Arterial Corridor Management (Snelling and Lexington)

Concept of Operations

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1. Introduction

The City of Saint Paul is seeking to relieve congestion and improve traffic signal operations, incident, emergency, and event management along two arterial corridors located west of downtown Saint Paul. The management of traffic in this area involves transportation agencies at the city, county, and state levels, as well as local law enforcement and businesses that generate traffic during events. Upgrades to the traffic management system include updating communications capabilities and traffic signal equipment, managing traffic incidents, and providing event traffic management. Improving these areas are critical to maintaining a modern transportation system. These improvements will be achieved with the installation of new traffic signal controllers, vehicle detection, advanced traffic management equipment, fiber optic communications, Dynamic Message Signs (DMS), and closed-circuit television (CCTV) cameras.

This document presents a Concept of Operations for the City of St. Paul's Arterial Corridor Management System project. The following topics will be described within this Concept of Operations:

- Current Environment;
- Identification of stakeholders;
- Define stakeholder needs;
- Presents an operational concept;
- Define system components;
- Describe operational scenarios for how the system will operate.

One of the fundamental objectives of a Concept of Operations is to identify needs in terms that all project stakeholders can understand. The needs expressed in this Concept of Operations were identified by St. Paul Public Works, key stakeholders, and documents relevant to the project. This Concept of Operations also provides a foundation for more detailed analyses that will lead into System Requirements and eventually design.

1.1 Current Environment

The current environment for managing traffic in the project area provides context for understanding the needs and conceptual operation of an updated Traffic Management System (TMS). St. Paul is the capital city of Minnesota, with a population of approximately 309,000. Since 2010, St. Paul has had an overall increase in population of 24,000 residents. The project corridor boundaries are along Snelling Avenue from Montreal Avenue to Hewitt Avenue, and along Lexington Parkway from Randolph Avenue to Hoyt Avenue. There are numerous major routes leading into or adjacent to the corridors, which include: Interstate 94, Interstate 35E, University Avenue, Marshall Avenue, and Ford Parkway.

The area impacted by this project is highlighted in orange and green as shown in **Figure 1**. The corridors are home to numerous businesses, residents, Concordia University, Hamline University, Macalester College, and serve traffic to large event venues including Allianz Field and the State Fairgrounds.

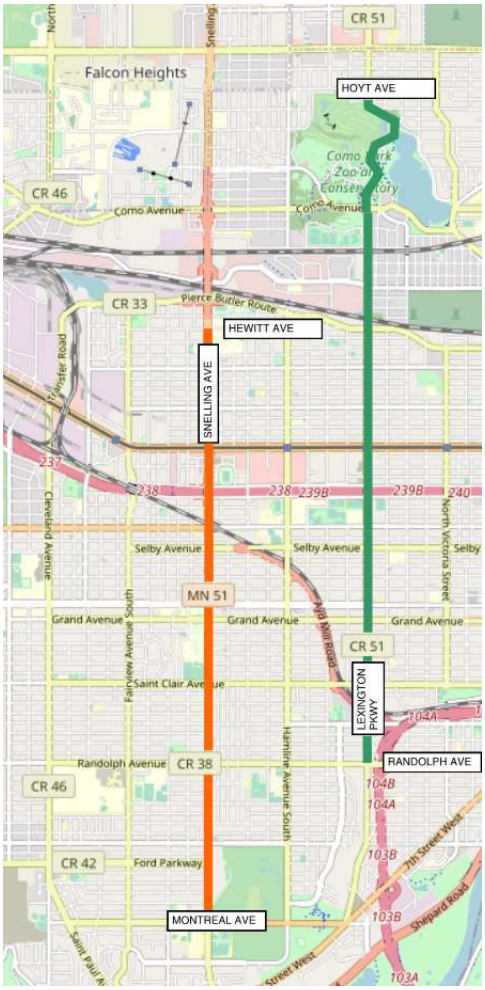

Figure 1: Snelling Ave. (TH 51) & Lexington Pkwy. Corridor Project Limits

The Snelling Avenue and Lexington Parkway corridors each have a daily traffic volume of 30,000 vehicles and an average traffic signal spacing of one every quarter mile. Substantial changes have taken place over the last several years to areas adjacent to or along the two corridors including the addition of the Green Line street level Light Rail Transit (LRT) route, the A-Line Bus Rapid Transit (BRT) corridor along Snelling Avenue, and the opening of the Allianz Field soccer stadium.

Allianz Field is a purpose-built soccer field located adjacent to Snelling Avenue and Interstate-94. It is host to the Minnesota United Football Club and has a capacity of 19,400 people. [1] The stadium expects to host 20 to 25 events each year.

The main entrance to the Minnesota State Fairgrounds is located 1 mile north of the Snelling Avenue corridor limits. The venue hosts a variety of large events from horse shows, car shows, Comicon, to the Minnesota State Fair. In 2019, the Minnesota State Fair drew daily crowds ranging from 96,000 to 245,000 people each day of the 12-day event. [2]

[1] https://www.mnufc.com/stadium/facts
[2] https://www.mnstatefair.org/about-the-fair/attendance/

These event generators, in addition to the traffic generated by the local businesses, Concordia University, Hamline University, Macalester College, cause Snelling Avenue and Lexington Parkway to become highly congested. Events today at these venues are typically managed by each venue's operational staff. For large scale events, St. Paul Police are hired to help manage event traffic.

Both Lexington Parkway and Snelling Avenue have transit stations for the Green Line LRT on University Avenue. Both intersections have 3 or more approach lanes in all directions, with the light rail running through the middle of the intersection. Since the Green Line LRT has been operating, there have been approximately 8-10 incidents per year involving vehicles or pedestrians being struck by the train, often delaying traffic for several hours.[3] There are currently no dynamic message signs (DMS) deployed along the Snelling Avenue or Lexington Parkway corridors to help mitigate congestion or provide wayfinding to or from events or routes. The St. Paul Police Department has CCTVs at only three locations along the corridors: University Avenue/Snelling Avenue, University Avenue/Lexington Parkway, and Snelling Avenue/Ford Parkway.

The majority of signals along Lexington Parkway currently utilize legacy 170 traffic signal controllers that are not interconnected to the City's Traffic Management Center (TMC). The legacy 170 controllers offer limited or no functionality for Signal Performance Measures (SPM) or Adaptive Signal Control. The signals that do have copper interconnect do not currently have redundancy built into the system, so if one cabinet loses its connection, all subsequent cabinets lose connectivity as well. Most signals along Snelling Avenue have already been upgraded with new traffic signal controllers and have fiber optic interconnect as a result of previous projects, notably the Saint Paul Arterial Traffic Flow Improvement project and the A-Line BRT project. The City uses Econolite's Centracs Advanced Traffic Signal Management (ATMS) software from a TMC to manage the signals that are interconnected.

St. Paul's current arterial corridors show a need for a more robust TMS to better maintain the current traffic signal system and provide high-speed communications for future technology. The proposed upgrades to the TMS will provide the following benefits:

- Management of congestion for daily peak periods and events;
- Provide alternate route messaging during emergencies and other incidents;
- Provide advanced signal timing features;
- Provide remote monitoring of traffic signal systems for maintenance and operations;
- Provide reliable, high speed communications back to the City of St. Paul TMC.

[3] https://www.mprnews.org/story/2019/09/09/third-light-rail-accident-in-the-last-two-weeks

1.2 Stakeholders

There are several stakeholders with traffic management needs in the project area. There are travelers accessing the area on local roadways that are under the jurisdiction of transportation agencies at the city, county, and state levels. There are businesses and regional event venues that can generate high volumes of traffic at times. The following is a list of the primary stakeholders who will most directly benefit from the planned enhancements to the City's TMS. Each stakeholder is defined for consistent references and according to how they will interact with the system.

- **City of St. Paul Public Works:** Staff responsible for the safety and efficiency of the roads. Public Works staff will be the primary users of the proposed upgrades and be responsible for the maintenance of the system, with the exception of the CCTV cameras.
- **City of St. Paul Emergency Services (Police):** The TMS will be used to assist police with traffic management for events and incidents. The Police Department is responsible for the maintenance of the CCTV cameras, through the assistance of a third-party vendor contract.
- **Minnesota Department of Transportation (MnDOT)**: MnDOT has jurisdiction over freeways and the Trunk Highway (TH) system in the City of St Paul. MnDOT staff at the Regional Transportation Management Center (RTMC) and Traffic Engineering are responsible for the safety and efficiency of the freeways and TH system, including TH 51 (Snelling Avenue). As a city of the first class, the City of St. Paul operates and maintains signals located on MnDOT right of way. MnDOT is expected to be a beneficiary of the TMS. There is anticipated coordination for permits and agreements for construction and operations of TMS on TH 51 and for backups onto the freeway or major highway diversions due to events or incidents.
- **Ramsey County:** Ramsey County has jurisdiction over several roads in the project area, including Lexington Parkway. The City operates and maintains the signals along county routes via a Joint Powers Agreement with the County. The County will be a beneficiary to the TMS and provide coordination permits, and agreements as needed to construct and maintain TMS devices installed on County routes. Ramsey County is also partially funding the TMS.
- **Metro Transit:** Metro Transit operates the Green-Line LRT, A-Line BRT, and numerous local bus routes in the project area. It is anticipated that they will be a beneficiary of the system and provide coordination as needed.
- **Event venues**: Staff responsible for the operation and administration of the major event venues in the area.
- **Travelers:** People driving throughout the area or visiting event venues within the project area. All the other stakeholders are ultimately trying to provide safe, efficient transportation along the project corridors and to and from the event venues for these people. There are also commuters who travel through these corridors. The TMS enhancements are envisioned to serve them with reduced congestion, general wayfinding, emergency alerts, and traffic management during incidents.

The challenges and corresponding needs presented in the next section were identified from the perspective of these stakeholders.

2. Needs

This section presents a series of needs that have been identified for enhancements to the City's TMS. Needs were identified through discussions with stakeholders and review of key documents. The needs are presented in **Table 1** first by describing a challenge (column 1) facing one or more of the stakeholders identified above. Based on each challenge, one or more needs (column 2) are defined. The needs are numbered for identification and traceability purposes.

Table 1: Needs for St Paul Signal Enhancements

Challenge	Need
A. Event congestion or incidents that require traffic management may occur at any time of the day or on any day of the week.	1. City staff and authorized users need the ability to monitor and make modifications to the TMS components (signals, DMS, CCTV) 24/7/365.
B. Travelers may be unaware or untrusting of alternate routes for accessing the major venues, particularly if they are relying on navigation systems for guidance.	2. Travelers need directional signing in real time that is credible and assertive to guide them to alternate access points.
C. Event venues currently use St. Paul Police to direct traffic for large events. Police are posted at the same key congestion points for most large events.	3. The City needs a permanent solution that allows them to efficiently manage traffic during events and incidents to augment police operations.
D. Travelers may be unaware of current snow emergency status, amber alerts, other temporary restrictions or general alerts.	4. Travelers need general information about snow emergencies, temporary restrictions, or other alerts when necessary.
E. Event/Incident congestion causing traffic to build up on main entry routes when there are other access routes available.	5. The City needs a permanent solution that can dynamically direct traffic to the alternate routes. 6. The City needs travel time data to be used to make signal timing adjustments in real time.
F. Current copper communications system has no redundancy, limited data transfer rates, and lack of remote monitoring of devices connected to the system.	7. The City needs a reliable communications system that allows for redundancy in case of failure. 8. The City needs the ability to transfer large amounts of data between field devices and the TMC. 9. The City needs the capability to remotely monitor devices on the network (i.e. signal systems, DMS, CCTV cameras).

Challenge	Need
G. Legacy 170 controllers are an old technology with limited functions. It does not allow for BRT, LRT operations, dynamic signal timing or signal performance measures.	10. The City needs Advanced Traffic Controllers (ATC) that can accommodate modern traffic signal operations and future Connected Autonomous Vehicle (CAV) technologies. 11. The City needs modern signal controllers that allow for collecting signal performance measurement data. 12. The City needs an update to its traffic signal optimization capabilities along the corridors to keep up with the significant changes in the area.
H. During events or peak hours, signalized intersections may become overloaded and not optimized for the current traffic flow.	13. The City needs real-time signal operation capability from a remote facility in order to monitor, review, and optimize timing plans during events.
I. When corridors are experiencing major congestion, it can take time for City and Police staff to arrive at the location of the incident.	14. The City needs real time CCTV capability from a remote facility in order to monitor, review, and efficiently manage incidents or congestion. 15. St. Paul Police need priority access to CCTVs in order to efficiently manage traffic incidents.

These needs are further referenced in the next two sections as they are used to describe the operational concept and the proposed system components. The need identification number will allow each subsequent reference to be traced back to the original needs and corresponding challenges. The needs will also serve as the basis for developing system requirements for the enhancements to the City's TMS.

3. Operational Concept

This section describes the operational concept from each stakeholder's perspective and in terms of how the TMS enhancements will address their needs. The operational concept is intended to help each stakeholder see how their needs have been interpreted and how the system is expected to address their needs. It is presented in a sequential manner from each stakeholder's perspective. The original needs and corresponding challenges identified in the previous section are noted in parentheses following each description. Each piece of the description is numbered for reference purposes. Following the description of the operational concept, this section also includes an overview of the anticipated roles and responsibilities for TMS operations and maintenance.

3.1 City of St. Paul Public Works

The City of St. Paul Public Works staff are responsible for the safety and efficiency of city streets within the project area. As such, they are expected to be the primary user of the TMS.

3.1.1 When travelers enter the area for an event, St. Paul Public Works may **observe traffic flows** around the event venue and **direct traffic, in real time, to alternative routes** during times of heavy congestion. (Needs 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14,)

3.1.2 When a large event causes congestion, **activate special event signal timing plans** for inbound/outbound traffic. (Needs 1, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14)

3.1.3 St. Paul Public Works will **provide Time of Day (TOD) wayfinding signing on local roads** to support the direction of travelers when entering or leaving the area for an event or incident. (Needs 1, 2, 3, 4, 5, 7, 9)

3.1.4 St. Paul Public Works will **maintain the TMS** so that it is available for monitoring and dynamically directing traffic during events and incidents **as needed 24/7/365**. (Needs 1, 2, 5, 7, 8, 9, 10, 11, 12, 13, 14)

3.1.5 During business hours, St. Paul Public Works will manage the signal timing along local roads by **activating operational plans in the TMS** based on traffic when travelers are entering or leaving the area daily, for an event, or during incidents. (Needs 1, 6, 7, 8, 9, 10, 11, 12, 13)

3.1.6 During business hours as travelers enter or leave the area daily for an event, or during incidents, St. Paul Public Works will **dynamically direct traffic to alternate routes** by activating operational plans in the TMS. (Needs 1, 2, 5, 6, 7, 8, 9, 10, 11, 12, 13)

3.1.7 When an incident or congestion occurs, St. Paul Public Works need access to CCTV cameras to fully understand or assess the incident remotely. (Need 14)

3.2 City of St. Paul Emergency Services (Police)

The St. Paul Police Department is actively involved in traffic management for the large events hosted by Allianz Field, and the Minnesota State Fairgrounds. They provide staff and coordinate with the event venue to help manage traffic and pedestrians exiting the venue. The St. Paul Police Department currently maintains a CCTV system and is anticipated to be the primary user of the proposed CCTV cameras along the corridor with priority control of the system when needed.

3.2.1 Whenever a major event or incident occurs that causes major congestion on the roadways, St. Paul Police will **utilize CCTV and coordinate with St. Paul Public Works to activate the relevant dynamic message signs** to alert drivers of the congestion and/or direct traffic to alternate routes. (Needs 1, 2, 3, 5, 7, 9)

3.2.2 Whenever an incident occurs that needs urgent CCTV access, St. Paul Police will get **priority operational access to the relevant CCTV**. (Need 15)

3.2.3 **Operate and maintain CCTV cameras**. Provide the data to St. Paul Public Works when needed. (Need 14)

3.3 MnDOT

MnDOT has jurisdiction over the Trunk Highway 51 (Snelling Avenue) corridor. St. Paul Public Works is responsible for operating and maintaining the traffic signals in the project area. St. Paul Public Works

staff will coordinate with MnDOT RTMC staff for any situation that may require the use of MnDOT dynamic message signs along the freeway in the vicinity. It is anticipated that MnDOT will be a beneficiary of the system and provide any permits and agreements required to construct and maintain TMS devices installed on TH 51 (Snelling Avenue) as needed.

3.3.1 When a large event or incident occurs that is expected to impact the major freeway system near the Snelling Avenue or Lexington Parkway corridors, **St. Paul Public Works staff will coordinate with MnDOT to activate the appropriate dynamic message signs along the freeway**. (Needs 2, 5)

3.3.2 When the freeway system is diverted to local roads, **MnDOT will coordinate with St. Paul Public Works to activate dynamic message signs to route traffic through the detoured routes**. (Needs 4, 5)

3.3.3 Provide approval or agreements for the construction, operation, and maintenance of TMS equipment on Snelling Avenue.

3.4 Ramsey County

Ramsey County has jurisdiction over several roadways in the project area, including Lexington Parkway. St. Paul Public Works is responsible for operating and maintaining the traffic signals located along county roadways. It is anticipated the County will be a beneficiary of the system and provide any permits and agreements required to construct and maintain TMS devices installed on County routes as needed. Ramsey County is also partially funding the TMS.

3.4.1 Provide approval or agreements for the construction, operation, and maintenance of TMS equipment on County owned intersections.

3.5 Metro Transit

Metro Transit operates the Green Line Light Rail Train (LRT), the A-Line BRT, and other local bus routes in the project area. It is anticipated Metro Transit will not be direct users of the TMS, but they will benefit from improved traffic signal operations that will allow for improved transit signal operations on bus lines routes.

3.5.1 Metro Transit has several transit routes along the Snelling Avenue, Lexington Parkway, and cross streets that rely on efficient traffic signal operations to help keep buses on schedule.

3.6 Event Venues

Allianz Field and Minnesota State Fairground have staff responsible for operation and administration of events hosted by their venue. They are concerned with travelers having a positive experience when attending events, including their transportation needs.

3.6.1 Prior to a large event, the hosting event venue will **provide information about the event to St. Paul Public Works to prepare for traffic management and notify others of potential impacts**. (Needs 1, 2, 3, 4, 5, 7, 9, 13)

3.6.2 Event venues will **coordinate, as needed, with St. Paul Public Works and Police Department** during events to ensure that travelers are directed to the safest, most efficient routes for accessing and leaving their venues. (Needs 1, 2, 3, 4, 5, 6, 10, 11, 12, 13)

3.7 Travelers

Travelers represent the largest group of stakeholders with TMS interaction. They have the most fundamental needs associated with navigating roadways within the project area during daily trips, events, incidents and construction. They are the group for whom the TMS enhancements are being developed so that their travel is safer and more efficient.

3.7.1 **When entering the project area for an event** at event venues, travelers will **see static and dynamic signs** guiding them toward the safest, most efficient access to parking for the event venue. Alternate routes may be used based on congestion. (Needs 2, 5, 9)

3.7.2 **When entering or driving through the corridors during an incident or snow emergency**, travelers will be **informed by dynamic signs** of congestion, closures, snow emergencies/amber alerts, and appropriate alternate routes. (Needs 2, 4, 5)

3.7.3 **When leaving the event venue**, travelers will **see static and dynamic signs** guiding them toward the safest, most efficient access to the major highways through local roads. (Needs 3, 5)

3.8 Operational Roles and Responsibilities

Based on the operational concept, this section summarizes the roles and responsibilities for the stakeholders who will operate or contribute to the TMS operations. The roles and responsibilities described in **Table 2** are intended to maintain consistency and familiarity among the stakeholders who will ultimately make the TMS operate effectively and efficiently. As operational plans are more formally developed for the TMS, these roles and responsibilities will be discussed again and may be further modified. The roles and responsibilities presented here should be viewed as a starting point for that discussion.

Table 2: Potential Roles and Responsibilities

Stakeholder	Role / Responsibility
St. Paul Public Works	Coordinate with event venues, St. Paul Police Department and MnDOT to review and select appropriate operational plans for events. (3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6)
	Based on traffic conditions, activate operational plans for signals and DMS. (3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6)
	Notify and coordinate activation of operation plans with St. Paul Police Department and MnDOT. (3.1.1, 3.1.2, 3.1.3, 3.1.5, 3.1.6)
	Maintain TMS components to ensure 24/7/365 availability. * (3.1.4)
	Monitor roadway conditions to determine if travelers need to be alerted of roadway closures, incidents, or other information that may impact the use of the roadways in the project area. (3.1.3, 3.1.5, 3.1.6)
	Periodically review operational plans and current traffic for performance impacts that may require changes in operational parameters. (3.1.5)

Stakeholder	Role / Responsibility
St. Paul Police Department	During events and incidents, coordinate with St. Paul Public Works to activate an operation plan as needed to alert traffic of the incident and/or provide alternate routes. (3.2.1)
	Coordinate with event venues, St. Paul Public Works and MnDOT to review and select operational plans appropriate for events. (3.2.1)
	During incidents or other occasions needing monitoring, take control of CCTVs for monitoring accident locations or other incidents. (3.2.1, 3.2.2)
	Maintain and operate CCTVs installed from this project. (3.2.3)
MnDOT	Coordinate with St. Paul Public Works for any operation plans that impact MnDOT roads during large events. (3.3.1)
	Coordinate with St. Paul Public Works when traffic on the freeway system is expected to be diverted to local roads. (3.3.2)
	Coordinate with St. Paul Public Works on permits and agreements to construct and maintain TMS devices on Trunk Highway 51 (Snelling Avenue). (3.3.3)
Ramsey County	Coordinate with St. Paul Public Works on permits and agreements to construct and maintain TMS devices on County owned intersections. (3.4.1)
Event Venues	Notify St. Paul Public Works of upcoming event schedules. (3.6.1)
	Coordinate with St. Paul Public Works and Police Departments during events as needed. (3.6.2)

** Additional detail regarding the maintenance of specific TMS components is provided in the next section.*

4. System Components

Based on the operational concept and needs described in the previous sections, this section presents a list of proposed system components and an overview of the support responsibilities that may be associated with each. The components list, and subsequent maintenance responsibilities will be discussed again and may be further modified during design and procurement of the enhancements to the system. The information provided at this stage is intended as a starting point for stakeholders to discuss the scale and scope of ongoing support that will be required for the TMS.

4.1 Component List

Table 3 provides a list of system components that could function together as parts of the TMS. Each component is listed under a primary function. A general description of the component and the potential locations, as described in the CMAQ application, where it may be placed are also provided. Some of the components already exist within the project area and they are noted in **Table 2** to distinguish them from proposed components that may be added for TMS enhancements.

Table 3: System Components

Function	Component	Description	Potential Locations
Monitoring	Camera	Proposed Pan, Tilt, Zoom (PTZ) cameras are located at various intersections along the corridors.	Snelling Ave at Grand Ave Snelling Ave at Selby Ave Snelling Ave at Marshall Ave Snelling Ave at Concordia Ave

Function	Component	Description	Potential Locations
			Snelling Ave at St Anthony Ave Lexington Pkwy at Randolph Ave Lexington Pkwy at Grand Ave Lexington Pkwy at Summit Ave Lexington Pkwy at Concordia Ave Lexington Pkwy at St Anthony Ave
	Traffic Signals	Existing traffic signals used to manage traffic at intersections operated by St. Paul Public Works. Some intersections still have the legacy 170 controllers.	There are 30 intersections along the corridors that have traffic signals. The legacy 170 controllers will be replaced with new controllers that provide more features and allow for adaptive signal control, and monitoring capabilities using SPMs and travel time data.
Processing	Control Software (Traffic Signals)	Existing software used to monitor, and process data gathered from traffic signals to activate signal timing plans according to predefined operational plans.	St. Paul Public Works currently operates a central control software for traffic signals. Public Works staff operates the software from the City's TMC. The software may also be accessed via the Internet by staff to monitor and adjust timing plans remotely.
	Control Software (DMS)	Software used to monitor and operate DMS devices according to predefined operational plans.	St. Paul Public Works TMC. Software may also be accessed via the Internet by other stakeholders for viewing purposes.
	Control Software (CCTV)	Existing software used to monitor and operate CCTV devices.	St. Paul Police Department with priority. St. Paul Public Works TMC may also view/operate with 2nd priority to Police.
	Adaptive Signal Control	Software and hardware used to adjust signal timing based on real time data	Snelling Ave at Selby Ave Snelling Ave at Marshall Ave Snelling Ave at Concordia Ave Snelling Ave at St. Anthony Ave Snelling Ave at Shields Ave Snelling Ave at University Ave Lexington Pkwy at Randolph Ave Lexington Pkwy at Jefferson Ave Lexington Pkwy at Grand Ave Lexington Pkwy at Summit Ave Lexington Pkwy at Marshall Ave Lexington Pkwy at Concordia Ave Lexington Pkwy at St. Anthony Ave Lexington Pkwy at University Ave
	Third-Party Travel Time & Historical Probe	Hardware and software used to monitor traffic flow in real time	Software accessed via the Internet.

Function	Component	Description	Potential Locations
	Data Website Access		
Dissemination	Dynamic Message Signs (DMS)	Signs used to convey changing information and general direction to travelers based on current status of the roadway network.	Snelling Ave at Selby Ave Snelling Ave at Marshall Ave Snelling Ave at Shields Ave Snelling Ave at University Ave Snelling Ave at Hewitt Ave Lexington Pkwy at Randolph Ave Lexington Pkwy at Grand Ave Lexington Pkwy at University Ave Lexington Pkwy at Horton Ave/Como Ave
	Communications Equipment (Fiber Optic Cable, Radios and Network Switches)	Communications equipment required to operate and bring back data from field devices to the TMC (i.e. traffic signals, DMS, CCTV cameras)	Fiber optic connection made to all traffic signals that don't currently have fiber, and all DMS locations along the corridors. Snelling Ave has fiber for most of the corridor, and Lexington Pkwy has fiber at only a few locations. Radio communications may be used to connect to the CCTV cameras.

4.2 Maintenance Support and Responsibilities

Each component of the TMS will require deployment, operations, and maintenance activities to support their function. The operational roles associated with the system were described in a previous section. Table 4 now describes some of the more likely activities that will be required to maintain various components of the TMS. This is not an all-inclusive list of activities as there will be additional maintenance specified by manufacturers of the specific technologies that are ultimately chosen for the TMS. It is also assumed that all of these activities except for the CCTV maintenance will be performed by City of St. Paul Public Works; however, they may also choose to contract all or some of the activities to another party. It is anticipated that St. Paul Police Department will be responsible for maintenance of the CCTV cameras. As with the previous sections, this list is intended as an initial reference point for City of St. Paul Public Works to begin understanding the ongoing maintenance implications of the TMS.

Table 4 Maintenance Activities for System Components

Component	Maintenance Activity
Traffic Signal Controllers	• Periodic checks of database parameters and controller settings • Maintain backups for software and databases
Adaptive Signal Control	• Test to check for accuracy in performing operations • Monitor performance of operational plans • Administrative adjustments to operational parameters • Maintenance of user access and authorizations • Maintenance of software and associated servers and databases
DMS	• Remove dust and dirt from exposed elements • Clean display screen • Check wiring and cable, harnesses and connectors for wear

	• Check mounting structures for overall stability • Testing to ensure all pixels are working and to check for accuracy and timeliness in displaying information
Network Switches	• Periodically verify network switch firmware is up to date. • Review logs for issues or trends. • Verify virus protection is up to date. • Periodically verify messaging alarms are functioning. • Maintain network switch configuration backups. • Maintain list user accounts and passwords.
CCTV Cameras	• Lens cleaning • Check pan/tilt/zoom features • Check wiring and cable, harnesses and connectors for wear • Check monitors for burn-in or distortion • Management of recorded video

4.3 Performance Measures

Establishing performance measures is helpful for setting and managing expectations for how the TMS will operate. However, measures should be meaningful to a specific audience and should ultimately be applicable to the goal for operating the system – to balance traffic during special events to reduce congestion and safety issues. In general, performance measures should be specific, measureable, agreed-upon, realistic and time-bound. Measures can be qualitative or quantitative. Following are three measures that have been established for the TMS. The measures may also change over time as operational experience is gained or as performance reporting requirements for transportation agencies change.

Measure	1. Traveler complaints
Target	Reduce traveler complaints regarding congestion during special events
Data	Customer comments
Data Source	
Analysis	Compare feedback from event prior to TMS operation to event after TMS operation
Reporting	Share summary during post-event debriefing

Measure	2. Event congestion
Target	Reduce congestion during special events
Data	Observations
Data Source	
Analysis	Compare feedback from event prior to TMS operation to event after TMS operation
Reporting	Share summary during post-event debriefing

Measure	3. Event-related crashes
Target	Reduce event-related crashes due to congestion during special events
Data	Crashes
Data Source	
Analysis	Compare feedback from event prior to TMS operation to event after TMS operation
Reporting	Share summary during post-event debriefing

Measure	4. Corridor travel times
Target	Reduce corridor travel times due to inefficient signal timing
Data	Third-Party Travel Time Website & Adaptive Signal Control
Data Source	
Analysis	Compare pre-signal timing update corridor travel times to post-signal update travel times from event prior to TMS operation to event after TMS operation
Reporting	Share summary during post-event debriefing

5. Operational Scenarios

Now that the needs have been identified and an operational concept has been described, along with the potential operational and maintenance roles and responsibilities, this final section presents operational scenarios that describe how the TMS may be used in actual situations that commonly occur in the project area. Scenarios are designed to help stakeholders understand how they may interact with the TMS and with one another during the situations that will most commonly require activation of the system. The scenarios generally describe the situation and identify which components may be used. Then the scenarios describe how the system performs and who interacts with the system in response to the actions performed before, during and after an event. The scenarios use times of day as a general reference to illustrate changing conditions over the passage of time. The scenarios also describe system performance only to the extent necessary for stakeholders to understand how the TMS will operate. Following is a summary of the scenarios that are featured in greater detail later in this section.

1. **Incident/Emergency Management**. During a normal day when there are no special events taking place in the area, there are still significant morning and afternoon peak periods of commuter

traffic. If an unplanned incident (e.g. crash, stalled vehicle, pavement heave, etc.) were to occur, the TMS could be used to alert travelers of lane closures, detour or alternate routes. Other incident cases include snow emergencies and amber alerts.

2. **Allianz Field:** Allianz Field is host to 20-25 soccer events that can draw up to 19,400 fans and is available for rental for other special events. On gamedays, congestion is expected to occur near the adjacent freeway. The TMS could be used to alert travelers of alternate routes, temporary road closures, and allow TMC staff to adapt signal plans to properly manage the incoming traffic.
3. **MN State Fair**: The 12-day event of the Minnesota State Fair draws major traffic and congestion to the Snelling Avenue corridor. The event operates from 6 a.m. to midnight on every day except Labor Day, when it ends at 10 p.m. The TMS could be used to show alternate routes, run special event signal timing, and make use of adaptive signal controls. Operational plans for the TMS use during these events may have unique details for alternate routes.
4. **Minnesota State Fairgrounds**: The Minnesota State Fairgrounds hosts a variety of other events throughout the year outside of the MN State Fair. These events include horse shows, car shows, and Comicon, and can draw large volumes of visitors. The events can occur on any day of the week and during a wide variety of times. Operational plans for the TMS use during these events may have unique details for alternate routes.

5.1 Scenario 1: Incidents/Emergency Management

Incident Occurrence

5.1.1 During a Wednesday in July, there are no scheduled special events at Allianz Field or the MN State Fairgrounds. However, at 8:15 am during the morning commute peak period, St. Paul Police are notified of a vehicle that struck the light rail train at the intersection of Lexington Parkway at University Ave. The incident has blocked all north and southbound movement and is expected to take approximately 2 hours to clear.

5.1.2 St. Paul Police notify St. Paul Public Works of the incident and dispatch an officer to the scene to direct traffic away from the incident.

5.1.3 St. Paul Police takes priority control of the TMS (cameras) to monitor traffic in the area of the incident. St. Paul Public Works accesses the TMS (cameras) as view only and activates the relevant DMS to alert travelers of the closure and alternate routes. St. Paul Public Works also has adaptive signal control capability at this intersection. Using detection, the adaptive signal control is able to identify that there is a reduced number of vehicles exiting the intersection from the blocked approach. The adaptive signal control adjusts timings, within a threshold, to grant more green time to movements that are not being blocked.

5.1.4 At 10:15 am, the incident has cleared, and St. Paul Police notify Public Works that the road is now open.

5.1.5 St. Paul Public Works removes the posted messages from the DMS, ensures the adaptive signal controls have resumed their typical operation, and traffic flows as normal.

Snow Emergency or other Citywide Alert

5.1.6 On a Thursday at 3 pm, snow has accumulated up to 6" and the City of St. Paul has declared a snow emergency for that night beginning at 9pm.

5.1.7 St. Paul Public Works activates the operation plan for displaying snow emergency routes on all relevant DMS to alert travelers of the scheduled snow emergency.

5.1.8 Once the City has lifted the snow emergency, St. Paul Public Works removes the snow emergency messages from all DMS.

Other operation plans for general citywide alerts such as an amber alert would have similar operation plans activated when the city deems it necessary to alert travelers.

5.2 Scenario 2: Allianz Field Weekend Event

Pre-Event Activities

5.2.1 The City monitors the Allianz Field event schedules independently. The City notes that there is a large event in a month that is anticipated to produce heavy traffic.

5.2.2 For the first few events, St. Paul Public Works will coordinate with St. Paul Police to establish an operational plan for Allianz Field events. The operational plan will identify how and when the signage will be used around the field to ensure accurate and up to date messages for display on the dynamic message signs. After the first few events, Public Works and St. Paul Police will perform the operational plan with minimal communications between each party.

Day of Event Activities

5.2.3 At 5 pm on the day of the event, St. Paul Police begins monitoring vehicle traffic heading towards nearby parking for an event at Allianz Field. Signal timing event plan for ingress traffic is enabled based on a predefined schedule. The adaptive signal control adjusts signal timing parameters based on actual traffic demand.

5.2.4 At 6:15 pm, traffic is backing up on Snelling Avenue near the Shields Avenue entrance to the stadium. The Allianz Field ingress event operation plan for the DMS is automatically activated in the ATMS system at 6:15 pm, which will activate nearby DMS to direct vehicles attempting to park on-site to alternate parking locations nearby.

5.2.5 At 6:30 pm, traffic is queuing on the I-94 EB on-ramp and freeway. The City of St. Paul notices the queue using the CCTV system and notifies the MnDOT RTMC. MnDOT RTMC is activates the appropriate DMS along I-94 EB to warn drivers of event congestion at Snelling Avenue.

5.2.6 At 7 pm, the event has begun, and traffic has reduced to normal flow. The signal timing and DMS event operation plans for ingress are disabled.

5.2.7 At 10 pm, the event has ended, and traffic is using Snelling Ave and Lexington Pkwy to access I-94. The Allianz Field DMS event operation plan for egress, which will direct traffic to nearby freeway entrances and alternative routes is enabled. The signal timing event operation plan for

egress is also enabled. Adaptive signal control will adjust signal timing parameters based on actual traffic demand.

5.2.8 Around 11 pm traffic has calmed to normal levels. Both the signal timing and DMS event operation plans for egress are disabled.

Post-Event Activities

5.2.9 If issues arise during the ingress or egress operations, St. Paul Public Works fields feedback from event venue staff and St. Paul Police on the overall operations to/from the event and adjusts the messages or signal timing accordingly.

5.3 Scenario 3: Minnesota State Fair

Pre-Event Activities

5.3.1 One month before the scheduled event, Minnesota State Fairgrounds event staff notifies St. Paul Public Works and Police of the event dates, times, and anticipated traffic for the event.

5.3.2 St. Paul Public Works develops an operation plan to route traffic to and from the fairgrounds and nearby parking.

Day of Event Activities

5.3.3 Just prior to the 12-day event, St. Paul Public Works activates the DMS event operation plan to direct people to the fairgrounds and nearby parking using the Snelling Avenue and Lexington Parkway corridors. The signal timing event plan for ingress and egress traffic is enabled.

5.3.4 Since traffic is entering and exiting the area throughout the day without a single end time for the event, the inbound/outbound traffic operations plan and DMS messages continue throughout the entire day. The adaptive signal control software consistently monitors traffic levels at various locations throughout the corridor and adjust signal timing in real time. At midnight each day of the event, St. Paul Public Works deactivates the operation plan until 6am the following morning. The signal timing event operation plan for inbound and outbound traffic is disabled until 6am the following morning for the duration of the event.

Post-Event Activities

5.3.5 If issues arise during the event, St. Paul Public Works fields feedback from St. Paul Police on the overall operations to/from the event and adjusts messages and signal timing plans accordingly.

5.4 Scenario 4: State Fairgrounds Event

Pre-Event Activities

5.4.1 One month before the scheduled event, Minnesota State Fairgrounds event staff notifies St. Paul Public Works and Police of the event dates, times and anticipated traffic for the event.

5.4.2 St. Paul Public Works develops an operation plan to route traffic to and from the fairgrounds and nearby parking.

Day of Event Activities

5.4.3 Just prior to the event, St. Paul Public Works activates the DMS event operation plan to direct people to the fairgrounds and nearby parking using the Snelling Avenue and/or Lexington Parkway corridors. The signal timing event operation plan for ingress traffic is enabled, and the DMS event operation plan is activated.

5.4.4 Since traffic is typically entering and exiting the area throughout the day without a single end time for the event, the inbound/outbound signal timing event operation plan and DMS messages continue throughout the entire duration of the event. The adaptive signal control software consistently monitors traffic levels at various locations throughout the corridor and adjust signal timing in real time. Once the event ends, St. Paul Public Works deactivates the operation plan and changes the signal timing event operation plan back to normal operations.

Post-Event Activities

5.4.5 St. Paul Public Works fields feedback from event venue staff and St. Paul Police on the overall operations to/from the event and adjusts messages and signal timing plans accordingly.