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

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**FINAL**

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# Contents

# 1.0 Executive Summary

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

## *1.1 Rural Minnesota Perspective*

In outstate (rural) areas of Minnesota, a number of ITS tools are used to help manage traffic on arterials. In rural areas, it is common for these ITS tools to operate as stand-alone systems, fully functioning without connections to other systems. This document describes these ITS tools, including summaries of how they are used today (if they are) and how the use of the tools might change in coming years.

## *1.2 Metro Areas Perspective*

In the metro areas of the state (including the Twin Cities as well as smaller cities throughout the state), real-time traffic management activities have traditionally focused on the freeway network. This is evident by the fact that the Mn/DOT Regional Transportation Management Center (RTMC) currently houses freeway operations personnel, and the workstations designed for arterial operations are typically vacant.

In recent years, Mn/DOT has begun a number of deployments that will begin a transition towards increased metro area real-time arterial traffic management (initially in the Twin Cities but later expanding to additional cities). This transition will deploy surveillance, information dissemination, remote signal timing control, and other traffic management tools.

However, this shift towards an increased focus on arterial traffic management must go beyond simply deploying technologies, otherwise Mn/DOT risks a situation where the technology devices will be largely underutilized. The increased arterial ITS deployments will actually require a paradigm shift in the definition of the role of the Mn/DOT Arterial Operations Group. Currently, the Mn/DOT Arterial Operations Group consists of traffic engineers who work to deploy and operate systems on the arterials. However, the staff members' positions are not focused on real-time monitoring and response to conditions in the same way freeway operations dispatchers in the RTMC focus on real-time response. Later sections of this document describe the likely transition to a more real-time operational management perspective of the Mn/DOT Metro Area Arterial Operations Group.

## 1.3 Arterial Traffic Management Transitions Described in this Document

The remaining sections of this ConOps describe three key transitions likely to occur in arterial traffic management:

- A more formally defined real-time traffic management role for the Arterial Operations Group.
- A migration of the Arterial Operations Group to staff the RTMC when appropriate; and
- A transition towards interconnecting what are now stand-alone arterial traffic management tools.

## 1.4 Defining New Roles for Metro Arterial Traffic Management

Sections 2-10 of this document describe who uses ITS tools, why the tools are used, and how the tools are used. Throughout the document, the recurring theme is that Mn/DOT is beginning to increase the number of arterial ITS deployments. This increased activity introduces a number of gaps in the operations of the devices. This section first summarizes the questions that must be answered, and then presents a summary table (Table 1) of the suggested roles to be performed in the coming years as arterial ITS deployments increase.

***Questions to be Answered as Arterial ITS Deployments Increase***

1. ***Cameras.*** Camera deployments on arterials should be supported by a formal definition of who will monitor the cameras (e.g. Mn/DOT Arterial Operations, Freeway Operations, Metro Maintenance).

   - Are cameras to be monitored during peak periods only or during RTMC hours?
   - Are cameras actively monitored (operator sitting watching) or only when triggered by data (e.g. if the arterial travel time algorithm detects a deviation from typical travel times or when an incident is reported to MSP)?
   - Are cameras monitored from within the RTMC or from the Mn/DOT Arterial Operations office (cameras can be viewed at Arterial Operations desks but not controlled)?

2. ***Websites.*** Mn/DOT is exploring approaches for increased web dissemination of arterial information (e.g. websites that color arterial highways in real-time to represent the speed of traffic on the highway). If deployed, a logical transition will be to also display incidents and events on these website displays. Mn/DOT's Condition Reporting System allows for arterial incident and event entry, but a formal operations procedure is needed for consistency of event entry.

   - Who will perform the entry (e.g. Mn/DOT Arterial Operations, Freeways Operations, Metro Maintenance)?
   - What hours will entry be performed (e.g. peak periods, RTMC hours)?

3. ***RTMC Radio.*** The RTMC radio dispatcher currently announces metro-wide reports every 10 minutes during peak periods. These traffic reports traditionally cover the freeways where camera images and data are available. As camera and data feeds will increasingly be available for arterials, a policy is needed to define the extent to which the dispatcher reports on arterials (ideally coupled with public outreach explaining the expanded role if there is one).

   - Will the freeways receive priority during reporting times or will radio broadcasters cover the arterial network as well?

4. ***DMS.*** Increased deployment of DMS on arterials will allow for automatic and manually created messages on arterials.

   - Who will be responsible for posting arterial DMS messages (e.g. Mn/DOT Arterial Operations, Freeways Operations, Metro Maintenance)?

   - What hours will incident/event messages be posted for arterials?

**Table 1: Summary of Suggested Roles for Mn/DOT Metro Area Arterial Traffic Management**

| What Tool will be Used? | Arterial Operations Activity | Who will Perform it? | When will it be Performed? | Where will it be Performed? |
|---|---|---|---|---|
| Condition Reporting System | Entry of incidents/ events into Condition Reporting System | ▪ Mn/DOT Metro Arterial Operations<br>▪ Mn/DOT Metro Freeway Operations support as needed during times arterial operators are not staffed | ▪ Peak Periods (as long as less than 50% of the metro arterial corridors are covered)<br>▪ RTMC Freeway Operations hours (once more than 50% of the metro arterial corridors are covered) | RTMC Arterial Operations Workstation |
| TMC Software | Monitoring Arterial Cameras (note: cameras can be viewed at Arterial Operations desks but not controlled) | ▪ Mn/DOT Metro Arterial Operations<br>▪ Mn/DOT Metro Freeway Operations support as needed during times arterial operators are not staffed | ▪ Peak Periods (as long as less than 50% of the metro arterial corridors are covered)<br>▪ RTMC Freeway Operations hours (once more than 50% of the metro arterial corridors are covered) | RTMC Arterial Operations Workstation |
| | Posting Arterial incident messages to Arterial DMS | | | |
| | Posting Freeway incident messages to Arterial DMS | | ▪ Peak periods by Metro Arterial Operations<br>▪ Other times by RTMC or Maintenance staff | |
| | Posting Arterial incident messages to Freeway DMS | ▪ Mn/DOT Metro Freeway Operations | ▪ All hours RTMC is staffed | RTMC Freeway Operations Workstation |
| | Implementing Arterial 'flush' signal timing plans for Corridor control (e.g. ICM) | ▪ Mn/DOT Metro Arterial Operations | ▪ Peak Periods (as long as less than 50% of the metro arterial corridors are covered)<br>▪ RTMC Freeway Operations hours (once more than 50% of the metro arterial corridors are covered) | Arterial Operations Desk/Office |
| | Real-time Operational Changes (e.g. temporarily extending a signal phase if an approach is not clearing ) | | | RTMC Arterial Operations Workstation |

# 2.0 Background

## *2.1 Intended Use of this Document*

The intended uses of this ConOps are:

- To guide future ITS deployments on arterials throughout Minnesota; and
- To be a resource for the operations, maintenance, expansion and enhancements to existing ITS tools used today for arterial traffic management.

To accomplish these uses, the ConOps first introduces the needs for effective traffic management. The ConOps then introduces the concept of arterial traffic management, and describe a likely transition towards increased arterial traffic management. Next, the document 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 (or will use) the tool, 'why' the tool is (or will be) used, and 'how' the tool is (or will be) used.

*Consider the following example:*

A common deployment of technologies on arterial highways involves signal pre-emption for at-grade rail crossings. When a train is traveling through, a pre-emption signal ensures that cross traffic receives a red light until the train is past (regardless of whether the train system deploys gates). While this deployment has traditionally been a stand-alone technology, if this pre-emption signal at the intersection could be communicated to a central location, this could allow information dissemination to inform travelers of the train passing through the intersection. In the case of emergency vehicles that may be transporting injured people or traveling to crash scenes, knowing that a train is blocking an intersection could allow them to take alternate routes such as a bridge over the train track.

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 arterial traffic management ConOps.

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

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

Section 5 presents the overall concept for arterial traffic management, including the evolving role that traffic management is likely to take on arterials. 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 the following 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 Arterial Network**

The Mn/DOT statewide road network consists of approximately 11,895 miles, of which 10,981 miles are not part of the Interstate Trunk Highway system. Many of the Mn/DOT non-freeway roadways are considered arterials. An arterial roadway is defined as a moderate or high-capacity road which is immediately below a freeway level of service. Arterial roads typically carry large volumes of traffic between regional areas. It is common for arterial roadways to have at-grade intersections, some of which are controlled with traffic signals.

In many instances, arterial roads were established prior to the construction of the Interstate Highway network. Due to this fact, many arterials parallel freeways within the state and serve as alternate routes during incidents or congestion. One such example is US Highway 10 which takes a route approximately parallel to I-94 through much of the state. Some arterials are considered so vital that they were included within the Minnesota State Constitution. Figure 1 depicts the Minnesota Arterial System.

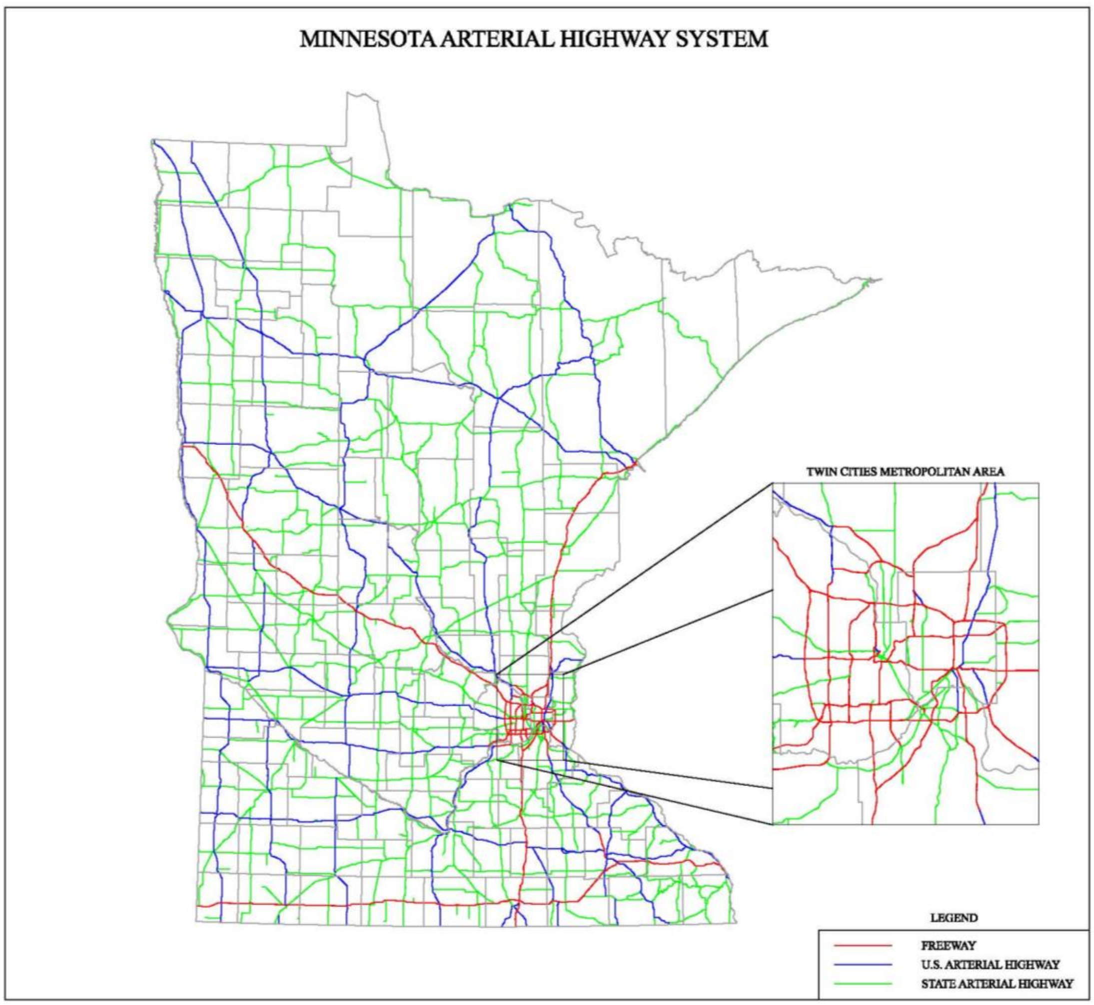


**Figure 1: Minnesota Arterial Highway System**

The Minneapolis-St. Paul Metro Area (Twin Cities) operates the most complex network of arterials. Major arterial highways include but are not limited to US Highway 10, US Highway 12, US Highway 61, US Highway 169, US Highway 212, MN Highway 7, MN Highway 13, MN Highway 36, MN Highway 47, MN Highway 55, MN Highway 65, and MN Highway 77. In addition, other arterials contribute to the overall network. In summary, the Twin Cities arterial 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 numerous major arterials. In addition to the US Highways mentioned previously, US Highway 2 in northern Minnesota provides a critical east/west route across the state connecting Duluth and East Grand Forks. US Highway 14 in southern Minnesota provides a critical east/west route across the state connecting Rochester to Mankato before continuing west into South Dakota. US Highway 52 in south eastern Minnesota provides a critical north/south route between Rochester and the Twin Cities. Many of the regional population centers in the outstate area are located along (or near) major arterial highways. The numerous US and Minnesota Highways crisscross the state connecting regional centers, serving local communities, and support economic development.

**Current Traffic Management**

The at-grade interactions of vehicles along different paths require full-time traffic management on arterials. The most common ‘traffic management’ activity performed on arterials is signalized control of at-grade intersections, either as stand-alone or coordinated systems. Mn/DOT has developed a Concept of Operations document specifically for traffic signal control, and therefore this will not be covered in detail in this document.

Beyond the common traffic signal operations, arterial traffic management supports the needs of emergency vehicles, transit vehicles, pedestrians and bicyclists by facilitating the safest and most efficient progression of traffic along arterial highways. These arterial highways range from rural to metro highways.

**Intelligent Transportation Systems**

Mn/DOT has operated transportation technologies (ITS) since the 1970’s. With the exception of traffic signal controllers, the use of ITS for arterial traffic management has not been as comprehensive as that for freeways. However, Mn/DOT is increasing the number of planned arterial ITS traffic management deployments.

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 Arterial 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. Alhtough 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 arterials 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 below.

**Table 2: Arterial Traffic Management Needs**

| Problem | Needs (As a Result of the Problem) |
|---|---|
| Incidents and events significantly reduce arterial 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 arterial levels of service that impede traffic flow and limit capacity. | ***Need 2: Traffic monitoring*** There is a need to monitor traffic volumes and congestion levels. |
| Travelers unaware of congestion or delays miss opportunities to divert to alternate routes and encounter delays. | ***Need 3: 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 planned events (e.g. roadwork, special events) encounter unexpected stopped traffic and delays without the option to divert. | ***Need 4: Real-time planned event notification*** There is a need to inform travelers en-route and pre-trip of planned events (e.g. special events, roadwork). |
| Travelers unaware of incidents, isolated inclement driving 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 alert travelers en-route and pre-trip of active unplanned events (e.g. crashes, unusual driving conditions, Amber Alerts, special events, weather condition alerts). |
| Numerous factors must be considered when formulating traffic management responses to operational problems. | ***Need 6: Arterial operational analysis*** There is a need for short-term analysis of multiple data sources and for long term performance measurement analyses. |
| Numerous factors must be considered when planning traffic management adjustments and improvements to operational problems. | ***Need 7: Arterial data storage, archive and access*** There is a need to store, archive, and share arterial traffic data. |
| Many incidents and events are not automatically detected and reported, but are known by some member of the operations team. | ***Need 8: Manual Event Reporting*** There is a need for manual incident and event reporting. |
| Traffic management devices in the field must be controlled by operators without requiring operators to be local to the device. | ***Need 9: Device control*** There is a need to control arterial management devices remotely. |
| In metro areas, traffic movement is inefficient if travelers stop at multiple traffic signals along a stretch of road. | ***Need 10: Coordinated control*** There is a need for coordinated signal control. |
| Speed differentials contribute to the risk of crashes. | ***Need 11: Speed control*** There is a need to slow traffic exceeding the speed limit. |

| Problem | Needs<br>(As a Result of the Problem) |
|---|---|
| Arterials are used by a combination of vehicles, pedestrians, and bicycles. | ***Need 12: Multimodal options***<br>There is a need to allow multimodal use of the arterial system. |
| During highway and non-highway emergencies, emergency vehicles must reach their destination quickly and safely. | ***Need 13: Emergency management***<br>There is a need to provide safe and effective travel for emergency vehicles responding to incidents. |
| Illegal movements at traffic signals contribute to the risk of crashes. | ***Need 14: Enforcement systems***<br>There is a need to enforce and reduce unsafe driving practices at signal systems. |
| Transit vehicles operating behind schedule cause delays for all riders and deter travelers from selecting the transit mode. | ***Need 15: Transit vehicle advantages***<br>There is a need for transit vehicles to have advantages. |
| In some locations, drivers' lack of attention contributes to a higher rate of crashes. | ***Need 16: Warning systems***<br>There is a need to alert drivers to potentially hazardous conditions. |
| Inconsistent information can impede incident response and congestion management. | ***Need 17: Center-to-Center communications***<br>There is a need for voice, data, and video sharing between public agencies. |

# 5.0 Overall Concept for Arterial Traffic Management

Mn/DOT is responsible for traffic management along arterial highways. Arterial highways are defined (for the purposes of this document) as all Mn/DOT maintained roads that are not limited access freeways. Arterial highways include highways with signalized intersections and non-signalized intersections, and range from rural relatively low volume roads to urban high volume roads.

In many ways, arterial traffic management is very similar to freeway traffic management (e.g. traffic management strategies and supporting technologies are used to promote safe and efficient movement of vehicles). However, unlike freeways, there is a wider range of highway designs for arterials (ranging from rural two-lane arterials with no sidewalks, curbs or gutters; to multi-lane arterials with controlled pedestrian access. Therefore, there is a wider range of traffic management strategies and technologies.

For these reasons, arterial traffic management systems range from simple stand-alone deployments (such as Dynamic Speed Display Signs ('Your speed is' signs) in rural school zones) to complex coordinated signal control systems in metro areas that function to optimize traffic flow and minimize emissions.

## *5.1 The Evolving Operational Concept for Arterial Traffic Management*

This section describes the current and evolving operational concept for arterial traffic management by dividing arterial traffic management into three categories:

- Metro Area Comprehensive arterial corridor traffic management
- Locally operated arterial traffic control and alert systems.
- Individual intersection traffic signal control

*Note: Mn/DOT is preparing a separate Concept of Operations for traffic signal controllers, therefore while individual intersection traffic signal control is recognized in this report, it is not a primary focus.*

The following sections describe the first two bullets above.

### 5.1.1 Metro Area Comprehensive arterial corridor traffic management

The Mn/DOT Regional Transportation Management Center (RTMC) is staffed with Mn/DOT Freeway Operations personnel and Mn/DOT Metro Area Maintenance dispatchers. However, there are currently no arterial operations staff members regularly in the RTMC (although workstations are available). Based on a brief survey of TMCs around the country, this is not a unique situation. In fact, most TMCs do not have the set aside space for arterial operations in the TMC. This is not simply a discussion of location. For the most part, real-time operator involved traffic management on arterial highways has been considerably less than freeways.

This lack of arterial operations presence can be traced to the following three factors:

- ***High Functioning Traffic Controllers.*** The hardware and software that control traffic signals are able to adjust on fixed schedules (time of day and day of week) and in response to local traffic detectors, while remaining coordinated with other signals. Simply put, for a well timed traffic signal system (and corridor) there is very little that an operations engineer could do manually to improve on these functions without causing other problems (e.g. signal coordination and progression issues). Therefore, there is very little need for an operator manually 'managing' arterial traffic signals in real-time. However, recent emerging strategies and technologies involving corridor management (either stand alone corridors or integrated corridor management) have defined approaches for changing the role of an arterial corridor when needed (e.g. to help clear a parallel freeway or to disperse event or incident traffic using corridor-wide 'flush' signal timing plans). Therefore, these 'corridor' approaches will likely increase the manual involvement in arterial traffic management.

- ***Traditional Traffic Management Approaches.*** Arterial traffic engineers typically use technologies to observe and correct *operational problems* as opposed to real-time *traffic problems*. In other words, arterial operations personnel may observe camera images to examine whether signal timing parameters are clearing queues effectively, or to follow-up on traveler complaints, but rarely use cameras to view current conditions to implement a real-time management strategy.

  Similarly, traffic data collected in the field is most commonly used for signal retiming or validation, as opposed to real-time incident detection or response.

- ***Freeway Focus for Technology Deployments.*** Over the past decades, the priority for deployment of technology management tools (such as visual surveillance and DMS) has initially been focused on the freeways, where incidents impact more travelers and cause greater delays. Therefore, it is not surprising that there is a greater emphasis on real-time freeway monitoring and response than there is on arterials. However, recent deployments (and planned future deployments) will continue to increase monitoring and control capabilities for arterials.

In conclusion, as traffic volumes increase along arterials, and as arterial corridors play an increasing role in the overall traffic network, there is likely to be an increased need for real-time arterial traffic management that is analogous to the freeway traffic management currently performed by the RTMC. While Mn/DOT has begun this transition by deploying technologies on arterial corridors throughout the metro, there is an equally important need for a transition in the overall approach to arterial traffic management - that is more real-time operations.

The transition towards metro-wide real-time arterial traffic management will likely involve two major transitions, defined as follows:

- ***Definitions of real-time operations roles.*** The Mn/DOT Metro Area Arterial Operations Group currently provides real-time operations of the traffic signals, including field response for operational problems. However, as noted above, there is no staff time dedicated to continuous monitoring of conditions (using cameras or traffic detectors) to proactively decide to respond to changing conditions. Mn/DOT may elect to create periods of time when Arterial Operations

Group staff members are dedicated to monitoring the cameras and detectors on the arterials to assess whether real-time response to traffic conditions is warranted.

- ***Migration to RTMC staffing.*** Over time, as the amount of time the Arterial Operations Group has staff dedicated to monitoring and responding to traffic conditions increases, it will become more efficient for these staff to sit in the RTMC during some (or all) periods of the time they are monitoring conditions. The RTMC offers increased camera control and the support of additional teams. Also, the presence of the Arterial Operations Group in the RTMC will increase efficiencies and coordination of system wide responses to incidents (for example an Integrated Corridor Management approach).

This document describes this impending evolution of arterial traffic management by not only describing what is done now, but also describing what will likely be done as the Mn/DOT Arterial Operations Group migrates to this new role.

### 5.1.2 Localized traffic control actions

The nature of arterial highways introduces aspects that are not encountered by freeway highways. The most obvious example is conflicting movements between passenger vehicles, emergency vehicles, transit vehicles, pedestrians, rail traffic and bicycles supported by at-grade intersections that may or may not be signalized. Another example is the fact that arterials encounter nature related challenges that most freeways do not, such as areas prone to flooding when nearby rivers crest. For these reasons, arterial traffic management involves localized traffic control actions – defined as those actions that do not require integration with other actions (for example a local dynamic speed display sign does not mandate connection to other actions and is locally 'self contained').

As arterial traffic management evolves in Minnesota, there may be increasing numbers of localized traffic control actions, and there might be coordinated corridor-wide arterial traffic management actions deployed together with the localized systems. Therefore, the localized deployments may transition to exchange data with other systems where they did not before. For example, speed detector data captured by dynamic speed display signs may one day be communicated to a nearby TMC or Transportation Operations Center (TOC) for inclusion in arterial performance analyses. As another example, local flood detectors that activate local warning signs may also communicate this information to centralized traveler information systems for statewide deployment.

## 5.2 Arterial Traffic Management Actions

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

The *Comprehensive Arterial Corridor traffic management* actions include:

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

The *Localized Traffic Control* actions include:

- Local (potentially stand alone) arterial traffic control and traveler alerts.

Figure 2 illustrates the arterial traffic management actions.

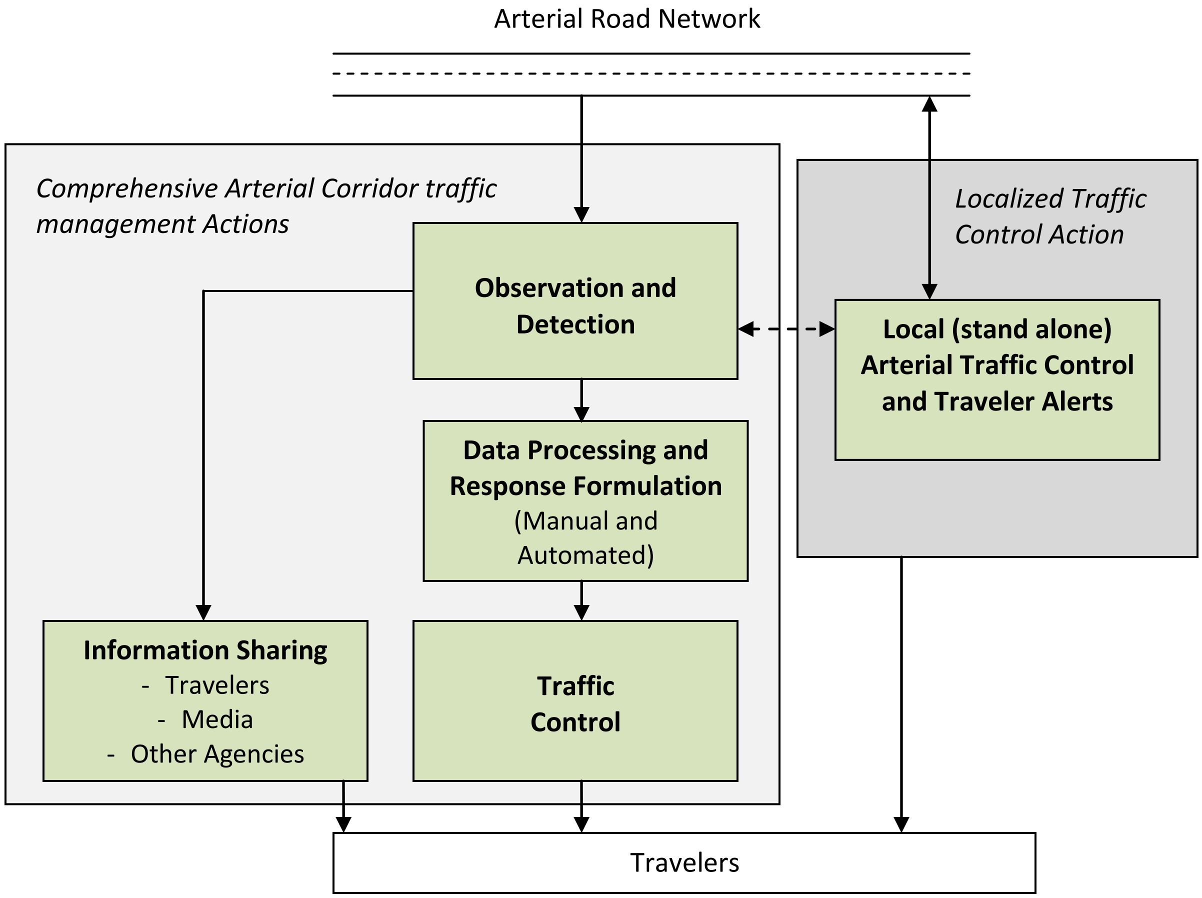


**Figure 2: High Level Summary of Arterial Traffic Management Actions**

## *5.3 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 arterial traffic management. Each ITS tool supports one or more of the actions performed for traffic management. Examples of ITS 'Tools' include dynamic message signs, CCTV cameras, and emergency vehicle preemption.

Figure 3 illustrates the 'Tools' that support each of the five traffic management actions.

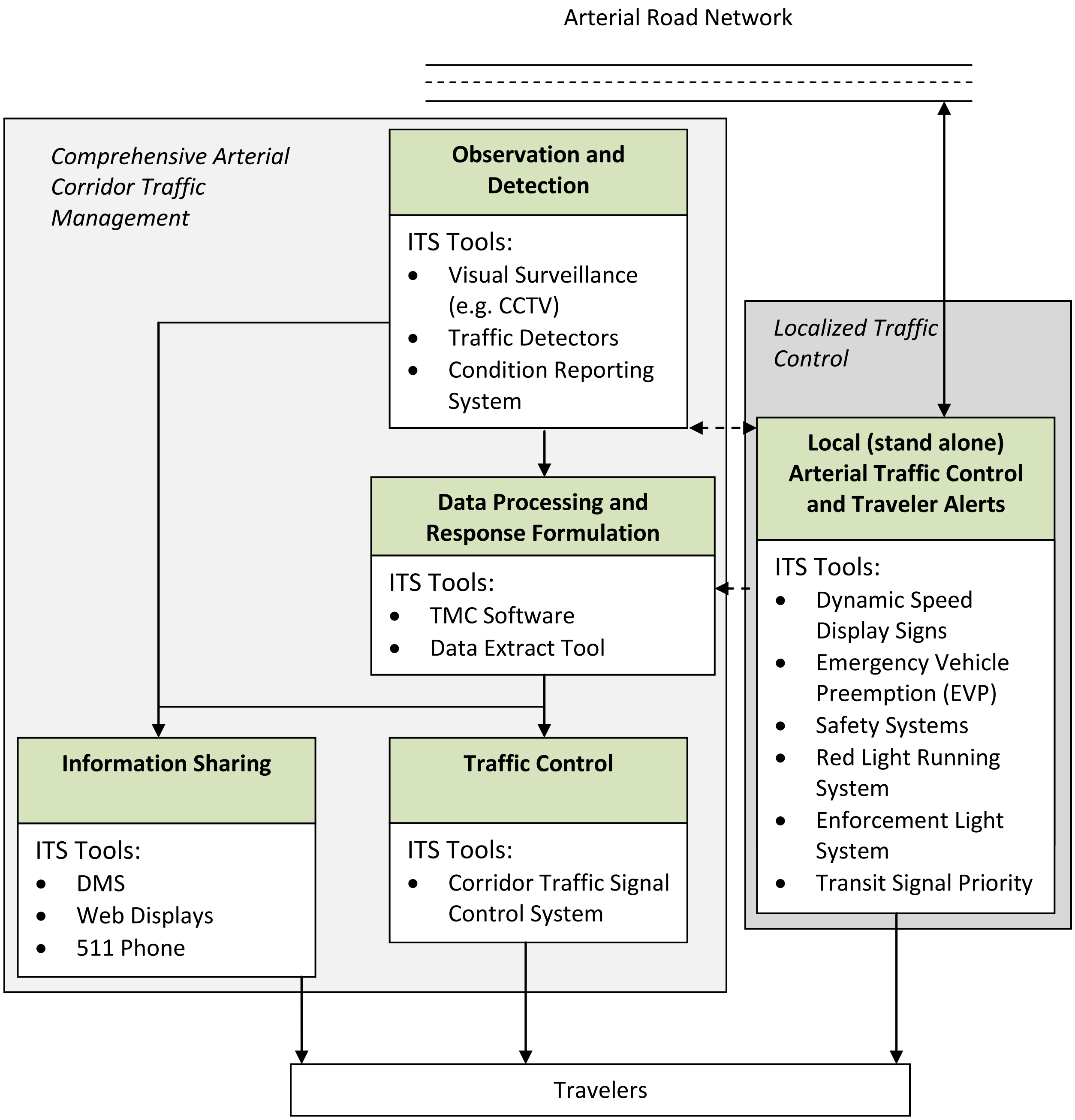


**Figure 3: Illustration of ITS Tools that Support Arterial Traffic Management**

## *5.4 Mapping of ITS Tools to Needs*

Table 3, 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 3: Real-time travel time/congestion notification is primarily addressed by three ITS Tools (DMS, web displays, and 511 phone). 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 3: Map of ITS Tools to Arterial Traffic Management Needs**

| Need | ITS Tools | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Metro Area Comprehensive Arterial Corridor Traffic Management | | | | | | | | | Local Arterial Traffic Control and Traveler Alerts | | | | | |
| | Observation and detection | | | Information Sharing | | | Data Processing & Response Formulation | | Traffic Control | | | | | | |
| | Visual Surveillance | Traffic Detectors | Condition Reporting System | DMS | Web Display | 511 Phone | Data Extract Tool | TMC Software | Traffic Signal Control Systems | DSDS | EVP | Safety Systems | Red Light Running | Enforcement Light | TSP |
| Need 1: Incident/event verification | P | | | | | | | | | | | | | | |
| Need 2: Traffic monitoring | P | P | | | | | | | | | | | | | |
| Need 3: Real-time travel time/congestion notification | | C | | P | P | P | | C | | | | | | | |
| Need 4: Real-time planned event notification | | | C | P | P | P | | | | | | | | | |
| Need 5: Real-time unplanned event notification | C | | C | P | P | P | | | | | | | | | |
| Need 6: Arterial operational analysis | C | C | C | | | | | P | | | | | | | |
| Need 7: Data storage, archive and access | | C | | | | | P | P | | | | | | | |
| Need 8: Manual Event Reporting | C | C | P | | | | | | | | | | | | |
| Need 9: Device control | | C | | | | | | P | | | | | | | |
| Need 10: Coordinated control | | C | | | | | | | P | | | | | | |
| Need 11: Speed control | | | | | | | | | | P | | | | | |
| Need 12: Multimodal options | | | | | | | | | P | | | | | | |
| Need 13: Emergency management | | | | | | | | | C | | P | | | | |
| Need 14: Enforcement systems | C | | | | | | | | | | | | P | P | |
| Need 15: Transit vehicle advantages | | | | | | | | | C | | | | | | P |
| Need 16: Warning systems | | | | | | | | | | | | P | | | |
| Need 17: Center-to-Center communications | | | | | P | | | | | | | | | | |

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

## 5.5 Supporting Infrastructure

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

### 5.5.1 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.

### 5.5.2 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.

### 5.5.3 Supporting Infrastructure Tool #3: Wireless Communications

Wireless communications are used to communicate with individuals while mobile (e.g. TMC 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.

### 5.5.4 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.

## *5.6 Structure of the Remaining Sections*

The emphasis of this document is on the ITS tools that support arterial traffic management. Each of the remaining sections is dedicated to one of the arterial traffic management 'Actions' illustrated in Figure 1, as follows:

- Section 6 describes Observation and Detection;
- Section 7 describes Information Processing and Response Formulation;
- Section 8 describes Information Sharing;
- Section 9 describes Traffic Management; and
- Section 10 describes Long Term Infrastructure Changes.

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.

### 5.6.1 Interdependencies of Needs Tables

Subsections 6.1, 7.1, 8.1, 9.1 and 10.1 describe 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 (Arterial Operational Analysis) addresses Need #7: *Arterial Data Storage, Archive, and Access.* However, in order for this Action to meet this need, Need #2: *Traffic 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 4: 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 |
|---|---|---|
| | | |

### 5.6.2 Operations and Maintenance Tables

Subsections 6.2, 7.2, 8.2, 9.2, and 10.2 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 5: EXAMPLE Operations and Maintenance Responsibilities Table**

| Operations & Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| | | |

### 5.6.3 Description of Use Tables

The second set of tables in Section 6.2, 7.2, 8.2, 9.2, and 10.2 describes the following for each ITS Tool:

- 'Why' the ITS Tool is or will be used - A direct correlation to the needs identified in Section 4;
- 'Who' Uses (or will use) the ITS Tool for each purpose;
- 'How' each specific user group uses (or will use) 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 6: EXAMPLE Operational Concept Table**

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

### 5.6.4 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 7: EXAMPLE Constraints Table**

| Constraint | Description of Constraint |
|---|---|
| | |

### 5.6.5 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 8: EXAMPLE ITS Architecture Table**

| Minnesota Statewide Regional ITS Architecture:<br>Market Package | Minnesota Statewide Regional ITS Architecture:<br>Need/Potential Solutions | Associated National ITS Architecture:<br>Market Package |
|---|---|---|
| | | |

# 6.0 Observation and Detection

## *6.1 Concept of Operations for Observation and Detection*

### 6.1.1 Role in Arterial 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 arterial traffic management as it provides arterial 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.

### 6.1.2 Needs Addressed by Observation and Detection

Based upon research and feedback, arterial 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 monitoring; and
- Need 8: Manual event reporting.

### 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***; and
- ***Condition Reporting Systems***.

### 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 9: 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 monitoring | N/A | |
| Need 8: Manual event reporting | N/A | |

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

## *6.2 Visual Surveillance (e.g. CCTV)*

Visual Surveillance tools (most commonly CCTV cameras) 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 ten distinct use case scenarios for visual surveillance:

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

- The Arterial Operations Group primarily use visual surveillance to observe and monitor signal operations to assess the performance of signal timing plans. Traffic engineers observe camera images at various times of the day to understand the traffic progression operated by the signal system.

- As additional visual surveillance devices are deployed, Arterial Operations Group staff will increasingly use the surveillance devices to observe traffic congestion (due to planned or unplanned events).

- Current technology allows the Arterial Operations Group to observe conditions from their desks, but not control the cameras from their desks. However, there is space allocated to the Arterial Operations Group in the RTMC. As the coverage of visual surveillance systems increases, the Arterial Operations Group may transition to allocating staff to the RTMC during peak periods to observe conditions, control cameras, and interact with freeway operators.

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

- Metro Freeway Operations may use available surveillance on arterials to observe conditions adjacent to the freeways. This may help to understand the impacts of such things as ramp metering, DMS message display, or to assist in selecting freeway closure points or incident messages to display on DMS.

- For strategies such as Integrated Corridor Management (ICM), freeway operations personnel will observe conditions on parallel arterials when selecting the messages to be displayed on DMS. *ICM seeks to integrate the management of freeways, arterials, and transit systems within a common corridor, in order to improve operations throughout the entire corridor.*

### 3. *Mn/DOT Metro Maintenance Dispatch Perspective*

- In the metro area, arterial traffic management includes the clearing of snow and ice from roadways to maintain as much capacity as possible. Metro Area Maintenance Dispatchers use visual surveillance to observe road conditions as part of their decision making process in order to dispatch crews for road maintenance (e.g. removal of snow, debris removal, pre-treatment of roads). Visual surveillance has typically been limited to freeways. However as coverage increases, maintenance dispatchers will be able to view an increased number of arterials to assist in planning for snow and ice removal.

### 4. *Mn/DOT Outstate District Perspective*

- Mn/DOT Outstate Districts that have visual surveillance on arterials typically select very specific locations for deployment. These locations allow surveillance of the following types of situations:

  - Intersections prone to crashes that result in traffic queues that back up and impact adjacent mainline roads (such as Interstates or major arterials);

  - Single or multiple intersections that require observation, either because they are prone to system failures or the signal timing requires regular adjustments. For example, a state highway through a city that will experience regular construction for multiple seasons (and therefore regular traffic pattern changes) might rely on visual surveillance to observe conditions and the retiming of signal systems.

  - Locations prone to congestion, including temporary work zones and bottleneck areas that experience congestion during special events.

### 5. *Mn/DOT Planning and Roadway Design Perspective*

- As visual surveillance coverage expands, buffered video may increasingly be reviewed by planning, roadway design, and signal timing teams to observe trends or validate data collected in the field.

### 6. *Television Information Service Providers / Media Outlets' Perspective*

- Local television news media observe camera video when preparing traffic reports and displaying 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. *Note: A RTMC Radio Announcer is contracted and collocated in the RTMC with access to the RTMC video viewing wall in the metro area.*

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

### *8. Minnesota State Patrol Perspective*

- The Minnesota State Patrol 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.

### *8. Emergency Management Agencies Perspective*

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

### *9. Other Public Agencies' Perspective*

- Local county and city traffic groups may observe Mn/DOT camera video to better understand the traffic flow conditions on local (county and city) roads.

### *10. 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 10: 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 Signal Maintenance | ▪ Mn/DOT District Information Technology (IT) Maintenance<br>▪ Mn/DOT Electric Services Section (ESS) |
| Overall maintenance of video switches (HW and SW) operated within the operations centers. | ▪ Mn/DOT Metro Area Maintenance<br>▪ Mn/DOT Metro Area Freeway Operations | ▪ Mn/DOT District IT Maintenance<br>▪ Mn/DOT ESS |
| Overall operations<br>▪ Camera control<br>▪ Video buffering | ▪ Mn/DOT Metro Area Freeway Operations<br>▪ Mn/DOT Metro Area Arterial Operations<br>▪ Minnesota Metro Area State Patrol | ▪ Mn/DOT District Traffic Operations controls cameras during business hours in response to incidents and roadwork.<br>▪ Minnesota Outstate State Patrol controls cameras in response to crashes. |

### 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 11: Observation and Detection Operational Concept: Visual Surveillance**

| **Traffic Management Action:** Observation and Detection<br>**ITS Tool:** Visual Surveillance | | | |
|---|---|---|---|
| **Why is Visual Surveillance Used?** | **Who Uses Visual Surveillance?** | **How Visual Surveillance is or will be Used** | **Visual Surveillance Requirements** |
| Need 1: Incident/ Event Verification | Mn/DOT Metro Freeway Operations | ▪ During incident events on the freeways, freeway operations personnel may view cameras located on arterials to plan incident response for freeways.<br>▪ Freeway operations may observe incidents on arterials to understand if freeway traffic management is needed. | VS1: Mn/DOT Metro Freeway Operators shall have the capability to view and control arterial cameras from the RTMC.<br>VS2: Mn/DOT Metro Freeway Operations shall have the capability to zoom arterials cameras to enough detail to observe debris and lane blockages through the cameras.<br>VS3: Mn/DOT Metro Freeway Operations shall have access to real-time full motion video.<br>VS4: Mn/DOT Metro Freeway Operations shall have the capability to buffer video. |

| **Traffic Management Action:** Observation and Detection<br>**ITS Tool:** Visual Surveillance | | | |
|---|---|---|---|
| **Why is Visual Surveillance Used?** | **Who Uses Visual Surveillance?** | **How Visual Surveillance is or will be Used** | **Visual Surveillance Requirements** |
| | Mn/DOT Metro Arterial Operations | ▪ Currently (2010) Mn/DOT Arterial Operations do not actively monitor visual surveillance (i.e. they are not located in the RTMC and no staff are dedicated to full time operations) to search for and verify incidents.<br>▪ If a major incident occurs, Mn/DOT Arterial Operations members may walk over to the RTMC to view arterial cameras (and adjacent freeway cameras) and use TMC software to control the camera(s).<br>▪ As arterial visual surveillance continues to expand, an initial transition may include Mn/DOT Arterial Operations personnel assuming a role of monitoring cameras during peak periods. Observation could look for congestion, incidents or breakdowns, debris/objects on the roadway, or other alerts.<br>▪ Long term transitions may involve Mn/DOT Arterial Operations staff located in the RTMC to:<br>○ Monitor for incidents during peak periods and assess the expected impacts, determine which traffic control to implement, activate DMS, and create traveler information descriptions for 511 and the web<br>○ Clarify lane closures, debris, and monitor the response actions<br>○ Buffer video for later viewing. | VS5: Mn/DOT Metro Arterial Operations shall have the capability to view images captured by cameras from their desks.<br>VS6: Mn/DOT Metro Arterial Operations shall have the capability to view and control arterial cameras from the RTMC.<br>VS7: Mn/DOT Metro Arterial Operations shall have the capability to zoom arterials cameras to enough detail to observe debris and lane blockages through the cameras.<br>VS8: Mn/DOT Metro Arterial Operations shall have access to real-time full motion video.<br>VS9: Mn/DOT Metro Arterial Operations shall have the capability to buffer video. |

| **Traffic Management Action:** Observation and Detection<br>**ITS Tool:** Visual Surveillance | | | |
|---|---|---|---|
| **Why is Visual Surveillance Used?** | **Who Uses Visual Surveillance?** | **How Visual Surveillance is or will be Used** | **Visual Surveillance Requirements** |
| | Mn/DOT Metro Maintenance Dispatch | ▪ Video is used to assess whether Mn/DOT Metro Maintenance will be needed to provide traffic control and/or clean up (incidents/events lasting > 1 hour)<br>▪ Mn/DOT Metro Maintenance Dispatch assumes the responsibilities of the RTMC Operators when not staffed. *As visual surveillance on arterials expands, Mn/DOT Metro Maintenance may assume a role of monitoring arterial cameras during periods when Mn/DOT Arterial Operations is not available.*<br>○ Video is used to verify and assess the expected impacts of incidents/events, determine which traffic control to implement, activate DMS, and to create traveler information descriptions for 511 and the web<br>○ Operators clarify lane closures, debris, and monitor the response actions<br>○ Operators can select to buffer video for later viewing. | VS10: Mn/DOT Metro Maintenance Dispatch shall have the capability to control arterial cameras from the RTMC.<br>VS11: Mn/DOT Metro Maintenance Dispatch shall have the capability to zoom arterials cameras to enough detail to observe debris and lane blockages through the cameras.<br>VS12: Mn/DOT Metro Maintenance Dispatch shall have access to real-time full motion video.<br>VS13: Mn/DOT Metro Maintenance Dispatch shall have the capability to buffer. |

| **Traffic Management Action:** Observation and Detection<br>**ITS Tool:** Visual Surveillance | | | |
|---|---|---|---|
| **Why is Visual Surveillance Used?** | **Who Uses Visual Surveillance?** | **How Visual Surveillance is or will be Used** | **Visual Surveillance Requirements** |
| | Mn/DOT Outstate Districts | ▪ Camera coverage is less complete, and typically camera locations are strategically selected where incidents are prone to occur (e.g. work zones, bottleneck areas, key tourist destinations).<br>▪ If crashes occur near cameras, the incident site (or the extent of the backup) is observed.<br>▪ Cameras intended primarily for travel information may not include remote control or full motion video relay, but rather may be low cost deployments to capture and relay fixed images. In rural areas, these images provide some information to understand incidents or events.<br>▪ Cameras in selected locations may include increased functionality to allow remote control and motion video.<br>▪ Video is not buffered or stored currently, but this is a requested feature.<br>▪ Cameras are typically viewed by MSP operators in the TOCs, however Mn/DOT staff are secondary users of the cameras. | VS14: Mn/DOT Outstate District Traffic Operators dispatchers shall have the capability to control selected cameras remotely (some cameras will not allow remote control).<br>VS15: Mn/DOT Outstate District Traffic Operators shall have the capability to buffer camera images long term..<br>VS16: Communications for outstate cameras shall provide a mechanism for temporary (portable) cameras to be viewed remotely. |

| **Traffic Management Action:** Observation and Detection<br>**ITS Tool:** Visual Surveillance | | | |
|---|---|---|---|
| **Why is Visual Surveillance Used?** | **Who Uses Visual Surveillance?** | **How Visual Surveillance is or will be Used** | **Visual Surveillance Requirements** |
| | Minnesota State Patrol | ▪ Video is viewed at operators' workstations or on the RTMC viewing wall (in the Metro Area)<br>▪ Video is used to assess the incident/event and dispatch emergency management response appropriately<br>▪ Camera controls allow operators to zoom to the event and view surrounding areas<br>▪ Video is used to verify and assess the expected impacts of incidents/events create event descriptions<br>▪ Operators clarify lane closures, debris, and monitor the response actions | VS17: State Patrol Operators shall have the capability to control selected cameras remotely.<br>VS18: State Patrol Operators shall have the capability to control cameras from the operations center.<br>VS19: State Patrol Operators shall have the capability to zoom cameras to enough detail to observe debris and lane blockages through the cameras to assess crash severity.<br>VS20: State Patrol shall have access to real-time full motion video. |
| | Emergency Management Agencies | ▪ Video is viewed at operators' workstations<br>▪ Video is used to assess the incident/event and dispatch emergency management response appropriately | VS21: Emergency Management Agencies shall have access to real-time streaming video. |
| | RTMC Radio Contractor Announcer | ▪ Radio Contractor Announcers in the metro area view incidents using RTMC cameras when creating content for traffic announcements. Currently, this is a freeway emphasis, but as visual surveillance expands to the arterials, this role will increase.<br>▪ As arterials surveillance increases, the role of the radio announcer should be re-examined to define whether they report on all instrumented arterials, partial arterials, etc. | VS22: RTMC Radio Contractor shall have access to real-time full motion video. |

| **Traffic Management Action:** Observation and Detection<br>**ITS Tool:** Visual Surveillance | | | |
|---|---|---|---|
| **Why is Visual Surveillance Used?** | **Who Uses Visual Surveillance?** | **How Visual Surveillance is or will be Used** | **Visual Surveillance Requirements** |
| Need 2: Traffic Monitoring | Mn/DOT Metro Arterial Operations | ▪ Mn/DOT Arterial Operations Operators monitor cameras to observe traffic volumes and signal clearance on a periodic basis to assess performance of the signal system. However, visual observation does not replace field detection.<br>▪ Currently (2010) real-time traffic monitoring for the purpose of implementing immediate control changes is not performed regularly.<br>▪ As corridor management approaches (e.g. ICM) are implemented, Arterial Operations may begin to monitor traffic during peak periods and times of special events to implement flush timing plans (changing the role of the corridor in order to clear incidents on parallel routes). | VS23: Arterial cameras shall be located to allow viewing of all approaches to the intersection. |
| | 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.<br>▪ As visual surveillance expands to arterials throughout the metro area, this use may expand. | VS24: Public Agencies shall have access to real-time streaming video. |

| **Traffic Management Action:** Observation and Detection<br>**ITS Tool:** Visual Surveillance | | | |
|---|---|---|---|
| **Why is Visual Surveillance Used?** | **Who Uses Visual Surveillance?** | **How Visual Surveillance is or will be Used** | **Visual Surveillance Requirements** |
| | Information Service Providers | ▪ Television and Non-television media outlets observe video to assess speeds, congestion locations, and prepare traffic reports<br>▪ Television media outlets display video on television broadcasts<br>▪ RTMC Radio Contractor view camera images within the RTMC to create content for broadcasts in the metro area. | VS25: Television broadcasters shall have a mechanism to receive and broadcast camera feeds from all metro area cameras (one simultaneous operating feed).<br>VS26: Metro Area Television broadcasters shall receive real-time, full motion video.<br>VS27: 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<br>▪ Images on websites allow travelers to view congestion and driving conditions assisting in pre-trip decision making | VS28: 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 12: Visual Surveillance Constraints**

| Constraint | Description of Constraint |
|---|---|
| Operational Staff and Procedures | ▪ The effectiveness of each camera deployment is constrained by the approach to monitor the cameras (e.g. whether Mn/DOT Arterial Operations or Freeways Operations actively monitor camera images). Deployment of cameras without staff time dedicated to monitoring will reduce effectiveness. |
| Camera Locations | ▪ Camera location and spacing between cameras is a factor on the usefulness of the device.<br>▪ The role of each user and use case scenario should be considered when deploying cameras.<br>▪ 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 | ▪ The communications bandwidth to each camera must allow full motion video communicated to the RTMC in the metro area.<br>▪ 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 Arterial 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 Arterial 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 Contractor Radio announcers 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 13: 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<br>▪ ATIS01 Broadcast Traveler Information | ▪ Traffic Management (TM)04 Provide cameras at locations with high incidents and areas of high importance for incident identification and verification<br>▪ TM09 Share surveillance video data, and other information with PSAPs<br>▪ TM25 Operate CCTV cameras which corresponds with National ITS Architecture Market Package<br>▪ TM36 Implement Integrated Corridor Management (ICM)<br>▪ Traveler Information(TI)15 Make camera images available to travelers | ▪ ATMS 01 Network Surveillance<br>▪ 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 arterial traffic volumes and occupancy.

### 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 Metro Arterial Operations Perspective***

- Currently (2010) the metro area has limited detectors on arterials capable of reporting data in real-time to central locations. However, additional detectors and communication is being deployed.
- The Mn/DOT Metro Arterial Operations Group will use traffic detectors on arterials in advance of traffic signals (typically mid-block detectors) to detect traffic volume and occupancy in real-time. The data collected from the traffic detectors will be used to calculate travel times and display congestion levels on a map similar to the freeway congestion map. Historic traffic detector data is also used as new signal timing plans are implemented.
- Traffic data (reported either in real-time or periodically) is used by Mn/DOT Metro Arterial Operations to monitor changing volumes of highways and to determine when signal retiming needs to be performed.
- Note: Presence detectors at the intersections are used for local traffic control. These uses are described briefly in the traffic control sections of this ConOps (Section 10.0), and more extensively in the ConOps for traffic signal controllers developed as a separate document by Mn/DOT.

***2. Mn/DOT Outstate District Perspective***

- Many of Mn/DOT's Outstate Districts do not have traffic detectors on arterials. Detection will be considered as outstate districts plan traffic management strategies.
- Note: Local detectors tied to warning systems are included in other sections of this report (Section 10.0).

***3. Mn/DOT Planning Perspective***

- The Mn/DOT Planning section will use traffic detector data to understand and study arterial conditions for planning purposes.

*4. Television Information Service Providers / Media Outlets' Perspective*

- Local television news media will 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 will 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 will use traffic detector data to understand arterial conditions.

### 6.3.2 Operations and Maintenance Responsibility

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

**Table 14: Traffic Detection Operations and Maintenance Responsibilities**

| Traffic Detection Operations & Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Validating detector data<br>▪ Periodic validation that detectors are still functioning properly and reporting accurate data. | ▪ Mn/DOT Metro Area Arterial Operations | ▪ Mn/DOT District Traffic |
| Monitoring detector functionality and performance<br>▪ 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 Arterial Operations | ▪ Mn/DOT District Traffic |
| Repair or replacement of non-functioning detectors | ▪ Mn/DOT Metro Area Arterial Operations | ▪ Mn/DOT District Maintenance<br>▪ Mn/DOT District Traffic<br>▪ Mn/DOT ESS |
| Repair communication with non-functioning detectors | ▪ Mn/DOT Metro Area Maintenance | ▪ Mn/DOT District Maintenance<br>▪ Mn/DOT District IT<br>▪ 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 15: Observation and Detection Operation Concept: Traffic Detection**

| **Traffic Management Action:** Observation and Detection<br>**ITS Tool:** Traffic Detection | | | |
|---|---|---|---|
| **Why is Traffic Detection Used?** | **Who Uses Traffic Detection?** | **How is Traffic Detection Is or Will Be Used** | **Traffic Detection Requirements** |
| Need 2: Traffic monitoring | Mn/DOT Metro Arterial Operations | ▪ Traffic detector data is collected in the field and communicated to Mn/DOT Arterial Operations for viewing and archive. Currently (2010) this is only done on limited arterial corridors.<br>▪ Mn/DOT Arterial Operations Operators will view traffic data using TMC Software.<br>▪ Traffic data will be used by a Travel Time algorithm to automatically calculate travel times on key segments of the arterial.<br>▪ Traffic data will be observed periodically by Mn/DOT Arterial Operations Engineers to assess the need to retime signal systems. | TD1: Detectors shall be placed in advance of traffic signals.<br>TD2: Traffic detectors shall record volume and occupancy.<br>TD3: Traffic detector data shall be communicated to a central location for storage and algorithm processing at frequency that meets the need of each individual deployment. |
| | Mn/DOT Outstate Districts | ▪ Mn/DOT Outstate Districts do not currently (2010) have traffic detection on arterials. Traffic detection will be considered as traffic management strategies are planned and implemented. | N/A |
| | Mn/DOT Planning | ▪ Traffic detector data will be used by the Mn/DOT Planning group to understand trends in arterial traffic volumes. | TD4: Traffic detector data shall be archived for later retrieval and analysis. |

| **Traffic Management Action:** Observation and Detection<br>**ITS Tool:** Traffic Detection | | | |
|---|---|---|---|
| **Why is Traffic Detection Used?** | **Who Uses Traffic Detection?** | **How is Traffic Detection Is or Will Be Used** | **Traffic Detection Requirements** |
| | Information Service Providers (ISPs) | ▪ Volume and occupancy data (as detected by arterial detectors) will be available as an RSS / XML feed.<br>▪ Television and Non-television media outlets will use traffic detector data to assess/calculate speeds and travel times, congestion locations, and prepare traffic reports.<br>▪ Some ISPs operate systems that produce color coded arterial maps that 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 | ▪ Agencies may ingest detector data to understand and study arterial conditions. | 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 16: 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)<br>▪ Location in the arterial network (e.g. proximity to bridges or utilities) may impact the availability and cost feasibility of communications. |
| Constraint to Information Sharing | ▪ Information sharing is needed to allow organizations, agencies, and travelers outside Mn/DOT to access detector data. |
| Constraint by Data Processing and Response Formulation | ▪ Data processing and response formulation places a constraint on Traffic Detectors. Data processing and response formulation relies on the outputs of 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 17: 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 | ▪ Archived Data (AD)1 Data Mart<br>▪ AD2 Data Warehouse |

## 6.4 Condition Reporting System

A Condition Reporting System supports the manual and automated creation and assembly of current and planned events to be used to populate traveler information systems. The current Mn/DOT Condition Reporting System (Condition Acquisition and Reporting System – CARS) includes all Mn/DOT state maintained highways. Therefore, operators have the capabilities to enter events on all arterial highways.

### 6.4.1 Scenarios for the use of the Condition Reporting System

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

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

- Mn/DOT Arterial Operations does not currently (2010) enter conditions in a condition reporting system. However, as the deployment of visual surveillance expands, Mn/DOT Arterial Operations will have an increased level of real-time knowledge of the status of the road network. In the interim, Mn/DOT Arterial Operations may request freeway operations personnel to enter real-time reports in the condition reporting system as incidents are detected.

- Over time, a transition might occur where Mn/DOT Arterial Operations personnel enter arterial incidents and events in the condition reporting system. The Internet nature of the condition reporting system would technically allow for this type of operation. However, operational procedures, training, and other institutional issues would be required to reach full operations of arterial incident/event entry.

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

- While the Metro Area Freeway Operations Group will primarily enter crashes and other real-time incidents impacting the metro area freeways, they have the capability (with the condition reporting system) to enter arterial incidents if they are known to the RTMC.

***3. Mn/DOT Metro Maintenance Dispatch Perspective***

- Metro Area Maintenance dispatchers input road condition information for freeways into the condition reporting system.

- Metro Area Maintenance enters planned maintenance that will impact travelers, such as lane or road closures for freeways.

- Current operational procedures are for metro maintenance to enter conditions on freeways when the RTMC is not staffed by freeway operations. Metro maintenance could assume a role of entering arterial conditions.

4. ***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.

5. ***Mn/DOT Construction Perspective***

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

6. ***Mn/DOT Public Affairs Perspective***

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

### 6.4.2 Operations and Maintenance Responsibilities

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

**Table 18: 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 Arterials Operations<br>▪ Mn/DOT Metro Area Freeway Operations<br>▪ Mn/DOT Metro Area Construction<br>▪ Mn/DOT Metro Area Maintenance | ▪ Mn/DOT District Construction<br>▪ Mn/DOT District Maintenance<br>▪ Minnesota State Patrol |
| System management:<br>▪ User account creation<br>▪ System Governance<br>▪ Contractor management<br>▪ Upgrades and enhancement prioritization | ▪ Mn/DOT Public Affairs | ▪ Mn/DOT Public Affairs |

### 6.4.3 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 19: Observation and Detection Operational Concept: Condition Reporting System**

| **Traffic Management Action:** Observation and Detection<br>**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 8: Manual Event Reporting | Mn/DOT Metro Freeway Operations<br><br>Mn/DOT Metro Arterial Operations<br><br>Mn/DOT Metro Maintenance<br><br>Mn/DOT Outstate Districts<br><br>Outstate Minnesota State Patrol<br><br>Mn/DOT Construction | ▪ Currently (2010) the majority of manual event entry on arterials is roadwork or driving condition reporting.<br>▪ As visual surveillance increases in the metro areas, and arterial operations takes a more real-time management role, there could be an increase in the entry of real-time events.<br>▪ The Condition Reporting System is available to any authorized user through Internet access<br>▪ Unplanned events (driving conditions, crashes, closures, Amber Alerts) are entered by authorized users from any Internet accessible location.<br>▪ Planned events (e.g. roadwork, planned closures) are entered into the system and automatically feed the traveler information systems.<br>▪ 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.<br>▪ Event locations are described by specifying the highway and the start/end locations on the highway; or an entire county. | CRS1: Mn/DOT Freeway Operators, Mn/DOT Arterial Operations, Mn/DOT Metro Maintenance, Mn/DOT Outstate Districts, Mn/DOT Construction, and Outstate Minnesota State Patrol shall have access via the internet to the Condition Reporting System<br>CRS2: The Condition Reporting System shall allow for event entry of current events or future planned events.<br>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.<br>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. |

### 6.4.4 External Constraints of the Condition Reporting System

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

**Table 20: 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. |

### 6.4.5 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 21: 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<br>▪ ATIS01 Broadcast Traveler Information | ▪ TM05 Provide incident and congestion information to travelers<br>▪ TI01 Provide incident information on freeways and major arterials<br>▪ TI05 Provide information on roadway construction and maintenance activities<br>▪ TI 08 Provide information on seasonal weight restrictions<br>▪ TI09 Provide information on CVO permit restrictions<br>▪ TI10 Operate a statewide web-based and telephone 511 systemTI17 Provide travel time or traffic condition maps for major signalized arterials<br>▪ TI22 Include information on local roads in 511 | ▪ ATIS01 Broadcast Traveler Information<br>▪ ATIS02 Interactive Traveler Information<br>▪ ATMS06 Traffic Information Dissemination |

# 7.0 Data Processing and Response Formulation

## *7.1 Operational Concept for Data Processing and Response Formulation*

### 7.1.1 Role in Arterial 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 formulation 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 6: Arterial operational analysis;
- Need 7: Arterial data storage, archive, and access;
- Need 9: Device control; and
- Need 10: Coordinated control.

### 7.1.3 ITS Tools for Data Processing and Response Formulation

The ITS Tool 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 22: 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 6: Arterial operational analysis | Need 2: Traffic monitoring | Observation and Detection |
| | Need 7: Arterial data storage, archive and access | Data Processing and Response Formulation |
| Need 9: Device Control | N/A | N/A |
| Need 10: Coordinated Control | Need 2: Traffic 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 traffic signal control systems. 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 Arterial Operations Perspective***

    - *Automated Traffic Controls* – Mn/DOT Arterial Operations personnel use TMC Software to operate a set of algorithms that control timing parameters of traffic signal control systems. Timing parameters can be implemented based on time of day, day of week, or in response to dynamic traffic conditions. TMC software is also used to operate a set of algorithms that calculate Travel Times on selected routes and post the Travel Times on DMS and to a website.

    - *Manual Traffic Controls* – Arterial Operations personnel use TMC Software to perform a variety of manual traffic management controls. TMC Software allows operators to view information about the arterials including volume, occupancy, and status of field devices. TMC Software also allows operators to control field devices such as deploying new timing parameters to traffic signal control systems, overriding automated timing parameters in traffic signal control systems with manually specified timing parameters, control the pan/tilt/zoom of cameras, view the camera images at workstations and on the wall display, and post messages to the DMS signs.

    - *Efficient Traffic Signal Operations* – TMC Software can be used for interconnected traffic signal control systems. Each individual traffic signal control system communicates with nearby systems in order to provide coordinated phase changes. This methodology allows for the clustering of vehicles into platoons and providing a series of green phases on the major intersection approaches. The platoon affect creates efficiency at each individual traffic signal control system by allowing the system to service a high number of vehicles on these approaches in a given portion of the signal cycle. By coordinating green phases along the corridor, efficiency for travelers is created by reducing the delays caused by stopping at several traffic signal control systems. TMC Software also allows for time synchronization of all individual traffic signal control systems to one authoritative source. This helps maintain the efficiency of the overall system over time and helps to reduce the need for maintenance activities.

### 2. *Mn/DOT Metro Maintenance Perspective*

- Mn/DOT Metro Maintenance Dispatchers use TMC Software to monitor and observe system outages and system performance. Alerts and/or notifications for traffic signal control system faults can be sent to maintenance personnel. Examples of these issues include a dark system, a system that is in flash, detector(s) continuously placing a request, pedestrian push button(s) continuously placing a request, detector that is not reporting or reporting inaccurate volume information, and Emergency Vehicle Preemption (EVP) activations.

- Metro Area Maintenance Dispatchers use TMC Software to post messages to DMS at times when Arterial 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.

### 7.2.2 Operations and Maintenance Responsibility

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

**Table 23: 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<br>▪ Mn/DOT Metro Area Arterial Operations | ▪ Mn/DOT Metro Area Arterial Operations<br>▪ Mn/DOT District Traffic Office<br>▪ Mn/DOT ESS<br>▪ Mn/DOT Metro Area Traffic Operations<br>▪ Mn/DOT District Traffic Office<br>▪ Software Vendor |
| Operate and maintain communications with field devices and server system | ▪ Mn/DOT Metro Area Arterial Operations<br>▪ Mn/DOT Metro Area Maintenance<br>▪ Mn/DOT Metro Area IT<br>▪ Mn/DOT Metro Area ESS | ▪ Mn/DOT District IT<br>▪ Mn/DOT District Maintenance<br>▪ Mn/DOT ESS |
| Maintain, support, and update the TMC Software Code | ▪ Mn/DOT Metro Area Freeway Operations<br>▪ Mn/DOT Metro Area Arterial Operations<br>▪ Mn/DOT Metro Area IT | ▪ Mn/DOT Metro Area Freeway Operations<br>▪ 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 24: Data Processing and Response Formulation Operational Concept: TMC Software**

| **Traffic Management Action:** Data Processing and Response Formulation<br>**ITS Tool:** TMC Software | | | |
|---|---|---|---|
| **Why is TMC Software Used?** | **Who Uses TMC Software?** | **How TMC Software Is or Will Be Used** | **TMC Software Requirements** |
| Need 6: Arterial operational analysis | Mn/DOT Metro Arterial Operations | ▪ Currently (2010) Mn/DOT Arterial Operations staff do not regularly monitor arterial conditions in real-time, post DMS messages, or implement real-time signal timing changes.<br>▪ Beginning in summer 2010, limited arterials in the metro area (Hwy 13, Hwy 55, Hwy 7) will be equipped with real-time monitoring and control.<br>▪ As arterials are equipped, Mn/DOT Arterial Operations will increasingly begin to monitor the highways. Initially, this will most likely consist of monitoring during busy peak periods (e.g. holiday weekends, inclement weather). Real-time monitoring will include:<br>○ Observing congestion, crashes or obstructions<br>○ Posting DMS messages<br>○ Entering events in the Condition Reporting System.<br>▪ As real-time monitoring and response becomes a higher priority, staff may one day be dedicated solely to perform real-time operations and response, either from their desk or from within a workstation at the RTMC.<br>▪ Metro Arterial Operations will operate one or more algorithms to calculate arterial travel times on those corridors equipped with real-time detection and communications. | N/A |

| **Traffic Management Action:** Data Processing and Response Formulation<br>**ITS Tool:** TMC Software | | | |
|---|---|---|---|
| **Why is TMC Software Used?** | **Who Uses TMC Software?** | **How TMC Software Is or Will Be Used** | **TMC Software Requirements** |
| Need 9: Device Control | Mn/DOT Metro Arterial Operations | ▪ 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 traffic signal timing plans).<br>▪ 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.<br>▪ The Travel Times computed by automated algorithms will be sent to the appropriate DMS as a message, and posted on the website for travelers to view by the TMC software.<br>▪ Operators use available data and information (volume, occupancy, camera views) to determine if automated traffic signal timing plans should be manual overridden. Timing plans are selected from pre-defined plan options stored in the TMC software and deployed to the system.<br>▪ Operators use the TMC software to modify traffic signal control system timing parameters.<br>▪ Operators use the TMC software to control signs on the managed corridors.<br>▪ The TMC software displays recommended messages to operators for the managed corridors.<br>▪ Operators use the TMC software to monitor status of field | TMC 1: The TMC Software shall communicate with detectors, DMS, CCTV, and traffic signal control systems.<br>TMC2: The TMC Software shall present operators with a view of current traffic detector data.<br>TMC3: The TMC Software shall provide a mechanism for operators to select a DMS to view current messages displayed and select messages from pre-defined message lists or symbol lists.<br>TMC4: The TMC Software shall prioritize DMS message displays according to rules and procedures stored in the TMC Software.<br>TMC5: The TMC Software shall provide operators a mechanism to control cameras.<br>TMC6: The TMC Software shall send control commands to field devices that cause the field devices to perform actions (e.g. display messages) either from manual commands or automated algorithm outcomes. |

| **Traffic Management Action:** Data Processing and Response Formulation<br>**ITS Tool:** TMC Software | | | |
|---|---|---|---|
| **Why is TMC Software Used?** | **Who Uses TMC Software?** | **How TMC Software Is or Will Be Used** | **TMC Software Requirements** |
| | | devices. | TMC7: The TMC Software shall report status of field devices connected to the TMC Software.<br>TMC8: The TMC Software shall be accessible to Mn/DOT and MSP operators at any location connected to the Mn/DOT Local Area Network (LAN).<br>TMC9: MSP shall have full entry authority to TMC Software.<br>TMC10: The TMC Software shall operate algorithms that execute calculations using data ingested, and control devices automatically based upon the algorithm rules (e.g. calculate arterial travel times and post travel times to DMS automatically).<br>TMC11: The TMC Software shall provide a mechanism for operators to override automated algorithms by performing manual controls. |
| | Mn/DOT Metro Maintenance | ▪ Operators control arterial management devices (DMS and cameras) from their workstations when critical events occur and Arterial Operations staff are not on duty. | |
| | Mn/DOT Outstate Districts<br><br>Outstate Minnesota State Patrol | ▪ State Patrol dispatchers are usually first alerted to crashes or incidents in outstate Minnesota. MSP dispatchers will post messages to be displayed on DMS. Mn/DOT Traffic personnel also have the capability to post messages on DMS. | |

| **Traffic Management Action:** Data Processing and Response Formulation<br>**ITS Tool:** TMC Software | | | |
|---|---|---|---|
| **Why is TMC Software Used?** | **Who Uses TMC Software?** | **How TMC Software Is or Will Be Used** | **TMC Software Requirements** |
| Need 10: Coordinated Control | Mn/DOT Metro Arterial Operations | ▪ An algorithm automatically determines the traffic signal control system timing plan to be activated based upon time of day. In traffic responsive systems, timing plans may be activated based upon detector data and an internal algorithm. Manual intervention from operators overrides the automated timing plan selection.<br>▪ An algorithm compares detector data on managed corridors and determines messages to be presented to operators based upon thresholds being met. | TMC12: The TMC Software shall provide a mechanism to retrieve, archive, store, and process traffic signal control system detector data.<br>TMC13: The TMC Software shall provide a mechanism to remotely upload and download traffic signal control system timing plans with field devices. |

### 7.2.4 External Constraints of TMC Software

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

**Table 25: TMC Software Constraints**

| Constraint | Description of Constraint |
|---|---|
| Open Source Software | ▪ Mn/DOT metro 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

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

**Table 26: 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<br>▪ ATMS04 Freeway Control | ▪ TM01 Provide efficient signal timing<br>▪ TM14 Monitor operation and performance of traffic signals<br>▪ TM22 Provide a system-coordinated response for incidents<br>▪ TM24 Operate freeway/expressway DMS<br>▪ TM25 Operate CCTV cameras<br>▪ TM36 Implement Integrated Corridor Management (ICM) strategies<br>▪ TM37 Provide safe signal phase transition | ▪ ATMS03 Surface Street Control<br>▪ ATMS07 Regional Traffic Management |

## *7.3 Data Extract Tool*

Beyond the real-time use of detector data, the detector data for arterials 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 Arterial Operational Analysis. However, there are a variety of users and a variety of reasons why arterial 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 Arterial Operations Perspective***

- Mn/DOT Arterial Operations personnel uses the data extract tool to analyze data from arterial 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. Research Organizations***

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

### 7.3.2 Operations and Maintenance Responsibility

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

**Table 27: Data Extract Tool Operations and Maintenance Responsibilities**

| Data and Extract Tool Operation and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Software and servers operations and maintenance | ▪ Mn/DOT Metro Freeway Operations<br>▪ Mn/DOT Metro Arterial Operations | ▪ Mn/DOT Metro Arterial Operations<br>▪ Mn/DOT District Traffic Office<br>▪ Mn/DOT District ESS<br>▪ Mn/DOT District Traffic Office<br>▪ 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 28: Data Processing and Response Formulation Operational Concept: Data Extract Tool**

| **Traffic Management Action:** Data Processing and Response Formulation<br>**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 7: Arterial data storage, archive, and access | Mn/DOT Metro Arterial Operations | ▪ The data extract is accessed over the internet, reports are downloaded as spreadsheets.<br>▪ The Data Extract Tool is used to request and receive reports from any combination of detectors on the arterials for any time periods (pending availability of data).<br>▪ Volume and occupancy data isviewed 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.<br>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 | ▪ The Data Extract Tool is used to access actual traffic data and used as inputs to e long term modeling and planning. | DET1: The Data Extract Tool shall be accessible to any agency using Internet connectivity. |
| | Other Agencies | ▪ The Data Extract Tool allows any user to access historical volume and occupancy data throughout the arterial system. Research agencies and consulting firms 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 29: 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 30: 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<br>▪ AD2 Data Warehouse |

# 8.0 Information Sharing

## *8.1 Operational Concept for Information Sharing*

### 8.1.1 Role in Arterial 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 arterial 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 #3: Real-time travel time/congestion notification;
- Need #4: Real-time planned event notification;
- Need #5: Real-time unplanned event notification; and
- Need #17: Center-to-Center communications.

### 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);***
- ***Web Displays; and***
- ***511 Phone systems.***

### 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 31: 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 3: Real-time travel time/congestion notification<br><br>Need 5: Real-time unplanned event notification | Need 6: Arterial Operational Analysis<br>Need 9: Device Control | Data Processing and Response Formulation |
| | Need 1: Incident/Event verification<br>Need 2: Traffic monitoring | Observation and Detection |
| Need 4: Real-time planned event notification | Need 8: Manual Event Reporting | |
| | Need 6: Arterial Operational Analysis<br>Need 9: 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 five distinct use case scenarios for DMS:

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

- *Travel times or congestion.* Travel times or related congestion descriptions may be 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.

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

- *Planned event notification.* DMS are used to inform travelers of planned events and incidents, including such things as roadwork, planned closures or recreational events. 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, when 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 or weather alerts 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 the RTMC is 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 events 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 32: DMS Operations and Maintenance Responsibilities**

| DMS Operations and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Content selection for DMS display<br>*Real-time decisions about the information to be disseminated to travelers (e.g. is there roadwork to report? Is a crash impacting the arterial?)* | ▪ Mn/DOT Metro Arterial Operations | ▪ State Patrol<br>▪ Mn/DOT District Traffic |
| Controlling and Activating DMS | ▪ Mn/DOT Metro Arterial Operations | ▪ State Patrol<br>▪ Mn/DOT District Traffic<br>▪ Mn/DOT District Construction<br>▪ Mn/DOT District Maintenance<br>▪ Construction Contractor |
| Maintain existing DMS | ▪ Mn/DOT Metro Maintenance | ▪ Mn/DOT District Maintenance<br>▪ Mn/DOT District IT Maintenance<br>▪ Mn/DOT District Traffic<br>▪ Mn/DOT District ESS |
| Maintain communications with DMS | ▪ Mn/DOT Metro 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 33: Information Sharing Operational Concept: Dynamic Message Signs**

<table>
<tr><td colspan="4">Traffic Management Action: Information Sharing<br>ITS Tool: Dynamic Message Sign</td></tr>
<tr><th>Why are DMS Used?</th><th>Who Uses DMS?</th><th>How are DMS Used?</th><th>DMS Requirements</th></tr>
<tr><td rowspan="2">Need 3: Real-time travel time/ congestion notification</td><td>Mn/DOT Metro Arterial Operations</td><td>▪ Automated calculations of travel times will generate messages describing arterial 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).<br>▪ Travel Time message will be posted only during peak periods and follow standard RTMC protocols for message priority.<br>▪ The Arterial Operations group is responsible for configuring which DMS display Travel Time messages and which landmarks are used to describe Travel Times.<br>▪ 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.<br>▪ Manually created messages are either entered with an expiration time/date, or are manually removed by operators.</td><td>DMS1: Arterial DMS shall receive communications from TMC Software describing messages to be displayed on the sign.<br>DMS2: Arterial DMS shall confirm successful receipt of the communications from TMC Software.<br>DMS3: Arterial DMS shall communicate to the TMC Software the current messages displayed on the DMS.</td></tr>
<tr><td>Traveling public (Arterial commuters)</td><td>▪ Travelers will view DMS message and select whether to use an alternate route or continue on the current route.<br>▪ Travelers benefit from understanding the extent of the travel delays (Travel Times) or the cause of the congestion (e.g. ‘crash ahead expect delays’).</td><td>DMS4: Arterial DMS shall be located strategically to support decision points for travelers.<br>DMS5: DMS displays shall be appropriate for viewing at arterial speeds.</td></tr>
</table>

| **Traffic Management Action:** Information Sharing<br>**ITS Tool:** Dynamic Message Sign | | | |
|---|---|---|---|
| **Why are DMS Used?** | **Who Uses DMS?** | **How are DMS Used?** | **DMS Requirements** |
| Need 5: Real-time unplanned event notification | Mn/DOT Metro Arterial Operations | ▪ When incidents are observed on cameras or reported through cellular 911 (via Minnesota State Patrol), or other delay causing events are observed, Arterial Operations dispatchers will post messages to arterial DMS informing travelers of conditions.<br>▪ Arterial Operations dispatchers will use the TMC software to enter events. | DMS1: Arterial DMS shall receive communications from TMC Software describing messages to be displayed on the sign.<br>DMS2: Arterial DMS shall confirm successful receipt of the communications from TMC Software.<br>DMS3: Arterial DMS shall communicate to the TMC Software the current messages displayed on the DMS.<br>DMS6: Arterial DMS shall be capable of displaying all possible messages pre-defined in the TMC Software. |
| | Outstate Districts | ▪ State Patrol dispatchers are usually first alerted to crashes or incidents. MSP dispatchers will post messages to be displayed on DMS. Mn/DOT Traffic personnel also have the capability to post messages. | DMS1: Arterial DMS shall receive communications from TMC Software describing messages to be displayed on the sign.<br>DMS2: Arterial DMS shall confirm successful receipt of the communications from TMC Software.<br>DMS3: Arterial DMS shall communicate to the TMC Software the current messages displayed on the DMS. |
| | 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 arterial driving. | N/A |

| **Traffic Management Action:** Information Sharing<br>**ITS Tool:** Dynamic Message Sign | | | |
|---|---|---|---|
| **Why are DMS Used?** | **Who Uses DMS?** | **How are DMS Used?** | **DMS Requirements** |
| | Traveling Public | ▪ View incident notifications on DMS to assist in selecting routes. | DMS4: Arterial DMS shall be located strategically to support decision points for travelers.<br>DMS5: DMS displays shall be appropriate for viewing at arterial speeds. |
| Need 4: Real-time planned event notification | Mn/DOT Metro Arterial Operations | ▪ Mn/DOT Arterial 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.<br>▪ Portable DMS are positioned in areas for temporary information dissemination (e.g. work zones) to alert travelers to specific conditions or events. | DMS1: Arterial DMS shall receive communications from TMC Software describing messages to be displayed on the sign.<br>DMS2: Arterial DMS shall confirm successful receipt of the communications from TMC Software.<br>DMS3: Arterial DMS shall communicate to the TMC Software the current messages displayed on the DMS. |
| | Mn/DOT Maintenance | ▪ Mn/DOT Maintenance will post maintenance and roadwork messages during times when Arterial Operations are not on duty. | DMS1: Arterial DMS shall receive communications from TMC Software describing messages to be displayed on the sign.<br>DMS2: Arterial DMS shall confirm successful receipt of the communications from TMC Software.<br>DMS3: Arterial DMS shall communicate to the TMC Software the current messages displayed on the DMS. |

| **Traffic Management Action:** Information Sharing<br>**ITS Tool:** Dynamic Message Sign | | | |
|---|---|---|---|
| **Why are DMS Used?** | **Who Uses DMS?** | **How are DMS Used?** | **DMS Requirements** |
| | Outstate Districts | ▪ Portable DMS may be located at locations requiring temporary information dissemination (e.g. work zones, tourist areas on busy weekends). Portable DMS may display locally programmed 'static' messages (e.g. 'expect heavy traffic ahead') or may be remotely controlled to display real-time information. | DMS1: Arterial DMS shall receive communications from TMC Software describing messages to be displayed on the sign.<br>DMS2: Arterial DMS shall confirm successful receipt of the communications from TMC Software.<br>DMS3: Arterial DMS shall communicate to the TMC Software the current messages displayed on the DMS.<br>DMS7: Portable Arterial DMS shall receive communication locally. |
| | Traveling Public | ▪ View event information to follow a path to an event or to avoid the route during construction/maintenance. | DMS4: Arterial DMS shall be located strategically to support decision points for travelers.<br>DMS5: DMS displays shall be appropriate for viewing at arterial speeds. |

### 8.2.4 External Constraints of Dynamic Message Signs

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

**Table 34: 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).<br>▪ The role of each user and use case scenario should be considered when identifying the location of a DMS.<br>▪ 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 35: Role of Dynamic Message 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 |
|---|---|---|
| ▪ ATMS06 Traffic Information Dissemination | ▪ TM24 Operate Freeway/Expressway DMS which corresponds with National ITS Architecture Market Package | ▪ ATMS 06 Traffic Information Dissemination |

## *8.3 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.

### 8.3.1 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 Arterial Operations Perspective***

- Arterial Operations will operate a website with a traffic flow map, camera images, travel times, and incidents/events.
- Arterial Operations Group staff will (at least initially) rely upon Mn/DOT website displays of camera images (still images or full motion) to view conditions. This use of the websites will allow Arterial Operations Group staff to monitor conditions from their desks in lieu of being within the RTMC.

***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.

### 8.3.2 Operations and Maintenance Responsibility

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

**Table 36: Web Pages Operations and Maintenance Responsibilities**

| Operational Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Information content creation<br>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 Arterial Operations<br>▪ Mn/DOT Metro Maintenance<br>▪ Mn/DOT Metro Construction | ▪ State Patrol<br>▪ Mn/DOT District Traffic<br>▪ Mn/DOT District Construction<br>▪ Mn/DOT District Maintenance |
| Overall Operations and Maintenance of Websites | ▪ Mn/DOT Metro Arterial Operations (Mn/DOT site)<br>▪ Vendor/contractor (statewide site) | ▪ Vendor Contractor |
| 24/7 operations, including monitoring and support to correct system outages | ▪ Mn/DOT Metro Arterial Operations<br>▪ 511 Contractor | ▪ 511 Contractor |
| Monitor bandwidth | ▪ Mn/DOT Metro Arterial Operations<br>▪ 511 Contractor | ▪ Mn/DOT District IT Maintenance<br>▪ 511 Contractor |

### 8.3.3 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 the web pages.

**Table 37: Information Sharing Operational Concept: Web Pages**

| **Traffic Management Action:** Information Sharing<br>**ITS Tool:** Web Pages | | | |
|---|---|---|---|
| **Why are Web Pages Used?** | **Who Uses Web Pages?** | **How are Web Pages Used?** | **Web Pages Requirements** |
| Need 4: Real-time planned event notification<br><br>Need 5: Real-time unplanned event notification<br><br>Need #17: Center-to-Center communica-tion | Mn/DOT Metro Arterial 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.<br>▪ Camera images are displayed on the web site as a mechanism for sharing camera views with the traveling public and other transportation agencies.<br>▪ Arterial Operations staff members will use website camera image displays to view conditions on the arterials. | WP1: Mn/DOT web pages shall receive data and information describing events, incidents, traffic, driving conditions.<br>WP2: Mn/DOT web pages shall format data and information and display content using a combination of map and text based displays.<br>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<br>▪ 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.<br>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 the image. |

### 8.3.4 External Constraints of Web Pages

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

**Table 38: 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. Inability to communicate 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. |

### 8.3.5 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 39: 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<br>▪ ATMS01 Network Surveillance | ▪ TM05 Provide incident and congestion information to travelers<br>▪ TM09 Share surveillance video data, and other information with PSAPs | ▪ ATIS01 Broadcast Traveler Information<br>▪ ATIS02 Interactive Traveler Information<br>▪ ATMS06 Traffic Information Dissemination<br>▪ ATMS08 Traffic Incident Management |

## 8.4 511 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.

### 8.4.1 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 System. 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.

### 8.4.2 Operations and Maintenance Responsibility

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

**Table 40: 511 Phone Operations and Maintenance Responsibilities**

| 511 Phone Operations and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| 24/7 Operations of the Phone system<br>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<br>▪ 511 Contractor | ▪ Mn/DOT Public Affairs<br>▪ 511 Contractor |
| Maintenance of the 511 Phone System | ▪ Mn/DOT Public Affairs<br>▪ 511 Contractor | ▪ Mn/DOT Public Affairs<br>▪ 511 Contractor |

### 8.4.3 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 System.

**Table 41: Information Sharing Operational Concept: 511 Phone**

| **Traffic Management Action:** Information Sharing<br>**ITS Tool:** 511 Phone | | | |
|---|---|---|---|
| **Why is 511 Phone Used?** | **Who Uses 511 Phone?** | **How is 511 Phone Used?** | **511 Phone Requirements** |
| Need 4: Real-time Planned Event Notification<br><br>Need 5: Real-time Unplanned Event Notification | Mn/DOT Public Affairs | ▪ Content for the 511 phone system is automatically generated from events in the Condition Reporting System<br>▪ Amber Alerts may be recorded as a "floodgate message" played at the onset of the call by authorized Mn/DOT representatives.<br>▪ 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.<br>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: Public shall have a mechanism to access the 511 Phone. |

### 8.4.4 External Constraints of 511 Phone

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

**Table 42: 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. |

### 8.4.5 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 43: Role of the 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<br>▪ ATIS02 Interactive Traveler Information<br>▪ ATMS06 Traffic Information Dissemination |

# 9.0 Corridor-wide Traffic Control

## *9.1 Operational Concept for Traffic Control*

### 9.1.1 Role in Arterial Traffic Management

Corridor –wide Traffic control describes the action of regulating or guiding traffic on an arterial corridor to optimize throughput while maintaining safety. Corridor traffic management also includes the capability to redefine the function of the corridor as needed for overall network traffic management, as in the case of integrated corridor management.

### 9.1.2 Needs Addressed by Traffic Control

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

- Need 10: Coordinated Control; and
- Need 12: Multimodal options.

### 9.1.3 ITS Tools for Traffic Control

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

- ***Traffic Signal Control Systems***

### 9.1.4 Interdependencies of Needs

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

**Table 44: Traffic Control Interdependencies of Needs**

| In Order for Traffic Management to Meet This Need | This Need Must Be Met (The Dependency) | Action Responsible for Meeting Dependency |
|---|---|---|
| Need 10: Coordinated Control | Need 2: Traffic Monitoring | Observation and Detection |

## *9.2 Traffic Signal Control System*

Traffic Signal Control Systems are utilized where arterial highways intersect at-grade with other roadways. Traffic Signal Control Systems are a right-of-way assignment device with a variety of operational schemes and subsystems. Depending on the specific configuration, Traffic Signal Control Systems may include detection (i.e. loop detectors, microwave detection, video detection, push button stations), indications (for vehicles, pedestrians, and/or bicycles), controller for the storage of timing logic and algorithms, communication hardware (for coordination and/or management), and hardware to make the system accessible for pedestrians with disabilities.

### 9.2.1 Scenarios for the use of Traffic Signal Control System

There are two distinct use case scenarios for traffic signal control systems:

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

- Mn/DOT uses traffic control signal systems to facilitate the movement of vehicular traffic through at-grade intersections.
- Traffic control signal systems are frequently designed and constructed to accommodate pedestrian crossings at the intersection.
- Recently, additional efforts have been made to make traffic signal control systems more accommodating for pedestrians with special needs and bicycles.

***2. Traveling public Perspective***

- The traveling public must adhere to green and red lights at traffic signal control systems. Pedestrians must adhere to walk/don't walk signs at traffic signal control systems.

### 9.2.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for traffic signal control systems are shown in the table below.

**Table 45: Traffic Signal Control Systems Operations and Maintenance Responsibilities**

| Traffic Signal Control Systems Operations and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Operations of Traffic Signal Control Systems | ▪ Mn/DOT Metro Signals Operations | ▪ Mn/DOT District Traffic |
| Maintenance of Traffic Signal Control Systems | ▪ Mn/DOT Metro Signals Operations<br>▪ Mn/DOT ESS | ▪ Mn/DOT District Traffic<br>▪ Mn/DOT ESS |

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

The following table describes:

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

**Table 46: Traffic Control Operational Concept: Traffic Signal Control Systems**

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Traffic Signal Control System (TSCS) | | | |
|---|---|---|---|
| **Why are TSCS Used?** | **Who Uses TSCS?** | **How are Traffic Signal Control Systems Used?** | **Traffic Signal Control Systems Requirements** |
| Need #10: Coordinated Control<br><br>Need #12: Multimodal Options | Mn/DOT Metro Arterial Operations | ▪ Traffic signal control systems are used to assign right-of-way to one or more movements at an intersection.<br>▪ Typically, traffic signal control systems are programmed to reduce intersection delay.<br>▪ Traffic signal control systems can be programmed with one or more timing plans. Plans can be implemented based upon time of day, day of week, or real-time traffic patterns in order to maintain operational efficiency.<br>▪ Data can be uploaded and downloaded (to/from an external center using TMC Software) when a traffic signal control system is connected to a communications system. Data sent to the TSCS includes timing plans. Data returned from the TSCS includes loop detector data, and notifications and/or alerts regarding system performance or issues.<br>▪ When feasible, several traffic signal control systems along a corridor are interconnected via a communications system. This allows for coordination amongst multiple traffic signal control systems reducing travel times along the corridor and providing efficiencies for all modes.<br>▪ Traffic signal control systems assist pedestrians in crossing arterials.<br>▪ Recently, traffic signal control systems are being constructed or retrofitted with devices to better accommodate users with disabilities.<br>▪ Typically, newly constructed or retrofitted traffic control | TSCS1: Traffic Signal Control Systems should be in installed in accordance with guidance provided in the Minnesota Manual on Uniform Traffic Control Devices (MMUTCD).<br>TSCS2: Traffic Signal Control Systems should be designed in accordance with guidance provided in the Mn/DOT Signal Design Manual.<br>TSCS3: Traffic Signal Control Systems should be installed in accordance with guidance provided in the Mn/DOT Traffic Engineering Manual (TEM).<br>TSCS4: Traffic Signal Control Systems should be operated in accordance with guidance provided in the Mn/DOT Traffic Signal Timing and Coordination Manual. |

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Traffic Signal Control System (TSCS) | | | |
|---|---|---|---|
| **Why are TSCS Used?** | **Who Uses TSCS?** | **How are Traffic Signal Control Systems Used?** | **Traffic Signal Control Systems Requirements** |
| | | signal systems include pedestrian countdown timer indications to inform pedestrians on the amount of time left they can safely cross the intersection.<br>▪ Traffic signal control systems are evaluated and prioritized regarding the installation of other subsystem devices in order to make the system more accessible to pedestrians with special needs. | |
| | Public | ▪ Travelers view signal phase indications en-route.<br>▪ The traveling public must adhere to green and red lights at traffic signal control systems. | TSCS5: Traffic Signal Control Systems shall display control messages to travelers using understood and unambiguous displays. |

### 9.2.4 External Constraints of Traffic Signal Control Systems

External constraints involving traffic signal controls systems are summarized in the following table.

**Table 47: Traffic Signal Control Systems Constraints**

| Constraint | Description of Constraint |
|---|---|
| Traffic Signal Control Systems Location | ▪ Traffic Signal System location and spacing is a factor for the usefulness of the device.<br>▪ The role of each user and use case scenario should be considered when deploying traffic signal control systems.<br>▪ Other factors such as natural and man-made obstructions should also be considered. |
| Traffic Signal Control Systems Power Source | ▪ The location of the power source for traffic signal control system deployment should be considered. |
| Communications with Traffic Signal Control Systems | ▪ Individual use case scenarios for each traffic signal control system should be considered when designing communications (e.g. whether communication to system or amongst several systems is required) |

### 9.2.5 Role of Traffic Control Systems in ITS Architecture

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

**Table 48: Role of Traffic Control 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 |
|---|---|---|
| ▪ ATMS03-Surface Street Control | ▪ TM01 Provide efficient signal timing; and<br>▪ TM 37 Provide safe signal phase transition. | ▪ ATMS07 Regional Traffic Management |

# 10.0 Local Arterial Traffic Control and Traveler Alerts

## *10.1 Operational Concept for Local Arterial Traffic Control and Traveler Alerts*

### 10.1.1 Role in Arterial Traffic Management

Local area traffic control and traveler alert strategies are used to manage traffic through scenarios where the safety, mobility, or efficiency of the travelers may be jeopardized at any time. Local traffic control systems typically do not rely on data or manual intervention from outside systems, but rather operate on a 'stand-alone' basis and focus on a very specific portion of the infrastructure.

### 10.1.2 Needs Addressed by Local Arterial Traffic Control and Traveler Alerts

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

- Need 11: Speed Control;
- Need 13: Emergency Management;
- Need 14: Enforcement Systems;
- Need 15: Transit Vehicle Advantages; and
- Need 16: Warning Systems.

### 10.1.3 ITS Tools for Local Arterial Traffic Control and Traveler Alerts

The ITS Tools used to perform Local Arterial Traffic Control and Traveler Alerts, and therefore address the stated needs include:

- ***Dynamic Speed Display Signs***;
- ***Emergency Vehicle Preemption;***
- ***Safety Systems;***
- ***Red Light Running System;***
- ***Enforcement Light System;*** and
- ***Transit Signal Priority***.

### 10.1.4 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 49: Traffic Control Interdependencies of Needs**

| In Order for Traffic Management to Meet This Need | This Need Must Be Met (The Dependency) | Action Responsible for Meeting Dependency |
|---|---|---|
| Need 11: Speed Control | Need 2: Traffic Monitoring | Observation and Detection |
| Need 13: Emergency Management | Need 2: Traffic Monitoring | Observation and Detection |
| | Need 8: Device Control | Data Processing and Response Formulation |
| Need 15: Transit Vehicle Advantages | Need 2: Traffic Monitoring | Observation and Detection |
| | Need 8: Device Control | Data Processing and Response Formulation |
| Need 16: Warning Systems | Need 2: Traffic Monitoring | Observation and Detection |
| | Need 8: Device Control | Data Processing and Response Formulation |

## 10.2 Dynamic Speed Display Signs

Dynamic Speed Display Signs (DSDS) typically consist of a dynamic message sign component, a sensor which detects vehicle speed, and a controller which provides the logic between the dynamic message sign and sensor. Dynamic Speed Display Signs are an interactive type of sign providing motorists with real-time information about vehicle speed in relation to the surrounding environment (i.e. school zone or work zone), roadway conditions that may pose a safety problem (i.e. advisory speed limit on sharp horizontal curve), speed zone transitions, or in areas with a history of excessive speeds. The most common operational procedure is to display the vehicle speed, and flash the speed display if the vehicle speed exceeds a threshold. Furthermore, the device usually has the ability to display a blank sign if the vehicle speed is higher than a maximum threshold (to discourage travelers from attempting to cause the sign to display excessive speeds).

### 10.2.1 Scenarios for the use of Dynamic Speed Display Signs

There are four distinct use case scenarios for dynamic speed display signs:

***1. Mn/DOT Construction Perspective***

- Mn/DOT utilizes dynamic speed display signs (generally portable units) in advance and within construction work zone areas to reduce vehicle operating speeds, reinforce regulatory or advisory speed limits, and to improve safety.

***2. Mn/DOT Arterial Operations Perspective***

- Mn/DOT utilizes dynamic speed display signs in areas where vehicle operating speeds are transitioning. Example areas where dynamic speed display signs are typically used include school zones, speed limit transition zones at municipal boundaries, and changes in roadway geometrics.

- Mn/DOT utilizes dynamic speed display signs in locations of substantial pedestrian movements, such as school zones, locations near parks or libraries where pedestrian traffic is prevalent.

- Mn/DOT utilizes dynamic speed display signs to mitigate public reports of excessive speeding.

***3. Law Enforcement Perspective***

- Law enforcement agencies utilize dynamic speed display signs in areas where excessive speeding is a known issue.

- Law enforcement agencies utilize dynamic speed display signs to mitigate public reports of excessive speeding.

***4. Traveling Public Perspective***

- The traveling public utilizes feedback provided by dynamic speed display signs to adjust vehicle operating speeds.

### 10.2.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for dynamic speed display signs are shown in the table below.

**Table 50: Dynamic Speed Display Signs Operations and Maintenance Responsibilities**

| Dynamic Speed Display Signs Operations and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Operations of Dynamic Speed Display Signs | ▪ Mn/DOT Metro Traffic<br>▪ Mn/DOT Metro Construction<br>▪ State Patrol | ▪ Mn/DOT District Traffic<br>▪ Mn/DOT District Construction<br>▪ State Patrol |
| Maintenance of Dynamic Speed Display Signs | ▪ Mn/DOT Metro Traffic<br>▪ Mn/DOT Metro Construction<br>▪ State Patrol | ▪ Mn/DOT District Traffic<br>▪ Mn/DOT District Construction<br>▪ State Patrol |

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

The following table describes:

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

**Table 51: Traffic Control Concept: Dynamic Speed Display Signs**

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Dynamic Speed Display Signs (DSDS) | | | |
|---|---|---|---|
| **Why are DSDS Used?** | **Who Uses DSDS?** | **How are Dynamic Speed Display Signs Used?** | **Dynamic Speed Display Signs Requirements** |
| Need 11: Speed Control | Mn/DOT Construction | ▪ DSDS are used in advance of work zones to reduce vehicle operating speeds.<br>▪ DSDS are used in work zones to increase driver awareness. | DSDS1: DSDS should be placed so as not to obstruct other regulatory, advisory, construction or guide signage. |
| | Mn/DOT Arterial Operations | ▪ DSDS are used in areas of changing geometrics (i.e. four lane highway transitions to two lane highway) to reinforce safe vehicle operating speeds.<br>▪ DSDS are used in speed transition zones (i.e. reduction in speed at town limit) to reinforce safe vehicle operating speeds.<br>▪ DSDS are used in school zones to reinforce safe vehicle operating speeds.<br>▪ DSDS are used in areas where excessive speeds are an issue to increase compliance with regulatory speed limits.<br>▪ In the future, DSDS may become traffic monitoring stations, recording traffic speeds to be relayed to a central TMC for processing and information dissemination message creation. | DSDS1: DSDS should be placed so as not to obstruct other regulatory, advisory, construction or guide signage.<br>DSDS2: DSDS shall display the vehicles speed to the driver.<br>DSDS3: DSDS shall flash the vehicle speed when it exceeds a threshold value above the speed limit.<br>DSDS4: DSDS shall display blank if vehicles speed exceeds a high speed threshold.<br>DSDS5: All DSDS thresholds shall be adjustable.<br>DSDS6: DSDS technology selections shall explore the capability of communicating speed readings to a TMC in real-time. |

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Dynamic Speed Display Signs (DSDS) | | | |
|---|---|---|---|
| **Why are DSDS Used?** | **Who Uses DSDS?** | **How are Dynamic Speed Display Signs Used?** | **Dynamic Speed Display Signs Requirements** |
| | Law Enforcement | ▪ DSDS are used in school zones to reinforce safe vehicle operating speeds.<br>▪ DSDS are used in areas where excessive speeds are an issue to increase compliance with regulatory speed limits. | DSDS1: DSDS should be placed so as not to obstruct other regulatory, advisory, construction or guide signage.<br>DSDS2: DSDS shall display the vehicles speed to the driver.<br>DSDS3: DSDS shall flash the vehicle speed when it exceeds a threshold value above the speed limit.<br>DSDS4: DSDS shall display blank if vehicles speed exceeds a high speed threshold.<br>DSDS5: All DSDS thresholds shall be adjustable.<br>DSDS6: DSDS technology selections shall explore the capability of communicating speed readings to a TMC in real-time. |
| | Public | ▪ Travelers receive real-time feedback regarding potentially unsafe vehicle operating speeds and may adjust vehicle operating speed.<br>▪ Travelers' awareness of regulatory or advisory speed limit is increased. | DSDS7: The traveling public shall have an unobstructed view of DSDS from the vehicle. |

### 10.2.4 External Constraints of Dynamic Speed Display Signs

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

**Table 52: Dynamic Speed Display Signs Constraints**

| Constraint | Description of Constraint |
|---|---|
| Location | ▪ Dynamic Speed Display Sign location is critical on its usefulness.<br>▪ The role of each user and use case scenario should be considered when deploying a safety system. |

### 10.2.5 Role of Dynamic Speed Display Signs in ITS Architecture

Dynamic Speed Display Signs were identified in the Minnesota Statewide Regional Architecture as a need/potential solution for ATMS, and Maintenance and Construction Management (MCM) as shown in the table below.

**Table 53: Role of Dynamic Speed Display 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 |
|---|---|---|
| ▪ ATMS01-Network SurveillanceATMS19-Speed Monitoring<br>▪ MC08 -Work Zone Management | ▪ TM15 Provide operating or actual speed information to travelers<br>▪ TM18 Provide dynamic speed feedback to drivers and enforcement agencies<br>▪ Work Zone (WZ) 15 Provide dynamic speed display | ▪ ATMS01 Network Surveillance<br>▪ ATMS06 Traffic Information Dissemination<br>▪ ATIS01 Broadcast Traveler Information<br>▪ ATMS19 Speed Monitoring<br>▪ MC08 Work Zone Management |

## *10.3 Emergency Vehicle Preemption (EVP)*

Preemption is a tool for providing priority through an intersection controlled by a traffic signal control system. Preemption can be provided for different users with railroad and emergency vehicles being the most common uses. Emergency Vehicle Preemption (EVP) almost always consists of a receptor installed at or near the traffic signal control system. Upon detecting a request from an approaching emergency vehicle, the receptor places a request to the traffic signal control system controller. The controller contains logic for EVP and attempts to provide an exclusive green phase for the approach with the emergency vehicle while providing red phases for all other approaches. EVP configurations typically include a confirmation light installed at or near the traffic signal control system which provides information to the approaching emergency vehicle that an EVP request has been received by the controller.

### 10.3.1 Scenarios for the use of Emergency Vehicle Preemption

There is one distinct use case scenarios for emergency vehicle preemption:

***1. Emergency Responder Perspective***

- Emergency responders activate the emergency vehicle preemption system as they approach a signalized intersection.
- Upon activation, the emergency responders receives indication the traffic signal control system has received the preemption request and whether the emergency vehicle has priority through the intersection.

### 10.3.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for Emergency Vehicle Preemption are shown in the table below.

**Table 54: Emergency Vehicle Preemption Operations and Maintenance Responsibilities**

| EVP Operations and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Configuration of traffic signal controller timing | ▪ Mn/DOT Metro Traffic | ▪ Mn/DOT District Traffic |
| Maintenance of Emitter Device(s) | ▪ Emergency Responder Agency | ▪ Emergency Responder Agency |
| Maintenance of Receiver Device(s) | ▪ Mn/DOT Metro ESS | ▪ Mn/DOT ESS |
| Maintenance of Confirmation Light | ▪ Mn/DOT Metro ESS<br>▪ Emergency Responder Agency | ▪ Mn/DOT ESS<br>▪ Emergency Responder Agency |
| Activation of Emergency Vehicle Preemption | ▪ Emergency Vehicle(s) | ▪ Emergency Vehicle(s) |

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

The following table describes:

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

**Table 55: Traffic Control Operational Concept: Emergency Vehicle Preemption**

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Emergency Vehicle Preemption (EVP) | | | |
|---|---|---|---|
| **Why is EVP Used?** | **Who Uses EVP?** | **How is Emergency Vehicle Preemption Used?** | **Emergency Vehicle Preemption Requirements** |
| Need 13: Emergency Management | Emergency Responders | ▪ EVP is used to provide emergency vehicles responding to a call safe and rapid travel through a signalized intersection.<br>▪ EVP is typically wired into the traffic signal control system.<br>▪ EVP typically includes sensors to monitor whether an emergency vehicle is approaching. The system is activated when an emergency vehicle's EVP emitter or siren (depending on specific EVP technology) is activated.<br>▪ Upon activation, a preemption request is placed in the traffic signal controller. The controller contains logic which modifies the signal timing in order to serve the approach with the emergency vehicle a green phase.<br>▪ EVP has a higher priority than transit signal priority, vehicle phases, bicycle phases and pedestrian phases.<br>▪ EVP has a lower priority than railroad preemption. | EVP1: Emergency responders shall only activate EVP when responding to an emergency call.<br>EVP2: Installation of confirmation indication(s) shall be included with all EVP deployments.<br>EVP3: Preemption requests shall be logged in order to verify system operational state and monitor system performance.<br>EVP4: Emergency responder agencies shall coordinate and standardize on one EVP technology to be deployed within the coverage area. |

### 10.3.4 External Constraints of Emergency Vehicle Preemption

External constraints involving emergency vehicle preemption are summarized in the following table.

**Table 56: Emergency Vehicle Preemption Constraints**

| Constraint | Description of Constraint |
|---|---|
| Emergency Vehicle Preemption Location | ▪ Emergency vehicle preemption location is a factor for the usefulness of the device.<br>▪ Locations on heavily used routes and those near emergency responders' base locations should receive priority when considering locations.<br>▪ Other factors such as natural and man-made obstructions should also be considered. |

### 10.3.5 Role of Emergency Vehicle Preemption in ITS Architecture

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

**Table 57: Role of Emergency Vehicle Preemption in ITS Architecture**

| Minnesota Statewide Regional ITS Architecture: Market Package | Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions | Associated National ITS Architecture: Market Package |
|---|---|---|
| ▪ ATMS03-Surface Street Control | ▪ TM37 Provide safe signal phase transition | ▪ ATMS03 Surface Street Control |

## *10.4 Safety Systems*

Safety Systems provide warning to motorists of potentially unsafe road conditions. Examples of Safety Systems include collision avoidance systems, curve warning systems, systems that detect flooded roads, animal crossing warning systems, and railroad active warning systems.

### 10.4.1 Scenarios for the use of Safety Systems

There are two distinct use case scenarios for safety systems:

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

- Safety systems are deployed in locations where potentially hazardous conditions exist at unpredictable or isolated times. The systems detect the potentially hazardous condition and provide a dynamic warning to vehicle operators.

***2. Traveling Public Perspective***

- The traveling public utilizes feedback provided by safety systems to adjust vehicle operating speeds, perform evasive maneuvers, or reroute as appropriate.

### 10.4.2 Operations and Maintenance Responsibility

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

**Table 58: Safety Systems Operations and Maintenance Responsibilities**

| Operations and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Repair non-functioning safety system | ▪ Mn/DOT Metro Traffic<br>▪ Mn/DOT ESS | ▪ Mn/DOT District Traffic<br>▪ Mn/DOT ESS |

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

The following table describes:

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

**Table 59: Traffic Control Operational Concept: Safety Systems**

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Safety Systems (SS) | | | |
|---|---|---|---|
| **Why are SS Used?** | **Who Uses Safety Systems?** | **How are Safety Systems Used?** | **Safety Systems Requirements** |
| Need 16: Warning Systems | Mn/DOT Arterial Operations | ▪ Curve warning systems are deployed in locations that experience a high number of run off the road type crashes near horizontal roadway sections. The systems are used to detect vehicles that may be approaching at an unsafe speed and provide a dynamic warning to vehicle operators.<br>▪ Animal crossing warning systems are deployed in locations that experience a high number of animal-vehicle crashes. The systems detect the presence of animals on or near the roadway and provide a dynamic warning to vehicle operators.<br>▪ Collision avoidance systems are deployed at intersections that experience a high number of right angle type crashes. The systems are used to detect approaching vehicles and provide a dynamic warning to vehicle operators who desire to cross or enter the roadway.<br>▪ Queue warning systems are deployed at locations where sight distance is limited by vertical curvature, horizontal curvature, or other man-made or natural obstructions. The systems detect the presence of stopped vehicles and provide a dynamic warning to vehicle operators in an attempt to reduce rear-end type crashes.<br>▪ School bus stop warning systems are deployed at rural bus stop locations. The systems detect the presence of an approaching or stopped bus and provide a dynamic warning to vehicle operators in an attempt to reduce rear-end type crashes and/or passing violations when the bus lights and | SS1: Safety Systems should be placed so as not to obstruct other regulatory, advisory, construction or guide signage.<br>SS2: Safety Systems signs and devices should be in accordance with guidance provided in the Minnesota Manual on Uniform Traffic Control Devices (MMUTCD).<br>SS3: Safety Systems shall consider real-time communications of alerts detected to a central location (e.g. TMC) to support information dissemination of conditions. |

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Safety Systems (SS) | | | |
|---|---|---|---|
| **Why are SS Used?** | **Who Uses Safety Systems?** | **How are Safety Systems Used?** | **Safety Systems Requirements** |
| | | stop arm are activated.<br>▪ Over height warning systems are deployed at locations where substandard vertical clearance to an overhead structure is present. The system is placed in advance of the structure and is ideally located in advance of an alternative route which would allow for diversion around the structure. The system detects the presence of a vehicle whose height is taller than the vertical clearance provided at the structure. The system provides a dynamic warning to the vehicle operators so that the vehicle can reroute and avoid damage to the structure and/or vehicle.<br>▪ Flood warning systems are deployed at location where the roadway is periodically covered in water creating a potentially hazardous condition. The systems detect the presence of water on the roadway and provide a dynamic warning to vehicle operators so that the vehicle can reroute. | |
| | Public | ▪ Travelers receive real-time feedback regarding potentially hazardous conditions and may adjust vehicle speed, perform evasive maneuvers, or reroute as appropriate. | SS4: The traveling public shall have an unobstructed view of Safety Systems from the vehicle. |

### 10.4.4 External Constraints of Safety Systems

External constraints involving safety systems are summarized in the following table.

**Table 60: Safety Systems Constraints**

| Constraint | Description of Constraint |
|---|---|
| Safety System Location | ▪ Safety system location is critical on its usefulness.<br>▪ The role of each user and use case scenario should be considered when deploying a safety system. |

### 10.4.5 Role of Safety Systems in ITS Architecture

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

**Table 61: Role of Safety 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 |
|---|---|---|
| ▪ ATMS13-Standard Railroad Grade Crossing)<br>▪ ATMS19-Speed Monitoring<br>▪ ATMS06-Traffic Information Dissemination<br>▪ ATMS03-Surface Street Control | ▪ TM28 Provide railroad flashing light signals and gates<br>▪ TM32 Provide curve speed warnings<br>▪ TM34 Provide roadway flood warnings<br>▪ TM37 Provide vehicle over height detection/warning systems | ▪ ATMS03 Surface Street Control<br>▪ ATMS13 Standard Railroad Grade Crossing<br>▪ ATMS14 Advanced Railroad Grade Crossing<br>▪ ATMS19 Speed Monitoring<br>▪ ATMS06 Traffic Information Dissemination |

## 10.5 Red Light Running Systems

Red Light Running Systems typically consist of a camera, a sensor which detects vehicle speed, and a controller which provides the logic between the camera and sensor. Red Light Running Systems are an automated enforcement device used for citations.

### 10.5.1 Scenarios for the use of Red Light Running Systems

There is one distinct use case scenarios for red light running systems:

***1. Law Enforcement Perspective***

- Law enforcement uses red light running systems to aide in issuing citations for red light running violations. Red light running systems are an evidence gathering tool which allows law enforcement to observe the evidence at a later date in order to make a determination on whether a vehicle committed a violation.

### 10.5.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for red light running systems are shown below.

**Table 62: Red Light Running Systems Operations and Maintenance Responsibilities**

| Red Light Running Operations and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Repair non-functioning red light running system | ▪ Mn/DOT Metro Arterial Operations<br>▪ Mn/DOT ESS | ▪ Mn/DOT District Traffic<br>▪ Mn/DOT ESS |

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

The following table describes:

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

**Table 63: Traffic Control Operational Concept: Red Light Running Systems**

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Red Light Running Systems (RLRS) | | | |
|---|---|---|---|
| **Why are RLRS Used?** | **Who Uses RLRS?** | **How are Red Light Running Systems Used?** | **Red Light Running Systems Requirements** |
| Need 14: Enforcement Systems | Law Enforcement | ▪ Law Enforcement downloads violation data from red light running system locations and upon observing evidence, law enforcement issues a citation when a violation occurs. | RLRS1: Law Enforcement shall verify and issue citations for violations.<br>RLRS2: Red Light Running Systems shall not directly or indirectly modify or otherwise change traffic signal control system timing parameters. |

### 10.5.4 External Constraints of Red Light Running Systems

External constraints involving red light running systems are summarized in the following table.

**Table 64: Red Light Running Constraints**

| Constraint | Description of Constraint |
|---|---|
| Red Light Running System Location | ▪ Red light running system location is critical on its usefulness.<br>▪ The role of each user and use case scenario should be considered when deploying a red light running system.<br>▪ Other factors such as natural and man-made obstructions should also be considered. |
| Visual Verification | ▪ Law enforcement utilizes red light running systems to gather evidence when a violation has occurred upon which a citation is issued.<br>▪ Legislation may require photographic evidence of the driver's face, vehicle identification, signal phase verification, and/or date and time of the violation for adequate enforcement. |

### 10.5.5 Role of Red Light Running Systems in ITS Architecture

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

**Table 65: Role of Red Light Running 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 |
|---|---|---|
| ▪ ATMS01-Network Surveillance | ▪ TM02 Implement red-light running technology | ▪ ATMS01 Network Surveillance<br>▪ ATMS03 Surface Street Control |

## 10.6 Enforcement Light Systems

Enforcement Light Systems typically consist of a light which is illuminated during the red phase of traffic signal control system. Enforcement Light Systems are typically passive systems requiring observation of the violation by law enforcement agencies.

### 10.6.1 Scenarios for the use of Enforcement Light Systems

There is one distinct use case scenarios for enforcement light systems:

***1. Law Enforcement Perspective***

- Law enforcement uses enforcement light systems to aide in issuing citations for red light running violations. Enforcement light systems are a visual tool which allows law enforcement to simultaneously observe if the signal phase is red (through the enforcement light system indication) and whether a vehicle is committing a violation.

### 10.6.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for enforcement light systems are shown below.

**Table 66: Enforcement Light Systems Operations and Maintenance Responsibilities**

| Operations and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Repair non-functioning enforcement light system | ▪ Mn/DOT Metro Arterial Operations<br>▪ Mn/DOT Metro ESS | ▪ Mn/DOT District Traffic<br>▪ Mn/DOT ESS |

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

The following table describes:

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

**Table 67: Traffic Control Operational Concept: Enforcement Light Systems**

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Enforcement Light Systems (ELS) | | | |
|---|---|---|---|
| **Why are ELS Used?** | **Who Uses ELS?** | **How are Enforcement Light Systems Used?** | **Enforcement Light Systems Requirements** |
| Need 14: Enforcement Systems | Law Enforcement | ▪ Law Enforcement is made aware, either through observation or public feedback, of a traffic signal control system with a high occurrence of red light running violations.<br>▪ Law Enforcement and Mn/DOT collectively agree on enforcement light system locations.<br>▪ The enforcement light system is a passive, stand-alone system.<br>▪ The enforcement light system does not record or otherwise store information regarding the violation.<br>▪ The indication is typically hard wired into the signal system. The indication does not require a separate activation method as it is always lit when the corresponding signal phase is red.<br>▪ The enforcement light system is a visual tool which allows law enforcement to simultaneously observe if the signal phase is red (through the enforcement light system indication) and whether a vehicle is committing a violation.<br>▪ Law enforcement observes the indication and issues citations when a violation occurs. | ELS1: Law Enforcement shall not record or otherwise store information regarding the violation.<br>ELS2: Enforcement Light Systems shall use indications that do not conflict with vehicle and pedestrian indications at the traffic signal control system. |

### 10.6.4 External Constraints of Enforcement Light Systems

External constraints involving enforcement light systems are summarized in the following table.

**Table 68: Enforcement Light Systems Constraints**

| Constraint | Description of Constraint |
|---|---|
| Enforcement Light System Location | ▪ Enforcement light system location is critical on its usefulness.<br>▪ The role of each user and use case scenario should be considered when deploying an enforcement light system. |
| Visual Verification | ▪ Law enforcement utilizes the enforcement light system to provide visual verification a violation has occurred upon which a citation is issued. |

### 10.6.5 Role of Enforcement Light Systems in ITS Architecture

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

**Table 69: 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 |
|---|---|---|
| ▪ ATMS01 Network Surveillance | ▪ TM02 Implement red-light running technology | ▪ ATMS01 Network Surveillance<br>▪ ATMS03 Surface Street Control |

## *10.7 Transit Signal Priority*

Transit Signal Priority (TSP) is a tool for providing priority through an intersection controlled by a traffic signal control system. Transit Signal Priority is typically used by transit agencies within the jurisdiction. TSP almost always consists of a receptor installed at or near the traffic signal control system. Upon detecting a request from an approaching transit vehicle, the receptor places a request to the traffic signal control system controller. The controller contains logic for TSP and attempts to modify timing for the approach with the transit vehicle to provide an advantage to transit riders.

### 10.7.1 Scenarios for the use of Transit Signal Priority

There are three distinct use case scenarios for transit signal priority:

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

- Mn/DOT does not use transit signal priority directly. Rather, Mn/DOT works with transit providers to determine locations for transit signal priority and methodologies for how transit signal priority should be implemented.

***2. Transit Agency Perspective***

- In the Twin Cities Metropolitan Area, Metro Transit uses transit signal priority to reduce delays at traffic signal control systems near park and ride facility entrance/exit locations as well as along signalized arterial highway corridors.

- In St. Cloud, St. Cloud Metro Bus uses transit signal priority to reduce delays along signalized arterial highway corridors.

***3. Traveling Public Perspective***

- The traveling public does not use transit signal priority directly. Rather, transit signal priority creates the perception that transit vehicles are provided an advantage. The advantage provided can lead to travelers experiencing less delay on their transit trips and improved schedule adherence.

### 10.7.2 Operations and Maintenance Responsibility

The operations and maintenance responsibilities for transit signal priority are shown in the table below.

**Table 70: Transit Signal Priority Operations and Maintenance Responsibilities**

| Operations and Maintenance Activities | Metro Area Responsibility | Outstate Responsibility |
|---|---|---|
| Configuration of traffic signal controller timing | ▪ Mn/DOT Metro Traffic | ▪ Mn/DOT District Traffic |
| Maintenance of Emitter Device(s) | ▪ Transit Agency | ▪ Transit Agency |
| Maintenance of Receiver Device(s) | ▪ Mn/DOT Metro ESS | ▪ Mn/DOT ESS |
| Activation of Transit Signal Priority | ▪ Transit Vehicle(s) | ▪ Transit Vehicle(s) |

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

The following table describes:

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

**Table 71: Traffic Control Operational Concept: Transit Signal Priority**

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Transit Signal Priority (TSP) | | | |
|---|---|---|---|
| **Why TSP is Used?** | **Who Uses TSP?** | **How is Transit Signal Priority Used?** | **Transit Signal Priority Requirements** |
| Need 15: Transit Vehicle Advantages | Mn/DOT Arterial Operations | ▪ Intersections and approaches for TSP implementation are selected based on need and potential.<br>▪ Transit Operators and Mn/DOT collectively agree on TSP methodologies at the location. Considerations include:<br>○ Whether to activate TSP only when the transit vehicle is behind schedule.<br>○ Whether to activate TSP only when the transit vehicle is carrying a number of passengers above a set threshold.<br>▪ Traffic Operations staff review performance data (i.e. number of TSP requests and number of TSP requests granted) for transit vehicles. | |

| **Traffic Management Action:** Traffic Control<br>**ITS Tool:** Transit Signal Priority (TSP) | | | |
|---|---|---|---|
| **Why TSP is Used?** | **Who Uses TSP?** | **How is Transit Signal Priority Used?** | **Transit Signal Priority Requirements** |
| | Transit Agency | ▪ Intersections and approaches for TSP implementation are selected based on need and potential.<br>▪ Transit Operators and Mn/DOT collectively agree on TSP methodologies at the location. Considerations include:<br>○ Whether to activate TSP only when the transit vehicle is behind schedule.<br>○ Whether to activate TSP only when the transit vehicle is carrying a number of passengers above a set threshold.<br>▪ TSP is provided at or near entrance/exit locations to Park and Ride facilities to provide quick access.<br>▪ TSP is provided along routes that are frequently delayed or carry major transit traffic.<br>▪ TSP is used to modify traffic signal timing parameters for transit vehicles that are behind schedule.<br>○ The green phase is extended if the transit vehicle is approaching in order to allow the vehicle to proceed through the intersection. The effectiveness of this approach is diminished if a transit stop is located near-side of the intersection.<br>○ If the transit vehicle is stopped at the intersection, the red phase is truncated early to reduce the delay the vehicle experiences waiting at the traffic signal.<br>▪ Transit Operators review performance data (i.e. number of TSP requests and number of TSP requests granted) for transit vehicles. | |

**Traffic Management Action:** Traffic Control

**ITS Tool:** Transit Signal Priority (TSP)

| Why TSP is Used? | Who Uses TSP? | How is Transit Signal Priority Used? | Transit Signal Priority Requirements |
|---|---|---|---|
| | Public | ▪ Travelers have no direct interaction with TSP. One goal of TSP however, is the perception that advantages are provided to transit vehicles. Ideally, TSP allows travelers to experience less delay on their daily trips which results in more on-time route services. | |

### 10.7.4 External Constraints of Transit Signal Priority

External constraints involving transit signal priority are summarized in the following table.

**Table 72: Transit Signal Priority Constraints**

| Constraint | Description of Constraint |
|---|---|
| Transit Signal Priority Location | ▪ Transit signal priority location is a factor for the usefulness of the device.<br>▪ Other factors such as natural and man-made obstructions should also be considered. |

### 10.7.5 Role of Transit Signal Priority in ITS Architecture

Transit Signal Priority was identified in the Minnesota Statewide Regional Architecture as a need/potential solution for Advanced Public Transportation Systems (APTS) as shown in the table below.

**Table 73: Role of Transit Signal Priority in ITS Architecture**

| Minnesota Statewide Regional ITS Architecture: Market Package | Minnesota Statewide Regional ITS Architecture: Need/Potential Solutions | Associated National ITS Architecture: Market Package |
|---|---|---|
| ▪ APTS02 Transit Fixed-Route Operations | ▪ TR15 Optimize schedule efficiency | ▪ APTS02 Transit Fixed-Route Operations |