Model Concept of Operations - Remotely Operated and Dynamic Systems for Road Closures and Advisory Messages in Remote Areas

MnDOT Project: Systems Engineering for Snow and Ice Control (SEASIC)

Prepared by:
Athey Creek Consultants

FINAL – May 2015
# Table of Contents

1. Introduction ........................................................................................................................................ 1
   1.1 Purpose ......................................................................................................................................... 1
   1.2 Overview of Systems Engineering Documents ............................................................................... 2
   1.3 Document Overview ...................................................................................................................... 3
   1.4 Project Team .................................................................................................................................. 3
2. Roles and Responsibilities .................................................................................................................... 4
3. Stakeholders ......................................................................................................................................... 7
4. Needs .................................................................................................................................................. 8
5. System Types ...................................................................................................................................... 17
   5.1 System A: Road Closure System (with Gates) for Access Controlled Highways ......................... 18
   5.2 System B: Road Closure System (with Gates) for Non-Access Controlled Highways .................. 19
   5.3 System C: Road Closure System (No Gates) for Non-Access Controlled Highways .................... 20
   5.4 System D: Changeable Message Signs (CMS) for Advisory Messages ......................................... 21
   5.5 System E: Dynamic Advisory Signs for Recurring Hazardous Weather-Related Conditions .......... 22
6. Operational Concepts ........................................................................................................................... 23
   6.1 System A: Road Closure System (with Gates) on Access Controlled Highways .......................... 24
   6.2 System B: Road Closure System (with Gates) on Non-Access Controlled Highways ................. 33
   6.3 System C: Road Closure System (No Gates) on Non-Access Controlled Highways .................... 42
   6.4 System D: Changeable Message Signs (CMS) for Advisory Messages ......................................... 49
   6.5 System E: Dynamic Advisory Signs for Recurring Hazardous Weather-Related Conditions ......... 53

Appendix .................................................................................................................................................. 58
1. Introduction

1.1 Purpose
The Minnesota Department of Transportation (MnDOT) is responsible for implementing traffic control mechanisms and providing timely, accurate, information to motorists during weather events and other circumstances that impact travel on state operated highways. These events may require road closures and/or advisory messages to be displayed to the traveling public.

Because maintenance stations or operations functions may be located several miles from components that comprise road closure and advisory message systems, MnDOT Districts may wish to deploy systems that operate devices from the District office, rather than at the site of each deployment. This may be desired to minimize personnel exposure to unsafe conditions and to efficiently operate several devices (e.g. gates, signs, sensors that are located great distances from one another) from a central location.

This *Model Concept of Operations* document is intended for use by MnDOT Districts for future deployments of systems that provide *traveller information and traffic control for weather events and other hazardous conditions on interstates and state highways, primarily in “remote” areas*. While the systems described in this document can be deployed in either rural or urban settings, the document does not address specific scenarios common in metropolitan areas, where high traffic volumes exist and coordinated traffic management is needed. The document is intended to be used by MnDOT Districts, to implement new systems or to integrate with existing systems as needed during design.

As part of the project “Systems Engineering for Snow and Ice Control,” MnDOT created a series of systems engineering documents for use by districts for future deployments of systems that provide traveler information and traffic control for weather events and other hazardous conditions on interstates and state highways, primarily in “remote” areas. Systems engineering analysis is required when using federal highway trust funds for ITS deployments (TEA-21 5206(e) Section 940.11, [http://ops.fhwa.dot.gov/its_arch_.imp/policy_1.htm#940_5](http://ops.fhwa.dot.gov/its_arch_.imp/policy_1.htm#940_5)).

These “model” systems engineering documents can be utilized and adapted by MnDOT districts during the design of site-specific deployments, for the following five system types:

**Road Closure Systems:**
- System A: Road Closure System (with Gates) for Access Controlled Highways
- System B: Road Closure System (with Gates) for Non-Access Controlled Highways
- System C: Road Closure System (no Gates) for Non-Access Controlled Highways

**Advisory Message Systems:**
- System D: Changeable Message Signs (CMS) for Advisory Messages
- System E: Dynamic Advisory Messages for Recurring Hazardous Weather-Related Conditions

The purpose of these systems is to provide motorists with information regarding road closures, changing road weather conditions, construction and maintenance delays, and other conditions that could
adversely impact safety and travel routes in remote areas. In addition, the remotely operated and
dynamic/automated functions of the systems will assist MnDOT personnel with efficiently managing
road closure operations and providing advisory messages to the traveling public.

It is important to note that MnDOT Districts currently operate several road closure devices and message
signs that do not have remote operational or dynamic/automated capability; rather, they are operated
on-site (e.g. gates that are opened and closed manually with hand-operated cranks, beacons on static
signs that are controlled by a switch located on the sign itself, etc.) MnDOT Districts will likely continue
to deploy such devices and systems in the future, depending upon characteristics of the site and
available funding. Districts may also choose to add remotely operated components to in-place systems
that have manually/on-site operated devices in place (e.g. add a remotely operated CMS to a site where
manually/on-site gates are in place), resulting in “hybrid” systems that have some components that will
are operated on-site and other devices that can be operated from a remote location. This document
does not imply that all future systems or components deployed by MnDOT will be remotely operated or
have dynamic/automated components, nor does it imply that upgrades to remotely operated or
automated/dynamic systems are required for any future deployments. This document is intended to
serve as a resource for Districts to use when deploying remotely operated and/or dynamic systems;
however, it can be adapted during the design process to fit a number of deployment-specific scenarios.

1.2 Overview of Systems Engineering Documents
This Model Concept of Operations document provides end user needs, roles and responsibilities, and
operational concepts describing how the systems will perform, for each of the five road closure and
advisory message systems listed above.

The following companion documents provide model system requirements for each of these systems:

- **Volume 1: Model Requirements for System A Road Closure System (with Gates) for Access
  Controlled Highways**
- **Volume 2: Model Requirements for System B Road Closure System (with Gates) for Non-Access
  Controlled Highways**
- **Volume 3: Model Requirements for System C Road Closure System (no Gates) for Non-Access
  Controlled Highways**
- **Volume 4: Model Requirements for System D Changeable Message Signs (CMS) for Advisory
  Messages**
- **Volume 5: Model Requirements for System E Dynamic Advisory Messages for Recurring
  Hazardous Weather-Related Conditions**
1.3 Document Overview

This *Model Concept of Operations* document provides a summary of stakeholder groups, system types, determination of roles and responsibilities, stakeholder needs, and operational concepts that describe the sequence of operational events and activities carried out by each stakeholder group.

*The intent of this document is to be utilized by MnDOT districts when site-specific deployments are planned, during the design process for each deployment. This Model Concept of Operations document is written with flexibility to be adapted to various site conditions and individual district practices.*

This document, together with the companion *Model Requirements* documents, can be used by MnDOT while performing the systems engineering analysis for deployments of remotely operated or automated/dynamic road closure and advisory message systems.

1.4 Project Team

The project team assembled for this project provided valuable input for this document, including confirming system types, identifying end user needs, and reviewing operational concepts. Representatives on the project team included:

- Brian Bausman, MnDOT District 4
- Jesse Larson, MnDOT Regional Transportation Management Center
- Dan Rowe, MnDOT Office of Traffic, Safety, and Technology
- Bob Vasek, MnDOT Office of Maintenance
- Tom Zimmerman, MnDOT District 7
2. Roles and Responsibilities

The operations performed during road closures and advisory message activations require a high degree of oversight, management, and coordination, particularly among MnDOT and Minnesota State Patrol/local law enforcement personnel. It is therefore important to provide an overview of where authority lies and how roles and responsibilities will be determined for individual deployments.

Because differences exist in how each district performs operations related to road closures and advisory messages, this document is written such that it can be adapted to district-specific practices during the design process for each deployment. This section provides guidance for how roles and responsibilities will typically be determined, for the deployment, operations, and maintenance of the systems.

Throughout this document, the term “operators” refers to individuals who will perform activities from District offices (or other sites away from the location of field devices) such as: opening and closing gate arms, posting messages to changeable message signs, activating static signs with beacons, and viewing surveillance cameras. “Operators” may include personnel from MnDOT Districts or from State Patrol.

Authority and Coordination:

- **Authority for Road Closures and Messages to Motorists** - Minnesota Statute § 161.27 Subdivision 8 “Trunk highway closure; authority, notice” places authority for closing state trunk highways and notifying the public with the “commissioner” (commissioner of transportation), indicating that:

  “(a) The commissioner may restrict the use of, or close, any state trunk highway for the protection and safety of the public or for the protection of the highway from damage during and after storms if there is danger of the road becoming impassable or if visibility is so limited that safe travel is unlikely.
  
  (b) To notify the public that a trunk highway is closed or its use restricted, the commissioner shall give notice by one or more of the following methods:
  (1) erect suitable barriers or obstructions on the highway;
  (2) post warnings or notices of the closing or restricting of a trunk highway;
  (3) place signs to warn, detour, direct, or otherwise control traffic on the highway; or
  (4) place personnel to warn, detour, direct, or otherwise control traffic on the highway.”

Designated individuals within MnDOT Districts act on behalf of the commissioner of transportation, to determine when state-operated highways are to be closed and re-opened, provide traffic control, and provide motorists with relevant information. Designated individuals within MnDOT Districts also determine the need for specific information to be displayed to the traveling public, via on-road message signs and via MnDOT’s established traveler information tools (such as 511 website, 511 phone, Twitter feed, etc.), when conditions that impact travel.

---

1 Minnesota Statute § 161.27 Subdivision 8: [https://www.revisor.mn.gov/statutes/?id=160.27](https://www.revisor.mn.gov/statutes/?id=160.27)
are occurring. Internal documents, such as the *MnDOT Changeable Message Sign (CMS) Manual of Practice*, are utilized to provide guidance when posting site-and condition-specific messages.

- **Coordination with Minnesota State Patrol or Local Law Enforcement** - While MnDOT maintains overall authority to restrict the use of (or close) state-operated highways, a high degree of coordination with the Minnesota State Patrol and/or local law enforcement is required, particularly in preparation for and during road closures. MnDOT Districts typically coordinate closely with State Patrol/local law enforcement as road conditions are deteriorating or during emergency situations when making a decision to close a state-operated highway. In addition, State Patrol/local law enforcement personnel often work with MnDOT to staff gates during closures or to operate devices such as gates or signs, either on-site or from a dispatch center.

### Deployment and Ownership:

- **Site Selection** - MnDOT Districts will select sites to deploy permanent road closure infrastructure based upon experience and observed needs such as frequency of closures, recurring hazardous conditions, and other safety or operational factors. MnDOT Districts may consult with State Patrol/local law enforcement to gather input for site selection.

- **Design** – MnDOT Districts will lead design efforts, customizing the systems engineering documents (this *Model Concept of Operations* and its companion *Model System Requirements* document) to complete a site-specific design for each deployment. The design phase should include coordination with MnDOT personnel responsible for deploying, operating, and maintaining the MnDOT IRIS software system for the District in which the deployment is planned.

- **Optional System Components and Functionality** - MnDOT Districts will select optional system components and functionality (e.g. surveillance cameras, optional signs) based upon factors that include site-specific geometries and operational logistics such as distance from District offices to sites. Final site-specific design requirements may also drive the deployment of optional system components and functionality.

- **Ownership** - MnDOT Districts will purchase and install system components and retain ownership of each system unless unique circumstances, such as jointly funded deployments, are implemented.

### Operational Responsibilities:

- **Determination of Roles** – During the design and implementation phase of each individual deployment, MnDOT Districts, in coordination with State Patrol/local law enforcement, will determine roles and responsibilities for conducting road closure and advisory message operations using the Road Closure and Advisory Message Systems outlined in this *Model Concept of Operations* document. The operational concepts described in Section 6 of this document provide a framework for defining these roles and responsibilities specific to each deployment. The appendix of this document provides a list of operational tasks that can be used
to assign responsibilities for management and coordination, and for operating system components.

- **Documentation of Roles** - MnDOT Districts often use an “Operations Manual” that outlines overall criteria, preparation, and operational steps for conducting operations such as road closures. The operations manual will be supplemented with deployment-specific roles and responsibilities during the design phase of each system deployment. Districts are encouraged to create a brief (1-2 page) summary that outlines specific roles and responsibilities to be performed Minnesota State Patrol and/or local law enforcement personnel who will provide significant operational support, in particular for road closure operations that utilize systems in this document.

### Maintenance Responsibilities:

- **Determination of Roles** - MnDOT Districts, in coordination with other MnDOT units as applicable, will assign roles and responsibilities for ongoing maintenance and repair of all system components. For instance, MnDOT’s Electrical Services unit may conduct maintenance of components that require specialized electrical expertise.

- **Documentation of Roles** – MnDOT Districts will document roles and responsibilities for maintenance of system components during the design of site-specific deployments.
3. Stakeholders

The deployment and operations of the road closure and advisory message systems included in this document will be driven by the needs of stakeholder groups who will interact with each system.

Needs have been identified for the following stakeholder groups:

- **Drivers** who will encounter road closures and advisory messages equipped through system deployments
- **MnDOT Districts** who will deploy, operate, maintain, and own the systems
- **MnDOT Regional Transportation Management Center/511 Coordinator** who manages MnDOT’s statewide traveler information tools (e.g. 511 phone service, 511 website, 511 Smartphone mobile app, Twitter feed) that will display information to travelers
- **MnDOT Electrical Services** who may perform maintenance on components of system deployments
- **Minnesota State Patrol** who will coordinate with MnDOT Districts and participate in the overall process to implement road closures and advisory message activations
- **Local Law Enforcement** who may assist with traffic control operations during road closures
- **Local Agency Public Works** who may be impacted when MnDOT road closures divert traffic to local roads
4. Needs

This section presents end user needs for each stakeholder group that will interact with the road closure and advisory message systems. These needs will drive what the systems must do, and they will further define system requirements for how the systems must perform. As described in Section 3, the following stakeholder groups have been identified as end users of the road closure and advisory message systems included in this document:

- Drivers
- Minnesota Department of Transportation (MnDOT)
  - Districts
  - Regional Transportation Management Center (RTMC) / 511 Coordinator
  - Electrical Services
- Minnesota State Patrol
- Local Law Enforcement
- Local Agency Public Works

Table 1 provides stakeholder needs, segmented by each group listed above. Each need is identified by first describing a challenge facing one of or more of the stakeholder groups (column 1). Then, based on each challenge, one or more needs (column 3) are described. Each need has an associated ID number (column 2) for identification and traceability purposes. Because many of the needs apply to multiple system types while some needs may only apply to one system type, the system designation (column 4) lists or more system types to which each need applies.

Needs will be referenced by ID number in the operational concepts described in Section 6 of this document, allowing readers to reference back to the needs and challenges that drive each operational concept.
### Table 1: Stakeholder Needs for Road Closure and Advisory Message Systems

<table>
<thead>
<tr>
<th>Challenge</th>
<th>ID</th>
<th>Need</th>
<th>System(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drivers approaching a closed section of highway must exit the road at or prior to the closure point.</td>
<td>1</td>
<td><strong>Drivers on an access controlled highway</strong> approaching a road closure need to be notified in a safe and consistent manner <strong>prior to the closure point that the road is closed ahead and that they must exit.</strong></td>
<td>A</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td><strong>Drivers on a non-access controlled highway</strong> approaching a road closure need to be notified of the closure in a safe and consistent manner prior to closure point in locations where they can divert to other roads.</td>
<td>B, C</td>
</tr>
<tr>
<td>If drivers on are not informed of the extent of a road closure (e.g. start and end points), their ability to plan for alternate routes is diminished.</td>
<td>3</td>
<td>In some locations, drivers approaching a road closure need to be notified in a safe and consistent manner of the extent of the closure, to assist them with re-routing.</td>
<td>A, B, C</td>
</tr>
<tr>
<td>Drivers on access controlled highways such as interstates may become stranded in remote areas with limited services if they are required to exit during extended road closures.</td>
<td>4</td>
<td>In some locations and where possible, drivers need access to minimal services such as gas, food, and other supplies at exits where they are diverted off of an access controlled highway due to a road closure.</td>
<td>A</td>
</tr>
<tr>
<td>Drivers on cross-roads approaching a closed entrance ramp are not allowed to enter the ramp to an access controlled highway during a closure.</td>
<td>5</td>
<td><strong>Drivers on cross-roads</strong> approaching an entrance ramp with gate closure need to be notified in a safe and consistent manner prior to entering the entrance ramp that the highway is closed and they are not allowed to enter the ramp.</td>
<td>A</td>
</tr>
<tr>
<td>Drivers on cross-roads approaching a closed section of highway are not allowed to turn onto that highway during a closure.</td>
<td>6</td>
<td><strong>Drivers on cross-roads</strong> approaching a closed section of non-access controlled highway need to be notified of the closure in a safe and consistent manner at a location where they have options for diverting (e.g. either prior to turning onto the closed section of highway or after turning onto the closed section of highway but with access points that allow them to divert).</td>
<td>B, C</td>
</tr>
<tr>
<td>Drivers may be prosecuted by law enforcement (e.g. fines and/or jail time) if they proceed past barricaded roadways.</td>
<td>7</td>
<td><strong>Drivers approaching barricaded (gate-closed) sections of highway</strong> need to be notified of legal implications that could result if they proceed past closed gates and enter barricaded sections of highway.</td>
<td>A, B</td>
</tr>
<tr>
<td>Challenge</td>
<td>ID</td>
<td>Need</td>
<td>System(s)</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>----</td>
<td>----------------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>When drivers are not advised of approaching conditions that could impact their travel (e.g. congestion, weather-related situations that could cause hazardous driving conditions), their ability to proceed safely and efficiently may be compromised.</td>
<td>8</td>
<td>Drivers need to be advised when they are approaching adverse driving conditions such as reduced visibility, hazardous road conditions, delays, and other advisory messages so they can alter their driving approach or modify their course of travel.</td>
<td>D, E</td>
</tr>
<tr>
<td>Drivers without knowledge of road conditions may depart on trips during closures or proceed with less caution during hazardous conditions. Trip plans are often significantly impacted by road closures, especially when commercial vehicle/freight travel is impacted; information about the timing of road closure delays can be critical for travel planning.</td>
<td>9</td>
<td>Drivers (both en-route and pre-trip) need to receive information about conditions that may impact their travel (e.g. status of road closures, hazardous road conditions, delays) from MnDOT’s established traveler information tools (e.g. 511 phone service, 511 website, 511 Smartphone mobile app, Twitter feeds).</td>
<td>All</td>
</tr>
</tbody>
</table>

### MnDOT’s Needs

<p>| MnDOT aims to provide accurate, timely information to travelers on their roadways. | 10 | MnDOT District personnel need a mechanism to communicate messages to drivers en-route about known conditions that may impact their travel. | All       |
| During periods where extremely hazardous driving conditions occur or when an incident has blocked a highway section, MnDOT may decide to barricade a section of highway they deem to be unsafe or impassable. | 11 | MnDOT needs to inform motorists of closed sections of highway during a barricaded (gate-close) road closure. | A, B      |
| MnDOT maintenance stations may be located several miles from system deployments. MnDOT Maintenance personnel may be exposed to unsafe conditions while driving to sites to operate system components. | 12 | MnDOT District personnel need to avoid traveling to the site where gates, signage, and surveillance cameras are activated, in order to minimize their exposure to roadside or weather hazards and to maximize efficiencies. | All       |</p>
<table>
<thead>
<tr>
<th>Challenge</th>
<th>ID</th>
<th>Need</th>
<th>System(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordination of multiple remotely operated systems can be challenging unless it occurs through a central control software system.</td>
<td>13</td>
<td>MnDOT needs to <strong>avoid multiple individual software systems to control</strong> gates, signage, and surveillance cameras.</td>
<td>All</td>
</tr>
<tr>
<td>MnDOT is responsible for ensuring that system control is carried out by selected qualified personnel.</td>
<td>14</td>
<td>MnDOT needs the ability to <strong>allow assigned personnel (at an individual level, with proper credentials)</strong> to control system operations. Similarly, MnDOT needs to <strong>limit access to system control functions to only those individuals who have been assigned</strong> to operate the systems.</td>
<td>All</td>
</tr>
<tr>
<td>MnDOT is responsible for coordinating all aspects of executing a road closure and ensuring that motorists (such as stranded vehicles) are not present within closed highway sections.</td>
<td>15</td>
<td>MnDOT needs <strong>adequate personnel (MnDOT, State Patrol, and/or local law enforcement personnel) to be present at mainline gates and ramp gates</strong> as gates are closed and at ramp gates during road closures.</td>
<td>A, B</td>
</tr>
<tr>
<td></td>
<td>16</td>
<td>MnDOT needs to <strong>verify, on-site, that motorists are not present in the section of highway</strong> that has been closed (just after the mainline has been closed and just prior to re-opening the mainline), and needs to <strong>assist with removing motorists from the closed section</strong> of highway. MnDOT needs to provide travelers the ability to exit closed areas of highways (i.e. gates should not prevent egress from the highway).</td>
<td>A, B, C</td>
</tr>
<tr>
<td></td>
<td>17</td>
<td>MnDOT District personnel need to <strong>utilize on-road observations</strong> when deciding whether to close or re-open a section of highway. In some locations, MnDOT District personnel also need to supplement on-road observations by <strong>remotely viewing and monitoring changing weather conditions, driving conditions, and approaching traffic</strong> before activating system components such as signs and gates.</td>
<td>A, B, C</td>
</tr>
<tr>
<td>Challenge</td>
<td>ID</td>
<td>Need</td>
<td>System(s)</td>
</tr>
<tr>
<td>---------------------------------------------------------------------------</td>
<td>----</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>The traveling public’s safety may be impacted if traffic control and</td>
<td>18</td>
<td><strong>MnDOT District personnel</strong> need to remotely view gates prior to, during, and after controlling the gate, to verify that:</td>
<td>A, B</td>
</tr>
<tr>
<td>traveler information systems do not perform as intended. System</td>
<td></td>
<td>• No objects or persons are near the gate closure systems such that they may be hit when the gate closes or opens</td>
<td></td>
</tr>
<tr>
<td>malfunctions may impact safety if not verified and corrected.</td>
<td></td>
<td>• Gate closure has been completed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>19</td>
<td><strong>MnDOT needs gates to meet all requirements</strong> specified in federal and state design and safety standards.</td>
<td>A, B</td>
</tr>
<tr>
<td></td>
<td>20</td>
<td><strong>MnDOT District personnel</strong> need to remotely verify whether the appropriate messages have been posted to or removed from signs, or</td>
<td>A, B, C, D</td>
</tr>
<tr>
<td>the alert components of signs (e.g. flashing beacons on static signs)</td>
<td></td>
<td>that have been activated or deactivated properly.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td><strong>MnDOT District personnel</strong> need to remotely view dynamic signs** (i.e. signs that are automatically activated by on-site sensors)</td>
<td>E</td>
</tr>
<tr>
<td>(i.e. signs that are automatically activated by on-site sensors) to</td>
<td></td>
<td>verify that they have been activated or deactivated as intended.</td>
<td></td>
</tr>
<tr>
<td>verify that they have been activated or deactivated as intended.</td>
<td></td>
<td><strong>MnDOT District personnel</strong> need the ability to have authorized personnel <strong>manually operate system functions</strong> on-site at each</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td>system deployment, while preventing the general public from operating system functions.</td>
<td></td>
</tr>
<tr>
<td>On-site situations may warrant system changes due to changing conditions</td>
<td>22</td>
<td><strong>MnDOT District personnel</strong> need the ability to have authorized personnel <strong>manually operate system functions</strong> on-site at each</td>
<td>All</td>
</tr>
<tr>
<td>(e.g. emergency response efforts for crashes or rescues), communications</td>
<td></td>
<td>system deployment, while preventing the general public from operating system functions.</td>
<td></td>
</tr>
<tr>
<td>or power outages, or system malfunctions.</td>
<td></td>
<td>System malfunctions may impact traveler safety if sensors that automatically activate sign messages are not functioning as intended.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>23</td>
<td><strong>MnDOT needs any automated activation of advisory messages</strong> on signs to be triggered by a reliable data source. Individual MnDOT</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Districts may differ in their levels of acceptance of sources of the trigger, based on the type and location of deployment.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>24</td>
<td><strong>MnDOT needs to avoid traveling to sites</strong> to remove snow and ice from signs.</td>
<td>All</td>
</tr>
<tr>
<td>Signs placed in locations that are prone to snow and ice build-up on</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>vertical structures requires MnDOT maintenance resources to clear the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>signs during and after snow/ice events so they are visible to the</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>traveling public.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Challenge</td>
<td>ID</td>
<td>Need</td>
<td>System(s)</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>----</td>
<td>------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>MnDOT is responsible for understanding information has been displayed to the traveling public through automated messages.</td>
<td>25</td>
<td><strong>MnDOT District personnel</strong> need to be notified, both in real time and through a system-generated log function, when automated systems (e.g. dynamic signs triggered by sensors) are activated (or de-activated) and what activation has occurred.</td>
<td>E</td>
</tr>
<tr>
<td>If systems are not functioning properly, MnDOT is responsible for repairing issues on-site or implementing alternate traffic control or messaging mechanisms.</td>
<td>26</td>
<td><strong>MnDOT District personnel</strong> need to be able to view reports of malfunctions in the system devices and/or any losses of communications to the system devices.</td>
<td>A, B, C, D</td>
</tr>
<tr>
<td>MnDOT’s Traveler Information mechanisms such as the 511 website and phone app aim to relay current information to the traveling public as quickly as possible.</td>
<td>27</td>
<td><strong>MnDOT needs for automated activations of advisory messages</strong> (e.g. dynamic signs triggered by sensors) to automatically generate and send messages to the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS).</td>
<td>A, B, C, D, E</td>
</tr>
<tr>
<td>MnDOT needs for automated activations of advisory messages (e.g. dynamic signs triggered by sensors) to automatically generate and send messages to the statewide Traveler Information System Condition Reporting Entry Tool (CARS).</td>
<td>28</td>
<td><strong>MnDOT RTMC / 511 Coordinator needs each MnDOT district to enter and update closures or advisory messages</strong> in the statewide Traveler Information System Condition Reporting Entry Tool (CARS), as appropriate.</td>
<td>A, B, C, D</td>
</tr>
</tbody>
</table>
| MnDOT is responsible for performing diagnostics testing and measuring performance for systems that provide traveler information and traffic control. In addition, MnDOT is responsible for documenting system events for liability protection purposes. | 29 | **MnDOT needs to have an accurate log of system occurrences**, including timestamp and the content of messages, when:  
- A gate arm is closed  
- A gate arm is opened  
- Signs are activated manually  
- Signs are activated automatically by on-site sensors  
- Any component malfunctions occur | All       |
<p>| Unclear roles and responsibilities when operating road closure systems or when posting messages could result in inefficiencies or unsafe situations. | 30 | <strong>MnDOT needs to assign roles and responsibilities</strong> (e.g. identify staff who will have access to activate and operate systems) <strong>for operating each system</strong> that is deployed. | All       |</p>
<table>
<thead>
<tr>
<th>Challenge</th>
<th>ID</th>
<th>Need</th>
<th>System(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Responsibilities for maintaining various MnDOT-operated components and systems are often divided among district-level and statewide entities (e.g. Electrical Services, District Maintenance).</td>
<td>31</td>
<td><strong>MnDOT needs to assign maintenance responsibilities</strong> (e.g. costs, expertise, staff time available) for the components of each system that is deployed.</td>
<td>All</td>
</tr>
<tr>
<td>System components that vary widely tend to require more time and resources to operate and maintain than those that have similar features.</td>
<td>32</td>
<td><strong>MnDOT needs system components to be somewhat standardized across the deployments in outstate districts,</strong> for ease of operation and maintenance.</td>
<td>All</td>
</tr>
<tr>
<td>MnDOT may be unfamiliar with the installation, operational, and maintenance requirements associated with remotely operated and automated traveler information and traffic control systems.</td>
<td>33</td>
<td><strong>MnDOT needs installation, operational, and maintenance documentation and training for the road closure and advisory message systems.</strong></td>
<td>All</td>
</tr>
<tr>
<td>MnDOT Districts are responsible for maintaining many devices along roadways in their jurisdictions. The addition of new systems requires information to assist with setting priorities for repairs and replacements.</td>
<td>34</td>
<td><strong>MnDOT needs a maintenance prioritization process</strong> that can be followed to repair or replace system components, in context with other devices and systems in each district.</td>
<td>All</td>
</tr>
<tr>
<td>MnDOT aims to minimize traffic impacts and conduct maintenance activities as safely as possible for its personnel.</td>
<td>35</td>
<td><strong>MnDOT needs to be able to maintain road closure and advisory message systems with minimal impact on traffic and in a safe manner for those conducting maintenance.</strong></td>
<td>All</td>
</tr>
<tr>
<td>MnDOT’s maintenance and operations budgets are continually reviewed and subject to reductions.</td>
<td>36</td>
<td><strong>MnDOT needs the road closure and advisory message systems to be cost effective.</strong></td>
<td>All</td>
</tr>
<tr>
<td>In the event of a crash, vehicles may collide with roadside equipment.</td>
<td>37</td>
<td><strong>MnDOT needs all system components within the roadway clear zone to be crashworthy,</strong> in the event they are impacted by errant vehicles.</td>
<td>All</td>
</tr>
<tr>
<td>Challenge</td>
<td>ID</td>
<td>Need</td>
<td>System(s)</td>
</tr>
<tr>
<td>-----------</td>
<td>----</td>
<td>------</td>
<td>-----------</td>
</tr>
<tr>
<td><strong>Minnesota State Patrol’s Needs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong coordination between MnDOT and Minnesota State Patrol is necessary to conduct streamlined operations during road closures.</td>
<td>38</td>
<td>Minnesota State Patrol personnel need to be notified of deteriorating road conditions when road closures are likely, in order to coordinate with MnDOT on the closure and to assist with operations such as staffing at gates during barricaded road closures and driving closed highway sections to check for stranded vehicles.</td>
<td>A, B, C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In some MnDOT Districts, Minnesota State Patrol dispatch personnel need to operate system components (e.g. post or messages to changeable message signs, activate or de-activate static signs with beacons, open/close gates, view surveillance cameras) either on-site or from a remote location, in coordination with District personnel.</td>
<td>All</td>
</tr>
<tr>
<td></td>
<td></td>
<td>In some MnDOT Districts, Minnesota State Patrol personnel that are designated CARS 511 users need to update road closure and advisory message information in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS), in coordination with District personnel.</td>
<td>All</td>
</tr>
<tr>
<td>Minnesota State Patrol may issue citations to drivers who violate Minnesota state law by proceeding past closed gates during closures.</td>
<td>41</td>
<td>At selected locations, Minnesota State Patrol needs to identify vehicles (including visual verification of license plates) that proceed past closed gates during road closures.</td>
<td>A, B</td>
</tr>
<tr>
<td><strong>Local Law Enforcement’s Needs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>In some situations, traffic control required for road closures cannot be performed MnDOT and State Patrol alone, and local law enforcement personnel are needed.</td>
<td>42</td>
<td>Local law enforcement personnel need to be notified when road closures are likely, in situations when MnDOT and Minnesota State Patrol utilize local law enforcement to assist with staffing at gates during barricaded road closures and to drive closed highway sections to check for stranded vehicles.</td>
<td>A, B, C</td>
</tr>
<tr>
<td>Challenge</td>
<td>ID</td>
<td>Need</td>
<td>System(s)</td>
</tr>
<tr>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>----</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>Local law enforcement may issue citations to drivers who violate Minnesota state law by proceeding past closed gates during closures.</td>
<td>43</td>
<td>At selected locations, local law enforcement needs to <strong>identify vehicles</strong> (including visual verification of license plates) <strong>that proceed past closed gates</strong> during road closures.</td>
<td>A, B</td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>All Stakeholders’ Needs</strong></td>
<td></td>
</tr>
<tr>
<td>The safe, efficient movement of travelers on Minnesota’s roadways is central to the missions of both MnDOT and Minnesota State Patrol.</td>
<td>44</td>
<td><strong>All stakeholders</strong> need the systems to communicate messages to drivers in a safe, efficient, and consistent manner.</td>
<td>All</td>
</tr>
</tbody>
</table>
5. **System Types**

This section provides a short description and conceptual drawing of each system type that collectively meet the stakeholder needs identified in Section 4 of this document. Each system is briefly described, including the system’s purpose, deployment conditions, and system components. In addition, a statement about each system’s capability to be operated remotely, on-site, or in real-time triggered by on-site sensors, is provided.

The following five systems are included in this *Model Concept of Operations* document:

**Road Closure Systems:**
- System A. Road Closure System (with Gates) for Access Controlled Highways
- System B. Road Closure System (with Gates) for Non-Access Controlled Highways
- System C. Road Closure System (no Gates) for Non-Access Controlled Highways

**Advisory Message Systems:**
- System D. Changeable Message Signs (CMS) for Advisory Messages
- System E. Dynamic Advisory Messages for Recurring Hazardous Weather-Related Conditions
5.1 System A: Road Closure System (with Gates) for Access Controlled Highways

System A is intended to be used for complete road closures that restrict access to the driving lanes for selected sections of access controlled highways. MnDOT will consider deploying these systems at access controlled highway locations with a history of frequent hazardous weather events based on experiences and judgment of District personnel.

System components will include:

- Gates accompanied by signs/beacons - on the mainline and on entrance ramps along the closed highway section
- Signs on the mainline, upstream of the mainline gate
- Optional surveillance cameras along the mainline, to view and monitor weather, road, and traffic conditions
- Optional surveillance cameras near signs and gates, to view and verify sign activations/de-activations and gate closures/openings

Operators will have the ability to control system components from remote locations, using the MnDOT IRIS system. In addition, on-site personnel will have ability to control gates and signs at the site of each deployment.

Figure 1 shows a concept drawing of System A - Road Closure System (with Gates) for Access Controlled Highways.

![Figure 1: System A - Road Closure System (with Gates) for Access Controlled Highways](image)

Figure 1: System A - Road Closure System (with Gates) for Access Controlled Highways
5.2 System B: Road Closure System (with Gates) for Non-Access Controlled Highways

System B is intended complete road closures that restrict access to the driving lanes for selected sections of non-access controlled highways. MnDOT will consider deploying these systems at non-access controlled highway locations with a history of frequent hazardous weather events based on experiences and judgment of District personnel.

System components will include:

- Gates on the mainline (Because the portion of the road that is closed is likely to include intersecting roads and/or driveways where vehicles may enter, gates will not cross both directions of travel.)
- Signage on the mainline, upstream of each gate
- Optional additional signage along the mainline or on selected cross-roads
- Optional surveillance cameras along the mainline, to view and monitor weather, road, and traffic conditions
- Optional surveillance cameras near signs and gates, to view and verify sign activations/de-activations and gate closures/openings

Operators will have the ability to control system components from remote locations, using the MnDOT IRIS system. In addition, on-site personnel will have ability to control gates and signs at the site of each deployment.

Figure 2 shows a concept drawing of System B - Road Closure System (with Gates) for Non-Access Controlled Highways.

![Figure 2: System B - Road Closure System (with Gates) for Non-Access Controlled Highways](image-url)
5.3 System C: Road Closure System (No Gates) for Non-Access Controlled Highways

System C is intended to be used for road closures on sections of non-access controlled highways, where gates are not used to physically restrict access to the closed roadway sections. MnDOT will consider deploying these systems at non-access controlled highway locations with a history of frequent hazardous weather events based on experiences and judgment of District personnel.

System components will include:

- Mainline signage, upstream of the closure
- Optional additional signage along the mainline or on selected cross-roads
- Optional surveillance cameras along the mainline, to view and monitor weather, road, and traffic conditions
- Optional surveillance cameras near signs, to view and verify sign activations and de-activations.

Operators will have the ability to control system components from remote locations, using the MnDOT IRIS system. In addition, on-site personnel will have ability to control signs at the site of each deployment.

Figure 3 shows a concept drawing of System C - Road Closure System (No Gates) for Non-Access Controlled Highways.

Figure 3: System C - Road Closure System (No Gates) for Non-Access Controlled Highways
5.4 System D: Changeable Message Signs (CMS) for Advisory Messages

System D is intended to be used to communicate a wide variety of messages to drivers. MnDOT will consider deploying these systems to provide messages at strategically chosen locations (i.e. where there is a high frequency of adverse weather conditions or near key decision points where travelers would benefit from messages.) Messages will vary in content and may include advanced notice of hazardous weather or road conditions, construction, road closures, congestion, or detour options.

System components will include:

- Changeable message signs in advance of an “area of interest” where the adverse condition is occurring
- Optional surveillance cameras along the “area of interest,” to view and monitor weather, road, and traffic conditions
- Optional surveillance cameras near changeable message signs, to verify that messages have been posted/removed properly
- Optional use of existing or new in-road or roadside sensors along the “area of interest,” to view and monitor weather, road, and traffic conditions

Operators will have the ability to control system components from remote locations, using the MnDOT IRIS system. In addition, on-site personnel will have ability to control changeable message signs at the site of each deployment.

Figure 4 shows a concept drawing of System D - Changeable Message Signs (CMS) for Advisory Messages.
5.5 System E: Dynamic Advisory Signs for Recurring Hazardous Weather-Related Conditions

System E is intended to be used to communicate a specific message to drivers in advance of areas that are prone to a high frequency of recurring hazardous weather-related conditions such as flooding, high winds, fog, slippery/icy roadways, or reduced visibility, especially in areas where there is a lack of adequate surveillance to monitor conditions at all times. The system will detect recurring conditions and automatically activate message signs. MnDOT will consider deploying these systems when the hazardous condition recurs frequently at a specific site.

System components will include:

- In-road or roadside sensors at the site that experiences the recurring condition
- Signs upstream of the recurring condition
- Optional surveillance cameras at the site of the recurring condition, to view and monitor weather, road, and traffic conditions
- Optional surveillance cameras near signs, to verify sign activations and de-activations

In addition to the automatic activation capability, operators will have the ability to control system components from remote locations, using the MnDOT IRIS system. On-site personnel will also have the ability to control signs at the site of each deployment.

See Figure 5 for a concept drawing of System E - Dynamic Advisory Signs for Recurring Hazardous Weather-Related Conditions.

![Figure 5: System E - Dynamic Advisory Signs for Recurring Hazardous Weather-Related Conditions](image-url)
6. **Operational Concepts**

The operational concepts presented in this section describe what is to be done and who will do it, for each road closure and advisory message system. The concepts outline a sequence of operational events and activities carried out by each stakeholder group and describe how stakeholders are expected to interact with each system, with references made back to the stakeholder needs (presented in Section 4), as a means of verifying that all needs have been anticipated.

Within this section, the term “operators” refers to individuals who use the MnDOT IRIS software control system (or other device control systems) to open and close gate arms, post messages to changeable message signs, activate static signs with beacons, and view surveillance cameras. “Operators” may include personnel from MnDOT Districts or from State Patrol.

Typical sign configurations and messages are detailed in the following operational concepts. Other sign configurations and messages may be considered during the final design for each site-specific deployment.
6.1 System A: Road Closure System (with Gates) on Access Controlled Highways

Driver Perspective:

A 1. Drivers will see information describing current road closures, such as start and end locations, when they view MnDOT’s traveler information tools (e.g. 511 phone service, 511 website, 511 Smartphone mobile app, Twitter feed), prior to their trip or en-route. (Related to Needs: 9)

A 2. Drivers on the mainline approaching a road closure will encounter an exit ramp that allows them to exit the highway, prior to the closed section. (Related to Needs: 1)

A 3. Drivers on the mainline approaching the closure will see advanced signage, located on both the right and left hand side of the road, communicating the closure prior to approaching the exit ramp that is just upstream of a barricaded (gate-closed) roadway section. (Related to Needs: 1, 44)

A 4. In some locations, it will be desirable for mainline drivers to see messages upstream of the closure that advise them that they are approaching a closure and communicate the extent of closures, such as start and end points. (Related to Needs: 3, 44)

A 5. Drivers on the mainline approaching the exit ramp will see a closed gate across the mainline, with signage that communicates that the road is closed and state law related to implications that may result if drivers proceed past closed gate arms. (Related to Needs: 1, 7, 44)

A 6. Drivers on cross-roads approaching an entrance ramp at a closed section of highway will see a closed gate across the entrance ramp, with signage that communicates the road is closed and state law related to implications that may result if drivers proceed past closed gate arms. (Related to Needs 5, 7, 44)

MnDOT Perspective:

A 7. MnDOT will consider deploying road closure systems with gates at access controlled highway locations with a history of frequent hazardous weather events based on experiences and judgment of District personnel. (Related to Need: 10, 11)

A 8. The availability of minimal services such as gas, food, and supplies will be one factor that MnDOT considers when selecting locations to implement permanent installations of remotely operated gates creating the starting point of a closure. While MnDOT will not always be able to select the starting point of a closure to be at locations with services, it is a desirable feature. (Related to Needs: 4)

A 9. MnDOT, in coordination with State Patrol/local law enforcement, will determine specific roles and responsibilities for operating components of the road closure system during closures and providing traffic control (e.g. activating signs, opening and closing gates, staffing gates, etc.) Responsibilities for operating the system may be assigned to MnDOT District personnel “operators” and/or State Patrol personnel “operators.” (Related to Needs: 30)
MnDOT may choose to deploy optional surveillance cameras in strategic locations along the access controlled highway, in order to view weather and road conditions. The decision to deploy surveillance cameras will be a site-specific design decision. *(Related to Needs: 17)*

MnDOT may choose to deploy optional surveillance cameras near gates and signs, in order to view these devices to verify that they are operating properly (e.g. that posted messages are correct, that gates have opened or closed properly, etc.) The decision to deploy surveillance cameras will be a site-specific design decision. *(Related to Needs: 18, 20)*

MnDOT District personnel will primarily utilize on-road observations to determine whether an access controlled section of highway should be closed. MnDOT District personnel may also use surveillance cameras (if deployed) to remotely view and verify weather and driving conditions in order to assist in the decision. *(Related to Needs: 17)*

MnDOT District personnel, in coordination with State Patrol/local law enforcement, will make the determination to close a section of an access controlled highway in one direction, from one exit ramp to a downstream entrance ramp that is beyond the area impacted by the conditions. The mainline near the exit ramp where the closure begins and all entrance ramps within the planned closure area will be equipped with gates to prevent vehicle access and inform drivers of state laws regarding closures. Gates will be accompanied by a sign with beacons, indicating “Road Closed When Flashing” and a message communicating state laws regarding closures. This sign/beacon(s) combination will either be mounted to the gate arm or will be a stand-alone static sign with beacons located near the gate. *(Related to Needs: 5, 7, 11)*

To begin the closure, the ramp gate located at the entrance ramp at the interchange at the start point of the closure will be closed, in order to prevent vehicles from entering the mainline section soon to be closed. At the time of the gate closure, the sign/beacons at the gate will also be activated. Operators located in the District office will use the MnDOT IRIS system to close the ramp gate and activate the sign/beacons at the gate. NOTE: If remote operational capability is not deployed for the gate or the sign (or both), on-site personnel will activate these devices.

- If possible, MnDOT personnel and/or State Patrol/local law enforcement personnel will be on-scene at the entrance ramp gate located at the start point of the closure when the gate is closed. State Patrol/local law enforcement personnel will remain on-scene at this entrance ramp gate for approximately 1-3 hours after the gate is closed, as staffing allows.
- Radio communications with MnDOT or State Patrol/local law enforcement personnel on-site and surveillance cameras (if deployed) will be used to determine if an appropriate gap exists to close the gate located on the entrance ramp.
- The surveillance cameras (if deployed) at the entrance ramp being closed will be viewed to determine if the ramp gate is closed appropriately and that the sign-beacons at the gate have been activated properly.

*(Related to Needs: 11, 12, 15, 17, 18, 39)*
A 15. At the time the mainline is to be closed, operators located in the District office, will use radio communications with on-site personnel, to determine the appropriate time to lower the mainline gate (e.g. to determine if there is a large enough gap in oncoming traffic to close the mainline gate prior to vehicles arriving at the closure point). Operators located in the District office will also use the MnDOT IRIS system to view images from surveillance cameras (if deployed), to assess if the timing is appropriate to close the mainline gate. *(Related to Needs: 12, 17, 39)*

A 16. Operators located in the District office will follow a two-step process using the MnDOT IRIS system to activate advanced mainline signage and the mainline gate, following all procedures and protocols included in the IRIS software. First, IRIS will be used to activate changeable message signs located upstream of the planned closure, to display the message “Road Closed Exit Now.” Immediately following activation of the changeable message signs, the IRIS system will be used to activate the gate closure and to activate the sign/beacons at the gate. NOTE: If remote operational capability is not deployed for the gate or the sign (or both), on-site personnel will activate these devices.

*Alternate Concept A16. (Replaces changeable message signs with static signs and beacons): Operators located in the District office will follow a two-step process using the MnDOT IRIS system to activate advanced signage and the mainline gate, following all procedures and protocols included in the IRIS software. First, IRIS will be used to activate two sets of static signs with beacons, located upstream of the planned closure. The first set of static signs will display the message “Road Closed When Flashing.” The second set of static signs will display the message “Exit Now When Flashing.” Immediately following activation of the static signs with beacons, the IRIS system will be used to activate the mainline gate closure and to activate the sign/beacons at the gate. NOTE: If remote operational capability is not deployed for the gate or the sign (or both), on-site personnel will activate these devices.* *(Related to Needs: 10, 11, 12, 13, 39)*

A 17. After the mainline gate is closed, operators will view the surveillance cameras (if deployed) to verify that the mainline gate is closed properly and the sign/beacons at the gate have been activated properly. *(Related to Needs: 18)*

A 18. Operators will view the surveillance cameras (if deployed) to verify that the mainline changeable message signs are displaying the “Road Closed Exit Now” message.

*Alternate Concept A18. (Replaces changeable message signs with static signs and beacons): Operators will view the surveillance cameras (if deployed) to verify that the beacons on the two sets of mainline static signs are activated properly.* *(Related to Needs: 20, 39)*

A 19. After closing the ramp gate and the mainline gate at the interchange where the closure begins, operators will use the MnDOT IRIS system to close the remaining ramp gates and activate the sign/beacons at the gates, located at each entrance ramp along the closed highway section.
NOTE: If remote operational capability is not deployed for the gates or the signs (or both), on-site personnel will activate these devices.

- Radio communications with MnDOT or State Patrol/local law enforcement personnel on-site and surveillance cameras (if deployed) will be used to determine if an appropriate gap exists to close each gate located on the entrance ramps.
- If possible, MnDOT and/or State Patrol/local law enforcement will be on-scene each time a ramp gate is closed. State Patrol/local law enforcement personnel will remain on-scene at the entrance ramp gates within the closure section for approximately 1-3 hours after the gate is closed, as staffing allows.
- The surveillance cameras (if deployed) at each entrance ramp being closed will be viewed to determine if the ramp gate is closed properly and that the sign/beacons at the gates have been activated properly.

(Related to Needs: 11, 15, 17, 18, 39)

A 20. After the mainline gate is closed and all entrance ramp gates are closed, MnDOT District personnel and/or State Patrol/local law enforcement personnel will drive the closed portion of the mainline (access controlled highway), looking for any vehicles that remain in the closed section of highway. (Related to Needs: 16, 38)

A 21. MnDOT District personnel and State Patrol/local law enforcement personnel will repeat the process of closing gates and activating message displays for the reverse direction of travel, if necessary. (Related to Needs: 7, 10, 11, 12, 13, 15, 16, 17, 18, 20, 38, 39)

A 22. MnDOT District personnel or State Patrol District personnel that are designated CARS 511 users will enter and update road closure information in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). (Related to Needs: 28, 40)

A 23. After conditions within the barricaded (gate-closed) highway section have been restored to an acceptable state (e.g. road damage has been repaired, snow has been cleared, visibility has improved, etc.), MnDOT District personnel or State Patrol/local law enforcement personnel will drive the closed highway section looking for stranded vehicles and verifying that road conditions are acceptable to re-open to traffic. Operators will use surveillance cameras (if deployed) to remotely view and verify weather and driving conditions, to assist with the decision to re-open the highway section. (Related to Needs: 16, 17, 38)

A 24. MnDOT District personnel, in coordination with State Patrol/local law enforcement, will make the determination to re-open the closed section of an access controlled highway, in one direction. MnDOT District personnel and/or State Patrol/local law enforcement personnel will be on-site at the mainline gate, if possible, during the re-opening process. (Related to Needs: 15, 17, 38)

A 25. Operators located in the District office will use the MnDOT IRIS system to open the mainline gate and de-activate the mainline signs. NOTE: If remote operational capability is not deployed
for the gate or the sign (or both), on-site personnel will open the gate and de-activate the signs. The following steps will be carried out:

- Operators will use the MnDOT IRIS system to open the mainline gate and de-activate the sign/beacons at the gate. NOTE: If remote operational capability is not deployed for the gate or the sign (or both), on-site personnel will open the gate and de-activate the sign.

- The surveillance cameras (if deployed) will be viewed to determine if the mainline gate has opened properly and that the sign/beacons at the gate have been de-activated properly.

- Operators will use the MnDOT IRIS system to remove the “Road Closed Exit Now” message from the mainline changeable message signs located upstream of the exit ramp and the gate that has just been opened. NOTE: If remote operational capability is not deployed for the changeable message sign, on-site personnel will remove the message from the signs.

- The surveillance cameras (if deployed) will be viewed to determine if the “Road Close Exit Now” message has been removed from the mainline changeable message sign.

Alternate Concept A25. (Replaces changeable message signs with static signs and beacons): Operators located in the District office will use the MnDOT IRIS system to open the mainline gate and de-activate the mainline signage. NOTE: If remote operational capability is not deployed for the gate or the sign (or both), on-site personnel will open the gate and de-activate the signs. The following steps will be carried out:

- Operators will use the MnDOT IRIS system to open the mainline gate and de-activate the sign/beacons at the gate. NOTE: If remote operational capability is not deployed for the gate or the sign (or both), on-site personnel will open the gate and de-activate the sign.

- The surveillance cameras (if deployed) will be viewed to determine if the mainline gate has opened properly and that the sign/beacons at the gate have been de-activated properly.

- Operators will use the MnDOT IRIS system to de-activate the beacons on the two sets of mainline statics signs with beacons located upstream of the exit ramp and the gate that has just been opened properly. NOTE: If remote operational capability is not deployed for the static sign with beacons, on-site personnel will de-activate the sign.

- The surveillance cameras (if deployed) will be viewed to determine if the beacons on the two sets of mainline static signs have been removed de-activated properly.

(Related to Needs: 12, 13, 18, 20, 39)

A 26. After the mainline gate has been opened and mainline signs have been de-activated, operators will use the MnDOT IRIS system to open the ramp gates and de-activate signs/beacons located at each entrance ramp along the previously closed highway section. Entrance ramp gates will be opened in a cascade fashion, starting with the entrance ramp located at the most downstream point of the closure, working upstream to open each ramp gate within the closure section, up to
and including the ramp gate at the interchange where the closure began, until all ramp gates have been opened. Surveillance cameras (if deployed) will be viewed to determine if the gates have been opened properly and that the signs/beacons at the gates have been de-activated properly. NOTE: If remote operational capability is not deployed for the gate or the signs (or both), on-site personnel will open the gates and de-activate the signs. *(Related to Needs: 12, 18, 39)*

A 27. MnDOT District personnel and State Patrol/local law enforcement personnel will repeat the process of opening gates and de-activating message displays for the reverse direction of travel, if necessary. *(Related to Needs: 12, 13, 15, 17, 18, 20, 38, 39)*

A 28. MnDOT District personnel or State Patrol District personnel that are designated CARS 511 users will remove road closure information from the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). *(Related to Needs: 28, 40)*

A 29. On-site personnel will have the ability to lower or raise the mainline gate and entrance ramp gates on-site, without the need for any personnel in the District office to use the MnDOT IRIS system, in the event that that actions need to be over-ridden on-site, if remote communications or power are not operational, or if remotely operated functionality is not deployed. This will include provisions to prevent unauthorized individuals from being able to lower or raise gates. *(Related to Needs: 22, 39)*

A 30. On-site personnel will have the ability to control signs on-site, without the need for any personnel in the District office to use the MnDOT IRIS system, in the event that that actions need to be over-ridden on-site, if remote communications or power are not operational, or if remotely operated functionality is not deployed. This will include provisions to prevent unauthorized individuals from being able to activate the signs. *(Related to Needs: 22, 39)*

A 31. Mainline gates and ramp gates will operate according to federal and state design and safety standards, including provisions to prevent unauthorized individuals from being able to lower or raise gates. *(Related to Needs: 19, 22)*

A 32. The MnDOT IRIS system will maintain a log of system events, including timestamp and the content of messages posted, when:

- A gate arm is closed
- A gate arm is opened
- Signs/beacons at gates are activated and de-activated
- Mainline changeable message signs are activated and de-activated
- Mainline static signs with beacons signs are activated and de-activated

*(Related to Needs: 29)*

A 33. The MnDOT IRIS system will display alerts to the user for system-detectable errors encountered with gates, surveillance cameras (if deployed), and signs when these devices do not operate properly per a user command. *(Related to Needs: 26)*
A 34. Operators will access the MnDOT IRIS system with a user name and password. Multiple user levels and associated privileges will be available to grant or restrict access and operational control. *(Related to Needs: 14, 39)*

A 35. MnDOT will assign roles and responsibilities for maintenance of system components to personnel within various MnDOT units such as District Maintenance, other District functions, Electrical Services, or other MnDOT units as applicable. *(Related to Needs: 31)*

A 36. Operators will be able to view information about malfunctions occurring with gates, changeable messages signs, and static signs with beacons, as detected by IRIS (including communications outages). *(Related to Needs: 26)*

A 37. To the extent possible, specific sign placement and design will consider factors that avoid snow and ice build-up, so that MnDOT will not be required to remove snow and ice from signs. *(Related to Needs: 24)*

A 38. Gates, signs, and surveillance camera supports (if deployed) located within the roadway clear zone will be crashworthy. *(Related to Needs: 37)*

A 39. MnDOT will use the system to retrieve data logs about closures in order to assess performance and to assist with diagnostics testing. *(Related to Needs: 29)*

A 40. MnDOT will attempt to deploy consistent components (e.g. changeable message signs or static signs with beacons, gates, and cameras if included in the design) to achieve standardized systems across deployments in outstate districts, whenever practical. *(Related to Needs: 32)*

A 41. MnDOT will have written documentation and training for installation, operations, and maintenance of the system and its components. *(Related to Needs: 33)*

A 42. Each MnDOT District will be responsible for repair and maintenance of their respective systems, using a documented maintenance prioritization process for planning for repair or replacement of system components, in context with other maintenance priorities within the District. *(Related to Needs: 34)*

A 43. MnDOT will maintain system components within the public right of way with minimal impact on traffic, to the extent possible, and in a safe manner for those conducting maintenance. *(Related to Needs: 35)*

A 44. MnDOT will manage costs through scalability of the systems, such as case-by-case decisions about deploying optional features such as remote operational capability or the addition of surveillance cameras, as determined during design. *(Related to Needs: 36)*

A 45. At selected locations, MnDOT may operate an automated or semi-automated (i.e. involving human interaction) mechanism for detecting vehicles that violate Minnesota state law by driving past closed gates. This could include license plate recognition/video analytics, photo capture, personnel observing surveillance cameras (if deployed), or automated recording of surveillance cameras (if deployed). *(Related to Needs: 41)*
Minnesota State Patrol Perspective:

A 46. Minnesota State Patrol may communicate road condition information (as observed or as received from local law enforcement) to MnDOT District personnel, as appropriate, in order to enhance coordination when adverse road conditions occur. (Related to Needs: 17)

A 47. Minnesota State Patrol will be notified, by MnDOT District personnel, of deteriorating road conditions and the possibility of an upcoming closure of an access controlled highway. MnDOT Districts will coordinate with Minnesota State Patrol when deciding to close or re-open a section of highway. (Related to Needs: 38)

A 48. In some MnDOT Districts, State Patrol District personnel “operators” will use the IRIS system to operate system components for road closures. (Related to Needs: 39)

A 49. In some MnDOT Districts, State Patrol personnel who are designated CARS 511 users will enter, update, and remove road closure information in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). (Related to Needs: 40)

A 50. Minnesota State Patrol will be on-site at all entrance ramp gates prior to road closures, if possible, and will staff these entrance ramp gates for approximately the first 1-3 hours of a closure, as staffing allows. (Related to Needs: 15, 38)

A 51. At locations with applicable systems, Minnesota State Patrol will have the ability to obtain data (e.g. time-stamped photos, video recordings, etc.) from MnDOT that visually documents vehicles that have violated Minnesota state law by driving past closed gates during road closures. (Related to Needs: 41)

Local Law Enforcement Perspective:

A 52. Local law enforcement personnel may communicate observed road conditions to Minnesota State Patrol, as appropriate, based on established practices within each District. (Related to Needs: 17)

A 53. In instances when local law enforcement personnel are needed to assist with traffic control during a closure, local law enforcement will be notified (typically by Minnesota State Patrol personnel) of deteriorating road conditions and the possibility of an upcoming closure. In these instances, local law enforcement personnel may assist MnDOT or State Patrol by staffing gates for approximately the first 1-3 hours of a closure as staffing allows, by driving closed sections of highway to look for stranded vehicles, or by assisting with other traffic control operations as needed. (Related to Needs: 11, 42)

A 54. At locations with applicable systems, local law enforcement will have the ability to obtain data (e.g. time-stamped photos, video recordings, etc.) from MnDOT that visually documents vehicles that have violated Minnesota state law by driving past closed gates during road closures. (Related to Needs: 43)
6.2 System B: Road Closure System (with Gates) on Non-Access Controlled Highways

Driver Perspective:

B 1. Drivers will see information describing current road closures, such as start and end locations, when they view MnDOT’s traveler information tools (e.g. 511 phone service, 511 website, 511 Smartphone mobile app, Twitter feed), prior to their trip or en-route. (Related to Needs: 9)

B 2. Drivers on the mainline approaching a road closure will typically see a closed gate located immediately after an intersection with a cross-road, with signage that communicates the road closure and state law related to implications that may result if drivers proceed past closed gate arms. This will enable the driver to see that the road is closed and have time to divert onto the cross road. (Related to Needs: 2, 7, 44)

B 3. Drivers on the mainline approaching the closure will see advanced signage communicating the closure, prior to the intersection that is just upstream of the barricaded (gate-closed) highway section. In some locations, it will be desirable for mainline drivers to also see messages that communicate the extent of closures, such as start and end points. (Related to Needs: 2, 3, 44)

B 4. Drivers on the mainline approaching the closure will see a closed gate across the mainline, with signage that communicates that the road is closed and state law related to implications that may result if drivers proceed past closed gate arms. (Related to Needs: 2, 7, 44)

B 5. Drivers who are on the portion of the mainline that is closed (e.g. they entered from a driveway, intersecting road, or were on the road before the gates closed) will be able to drive around gate arm to exit the closed portion of the roadway because the gate arm will not extend across the entire lane of travel for vehicles exiting the closure area. (Related to Need 16, 38)

B 6. Drivers on cross-roads approaching the intersection just upstream of the mainline closure will typically see the closed mainline gate with road closed signage, while stopped at the intersection (gate is located just downstream of the intersection.) Using this information, drivers will be advised of the closure and not turn onto the mainline road that is closed. (Related to Needs: 6, 44)

B 7. In selected locations, drivers on cross-roads approaching a closed section of mainline may see signage facing them which communicates that the road they are about to cross (mainline closure described in this scenario) is closed. (Related to Needs 6, 44)

MnDOT Perspective:

B 8. MnDOT will consider deploying road closure systems with gates at non-access controlled highway locations with a history of frequent hazardous weather events based on experiences and judgment of District personnel. (Related to Needs: 10, 11)
B 9. MnDOT will select locations to place road closure signs (changeable message signs or static signs with beacons) to be activated when needed, with the goal of informing as many drivers as possible at locations where they have options to divert, while minimizing the sign infrastructure to be maintained. The quantity, location, and type of sign(s) will be a site specific design decision, based upon the roadway geometry and other site characteristics.

- Signs located upstream of mainline gates will be deployed, to advise drivers of the closure ahead.

- Additional optional mainline sign(s) (if deployed) will typically be located immediately downstream of an intersection, allowing drivers on the mainline the option to divert onto the intersecting road. This will also enable drivers approaching the highway to be closed from the intersecting cross-road to see that the signs are activated before turning onto the closed highway.

- Additional optional cross-road sign(s) (if deployed) will be located facing drivers when they are stopped at an intersection with the section of mainline highway that is closed. *(Related to Needs: 10)*

B 10. MnDOT, in coordination with State Patrol/local law enforcement, will determine specific roles and responsibilities for operating components of the road closure system during closures and providing traffic control (e.g. activating signs, opening and closing gates, staffing gates, etc.) Responsibilities for operating the system may be assigned to MnDOT District personnel “operators” and/or State Patrol/local law enforcement personnel “operators.” *(Related to Needs: 30)*

B 11. MnDOT may choose to deploy optional surveillance cameras in strategic locations along the non-access controlled highway, in order to view weather and road conditions. The decision to deploy surveillance cameras will be a site-specific design decision. *(Related to Needs: 17)*

B 12. MnDOT may choose to deploy optional surveillance cameras near gates and signs, in order to view these devices to verify that they are operating properly (e.g. that posted messages are correct, that gates have opened or closed properly, etc.) The decision to deploy surveillance cameras will be a site-specific design decision. *(Related to Needs: 18, 20)*

B 13. MnDOT District personnel will primarily utilize on-road observations to determine whether an access controlled section of highway should be closed. MnDOT District personnel may also use surveillance cameras (if deployed) to remotely view and verify weather and driving conditions in order to assist with the decision. *(Related to Needs: 17)*

B 14. MnDOT District personnel, in coordination with State Patrol/local law enforcement, will make the determination to close a section of a non-access controlled highway, typically in both directions, from one cross-road intersection to a downstream cross-road intersection that is beyond the area impacted by the conditions. The mainline near the intersection where the closure begins (in each direction) will be equipped with a gate to prevent vehicle access. Gates may be accompanied by a sign with beacons, indicating “Road Closed When Flashing” and a
message communicating state laws regarding closures. If utilized, this sign/beacon(s) combination will either be mounted to the gate arm or will be a stand-alone static sign with beacons located near the gate. *(Related to Needs: 6, 7, 11)*

**B 15.** Starting with one direction of travel, MnDOT and/or State Patrol/local law enforcement personnel will be on-site at the mainline gate where the highway closure begins. If possible, State Patrol/local law enforcement personnel will remain on the scene at the mainline gate for approximately 1-3 hours after the road is closed, as staffing allows. *(Related to Needs: 15)*

**B 16.** At the time it is determined the road is to be closed, operators located in the District office will use radio communications with MnDOT and/or State Patrol/local law enforcement personnel on-site to determine the appropriate time to lower the mainline gate (e.g. to determine if there is a large enough gap in oncoming traffic to close the mainline gate prior to vehicles arriving at the closure point). Operators located in the District office may also use the MnDOT IRIS system to view images from surveillance cameras (if deployed), to assess if the timing is appropriate to close the mainline gate. *(Related to Needs: 12, 17, 38, 39)*

**B 17.** At the time the mainline is to be closed, operators located in the District office will use the MnDOT IRIS system to activate mainline sign(s) and close the mainline gate, following all procedures and protocols included in the IRIS software. NOTE: If remote operational capability is not deployed for the gate or the signs (or both), on-site personnel will activate these devices.

- First, the IRIS system will be used to activate changeable message sign(s) located upstream of the planned closure, to display the message “Road Closed ___ to ___”, identifying the start and end locations of the closure. NOTE: If remote operational capability is not deployed for the changeable message signs, on-site personnel will post the message to the signs.

- Immediately following activation of the sign(s), operators will use the IRIS system to activate the mainline gate closure and to activate the sign/beacons at the gate, if present, at both ends of the closure. NOTE: If remote operational capability is not deployed for the gate or the sign (or both), on-site personnel will activate these devices.

*Alternate Concept B17. (Replaces changeable message sign(s) with static signs and beacons):*

At the time the mainline is to be closed, operators located in the District office will use the MnDOT IRIS system to activate mainline sign(s) and close the mainline gate, following all procedures and protocols included in the IRIS software. NOTE: If remote operational capability is not deployed for the gate or the signs (or both), on-site personnel will activate these devices.

- First, the IRIS system will be used to activate the static sign(s) with beacons located upstream of the planned closure, to display the message “Road Closed When Flashing.” NOTE: If remote operational capability is not deployed for the static sign with beacons, on-site personnel will activate the sign.

- Immediately following activation of the sign(s), operators will use the IRIS system to activate the mainline gate closure and to activate the sign/beacons at the gate, if present,
at both ends of the closure. NOTE: If remote operational capability is not deployed for the gate, on-site personnel will close the gate.

(Related to Needs: 10, 11, 12, 13, 39)

B 18. After the mainline gate is closed, operators will use the surveillance cameras (if deployed), to verify that the mainline gate is closed properly. (Related to Needs: 18, 39)

B 19. Operators will use the surveillance cameras (if deployed), to verify that the mainline changeable message sign(s) located upstream of the gate are displaying the “Road Closed ___ to ___”, message.

Alternate Concept B19. (Replaces changeable message sign(s) with static signs and beacons):
Operators will use the surveillance cameras (if deployed), to verify that the mainline static sign(s) with beacons located upstream of the gate have been activated properly.

(Related to Needs: 20, 39)

B 20. After closing the mainline gate and activating the mainline sign(s) upstream of the gate, operators will use the IRIS system to activate any additional signs located on the mainline within the closure area (if deployed.) These signs may either be changeable message signs that display the message “Hwy ___ Closed from ___ to ___” or static signs with beacons that display “Road Closed When Flashing.” NOTE: If remote operational capability is not deployed for the signs, on-site personnel will activate the signs.

- Operators will use the MnDOT IRIS system to activate the mainline signs within the closure, posting messages to changeable message signs and/or activating static signs with beacons. NOTE: If remote operational capability is not deployed for the signs, on-site personnel will activate the signs.

- The surveillance cameras (if deployed) will be viewed to the mainline signs within the closure area have been activated properly.

(Related to Needs: 10, 12, 20, 39)

B 21. After all mainline signs have been activated, operators will use the MnDOT IRIS system to activate any signs located on cross-roads that intersect the closed section of mainline highway (if deployed.) These signs may either be changeable message signs that display the message “Hwy ___ Closed from ___ to ___” or static signs with beacons that display “Hwy ___ Closed When Flashing”, providing the designation of the mainline highway, to clarify which highway is closed. NOTE: If remote operational capability is not deployed for the signs, on-site personnel will activate the signs.

- Operators will use the MnDOT IRIS system to activate the cross-road intersection signs, posting messages to changeable message signs and/or activating the static signs with beacons. NOTE: If remote operational capability is not deployed for the signs, on-site personnel will activate the signs.
– The surveillance cameras (if deployed) will be viewed to determine if the cross-road intersection signs have been activated properly.

(Related to Needs: 10, 12, 20, 39)

B 22. After the mainline gate is closed, and after all signs on the mainline and at cross-roads impacted by the mainline closure are activated, MnDOT District personnel and/or State Patrol/local law enforcement personnel will drive the closed portion of the mainline, if possible, looking for any vehicles that remain in the closed section of highway. (Related to Needs: 16, 38)

B 23. MnDOT District personnel and State Patrol/local law enforcement personnel will repeat the process of closing gates and activating message displays for the reverse direction of travel, if necessary. (Related to Needs: 7, 10, 11, 12, 13, 15, 16, 17, 18, 20, 38, 39)

B 24. MnDOT District personnel or State Patrol District personnel that are designated CARS 511 users will enter and update closure information in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). (Related to Needs: 28, 40)

B 25. After conditions within the barricaded (gate-closed) highway section, have been restored to an acceptable state (e.g. road damage has been repaired, snow has been cleared, visibility has improved, etc.), MnDOT District personnel and/or State Patrol/local law enforcement personnel will drive the closed highway section, if possible, looking for stranded vehicles and verifying that road conditions are acceptable to re-open to traffic. Operators may also use surveillance cameras (if deployed) to remotely view and verify weather and driving conditions, to assist with the decision to re-open the highway section. (Related to Needs: 16, 17, 38)

B 26. MnDOT District personnel, in coordination with State Patrol/local law enforcement, will make the determination to re-open the closed section of highway. MnDOT District personnel and/or State Patrol/local law enforcement personnel will be on-site at the mainline gate, if possible, during the re-opening process. (Related to Needs: 15, 17, 38)

B 27. Operators located in the District office will use the MnDOT IRIS system to open the mainline gate and de-activate the mainline sign(s) located upstream of the gate. NOTE: If remote operational capability is not deployed for the gate or the signs (or both), on-site personnel will open the gate and de-activate the sign(s). The following steps will be carried out:

– Operators will use the MnDOT IRIS system to open the mainline gate and de-activate the sign/beacons at the gate, if present. NOTE: If remote operational capability is not deployed for the gate or the signs (or both), on-site personnel will open the gate and de-activate the sign(s).

– The surveillance cameras (if deployed) will be viewed to determine if the mainline gate has opened properly.

– Operators will use the IRIS system to remove the “Road Closed ___ to ___” message from the changeable message sign(s) located upstream of the gate that has just been opened.
NOTE: If remote operational capability is not deployed for the changeable message sign(s), on-site personnel will remove the message from the sign(s).

- The surveillance cameras (if deployed) will be viewed to determine if the message has been removed from the mainline changeable message sign(s) located upstream of the gate.

**Alternate Concept B27. (Replaces changeable message sign(s) with static signs and beacons):**

Operators located in the District office will use the MnDOT IRIS system to open the mainline gate and de-activate the sign(s) located upstream of the gate. NOTE: If remote operational capability is not deployed for the gate or the signs (or both), on-site personnel will open the gate and de-activate the sign(s). The following steps will be carried out:

- **Operators will use the MnDOT IRIS system to open the mainline gate and de-activate the sign/beacons at the gate, if present.** NOTE: If remote operational capability is not deployed for the gate or the signs (or both), on-site personnel will open the gate and de-activate the sign(s).

- **The surveillance cameras (if deployed) will be viewed to determine if the mainline gate has opened properly.**

- **Operators will use the IRIS system to de-activate the beacons on the sign(s) located upstream of the gate that has just been opened.** NOTE: If remote operational capability is not deployed for the static sign with beacons, on-site personnel will open the gate and de-activate the sign(s).

- **The surveillance cameras (if deployed) will be viewed to verify that beacons on the sign(s) located upstream of the gate have been de-activated properly.**

**Related to Needs:  12, 13, 18, 20, 39**

**B 28.** After opening the mainline gate and de-activating the mainline sign upstream of the gate, operators will use the IRIS system to de-activate any additional signs (changeable message signs or static signs with beacons, if deployed) located on the mainline within the closure area. NOTE: If remote operational capability is not deployed for the sign(s), on-site personnel will de-activate the sign(s). The surveillance cameras (if deployed) will be viewed to determine if messages on changeable message signs are removed and/or if beacons on static signs have been de-activated properly. **(Related to Needs: 12, 20, 39)**

**B 29.** Operators will use the MnDOT IRIS system to de-activate any changeable message signs or static signs with beacons located on cross-roads that intersect the previously closed section of mainline highway (if deployed). NOTE: If remote operational capability is not deployed for the sign(s), on-site personnel will de-activate the sign(s). The surveillance cameras (if deployed) will be viewed to determine if the signs have been de-activated properly. **(Related to Needs: 12, 20, 39)**
B 30. MnDOT District personnel and State Patrol/local law enforcement personnel will repeat the process of opening gates and de-activating signs for the reverse direction of travel, if necessary. (Related to Needs: 12, 13, 15, 17, 18, 20, 38, 39)

B 31. MnDOT District personnel or State Patrol District personnel that are designated CARS 511 users will remove road closure information from the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). (Related to Needs: 28, 40)

B 32. On-site personnel will have the ability to lower or raise the mainline gate on-site, without the need for any personnel in the District office to use the IRIS system, in the event that that actions need to be over-ridden on-site, if remote communications or power are not operational, or if remotely operated functionality is not deployed. This will include provisions to prevent unauthorized individuals from being able to lower or raise gates. (Related to Needs: 22, 39)

B 33. On-site personnel will have the ability to operate changeable message signs and static signs with beacons on-site, without the need for any personnel in the District office to use the IRIS system, in the event that that actions need to be over-ridden on-site, if remote communications or power are not operational, or if remotely operated functionality is not deployed. This will include provisions to prevent unauthorized individuals from being able to activate the signs. (Related to Needs: 22, 39)

B 34. Mainline gates will operate according to federal and state design and safety standards, including provisions to prevent unauthorized individuals from being able to lower or raise gates. (Related to Needs: 19)

B 35. The MnDOT IRIS system will maintain a log of system events, including timestamp and the content of messages posted, when:
   - A gate arm is closed
   - A gate arm is opened
   - Changeable message signs are activated
   - Static signs with beacons signs are activated

(Related to Needs: 29)

B 36. The MnDOT IRIS system will display alerts to the user for system-detectable errors encountered with gates, changeable message signs, and static signs with beacons when these devices do not operate properly per a user command. (Related to Needs: 26)

B 37. Operators will access the MnDOT IRIS system with a user name and password. Multiple user levels and associated privileges will be available to grant or restrict access and operational control. (Related to Needs: 14, 39)

B 38. MnDOT will assign roles and responsibilities for maintenance of system components to personnel within various MnDOT units such as District Maintenance, other District functions, Electrical Services, or other MnDOT units as applicable. (Related to Needs: 30, 31)
B 39. Operators will be able to view information about malfunctions occurring with gates, changeable messages signs, and static signs with beacons, as detected by IRIS (including communications outages.) (Related to Needs: 26)

B 40. To the extent possible, specific sign placement and design will consider factors that avoid snow and ice build-up, so that MnDOT will not be required to remove snow and ice from signs. (Related to Needs: 24)

B 41. Gates, signs, and surveillance camera supports (if deployed) located within the roadway clear zone will be crashworthy. (Related to Needs: 37)

B 42. MnDOT will use the system to retrieve data logs about closures, in order to assess performance and to assist with diagnostics testing. (Related to Needs: 29)

B 43. MnDOT will attempt to deploy consistent components (e.g. changeable message signs or static signs with beacons, gates, and cameras if included in the design) to achieve standardized systems across deployments in outstate districts, whenever practical. (Related to Needs: 32)

B 44. MnDOT will have written documentation and training for installation, operations, and maintenance of the system and its components. (Related to Needs: 33)

B 45. Each MnDOT District will be responsible for repair and maintenance of their respective systems, using a documented maintenance prioritization process for planning for repair or replacement of system components, in context with other maintenance priorities within the District. (Related to Needs: 34)

B 46. MnDOT will maintain system components within the public right of way with minimal impact on traffic, to the extent possible, and in a safe manner for those conducting maintenance. (Related to Needs: 35)

B 47. MnDOT will manage costs through scalability of the systems, such as case-by-case decisions about deploying optional features like remote operational capability or surveillance cameras, as determined during design. (Related to Needs: 36)

B 48. At selected locations, MnDOT may operate an automated or semi-automated (i.e. involving human interaction) mechanism for detecting vehicles that violate Minnesota state law by driving past closed gates. This could include license plate recognition/video analytics, photo capture, personnel observing surveillance cameras (if deployed), or automated recording of surveillance cameras (if deployed). (Related to Needs: 41)

Minnesota State Patrol Perspective:

B 49. Minnesota State Patrol may communicate road condition information (as observed or as received from local law enforcement) to MnDOT District personnel, as appropriate, in order to enhance coordination when adverse road conditions occur. (Related to Needs: 17)

B 50. Minnesota State Patrol will be notified, by MnDOT District personnel, of deteriorating road conditions and the possibility of an upcoming closure of a non-access controlled state
maintained highway. MnDOT Districts will coordinate with Minnesota State Patrol when deciding to close (and re-open) a section of highway. *(Related to Needs: 38)*

**B 51.** In some MnDOT Districts, State Patrol District personnel “operators” will use the IRIS system to operate system components for road closures. *(Related to Needs: 39)*

**B 52.** In some MnDOT Districts, State Patrol District personnel that are designated CARS 511 users will enter, update, and remove road closure information in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). *(Related to Needs: 40)*

**B 53.** If possible, Minnesota State Patrol will be on-site at mainline gates prior to road closures, and will staff gates for approximately the first 1-3 hours of a closure, as staffing allows. *(Related to Needs: 15, 38)*

**B 54.** At locations with applicable systems, Minnesota State Patrol will have the ability to obtain data (e.g. time-stamped photos, video recordings, etc.) from MnDOT that visually documents vehicles that have violated Minnesota state law by driving past closed gates during road closures. *(Related to Needs: 41)*

**Local Law Enforcement Perspective:**

**B 55.** Local law enforcement personnel may communicate observed road conditions to Minnesota State Patrol, as appropriate, based on established practices within each District. *(Related to Needs: 17)*

**B 56.** In instances when local law enforcement personnel are needed to assist with traffic control during a road closure, local law enforcement will be notified (typically by Minnesota State Patrol personnel) of deteriorating road conditions and the possibility of an upcoming closure. In these instances, local law enforcement personnel may assist MnDOT or State Patrol by staffing gates for approximately the first 1-3 hours of a closure as staffing allows, by driving closed sections of highway to look for stranded vehicles, or by assisting with other traffic control operations as needed. *(Related to Needs: 11, 42)*

**B 57.** At locations with applicable systems, local law enforcement will have the ability to obtain data (e.g. time-stamped photos, video recordings, etc.) from MnDOT that visually documents vehicles that have violated Minnesota state law by driving past closed gates during road closures. *(Related to Needs: 43)*
6.3 System C: Road Closure System (No Gates) on Non-Access Controlled Highways

**Driver Perspective:**

C 1. Drivers will see information describing current road closures, such as start and end locations, when they view MnDOT’s traveler information tools (e.g. 511 phone service, 511 website, 511 Smartphone mobile app, Twitter feed), prior to their trip or en-route. *(Related to Needs: 9)*

C 2. Drivers on the mainline approaching a road closure will typically see a road closed sign located immediately after an intersection with a cross-road. This will enable the driver to see that the road is closed and have time to divert onto the cross road. In some locations, it will be desirable for mainline drivers to see messages that communicate the extent of closures, such as start and end points. *(Related to Needs: 2, 3, 44)*

C 3. Drivers on cross-roads approaching the intersection just upstream of the mainline closure will typically see the mainline signage while stopped at the intersection (sign is located just downstream of the intersection.) Using this information, drivers will be advised of the closure and not turn onto the mainline road that is closed. *(Related to Needs: 6, 44)*

C 4. In selected locations, drivers on cross-roads approaching a closed section of mainline may see signage facing them which communicates that the road they are about to cross (mainline closure described in this scenario) is closed. *(Related to Needs 6, 44)*

**MnDOT Perspective:**

C 5. MnDOT will consider deploying road closure systems (without gates) at non-access controlled highway locations with a history of frequent hazardous weather events based on experiences and judgment of District personnel. *(Related to Need: 10)*

C 6. MnDOT will select locations to place road closure signs to be activated when needed, with the goal of informing as many drivers as possible at locations where they have options to divert, while minimizing the sign infrastructure to be maintained. Typically, the location of the sign(s) will be immediately after an intersection, allowing drivers on the mainline the option to divert onto the intersecting road. This will also enable drivers approaching the road to be closed from the intersecting cross-road to see that the signs are activated before turning onto the closed road. The quantity, location, and type of sign(s) will be a site specific design decision, based upon the roadway geometry and other site characteristics. *(Related to Needs: 10)*

C 7. MnDOT, in coordination with State Patrol/local law enforcement, will determine specific roles and responsibilities for operating components of the road closure system during closures (e.g. activating signs) and providing traffic control as needed. Responsibilities for operating the system may be assigned to MnDOT District personnel “operators” and/or State Patrol/local law enforcement personnel “operators.” *(Related to Needs: 30)*

C 8. MnDOT may choose to deploy optional surveillance cameras in strategic locations along the non-access controlled highway, in order to view weather and road conditions. The decision to deploy surveillance cameras will be a site-specific design decision. *(Related to Needs: 17)*
C 9. MnDOT may choose to deploy optional surveillance cameras near signs, in order to verify that they are operating properly (e.g. that posted messages are correct or that beacons on static signs have been activated or de-activated properly.) The decision to deploy surveillance cameras will be a site-specific design decision. (Related to Needs: 20)

C 10. MnDOT District personnel will primarily utilize on-road observations to determine whether an access controlled section of highway should be closed. MnDOT District personnel may also use surveillance cameras (if deployed) to remotely view and verify weather and driving conditions in order to assist with the decision. (Related to Needs: 17)

C 11. MnDOT District personnel, in coordination with State Patrol/local law enforcement, will make the determination to close a stretch of a non-access controlled highway in both directions, from one cross-road intersection to a downstream cross-road intersection that is beyond the area impacted by the conditions. At the time the road is to be closed, operators located in the District office will use the MnDOT IRIS system (following all procedures and protocols in the IRIS software) to activate the mainline changeable message sign(s) located just upstream of the cross-road intersection and highway section to be closed. The quantity, location, and type of changeable message sign(s) will be a site-by-site design decision, based upon the roadway geometry and other site characteristics. The mainline changeable message sign(s) will indicate “Road Closed _____ to ____”, identifying the start and end points of the closure. NOTE: If remote operational capability is not deployed for the sign(s), on-site personnel will activate the sign(s).

Alternate Concept C11. (Replaces changeable message sign(s) with static signs and beacons): MnDOT District personnel, in coordination with State Patrol/local law enforcement, will make the determination to close a stretch of a non-access controlled highway in both directions, from one cross-road intersection to a downstream cross-road intersection that is beyond the area impacted by the conditions. At the time the road is to be closed, operators located in the District office will use the MnDOT IRIS system (following all procedures and protocols in the IRIS software) to activate the mainline static sign(s) with beacons located just upstream of the cross-road intersection and highway section to be closed. The quantity, location, and type of changeable message sign(s) will be a site-by-site design decision, based upon the roadway geometry and other site characteristics. The mainline static signs with beacons(s) will indicate “Road Closed When Flashing.” NOTE: If remote operational capability is not deployed for the sign(s), on-site personnel will activate the sign(s).

(Related to Needs: 10, 12, 39)

C 12. Operators will use the surveillance cameras (if deployed) to verify that the mainline changeable message sign(s) located upstream of the cross-road intersection and closed highway section are displaying the “Road Closed ___ to ___” message properly.

Alternate Concept C12. (Replaces changeable message sign(s) with static signs and beacons): Operators will use the surveillance cameras (if deployed) to verify that the mainline static sign(s) with beacons located upstream of the cross-road intersection and closed highway section have been activated properly.
C 13. Depending upon the traffic volumes of cross-roads that intersect the mainline in the closure area, MnDOT may decide to deploy optional intersection signs to advise drivers about the road closure. These optional cross-road signs would include two signs (one in each direction) located facing the cross-road drivers as they approach the mainline intersection. These signs may either be changeable message signs that display the message “Hwy ___ Closed from ___ to ___” or static signs with beacons that display “Hwy ___ Closed When Flashing”, providing the designation of the mainline highway, to clarify which highway is closed.

- Operators will use the MnDOT IRIS system to activate the cross-road intersection signs, posting messages to changeable message signs or activating the static signs with beacons. NOTE: If remote operational capability is not deployed for the sign(s), on-site personnel will activate the sign(s).

- Operators will use surveillance cameras (if deployed) to view the cross-road intersection signs to verify that been activated properly.

(Related to Needs: 10, 12, 20, 39)

C 14. Depending on the distance between mainline signs, proximity of signs to cross-roads and other geometric characteristics, MnDOT may decide to deploy additional optional mainline signs within the closure area, to communicate road closure information. This may consist of mainline changeable message signs that display the message “Road Closed ___ to ___” or mainline static signs with beacons that indicate “Road Closed When Flashing.”

- Operators will use the MnDOT IRIS system to activate these mainline signs within the closed road section. NOTE: If remote operational capability is not deployed for the sign(s), on-site personnel will activate the sign(s).

- Operators will use surveillance cameras (if deployed) to view these mainline signs, to verify that they have been activated properly.

(Related to Needs: 10, 12, 20, 39)

C 15. After all signs are activated, MnDOT District personnel or State Patrol/local law enforcement personnel will drive the closed portion of the mainline, if possible, looking for any vehicles that remain in the closed section of highway. (Related to Needs: 16, 38)

C 16. MnDOT District personnel or State Patrol District personnel that are designated CARS 511 users will enter and update closure information in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). (Related to Needs: 28, 40)

C 17. After conditions within closed highway section have been restored to an acceptable state (e.g. road damage has been repaired, snow has been cleared, visibility has improved, etc.), MnDOT District personnel or State Patrol/local law enforcement personnel will drive the closed highway.
section looking for stranded vehicles and verifying that road conditions are acceptable to re-
open to traffic. Operators may also use surveillance cameras (if deployed) to remotely view and
verify weather and driving conditions, to assist with the decision to re-open the highway section.
(Related to Needs: 16, 17, 38)

C 18. MnDOT District personnel, in coordination with State Patrol/local law enforcement, will make
the determination to re-open the closed section of highway. (Related to Needs: 17, 38)

C 19. Operators located in the District office will use the MnDOT IRIS system to remove the “Road
Closed ___ to ___” message from all mainline changeable message signs. This includes the
mainline changeable message signs located upstream of the previously closed section and any
other mainline signs within the previously closed highway section. NOTE: If remote operational
capability is not deployed for the sign(s), on-site personnel will activate the sign(s). The
surveillance cameras (if deployed) will be viewed to determine if all messages have been
removed from the changeable message signs. NOTE: If remote operational capability is not
deployed for the sign(s), on-site personnel will de-activate the sign(s).

Add Alternate Concept C19. (Replaces changeable message sign(s) with static signs and
beacons):
Operators located in the District office will use the MnDOT IRIS system to de-activate the
beacons on all mainline static sign(s) with beacons. This includes the mainline signs located
upstream of the previously closed section and any other mainline signs within the previously
closed highway section. NOTE: If remote operational capability is not deployed for the sign(s),
on-site personnel will de-activate the sign(s). The surveillance cameras (if deployed) will be
viewed to determine if the beacons on the sign(s) have been de-activated properly.
(Related to Needs: 12, 20, 39)

C 20. After messages have been removed from the mainline signs, operators will use the MnDOT IRIS
system to de-activate any changeable message signs or static signs with beacons located at
cross-road intersections. NOTE: If remote operational capability is not deployed for the sign(s),
on-site personnel will de-activate the sign(s). The surveillance cameras (if deployed) will be
viewed to determine if the beacons on the static signs have been de-activated properly.
(Related to Needs: 12, 20, 39)

C 21. MnDOT District personnel or State Patrol District personnel that are designated CARS 511 users
will remove road closure information from the statewide Traveler Information System Condition
Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). (Related to Needs:
28, 40)

C 22. On-site personnel will have the ability to operate changeable message signs and static signs with
beacons on-site, without the need for any personnel in the District office to use the MnDOT IRIS
system, in the event that that actions need to be over-ridden on-site, if remote communications
or power are not operational, or if remotely operated functionality is not deployed. This will
include provisions to prevent unauthorized individuals from being able to activate the signs. (Related to Needs: 22, 39)
C 23. The MnDOT IRIS system will maintain a log of system events, including timestamp and the content of messages posted, when:
   - Changeable message signs are activated or de-activated
   - Static signs with beacons signs are activated or de-activated
   (Related to Needs: 29)

C 24. The MnDOT IRIS system will display alerts to the user for system-detectable errors encountered with changeable message signs and static signs with beacons, when these devices do not operate properly per a user command. (Related to Needs: 26)

C 25. Operators will access the MnDOT IRIS system with a user name and password. Multiple user levels and associated privileges will be available to grant or restrict access and operational control. (Related to Needs: 14, 39)

C 26. MnDOT will assign roles and responsibilities for maintenance of system components to personnel within various MnDOT units such as District Maintenance, other District functions, Electrical Services, and other MnDOT units as applicable. (Related to Needs: 30, 31)

C 27. Operators will be able to view information about malfunctions with changeable message signs and static signs with beacons, as detected by IRIS (including communications outages.) (Related to Needs: 26)

C 28. To the extent possible, specific sign placement and design will consider factors that avoid snow and ice build-up, so that MnDOT will not be required to remove snow and ice from signs. (Related to Needs: 24)

C 29. Signs and surveillance camera supports (if deployed), located within the roadway clear zone will be crashworthy. (Related to Needs: 37)

C 30. MnDOT will use the system to retrieve data logs about closures, in order to assess performance and to assist with diagnostics testing. (Related to Needs: 29)

C 31. MnDOT will attempt to deploy consistent components (e.g. changeable message signs or static signs with beacons, cameras if included in the design) to achieve standardized systems across deployments in outstate districts, whenever practical. (Related to Needs: 32)

C 32. MnDOT will have written documentation and training for installation, operations, and maintenance of the system and its components. (Related to Needs: 33)

C 33. Each MnDOT District will be responsible for repair and maintenance of their respective systems, using a documented maintenance prioritization process for planning for repair or replacement of system components, in context with other maintenance priorities within the District. (Related to Needs: 34)

C 34. MnDOT will maintain system components within the public right of way with minimal impact on traffic, to the extent possible, and in a safe manner for those conducting maintenance. (Related to Needs: 35)
C 35. MnDOT will manage costs through scalability of the systems, such as case-by-case decisions about deploying optional features like remote operational capability or surveillance cameras, as determined during design. *(Related to Needs: 36)*

**Minnesota State Patrol Perspective:**

C 36. Minnesota State Patrol may communicate road condition information (as observed or as received from local law enforcement) to MnDOT District personnel, as appropriate, in order to enhance coordination when adverse road conditions occur. *(Related to Needs: 17)*

C 37. Minnesota State Patrol will be notified, by MnDOT District personnel, of deteriorating road conditions and the possibility an upcoming closure of a non-access controlled highway. MnDOT Districts will coordinate with State Patrol when deciding to close or re-open a section of highway. *(Related to Needs: 38)*

C 38. In some MnDOT Districts, State Patrol District personnel “operators” will use the IRIS system to operate system components for road closures. *(Related to Needs: 39)*

C 39. In some MnDOT Districts, State Patrol personnel that are designated CARS 511 users will enter, update, and remove road closure information in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). *(Related to Needs: 40)*

**Local Law Enforcement Perspective:**

C 40. Local law enforcement personnel may communicate observed road conditions to Minnesota State Patrol, as appropriate, based on established practices within each District. *(Related to Needs: 17)*

C 41. In instances when local law enforcement personnel are needed to assist with traffic control during a road closure, local law enforcement will be notified (typically by Minnesota State Patrol personnel) of deteriorating road conditions and the possibility of an upcoming closure. In these instances, local law enforcement personnel may assist MnDOT or State Patrol by driving closed sections of highway to look for stranded vehicles or other traffic control operations as needed. *(Related to Needs: 11, 42)*
6.4 System D: Changeable Message Signs (CMS) for Advisory Messages

Driver Perspective:

D 1. Drivers will see information about current conditions that impact their travel, such as status of road closures, hazardous road conditions, and delays, when they view MnDOT’s traveler information tools (e.g. 511 phone service, 511 website, 511 Smartphone mobile app, Twitter feed), prior to their trip or en-route. *(Related to Needs: 9)*

D 2. Drivers in locations equipped with MnDOT Changeable Message Signs (CMS) for Advisory Messages that are approaching adverse driving conditions that differ from the conditions they are already observing, such as reduced visibility, hazardous road conditions, construction, congestion/delays, inclement weather, or other conditions, will see advisory messages on changeable message signs in advance of encountering the condition. Advisory messages will indicate what the upcoming condition is. Advisory messages may also include information about the extent of the condition (start/end locations), available alternate routes, or other relevant information. *(Related to Needs: 1, 8, 44)*

D 3. After reading the message on the changeable message sign, drivers may slow down and proceed with caution, or may consider altering their route if the sign is upstream of a decision point. *(Related to Needs: 8)*

MnDOT Perspective:

D 4. MnDOT will consider deploying permanent changeable message signs, in strategically chosen locations, to periodically advise drivers of adverse or changing conditions. Selected locations might include sites upstream of an “area of interest” that experiences a high frequency of adverse weather conditions or congestion, to advise drivers to slow down and use caution; other selected locations might position changeable message signs upstream of intersections that provide options for taking alternate routes. The changeable message signs will be located where appropriate based on the ITS Warrants/ITS Planning Guidance documented in the “MnDOT ITS Design Manual” and guidance provided in the “MnDOT CMS Manual of Practice”. *(Related to Needs: 10)*

D 5. MnDOT, in coordination with State Patrol, will determine specific roles and responsibilities for operating changeable message signs (e.g. posting and removing messages.) Responsibilities may be assigned to MnDOT District personnel “operators” or State Patrol personnel “operators.” *(Related to Needs: 30)*

D 6. MnDOT personnel located in the District office will typically rely on reports from maintenance personnel in the field and/or data from on-site sensors or RWIS stations, to become aware of and verify conditions such as reduced visibility, hazardous road conditions, construction, congestion/delays, inclement weather, or other adverse driving conditions. This will assist in determining if advisory messages are needed on changeable message signs and what those messages will be. *(Related to Needs: 17)
D 7. MnDOT may choose to deploy optional roadside or in-road sensors and/or RWIS stations in strategic locations within the “area of interest,” in order to monitor changing weather and road conditions. The decision to deploy sensors or RWIS stations will be a site-specific design decision. (Related to Needs: 17)

D 8. MnDOT may choose to deploy optional surveillance cameras in strategic locations within the “area of interest,” in order to view and monitor changing weather and road conditions. The decision to deploy surveillance cameras will be a site-specific design decision. (Related to Needs: 17)

D 9. MnDOT may choose to deploy optional surveillance cameras near the changeable message signs, in order to view the signs to verify that they are operating properly (e.g. that messages have been posted.) The decision to deploy surveillance cameras will be a site-specific design decision. (Related to Needs: 20)

D 10. Operators located in the District office will use the MnDOT IRIS system to activate changeable message signs located upstream of the “area of interest” where the weather-related or other type of condition exists. Operators will use the MnDOT IRIS system to enter the appropriate message for the condition, following all procedures and protocols included in the IRIS software and utilizing guidance provided in the “MnDOT CMS Manual of Practice.” NOTE: If remote operational capability is not deployed for the changeable message sign, on-site personnel will activate the signs. (Related to Needs: 10, 12, 13, 39)

D 11. Operators will use surveillance cameras (if deployed) located near the changeable message signs to verify that the changeable message signs are displaying the appropriate messages. (Related to Needs: 20, 39)

D 12. MnDOT District personnel or State Patrol District personnel that are designated CARS 511 users will enter and update advisory messages posted to changeable message signs in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). (Related to Needs: 28, 40)

D 13. After the changeable message signs have been activated, MnDOT District personnel will use reports from maintenance personnel (supplemented with remotely accessed surveillance cameras or data from on-site sensors or RWIS sites in the “area of interest,” (if deployed) to monitor weather and driving conditions and determine if the content of advisory messages should be changed or removed from changeable message signs. (Related to Needs: 13, 17)

D 14. Operators will use the MnDOT IRIS system to alter the content of messages on changeable message signs as conditions change in the “area of interest” over time. NOTE: If remote operational capability is not deployed for the changeable message signs, on-site personnel will alter content of messages on the signs. (Related to Needs: 10, 12, 13, 39)

D 15. After conditions have subsided and MnDOT District personnel have determined that the advisory messages should be removed from the changeable message signs, operators will use the MnDOT IRIS system to de- activate the changeable message signs, removing the posted
advisory messages. NOTE: If remote operational capability is not deployed for the changeable message sign, on-site personnel will remove messages from the signs. *(Related to Needs: 12, 13, 39)*

D 16. MnDOT District personnel or State Patrol District personnel that are designated CARS 511 users will remove advisory messages posted to changeable message signs in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). *(Related to Needs: 28, 40)*

D 17. Operators will access the MnDOT IRIS system with a user name and password. Multiple user levels and associated privileges will be available to grant or restrict access and operational control. *(Related to Needs: 14, 39)*

D 18. On-site personnel will have the ability to operate changeable message signs on-site, without the need for any personnel in the District office to use the MnDOT IRIS system, in the event that actions need to be over-ridden on-site, if remote communications or power are not operational, or if remotely operated functionality is not deployed. This will include provisions to prevent unauthorized individuals from being able to activate the signs. *(Related to Needs: 22, 39)*

D 19. The MnDOT IRIS system will maintain a log of system events, including timestamp and the content of messages posted, when changeable message signs are activated. *(Related to Needs: 29)*

D 20. The MnDOT IRIS system will display alerts to the user for system-detectable errors encountered with changeable message signs when they do not operate properly per a user command. *(Related to Needs: 26)*

D 21. Operators will be able to view information about malfunctions occurring with changeable messages signs, as detected by IRIS (including communications outages.) *(Related to Needs: 26)*

D 22. MnDOT will assign roles and responsibilities for maintenance of system components to personnel within various MnDOT units such as District Maintenance, other District functions, Electrical Services, or other MnDOT units as applicable. *(Related to Needs: 30, 31)*

D 23. To the extent possible, specific sign placement and design will consider factors that avoid snow and ice build-up, so that MnDOT will not be required to remove snow and ice from signs. *(Related to Needs: 24)*

D 24. Changeable message signs and surveillance camera supports (if deployed) located within the roadway clear zone will be crashworthy. *(Related to Needs: 37)*

D 25. MnDOT will use the system to retrieve data logs about activations of changeable message signs in order to assess performance and to assist with diagnostics testing. *(Related to Needs: 29)*

D 26. MnDOT will attempt to deploy consistent changeable message signs and cameras (if included in the design) to achieve standardized systems across deployments in outstate districts, whenever practical. *(Related to Needs: 32)*
D 27. MnDOT will have written documentation and training for installation, operations, and maintenance of system components. (Related to Needs: 33)

D 28. Each MnDOT District will be responsible for repair and maintenance of their respective systems, using a documented maintenance prioritization process for planning for repair or replacement of system components, in context with other maintenance priorities within the District. (Related to Needs: 34)

D 29. MnDOT will maintain system components within the public right of way with minimal impact on traffic, to the extent possible, and in a safe manner for those conducting maintenance. (Related to Needs: 35)

D 30. MnDOT will manage costs through scalability of the systems, such as case-by-case decisions about deploying optional features like remote operational capability or the addition of surveillance cameras, as determined during design. (Related to Needs: 36)

Minnesota State Patrol Perspective:

D 31. Minnesota State Patrol may communicate road condition information (as observed or as received from local law enforcement) to MnDOT District personnel, as appropriate, in order to enhance coordination when adverse road conditions occur. (Related to Needs: 17)

D 32. In some MnDOT Districts, State Patrol District personnel “operators” will use the IRIS system to enter, update, and remove messages from changeable message signs and use surveillance cameras (if deployed) to verify sign activations. (Related to Needs: 39)

D 33. In some MnDOT Districts, State Patrol District personnel that are designated CARS 511 users will enter and update advisory messages posted to changeable message signs in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). (Related to Needs: 40)

Local Law Enforcement Perspective:

D 34. Local law enforcement personnel may communicate observed road conditions to Minnesota State Patrol, as appropriate, based on established practices within each District. (Related to Needs: 17)
6.5 System E: Dynamic Advisory Signs for Recurring Hazardous Weather-Related Conditions

Driver Perspective:

E 1. When drivers view MnDOT’s traveler information tools (e.g. 511 phone service, 511 website, 511 Smartphone mobile app, Twitter feed), prior to their trip on en-route, they will see advisory messages about hazardous weather-related conditions (e.g. flooding, high winds, fog, slippery/icy roads, or reduced visibility) at locations that are currently experiencing these conditions. (Related to Needs: 9)

E 2. Drivers in locations equipped with Dynamic Advisory Signs for Recurring Hazardous Weather-related Conditions that are approaching the recurring hazardous weather-related condition will see an advisory message on advanced signage, prior to encountering the condition. (Related to Needs: 8, 44)

MnDOT Perspective:

E 3. MnDOT will consider deploying Dynamic Advisory Signs for Recurring Hazardous Weather-Related Conditions to display advisory messages in advance of areas that are prone to a high frequency of recurring hazardous weather-related conditions such as flooding, high winds, fog, slippery/icy roadways, or reduced visibility, especially in areas where there may be a lack of adequate surveillance to monitor conditions at all times. (Related to Needs: 10, 12)

E 4. MnDOT Districts will locate roadside or in-road sensors in an area prone to recurring hazardous weather-related conditions. The sensors will detect the condition and automatically activate a changeable message sign located upstream of the condition, to display an advisory message that is pre-selected based on the sensor. The advisory message on the changeable message sign will be specific to the known recurring condition, such as “Ice on Road Ahead.” The “MnDOT CMS Manual of Practice” will be utilized to provide guidance when choosing the pre-selected message to display on the changeable message sign.

Alternate Concept E4. (Replaces changeable message sign with static sign and beacons): MnDOT Districts will locate roadside or in-road sensors in an area prone to recurring hazardous weather-related conditions. The sensors will detect the condition and automatically activate a static sign with beacons located upstream of the condition, to display an advisory message. The advisory message on the static sign will be specific to the known recurring condition, such as “Ice on Road When Flashing.”

(Related to Needs: 10, 12)

E 5. MnDOT will only deploy automated systems (changeable message signs or static signs with beacons that are activated by on-site sensors) when the sensors are reliable. Individual MnDOT Districts may differ in their levels of acceptance of sensor reliability, based on the type and location of the deployment. (Related to Needs: 23)
E 6. MnDOT, in coordination with State Patrol, will determine specific roles and responsibilities for operating signs (e.g. posting and removing messages from changeable message signs, activating and de-activating static signs with beacons) in the event that signs need to be controlled manually. Responsibilities may be assigned to MnDOT District personnel “operators” or State Patrol personnel “operators.” (Related to Needs: 30)

E 7. Depending on the site and conditions being monitored, optional surveillance cameras located within the area of recurring hazardous weather-related conditions may be included in the design, to observe and monitor conditions. The decision to deploy optional surveillance cameras will be a site-specific design decision. (Related to Needs: 17)

E 8. MnDOT District personnel will be notified, both in real-time and through a system-generated log function, when the changeable message sign has been automatically activated by sensors. The notification will indicate the location of the sign and will detail what activation has occurred.

**Alternate Concept E8. (Replaces changeable message sign with static sign and beacons):**
MnDOT District personnel will be notified, both in real-time and through a system-generated log function, when the static sign with beacons has been automatically activated by sensors. The notification will indicate the location of the sign and will detail what activation has occurred. (Related to Needs: 25)

E 9. Operators will have the ability to view a surveillance camera (if deployed) located near the changeable message sign to verify that the sign has been activated properly after the on-site sensors have detected that the hazardous condition is occurring.

**Alternate Concept E9. (Replaces changeable message sign with static sign and beacons):**
Operators will have the ability to view a surveillance camera (if deployed) located near the static sign with beacons to verify that the beacons have been activated properly after the on-site sensors have detected that the hazardous condition is occurring. (Related to Needs: 21, 39)

E 10. After the sensors located in the area of the recurring hazardous weather-related condition have detected that the condition has subsided, the on-site sensors will automatically de-activate the changeable message sign located upstream of the condition, removing the advisory message from the sign.

**Alternate Concept E 10. (Replaces changeable message sign with static sign with beacons):** After the sensors located in the area of the recurring hazardous weather-related condition have detected that the condition has subside, the on-site sensors will automatically de-activate the beacons on the static sign located upstream of the condition. (Related to Needs: 10, 12)

E 11. MnDOT District personnel will be notified, both in real-time and through a system-generated log function, when the changeable message sign has been automatically de-activated by the on-site
sensors. The notification will indicate the location of the sign and will detail what activation has occurred.

Alternate Concept E11. (Replaces changeable message sign with static sign and beacons): MnDOT District personnel will be notified, both in real-time and through a system-generated log function, when the static sign with beacons has been automatically de-activated by the on-site sensors. The notification will indicate the location of the sign and will detail what activation has occurred.

(Related to Needs: 25)

E 12. Operators will have the ability to use the MnDOT IRIS system to view a surveillance camera (if deployed) located near the changeable message sign to verify that the sign has been de-activated properly.

Alternate Concept E12. (Replaces changeable message sign with static sign and beacons): Operators will have the ability to use the MnDOT IRIS system to view a surveillance camera (if deployed) located near the static sign with beacons to verify that the static sign with beacons has been de-activated properly.

(Related to Needs: 21, 39)

E 13. When activations or de-activations of changeable message signs occur, the system triggering the changeable message signs will automatically generate and make a message accessible to the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS), indicating the location of the sign and the corresponding advisory message.

Alternate Concept E13. (Replaces changeable message signs with static signs and beacons): When activations or de-activations of static signs with beacons occur, the system triggering the beacons will automatically generate and make a message accessible to the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS), indicating the location of the sign and the corresponding advisory message.

(Related to Needs: 27)

E 14. Operators in District offices or on-site personnel will have the ability to activate and de-activate static signs with beacons or post/remove messages from changeable message signs, as needed, in instances when on-site personnel observe the hazardous condition but the automated functions of the system are not performing properly. In these instances, MnDOT District personnel or State Patrol District personnel that are designated CARS 511 users will also post the appropriate messages to the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS). (Related to Needs: 12, 22, 39, 40)
E 15. Operators will access the Central Control Systems (which may include the MnDOT IRIS system and/or other vendor control systems) with a user name and password. Multiple user levels and associated privileges will be available to grant or restrict access and operational control. *(Related to Needs: 14, 39)*

E 16. On-site personnel will have the ability to operate the changeable message signs on-site, without the need for any personnel in the District office, in the event that actions need to be overridden on-site, if remote communications or power are not operational, or if remotely operated functionality is not deployed. This will include provisions to prevent unauthorized individuals from being able to activate the signs.

*Alternate Concept E16. (Replaces changeable message signs with static signs and beacons): On-site personnel will have the ability to operate the beacons on the static signs on-site, without the need for any personnel in the District office, in the event that actions need to be over-ridden on-site, if remote communications or power are not operational, or if remotely operated functionality is not deployed. This will include provisions to prevent unauthorized individuals from being able to activate the signs.* *(Related to Needs: 22, 39)*

E 17. MnDOT operators will have access to a log of system-detectable malfunctions with signs. *(Related to Needs: 29)*

E 18. Operators and designated District personnel will be notified in real-time of detected malfunctions (including communications outages). *(Related to Needs: 26)*

E 19. MnDOT will assign roles and responsibilities for maintenance of system components to personnel within various MnDOT units such as District Maintenance, other District functions, Electrical Services, and other MnDOT units as applicable. *(Related to Needs: 30, 31)*

E 20. To the extent possible, specific sign placement and design will consider factors that avoid snow and ice build-up, so that MnDOT will not be required to remove snow and ice from signs. *(Related to Needs: 24)*

E 21. Signs and surveillance camera supports (if deployed) located within the roadway clear zone will be crashworthy. *(Related to Needs: 37)*

E 22. MnDOT will use the system to retrieve data logs about activations of signs, in order to assess performance and to assist with diagnostics testing. *(Related to Needs: 29)*

E 23. MnDOT will attempt to deploy consistent components (e.g. changeable message signs or static signs with beacons, cameras if included in the design) to achieve standardized systems across deployments in outstate districts, whenever practical. *(Related to Needs: 32)*

E 24. MnDOT will have written documentation and training for installation, operations, and maintenance of system components. *(Related to Needs: 33)*
E 25. Each MnDOT District will be responsible for repair and maintenance of their respective systems using a documented maintenance prioritization process for planning for repair or replacement of system components, in context with other maintenance priorities within the District. (Related to Needs: 34)

E 26. MnDOT will maintain system components within the public right of way with minimal impact on traffic, to the extent possible, and in a safe manner for those conducting maintenance. (Related to Needs: 35)

E 27. MnDOT will manage costs through scalability of the systems, such as case-by-case decisions about deploying optional features like remote operational capability or the addition of surveillance cameras, as determined during design. (Related to Needs: 36)

Minnesota State Patrol Perspective:

E 28. In some MnDOT Districts, State Patrol District personnel “operators” will activate and de-activate static signs with beacons, post/remove messages from changeable message signs, and view surveillance cameras (if deployed), as needed, in instances when the recurring hazardous condition is present but the automated functions of the system are not performing properly. (Related to Needs: 39)

E 29. In some MnDOT Districts, State Patrol District personnel that are designated CARS 511 users will enter and update advisory messages posted to changeable message signs in the statewide Traveler Information System Condition Reporting Entry Tool (Condition Acquisition and Reporting System – CARS), as needed, in instances when the recurring hazardous condition is present but the automated functions of the system are not performing properly. (Related to Needs: 40)
Appendix

The table below provides a tool MnDOT districts can use when assigning responsibilities for managing, coordinating, and operating the road closure and advisory message systems included in this document.

<table>
<thead>
<tr>
<th>Operational Tasks</th>
<th>Applicable Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td><strong>Management and Coordination</strong></td>
<td></td>
</tr>
<tr>
<td>Communicate observed road conditions to MnDOT District personnel</td>
<td>x</td>
</tr>
<tr>
<td>Notify State Patrol/local law enforcement of deteriorating conditions that may lead to a road closure</td>
<td>x</td>
</tr>
<tr>
<td>Make the decision to close and re-open sections of highway</td>
<td>x</td>
</tr>
<tr>
<td>Provide lead coordination of all operations of the road closure</td>
<td>x</td>
</tr>
<tr>
<td>Determine when to activate changeable message signs and message content</td>
<td>x</td>
</tr>
<tr>
<td><strong>Remote System Operations from MnDOT District Office</strong></td>
<td></td>
</tr>
<tr>
<td>Remotely raise and lower gate arms</td>
<td>x</td>
</tr>
<tr>
<td>Remotely post and remove messages to changeable message signs</td>
<td>x</td>
</tr>
<tr>
<td>Remotely activate and de-activate static signs with beacons</td>
<td>x</td>
</tr>
<tr>
<td>Remotely activate changeable message signs or static signs with beacons, in the event that automatic activation from sensors is not performing properly</td>
<td>x</td>
</tr>
<tr>
<td>Remotely view surveillance cameras to verify weather, road, traffic, or traffic conditions</td>
<td>x</td>
</tr>
<tr>
<td>Remotely view surveillance cameras to assist in determining appropriate gaps in traffic, for lowering gate arms</td>
<td>x</td>
</tr>
<tr>
<td>Remotely view surveillance cameras to verify that gates have been opened or closed properly</td>
<td>x</td>
</tr>
<tr>
<td>Remotely view surveillance cameras to verify that changeable message signs have been activated or de-activated properly</td>
<td>x</td>
</tr>
<tr>
<td>Enter, update, and remove road closure information in the Statewide Traveler Information System Condition Reporting Entry Tool (Condition acquisition and Reporting System - CARS)</td>
<td>x</td>
</tr>
<tr>
<td>Enter, update and remove advisory messages in CARS</td>
<td>x</td>
</tr>
<tr>
<td>Enter, update and remove advisory messages in CARS, in the event that the system triggering the automatic message to CARS is not functioning properly.</td>
<td>x</td>
</tr>
<tr>
<td><strong>Authorized Personnel at the Site of the Deployment</strong></td>
<td></td>
</tr>
<tr>
<td>Perform roadway “sweeps,” driving highway sections to look for stranded vehicles during road closures (after all gates and signs are activated and prior to re-opening a closed section of highway)</td>
<td>x</td>
</tr>
<tr>
<td>Staff mainline gates on-site, to determine timing for opening/closing gates</td>
<td>x</td>
</tr>
<tr>
<td>Staff ramp gates on-site, to determine timing for opening/closing gates</td>
<td>x</td>
</tr>
<tr>
<td>Staff gates for approximately the first 1-3 hours of a closure, as staffing allows</td>
<td>x</td>
</tr>
<tr>
<td>Manually open and close gates on-site, to override remote control functions or to operate gates that do not have remotely operated functionality</td>
<td>x</td>
</tr>
<tr>
<td>Manually operate changeable message signs and static signs with beacons on-site, to override remote control functions or to operate signs that do not have remotely operated functionality</td>
<td>x</td>
</tr>
</tbody>
</table>