);
- Who uses ramp meters (for each purpose);
- How they use ramp meters; and
- High level requirement considerations based on the use of ramp meters.

Table 65: Traffic Control Concept: Ramp Meters

Traffic Management Action: Traffic Control **ITS Tool:** Ramp Meters			
Why are Ramp Meters Used?	**Who Uses Ramp Meters?**	**How are Ramp Meters Used?**	**Ramp Meter Requirements**
Need 9: Zonal Freeway Access Control	Mn/DOT Metro Freeway Operations	• Ramp meters are used over a zone to maintain a smooth flow of traffic by monitoring the vehicles entering the freeway zone (upstream mainline and onramps) to ensure they do not exceed the capacity downstream (mainline and exit ramps). • Ramp meter algorithms are programmed to operate ramp meters at designated times of the day/days of the week. • Ramp meter algorithms calculate timing based upon freeway detector data. • Ramp queue detectors are used to ensure ramps do not back up to other freeways or arterials. When backups occur, ramps flush vehicles to clear the queue.	RM1: Ramp meters shall receive communications from TMC Software describing metering rates and shall execute these meter rates. RM2: Ramp meters shall operate pre-defined Time of Day plans. RM3: Ramp meters shall communicate their current meter rates to TMC Software. RM4: Ramp meters shall detect queue lengths that exceed a threshold (in locations where extended queues are an issue). RM5: Ramp meters shall execute a flush of traffic when receiving a flush command from the TMC Software, to remove vehicles from the ramp as quickly as possible.
	Public	• The traveling public must adhere to green and red lights at ramp meters as they would any traffic signal. • In addition to the spreading of platoons, travelers may alter trip patterns to avoid ramp meters.	RM6: Ramp meters shall display control message to travelers using understood and unambiguous displays.

Traffic Management Action: Traffic Control **ITS Tool:** Ramp Meters			
Why are Ramp Meters Used?	**Who Uses Ramp Meters?**	**How are Ramp Meters Used?**	**Ramp Meter Requirements**
Need 9: Isolated Freeway Access Control	Mn/DOT Metro Freeway Operations	• Ramp meters are used at isolated intersections where the traffic patterns contribute to queues of traffic entering the freeway. • Ramp meters are also used at isolated intersections for demand management, as an incentive for travelers to use other freeway access points. • Ramp meter algorithms turn on ramp meters at designated times of the day. • Ramp meter algorithms calculate timing based upon freeway detector data. • Ramp queue detectors are used to ensure ramps do not back up to other freeways or arterials. When backups occur, ramps flush vehicles to clear the queue.	RM1: Ramp meters shall receive communications from TMC Software describing metering rates and shall execute these meter rates. RM2: Ramp meters shall operate pre-defined Time of Day plans. RM3: Ramp meters shall communicate their current meter rates to TMC Software. RM4: Ramp meters shall detect queue lengths that exceed a threshold (in locations where extended queues are an issue). RM5: Ramp meters shall execute a flush of traffic when receiving a flush command from the TMC Software, to remove vehicles from the ramp as quickly as possible.

9.3.4 External Constraints of Ramp Meters

External constraints involving ramp meters are summarized in the following table.

Table 66: Ramp Meters Constraints

Constraint	Description of Constraint
Data coverage	• The Mn/DOT Ramp Meter algorithm requires volume and occupancy data at a maximum spacing of every ½ mile.
Constraint to Data Processing and Response Formulation	• Ramp meters place a constraint on data processing and response formulation, as the functionality of ramp meters is dependent upon the actions performed by data processing and response formulation.
Constraint to Observation and Detection	• Ramp meters place a constraint on observation and detection, as the functionality of ramp meters is dependent upon the data collected.

9.3.5 Role of Ramp Meters in ITS Architecture

Ramp Meters were identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 67: Role of the Ramp Meters in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS04 Freeway Control	• TM23 Operate Ramp Meters	• ATMS04 Freeway Control

9.4 Electronic Toll Collection

Electronic Toll Collection allows for electronic payment of highway tolls.

9.4.1 Scenarios for the use of Electronic Toll Collection

There are two distinct use case scenarios for electronic toll collection:

1. Mn/DOT Metro Freeway Operations Perspective

- The Metro Area Freeway Operations uses electronic toll collection to allow solo drivers the option to access the travel lane typically used by HOV and buses.

2. Traveling Public Perspective

- The traveling public views the access and price en-route for using a lane typically used by HOV and buses. As a result, they may select to travel in the lane (provided they are a Mn/PASS subscriber) by paying the fee.

- Travelers in the toll lane typically observe uncongested travel conditions (prices are varied to maintain a high level of service).

9.4.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for Electronic Toll Collection are shown in the table below.

Table 68: Electronic Toll Collection Operations and Maintenance Responsibilities

Electronic Toll Collection Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Data collection and communications to Mn/PASS system	• Mn/DOT Metro Area Freeway Operations	N/A
Calculation of Mn/PASS pricing rates and operations of Mn/PASS systems	• Mn/PASS contractor	N/A
Administration of user accounts	• Mn/PASS contractor	N/A
Maintenance of field equipment	• Mn/DOT Metro Area FMS Maintenance	N/A
Enforcement patrol	• MSP	N/A

9.4.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why electronic toll collection is used (the purposes it performs);
- Who uses electronic toll collection (for each purpose);
- How they use electronic toll collection; and
- High level requirement considerations based on the use of electronic toll collection.

Table 69: Traffic Control Operational Concept: Electronic Toll Collection

Traffic Management Action: Traffic Control **ITS Tool:** Electronic Toll Collection (ETC)			
Why is ETC Used?	**Who Uses ETC?**	**How is Electronic Toll Collection Used?**	**Electronic Toll Collection Requirements**
Need 12: Lane Access Management	Mn/DOT Metro Freeway Operations	• Typically, Mn/PASS is operated by the Mn/PASS contractor and primarily operates in automated mode. • An algorithm determines the price for access to the lane based upon the need to maintain a Level of Service C or better in the HOT lane (e.g. as conditions worsen in the HOT lane, the price goes up). • During rare and serious incidents, Metro Freeway Operations personnel can request that Mn/PASS lane status be changed to all vehicles / no tolls (e.g. in the event of multiple lane closures and severe congestion). This would be executed by verbally communicating to the Mn/PASS contractor.	ETC1: The Mn/PASS system performs automated operations to calculate pricing rates. ETC2: The Mn/PASS system displays current rates to drivers. ETC3: The Mn/PASS system charges customers according to the current rates. ETC4: The Mn/PASS system allows manual overrides.
	Public	• Travelers view electronic toll collection signs en-route to understand the rate being charged for access to the lane. • Single Occupant Vehicle (SOV) drivers may elect to drive in the HOT lane by paying the fee if they have an electronic payment device in their vehicle. • Vehicles with 2 or more passengers may travel in the HOT lane any time without paying a fee.	ETC 5: Travelers shall have an unobstructed view of Electronic Toll Collection Signs from vehicle

9.4.4 External Constraints of Electronic Toll Collection

External constraints involving electronic toll collection are summarized in the following table.

Table 70: Electronic Toll Collection Constraints

Constraint	Description of Constraint
Data coverage	• The Mn/DOT Electronic Toll algorithm requires volume and occupancy data.
Constraint to Observation and Detection	• The ITS Tool DMS places a constraint on observation and detection as detector data is needed to operate Mn/PASS.

9.4.5 Role of Electronic Toll Collection in ITS Architecture

Electronic Toll Collection was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 71: Role of the Electronic Toll Collection in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS05 HOV Lane Management	• TM26 Operate MnPASS HOT Lanes	• ATMS10 Electronic Toll Collection • ATMS18 Reversible Lane Management

9.5 Gate Closure Systems

Gate closures provide a means to close and barricade a road.

9.5.1 Scenarios for the use of Gate Closure Systems

There are three distinct use case scenarios for freeway gate closure systems:

1. Mn/DOT Metro Maintenance Perspective

- Metro Area Maintenance manually open and close gates on the reversible lanes in the twin cities. Metro Maintenance drives the reversible lane once to verify the lane is clear.

2. Mn/DOT Outstate District Perspective

- Mn/DOT Outstate Maintenance use gate closure systems to close a road due to an event or weather conditions.

3. Traveling Public Perspective

- The traveling public views gate closures en-route.

9.5.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for gate closure systems are shown in the table below.

Table 72: Gate Closure Systems Operations and Maintenance Responsibilities

Gate Closure Systems Operations and Maintenance Activities	Metro Area Responsibility	Outstate Responsibility
Repair non-functioning gate closure system	• Mn/DOT Metro Area FMS Maintenance	• Mn/DOT District Maintenance
Manually close gates from the field	• Mn/DOT FIRST vehicle	• Mn/DOT Maintenance • MSP
Close gates using remote control devices	N/A	• Mn/DOT Maintenance

9.5.3 Operational Concept (Why is it used, Who uses it, How is it used?)

The following table describes:

- Why gate closure systems are used (the purposes it performs);
- Who uses gate closure systems (for each purpose);
- How they use gate closure systems; and
- High level requirement considerations based on the use of gate closure systems.

Table 73: Traffic Control Operational Concept: Gate Closure System

Traffic Management Action: Traffic Control **ITS Tool:** Gate Closure System			
Why are Gate Closures Used?	**Who Uses Gate Closures?**	**How are Gate Closure Systems Used?**	**Gate Closure System Requirements**
Need 16: Manual Road Closure	Mn/DOT Metro Maintenance	• Maintenance crews manually activate gate closure system in the field. • Maintenance crews drive the reversible lanes to ensure the lane is cleared before a gate is opened.	GS1: Mn/DOT Metro Maintenance shall be able to manually activate a gate closure system.
	Mn/DOT Outstate Districts	• Maintenance crews manually activate gate closure system in the field.	GS2: Mn/DOT District Maintenance shall be able to manually activate a gate closure system.
	Public	• Travelers view gate closure system en-route.	GS3: Travelers shall have an unobstructed view of the Gate Closure System from vehicle.
Need 16: Automated Road Closure	Mn/DOT Metro Maintenance	• Maintenance crews remotely activate gate closure system.	GS4: Mn/DOT Metro Maintenance shall be able to automatically activate a gate closure system.
	Mn/DOT Outstate Districts	• Maintenance crews remotely activate gate closure system.	GS5: Mn/DOT District Maintenance shall be able to automatically activate a gate closure system.
	Public	• Travelers view gate closure system en-route.	GS3: Travelers shall have an unobstructed view of the Gate Closure System from vehicle.

9.5.4 External Constraints of Gate Closure Systems

External constraints involving gate closure systems are summarized in the following table.

Table 74: Gate Closure Systems Constraints

Constraint	Description of Constraint
Gate Closure Location	• Gate Closure Location is critical on its usefulness. • The role of each user and use case scenario should be considered when deploying a gate closure system.
Communication	• The power source and communication to an automated gate closure system is a critical piece of the system, especially in rural areas.
Visual verification	• When using remote controlled gate closure systems, visual observation is needed to validate that the gate can be closed safely and to ensure the closure has occurred.

9.5.5 Role of Gate Closure Systems in ITS Architecture

Gate Closure Systems were identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS as shown in the table below.

Table 75: Role of Gate Closure Systems in ITS Architecture

Minnesota Statewide Regional ITS Architecture: Market Package	Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions	Associated National ITS Architecture: Market Package
• ATMS21-Roadway Closure Management	• TM29 Provide automated/remote control gate systems	• ATMS21 Roadway Closure Management