DEPARTMENT OF TRANSPORTATION

Model Systems Engineering Document

ITS Application: Video

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Contents

Acronyms

ARC-IT	•	National Architecture Reference for Cooperative and Intelligent Transportation
CAD	•	Computer Aided Dispatch
CAV	•	Connected and Automated Vehicle
DMS	•	Dynamic Message Signs
DVR	•	Digital Video Recordings
FAT	•	Factory Acceptance Tests
IRIS	•	Intelligent Roadway Information System
ITS	•	Intelligent Transportation System
IP	•	Internet Protocol
LAN	•	Local Area Network
MAP	•	Map Data
MnDOT	•	Minnesota Department of Transportation
MUTCD	•	Manual on Uniform Traffic Control Devices
NRTL	•	Nationally Recognized Testing Laboratory
OSHA	•	Occupational Safety and Health Administration
PTZ	•	Pan, Tilt, Zoom Functionalities of Cameras
RTMC	•	Regional Transportation Management Center
SPaT	•	Signal Phase and Timing
SEA	•	Systems Engineering Analysis
TTC	•	Temporary Traffic Control
VPN	•	Virtual Private Network
WAN	•	Wide Area Network

Purpose and Description of ITS Application: Video

Document Purpose

This document is intended to support the Systems Engineering Analysis (SEA) activities for the Minnesota Department of Transportation (MnDOT) and other local transportation agencies within Minnesota as they consider, plan, develop, design, implement, and operate video. The content of this document will be a systems engineering analysis resource to support project compliance as set forth in 23 CFR Section 940 (Rule 940). This document can be used in conjunction with the Minnesota Statewide Regional Intelligent Transportation System (ITS) Architecture and related systems engineering resources to complete an ITS Systems Engineering project-specific checklist as part of the initial analysis of applications considered for implementation. To access the available checklists for ITS-related deployments, visit the MnDOT Systems Engineering web page at: https://www.dot.state.mn.us/its/systemsengineering.html.

In situations where projects are not consistent with this systems engineering document, the contents of this document may be used as a base to support the development of project specific systems engineering documents, including a concept of operations, functional requirements, and test plans specific to the project.

Description of Video

Video applications provide operators with the ability to view live footage of activities occurring on the transportation network. This footage offers context and visual information on traffic and road conditions that supplements other applications, such as traffic detection and road weather monitoring. In addition to the uses by the agency operators, video is also viewed by travelers to better understand road and traffic conditions.

Video Environment/Components

The video application includes the cameras in the field, the communications network, and the supporting video systems that enable the viewing, sharing, storing, and overall management of video. Table 1 presents the environment/components included in the video application and describes the function of each.

Table 1: Video Environment/Components

Environment/Component	Function
1. Video Cameras	Field devices that provide remote view of transportation system. Includes permanent and portable cameras that are either analog or Internet Protocol (IP) based.
2. Supporting Communications	Supporting communications are used to transmit video from cameras in the field to the MnDOT network and eventually to the video management system. Control commands initiated by users are transferred by the video management system and communicated to the cameras. Communications typically utilize fiber connections, but other alternate communications are used when fiber is not available. (See details in the *Model System Engineering Document, ITS Application: Communications* document.)

Environment/Component	Function
3. Video Application	The overall collection of components that perform functions to capture video, control cameras, manage video, manage users, etc. Note: As there are various options for the roles that the video management system and video control system perform, many requirements and concepts refer only to video application.
4. Video Management System	Central video switch and supporting devices that is the interface between the cameras and video control software. Also supports aspects of video sharing, buffering and archiving.
5. Video Control Software	Software and user interface that allows users to view video and control cameras from their workstations. Video control software also performs supporting actions such as adding identification labels to video, displaying video on the video wall monitors. Examples of video control software are MnDOT's Intelligent Roadway Information System (IRIS) and Milestone.
6. Connected and Automated Vehicle (CAV) Infrastructure Systems	The systems deployed by the DOTs to communicate with on-board units within CAVs. Video is likely to play a supporting role in monitoring and verifying functionality of CAV Infrastructure Systems.
7. CAVs	The vehicles and on-board applications that communicate with CAV Infrastructure Systems and other CAVs. Video is likely to play a supporting role in monitoring and evaluating CAVs during testing or demonstrations.

The primary video application components and related systems are illustrated in Figure 1 below.
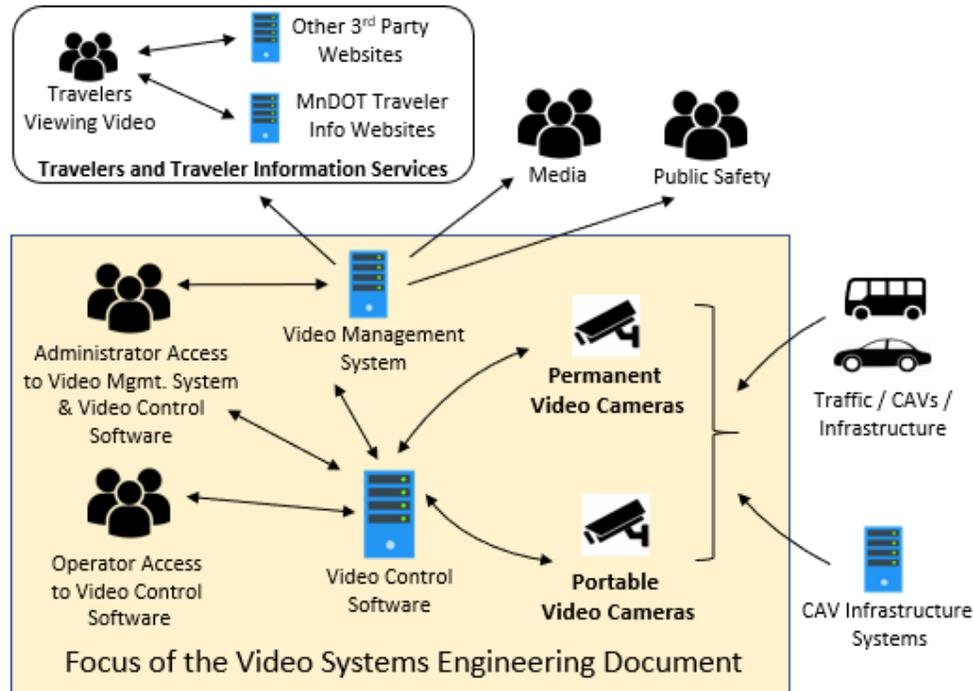
Figure 1: Illustration of Primary Video Application Components and Related Systems/Users

Examples of Video Camera Field Devices

As noted above, the primary field devices described in this document are cameras that capture and communicate video. Video cameras are typically permanently installed with permanent power and communications supporting operations. However, portable video cameras are used in situations such as work zone to provide video access to locations that would not require permanent installations.

Table 2 provides an overview of the video camera field equipment included in this document.

Table 2: Overview of Video Camera Field Devices

Video Camera Type	Description
Full Pan Tilt Zoom (PTZ) Cameras	Full functioning PTZ cameras allow operators to pan and zoom the orientation of the camera. Depending upon the camera mounting and housing components, the camera may offer full 360 degree panning or may limit the viewing positions.
Fixed Position Video Cameras	In some locations, fixed position video cameras may be deployed, either without the ability to pan and zoom the camera, or with this ability disabled. These cameras may support designated areas (e.g. tunnels, reversible lanes, etc.) where one designated view position is desired. Another example of the use would be if video analytics systems were to use the video generated and process the video.
Portable Cameras	Cameras mounted on trailers or other temporary structures and located in positions where it is desirable for operators and the traveling public to visually monitor conditions remotely. Depending upon local need, portable cameras may either be full PTZ or fixed position.

Examples of Communications Technologies Supporting Video Applications

The video application relies upon a number of communications technologies (detailed in a separate document - *Model System Engineering Document, ITS Application: Communications*) to transfer the video from field devices to eventual end users. The following table summarizes examples of communications technologies used today.

Table 3: Examples of Current Communications Supporting Video Applications

Video Application Communications	Communications Technologies Supporting Video Applications
Camera control and video communications	• **Long range communications** - Ethernet connections using fiber or copper mediums to communicate video to central systems. • **Short-range wireline or wireless communications** - Ethernet or serial connections using fiber or copper mediums to support two-way communications over short distances to connect cameras to switches or cabinets where video is then communicated using long-range communications. • **DOT operated Local Area Network (LAN) or Wide Area Network (WAN)** - Private communications network that allows communications of video from camera to central servers. • **Commercial wireless communications** - Services provided by third party providers to perform wireless communications over commercial networks enable communications of video from cameras where wireline communications are not practical. • **Virtual Private Network (VPN) over public internet** - Secure and encrypted communications over less secure networks and the public Internet allow communication of video in locations where agency owned communications are not practical.
Video transfer to media or other partners	• **Public internet** - Use of the public Internet allows video to be shared with media providers that are not connected to the agency LAN or WAN. • **VPN over public internet** - Secure and encrypted communications enables video to be shared with partner agencies.
Traveler access to video and images	• **Public internet** - Use of the public Internet allows the traveling public to access video and still images from their computers and mobile devices. • **Commercial wireless communications** - Services provided by third party providers to perform wireless communications over commercial networks enable travelers and partner agencies to view video from mobile devices.

Stakeholders and Typical Conditions

Stakeholders

Table 4 identifies the stakeholder groups that interface with one or more aspects of video deployment and operations.

Table 4: Stakeholder Groups Interfacing with Video Deployment and Operations

Stakeholder	Description
Administrators	A combination of operators and technical staff responsible for configuring, updating, verifying agency owned video cameras and related systems for viewing, buffering, archiving, and sharing video.
Technicians and Installers	Technical staff responsible for the design, installation, maintenance, and troubleshooting of the hardware and software associated with video cameras owned by the agency. May include MnDOT staff, contractors, and consultants, performing actions both in the field and remotely.
Operators	Primary users of video. Require camera control and live viewing to: • Verify incidents • Observe traffic for signal control changes, freeway management, or work zone management • Observe/verify weather and road conditions • Verify field device functionality (e.g. Dynamic Message Signs (DMS), gates, etc.) Require buffered viewing and archive viewing of video to: • Conduct training • Performance management • Incident debriefing This group will also include those requiring access to video for traffic studies and monitoring of the transportation system.
Media	External users that either rebroadcast video feeds or use the video feeds to support Internet/print/radio communications.
Public Safety Agencies	External users who typically use video for incident management or other emergency management functions.
Travelers and Traveler Information Services	Typically includes travelers and Traveler Information Services (e.g. 511mn.org and privately-operated traveler information systems) that support travelers by allowing them to view on-line video or snapshots, as well as attorneys or others (e.g. researchers or other citizens) that may request buffered video clips.
CAV Infrastructure Systems and CAVs	External systems that include both CAV infrastructure systems (systems operated by MnDOT) and CAVs (vehicles and on-board units in the vehicles) that support connected and automated vehicle operations.

Typical and Local Conditions

Video is provided from MnDOT cameras that are installed at periodic spacing along freeways, placed at locations for optimal view of traffic conditions in metro areas and at key locations in rural areas.   The video provided is viewed by operators through a video wall in the Regional Transportation Management Center (RTMC), individual monitors, and may also be viewed by the public through public and private traveler information systems.

Stakeholder Needs

Table 5 identifies a series of problems or challenges and the related needs for each stakeholder group identified above.

Table 5: Stakeholder Needs

Problem / Challenge	Needs (As a Result of the Problem / Challenge)
Administrators Needs	
- Video cameras must be configured to work properly with control and viewing systems.	**Need 1. Camera configuration** Administrators need to be able to configure video cameras to work with supporting systems.
- Access to video images and video varies by stakeholder group.	**Need 2. Video access configuration** Administrators need to be able to configure different stakeholder groups' access to video in order to serve as video data stewards in accordance with the Minnesota Government Data Practices Act.
Technicians and Installers Needs	
- Proper use of video cameras requires communications, power, and installation at the deployment site.	**Need 3. Video supporting infrastructure** Technicians and installers need power, communications, and a support structure to be available at the location where the camera is installed.
- Cameras deployed in the field must not harm technicians, installers, or anyone in vicinity of the cameras.	**Need 4. Safety standards** Technicians and installers need the cameras to adhere to appropriate safety standards, specifications, and protocols.
- Installing, maintaining, and training staff on many different video vendor products consumes staff time and increases the risks of system down-time.	**Need 5. Equipment consistency** Technicians and installers need the video equipment to be as consistent and compatible with existing equipment as possible.
Operators Needs	
- Operators cannot view the area they need to observe without panning and zooming cameras.	**Need 6. Remote camera control and live viewing** Operators need to be able to control the video cameras remotely and view live video from the cameras.

Problem / Challenge	Needs (As a Result of the Problem / Challenge)
- Operators sometimes need to zoom in to events to understand the situation and need to restrict access to details visible through the cameras.	**Need 7. Block video access** Operators need a mechanism to block live video access to users outside their organization (e.g. traveling public and media).
- Operators may wish to review recent video to better understand crashes or other events that occur on the road network.	**Need 8. Buffer video** Operators need a mechanism to access recent video both to review and to consider whether they should archive the video for long-term storage.
- In some situations, there is value in archiving video clips for viewing in the future.	**Need 9. Archive video** Operators need a mechanism to archive selected video clips for long-term retention.
- Slow responding camera control or inadequate images will lessen the impacts of video.	**Need 10. Minimum performance measures** Operators need all components of the video application to perform at least to a minimum performance level.
Media Needs	
- News media provide information about traffic conditions during newscasts.	**Need 11. External access to high quality video** Some media providers need real-time access to high quality video from MnDOT cameras to display live and/or record for later display or rebroadcast.
- Reporters need condition information for radio or blogging forums.	**Need 12. External access to low or medium quality video** Media providers' needs may be met using low resolution video which requires less bandwidth to transmit/receive.
Public Safety Agencies Needs	
- Information provided to emergency responders about incident details before arriving help them respond.	**Need 13. Remote access to video** Public safety agencies (e.g. law enforcement and emergency responders) need access to view live video when responding to incidents.
- Public agencies cannot view the area they need to observe without panning and zooming cameras.	**Need 14. Limited control of video** Public safety agencies need an approach to request MnDOT to pan and zoom cameras to enhance the images they view when responding to incidents.
Travelers and Traveler Information Services Needs	
- Travelers benefit if private operated traveler information providers are able to communicate camera images and video.	**Need 15. Access to live video feeds** Traveler information service providers and researchers need access to live video streams or snap shot images in order to rebroadcast and communicate to travelers or use for research.
- Travelers rely on visual images to confirm event reports or understand traffic conditions along their planned routes.	**Need 16. Viewing real-time video camera images** Travelers need a mechanism to view still images and/or video from video cameras to make decisions or confirm traveler information reports of conditions.

Problem / Challenge	Needs (As a Result of the Problem / Challenge)
- Travelers and other interested citizens may request to view archived video clips.	**Need 17. Public requests for archived video clips** MnDOT needs an approach and supporting systems to assist in responding to requests for video clips appropriately.
CAV Infrastructure Systems and CAVs Needs	
- Validation of CAV infrastructure systems' operations is critical to maintaining successful communications with CAVs.	**Need 18: Validation of CAV infrastructure systems** Individuals responsible for operating CAV infrastructure systems need visual verification of infrastructure status (e.g. traffic signal phase, road work lane closures) to validate messages broadcast to CAVs.

Operational Concepts

The previous section defined a series of stakeholders that are expected to interact with video cameras and their needs likely to be addressed by videos. This categorization will be further used in this section to describe the operational concept for video camera from each user's perspective. The operational concept is intended to help each user see how their needs have been interpreted and how videos are expected to address their needs. It is presented in a sequential manner from each user's perspective, with the needs included in the tables for reference.

Administrators' Perspective

Table 6 describes the video operational concepts from the administrators' perspective, and relates each concept to a need, as defined in the previous section.

Table 6: Video Operational Concepts – Administrators' Perspective

Need (Administrators' Perspective)	Operational Concept
Administrators' Perspective linked to **Need 1: Camera configuration**	1.1 Administrators will configure cameras once they are installed. Configuration will link the cameras to the video management system and camera control software. 1.2 Administrators may configure cameras to display video layovers (e.g. MnDOT logo) on video. 1.3 If temporary portable cameras are installed, Administrators will configure the cameras to be controlled by and viewed with the video management systems.
Administrators' Perspective linked to **Need 2: Video access configuration**	2.1 Administrators will receive and respond to requests for access to video from cameras. Administrators will use the video management system to assign access as appropriate. 2.2 Administrators will create and manage user groups that have consistent access to video. Each group will have unique privileges such as viewing only, adjusting view (panning/zooming), turning off live streaming when necessary, adding new users and assigning groups, updating existing users' information, and deleting users. 2.3 Administrators will track usage by user groups given access. Any data usage that seems particularly high may warrant further scrutiny. 2.4 Administrators will manage system upgrades, testing, maintenance, and outages, including notifying operators and user groups of expected periods without access to video from one or more cameras.

Technicians and Installers' Perspective

Table 7 describes the video operational concepts from the technicians and installers' perspective and relates each concept to a need, as defined in the previous section.

Table 7: Video Operational Concepts – Technicians and Installers' Perspective

Need (Technicians and Installers' Perspective)	Operational Concept
Technicians and Installers Perspectives related to **Need 3: Video supporting infrastructure**	3.1 Preparation for cameras includes analysis and selection of an existing structure to support the camera (housing and unit). If an existing structure is not available, installers will design and deploy a supporting pole to support the camera.
	3.2 Installation of the cameras will include the necessary design and installation of supporting infrastructure, including power, communications, site range of the camera, etc.
	3.3 Environmental factors such as morning or evening glare and natural or man-made obstructions will be considered when selecting an installation location.
	3.4 In situations where temporary cameras are installed (e.g. roadwork or special events) the temporary camera unit will include power and communications.
	3.5 When the cameras or supporting infrastructure is unavailable (e.g. during road construction) and the camera feed is not available, technicians and installers will work with administrators to identify the camera as out of service and alert operators.
Technicians and Installers Perspectives related to **Need 4: Safety standards**	4.1 Installers will only install cameras that are tested, certified, and labeled by a Nationally Recognized Testing Laboratory (NRTL) as acceptable under Occupational Safety and Health Administration (OSHA) regulations.
	4.2 Technicians and installers will rely upon installation instructions and guidelines from the camera vendor.
	4.3 Technicians and installers will be responsible for performing appropriate temporary traffic control (TTC) in compliance with the Manual on Uniform Traffic Control Devices (MUTCD) when installing or performing field work on cameras.
Technicians and Installers Perspectives related to **Need 5: Equipment consistency**	5.1 In-place cameras will continue to be used as new cameras are added.
	5.2 As new cameras are procured, IP based cameras will be consistently deployed.
	5.3 Procurement of new cameras will be consistent with in-place devices to the extent possible, so that installers and

Need (Operators' Perspective)	Operational Concept
	technicians will be well-trained to install and repair new devices and can interchange parts.
	5.4 New cameras purchased and installed will be compatible with existing equipment and systems such as communications (fiber, etc.) and the video management systems.
	5.5 New cameras will be compliant to national standards for communications.

Operators' Perspective

Table 8 describes the video operational concepts from the operators' perspective, and relates each concept to a need, as defined in the previous section.

Table 8: Video Operational Concepts – Operators' Perspective

Need (Operators' Perspective)	Operational Concept
Operators' perspective related to: **Need 6: Remote camera control and live viewing**	6.1 After receiving notification of incidents, operators will identify the nearest camera and pan and zoom to view and verify the incident.
	6.2 Once incidents are verified, operators will pan and zoom one or more nearby cameras to assess the impact of the incident to assist in dispatching incident response and to understand the impact on travelers.
	6.3 Operators will configure selected cameras to home/default pan/zoom positions and these positions will be displayed predominantly in the operations center during peak periods.
	6.4 During inclement weather conditions, operators will position cameras at key locations (e.g. bridges or overpasses) to monitor driving impacts of the conditions.
	6.5 Operators will monitor camera images at other times, periodically panning and zooming to view details as appropriate.
	6.6 Operators will view live video to monitor field devices (e.g. DMS, curve warning system, road closure gate systems MnPASS signs, etc.) to ensure they have activated properly.
	6.7 Operators will have the option for full 360 degree panning of the cameras.
	6.8 Operators may view video from temporary cameras, installed at work zones or event locations.
	6.9 Operators will use the video management system to understand if any cameras are not functioning or that have lost communications.

Need (Operators' Perspective)	Operational Concept
Operators' perspectives related to: **Need 7: Block video access**	7.1 In situations where cameras are capturing images of situations that are sensitive or a security risk, operators will temporarily block the live video to outside organizations, while still enabling viewing by the operators.
Operators' perspectives related to: **Need 8: Buffer video**	8.1 During some incidents, operators will access and view video from cameras recorded recently (buffered video) to help understand recent activities regarding the event as they manage the event. 8.2 Operators will periodically receive requests from others in their organization or outside their organization to permanently archive buffered video and will access the buffered video to assess and respond to these requests.
Operators' perspectives related to: **Need 9: Archive video**	9.1 After events occur, operators may select a time period and camera that they wish to archive the video. 9.2 Operators may also receive requests from others within and external to the agency to archive a time period of video from a specific camera. These requests may be to support incident analyses, safety improvements, or for training purposes. 9.3 Operators will use the video management system to archive video during the time period that it is still available in the buffer. 9.4 Only video specifically selected for archive will be permanently saved, and other video that is buffered will be removed at the end of the buffer date in response to data practices considerations as well as storage requirements.
Operators' perspectives related to: **Need 10: Minimum performance measures**	10.1 Operators viewing video will experience performance of the video that, as a minimum, meets some minimal performance levels. 10.2 When panning and zooming the cameras, operators will see the impacts immediately with unnoticeable delay between the pan/zoom request a camera reaction. 10.3 The position and zoom of the cameras will enable operators to view details of vehicles and objects in the road and surrounding areas.

Media Perspective

Table 9 describes the video operational concepts from the medias' perspective, and relates each concept to a need, as defined in the previous section.

Table 9: Video Operational Concepts - Media Perspective

Need (Media Perspective)	Operational Concept
Medias' perspective related to **Need 11: External access to high quality video**	11.1 Media providers will view and display to their viewers video from MnDOT cameras during on-air broadcasts. The quality of video will be sufficient for television viewers to view and understand the situation. While media providers vary in their use of video, MnDOT will make accessible a single video quality to all media that is good enough for media use in all conditions but might not be the highest quality video capabilities. Media may record the video streams they receive for display during a later broadcast.
Medias' perspective related to **Need 12: External access to low or medium quality video**	12.1 Media not broadcasting live video streams to viewers (e.g. radio or news media) may still view video to create reports that are verbally or textually relayed to travelers.

Public Safety Agencies' Perspective

Table 10 describes the video operational concepts from the perspective of the public safety agencies, and relates each concept to a need, as defined in the previous section.

Table 10: Video Operational Concepts - Public Safety Agencies' Perspective

Need (Public Safety Agencies' Perspective)	Operational Concept
Public safety agencies' perspective related to **Need 13: Remote access to video**	13.1 Video access will be provided to public safety agencies (e.g. law enforcement and emergency responders) to view live video. 13.2 Emergency and maintenance response dispatchers will view video to assess response and resources needed during incidents. 13.3 In situations where events are identified as possible training or performance management resources, public safety agencies may request archive of specific video and will view the archived video for training or procedure development.
Public safety agencies' perspectives related to **Need 14: Limited control of video**	14.1 Public safety agencies may request that MnDOT operators control cameras to position them to adequately view incident situations.

Travelers and Traveler Information Services' Perspective

Table 11 describes the video operational concepts from the perspective of travelers and traveler information services and relates each concept to a need, as defined in the previous section.

Table 11: Video Operational Concepts - Travelers and Traveler Information Services' Perspective

Need (Travelers and Traveler Information Services' Perspective)	Operational Concept
Travelers' Perspective on *Need 15: Access to live video feeds*	15.1 Travelers will continue to watch local media broadcasts before driving to their destination in order to view traffic and understand driving conditions. They may elect to take an alternate route based on this information. 15.2 Travelers viewing the video may recognize the cameras as MnDOT by the video layover, website branding, or other common display approaches (i.e. layover may not always be available).
Travelers' Perspective on *Need 16: Viewing real-time video camera images*	16.1 Travelers may select and view video or snapshot images through MnDOT-operated public websites from home computers or mobile devices. They make decisions or confirm traveler information reports of conditions affecting their trip. 16.2 Travelers select and view cameras while visiting third-party travel information websites operated by non-MnDOT agencies to make decisions or confirm traveler information reports of conditions affecting their trip. 16.3 Travelers will identify the camera images as MnDOT's by the video layover, website branding, or other common display approaches.
Travelers' Perspective on *Need 17: Public requests for archived video clips*	17.1 Travelers may experience situations where they would benefit from viewing past video clips resulting in an inquiry (typically a phone call to MnDOT) about video availability. 17.2 MnDOT staff will use the Video Management System to determine if video clips capturing the requested situation are available. 17.3 If video clips are available that match the request, MnDOT would provide video clips to individuals that requested the clips.

CAV Infrastructure Systems and CAVs' Perspective

Table 12 describes the video operational concepts from the perspective of CAV Infrastructure Systems and CAVs, and relates each concept to a need, as defined in the previous section.

Table 12: Video Operational Concepts - CAV Infrastructure Systems and CAVs' Perspective

Need (CAV Infrastructure Systems and CAVs' Perspective)	Operational Concept
CAV Infrastructure Systems and CAVs Perspectives on *Need 18: Validation of CAV infrastructure systems*	18.1 Staff responsible for monitoring Connected Corridors' Signal Phase and Timing (SPaT)/Map Data (MAP) broadcasts may rely on video positioned to view current signal light displays to compare with data received and displayed on monitoring devices. 18.2 Staff responsible for monitoring CAV infrastructure systems that are broadcasting work zone or lane closure data may view camera images to compare with data received and displayed on monitoring devices. 18.3 Automated verification systems created to monitor status of CAV infrastructure systems may rely on video or video processing to generate data to compare and assess operational status of systems.

Operational Scenarios / Roles and Responsibilities

Roles and Responsibilities

The *Operational Concept* section defined interactions of the primary stakeholders with video and supporting software. The table below provides a high-level summary of the roles and responsibilities of the stakeholder groups.

Table 13: Operation and Maintenance Roles and Responsibilities

User Group	Role / Responsibility
Administrators	• Configure cameras (permanent and temporary) once they are installed to link cameras to the video management system and camera control software. • Provide access to video to select users, manage user groups, track user group usage. • Manage system upgrades, testing, maintenance, and outages.
Technicians and Installers	• Install camera (permanent and temporary) including power, communications site range of the camera etc. on existing structure or design and deploy a structure to support the camera. • Respond to malfunctioning or out of service cameras (as typically reported by operators) and perform field repairs or replacements. • Perform regular routine maintenance on cameras.
Operators	• Verify incidents using pan and zoom on nearest camera and view traffic conditions surrounding the incidents. • Configure selected cameras to home positions for display during peak periods. • Position cameras at key locations during inclement weather to video driving impacts. • Monitor field devices. • Use the video management system to identify cameras that are not functioning. • Temporarily block live video to outside organizations in sensitive or security risk situations. • Archive selected video and view recorded video.
Media	• View video from MnDOT cameras and display video to their viewers.
Public Safety Agencies	• View live video. • Request that buffered video be archived for training or procedure development. • Request MnDOT operators to pan and zoom cameras, as needed, to improve viewing of current activities.
Travelers and Traveler Information Services	• Watch local media broadcasts that display MnDOT video. • View camera images through MnDOT or third-party traveler information systems.

Operational Scenarios

Scenarios are intended to describe how users will interact with the video application and specifically to provide a temporal description of the sequence of events. The following scenarios briefly describe how users will be impacted and how they are expected to respond.

- Scenario A: Incident
- Scenario B: Winter Conditions
- Scenario C: Travelers Use
- Scenario D: Camera Outage

Scenario A: Incident

An operator in the RTMC is alerted of an incident that is reported by a caller dialing 911 from a cell phone in the Twin Cities Metro Area and State Patrol receiving the phone call. The MnDOT RTMC operator is automatically notified of the location through the State Patrol's Computer Aided Dispatch (CAD) system that is integrated with the RTMC. The operator identifies the cameras nearest to the incident and starts to monitor traffic in both directions. The video of the incident location is used to consider and eventually dispatch a freeway service patrol to assist in traffic control. State Patrol dispatch is also viewing the incident location to assist officers on the scene. The State Patrol requests a zoomed in view of the incident. MnDOT blocks the video feed from the media and public during this time due to the nature of the incident and the zoom levels being viewed. The RTMC operator posts messages on DMS in the surrounding area to notify travelers of the incident. The RTMC operators continue to view the video and once the incident is cleared, the operators modify the DMS messages to alert drivers the incident has cleared. Video cameras are eventually returned to their normal default pan and zoom positions.

Scenario B: Winter Conditions

During the AM peak in Twin Cities Metro Area, heavy snow is falling, causing traffic to slow and back up in many locations. RTMC operators monitor video and, based on conditions observed, input manual entries into the condition reporting system to describe driving conditions. In addition, the RTMC operators are assisting the State Patrol by alerting them of any incidents. RTMC operators post message on DMS and work with MnDOT maintenance dispatch to dispatch assistance. The snow stops an hour after the AM peak. RTMC operators continue to monitor traffic as MnDOT snowplows continue to clear the roads.

Scenario C: Travelers Use

Prior to leaving Minneapolis, a traveler views MnDOT's traveler information system to determine which route to take to their house. The traveler views the congestion information provided on the MnDOT traffic map and selects to view camera image snap shots of the congestion. Based on this information, the traveler selects their route home. In addition, the traveler utilizes third party data (e.g. Google) to confirm their choice.

Scenario D: Camera Outage

During the afternoon, an RTMC operator notices that a video feed is unavailable. The RTMC operator resets the camera and the feed is still not restored. The operator views the video feed from nearby cameras and is still unable to diagnose the issue. The RTMC operator contacts a MnDOT technician to assess the issue in the field. The technician determines that that the communication to the camera had been damaged and establishes a new communication cable to the camera.

System Requirements

System requirements are verifiable details that define what a system will do, but not how the system will do it. Requirements can describe the functional, performance, interface, communications, operational, and maintenance conditions of what a system will do.

Requirements for video are listed in the table below first by needs (column 1). These represent the needs of all the stakeholders described in the *Stakeholder Needs* section. Based on each need and on the operational concepts presented in the *Operational Concepts and Typical Conditions* section, one or more system requirements (column 2) are described. Requirements are all numbered to facilitate traceability back to the original needs and further traceability through design and validation.

Table 14: Video Needs and System Requirements by Stakeholder

Need	System Requirement
Administrators	
1. Administrators need to be able to configure video cameras to work with supporting systems.	1.1 The overall video application shall provide a mechanism for administrators to add and delete cameras such that the cameras can be controlled, and video captured by the overall application.
	1.2 The overall video application shall support remote configuration of the cameras (i.e. not require administrators to be at the site of the cameras when configuring).
	1.3 The overall video application shall provide a mechanism for administrators to add and delete temporary portable cameras that can be controlled by the video application.
2. Administrators need to be able to configure different stakeholder groups' access to video in order to serve as video data stewards in accordance with the Minnesota Government Data Practices Act.	2.1 The video application shall provide a mechanism for administrators to create and manage user groups for assigning access and privileges.
	2.2 The video application shall provide a mechanism for administrators to assign unique privileges and functionality to support each user group that include viewing only, adjusting view (panning/zooming), turning off live streaming when necessary, adding new users and assigning groups, updating existing users' information, and deleting users.
	2.3 The video application may provide a mechanism for administrators to track number of simultaneous connections bandwidth usage by user group.
	2.4 The video management application shall provide a mechanism for administrators to manage system upgrades, testing, maintenance, and outages, including notifying operators and user groups of expected periods without access to video from one or more cameras.

Need	System Requirement
Technicians and Installers	
3. Technicians and installers need power, communications, and a support structure to be available at the location where the camera is installed.	3.1 Video cameras shall only be installed after design and deployment of a structure. 3.2 Video camera installation design shall include the approach to mounting and housing the camera, considering external environmental factors. 3.3 Video camera installation design shall be in accordance with requirements for roadway clearance and crashworthiness (e.g. breakaway structures or protected as needed). 3.4 Video camera installation design shall include power connections. 3.5 Video camera installation design shall include communications connections. 3.6 Video camera installation design shall include electrical grounding and surge suppression. 3.7 Video camera installation design shall include site range considerations (including consideration of obstructions, solar glare, nearby ITS and CAV equipment, and seasonal aspects). 3.8 Temporary video cameras shall be installed by technicians and installers in approved locations with power and communications.
4. Technicians and installers need the cameras to adhere to appropriate safety standards, specifications, and protocols.	4.1 Video cameras shall be tested, certified, and labeled by NRTL as acceptable under OSHA regulations in order to be installed by technicians and installers. 4.2 Video cameras shall include installation instructions and guidelines from the camera vendor for technicians and installers to rely upon during installation. 4.3 Technicians and installers shall perform appropriate TTC in compliance with MUTCD when installing or performing field work on cameras.
5. Technicians and installers need the video equipment to be as consistent and compatible with existing equipment as possible.	5.1 Video cameras that are in-place shall continue to be used as new video cameras are added. 5.2 As new cameras are procured (either for new locations or to replace existing cameras) IP-based cameras shall be deployed unless external factors prevent their use. 5.3 Newly procured video cameras and housing units shall be consistent with in-place video cameras to the extent

Need	System Requirement
	possible as technicians and installers are well-trained to install and repair these devices and can interchange parts.
	5.4 Newly purchased and installed video cameras shall be compatible with existing equipment and systems such as communications (fiber, etc.) and the video management systems.
	5.5 New video cameras shall use appropriate protocols where needed and open standards when available.
Operators	
6. Operators need to be able to control the video cameras remotely and view live video from the cameras.	6.1 The video application shall provide a mechanism for authorized operators to control video cameras remotely.
	6.2 The video application shall manage the control of cameras by multiple users and presets happening at scheduled times.
	6.3 The video application shall provide a mechanism for operators to view real-time full motion video and to select the specific display location for viewing video from cameras.
	6.4 The video application shall provide a mechanism for operators to view the geographic location of cameras in order to find the nearest video camera to a selected location.
	6.5 The video application shall provide a mechanism for operators to configure selected video cameras to home/default pan/zoom positions for prominent display in the operations center.
	6.6 The video application shall provide a mechanism for operators to have full 360 degree panning of the cameras.
	6.7 Video cameras shall be capable of panning a full 360 degrees.
	6.8 The video application shall provide a mechanism for operators to view video from temporary cameras, installed at work zones or event locations.
	6.9 The video application shall provide a mechanism for operators to understand if any video cameras are not functioning or have lost communications.
	6.10 The video application shall provide a mechanism for users to restore connections and restart cameras that are not responding.

Need	System Requirement
	6.11 The video application shall use appropriate protocols where needed and open standards when available for camera control.
	6.12 The video application shall support video switching with external 'consumers' of the video.
7. Operators need a mechanism to block live video access to users outside their organization (e.g. traveling public and media).	7.1 The video application shall provide a mechanism for operators to temporarily block the live video to outside organizations while still enabling viewing by the operators during situations where video cameras are capturing images of situations that are sensitive or a security risk.
	7.2 The video application shall provide a mechanism for operators to select the camera(s) to be blocked, while still allowing outside users to access video from other cameras.
8. Operators need a mechanism to access recent video both to review and to consider whether they should archive the video for long-term storage.	8.1 The video application shall provide a mechanism for operators to buffer video (i.e. temporarily store video to allow playback and archiving within the buffer period).
	8.2 The period of time video is buffered by the system shall be configurable by operators or administrators.
	8.3 The video application shall provide a mechanism for operators to access and view video from cameras recorded recently (buffered video) to help understand recent activities regarding an event as they manage the event.
	8.4 The video application shall provide a mechanism for users to search and retrieve recorded video using search criteria such as camera, time of day, day of year.
	8.5 The video application shall provide a mechanism for operators to permanently archive buffered video following a request from others in or outside of their organization to access the buffered video, as operators decide is appropriate.
9. Operators need a mechanism to archive selected video clips for long-term retention.	9.1 The video application shall provide a mechanism for operators to select a time period and camera that they wish to archive video after events occur.
	9.2 The video application shall provide a mechanism for operators to archive a time period of video from a specific camera following a request from others in or outside of their organization in order to support incident analyses, safety improvements, or training efforts, as operators decide is appropriate.

Need	System Requirement
	9.3 The video application shall provide a mechanism for operators to archive video during the time period that it is still available in the buffer.
	9.4 The video application shall permanently save video that is specifically selected for archive.
	9.5 The video application shall remove all video that is buffered at the end of the buffer date, unless it is specifically selected for archive, in response to data practices considerations as well as storage requirements.
10. Operators need all components of the video application to perform at least to a minimum performance level.	10.1 The video application shall provide a mechanism for operators to see immediate real-time impacts with unnoticeable delay between the pan/zoom request and camera reaction.
	10.2 The video cameras shall be positioned and have sufficient zoom capabilities to enable operators to view details of vehicles and objects in the road and surrounding areas.
Media	
11. Some media providers need real-time access to high quality video from MnDOT cameras to display live and/or record for later display or rebroadcast.	11.1 The video application shall provide a mechanism for media providers to view and display to their viewers video from MnDOT cameras during on-air broadcasts that is of sufficient quality for media use in all conditions.
	11.2 The video application shall provide a web interface for media to select the camera to stream.
12. Media providers' needs may be met using low resolution video which requires less bandwidth to transmit/receive.	12.1 The video application shall provide a mechanism for media to view video to create reports that are verbally or textually relayed to travelers, in addition to broadcasting live video streams to viewers.
Public Safety Agencies	
13. Public safety agencies (e.g. law enforcement and emergency responders) need access to view live video when responding to incidents.	13.1 The video application shall provide video access to public safety agencies (e.g. law enforcement and emergency responders) to view live video.
	13.2 The video application shall provide a mechanism for emergency and maintenance response dispatchers to view video to assess response and resources needed during incidents.

Need	System Requirement
14. Public safety agencies need an approach to request MnDOT to pan and zoom cameras to enhance the images they view when responding to incidents.	14.1 MnDOT procedures shall allow for phone or email requests from partner public safety agencies to perform video camera panning and zooming such that public safety agencies can better view conditions.
Travelers and Traveler Information Services	
15. Traveler information service providers and researchers need access to live video streams or snap shot images in order to rebroadcast and communicate to travelers or use for research.	15.1 The video application shall provide video feeds that can be accessed by traveler information service providers and researchers. 15.2 The video application shall provide one or more optional ways for researchers and other information providers viewing the video to recognize the source as a MnDOT camera, such as the video overlay.
16. Travelers need a mechanism to view still images and/or video from video cameras to make decisions or confirm traveler information reports of conditions.	16.1 The video application shall provide a mechanism for MnDOT operated websites to display video or still images to web site visitors. 16.2 The video application shall provide a mechanism for other third-party traveler information providers to access video and snapshot pictures generated by MnDOT video cameras. 16.3 The video application shall provide one or more ways for the travelers viewing the video or still images to recognize the source as a MnDOT camera, such as the video layover, website branding, or other common display approaches.
17. MnDOT needs an approach and supporting systems to assist in responding to requests for video clips appropriately.	17.1 The video application shall provide a mechanism for MnDOT to generate video clips of buffered or archived video to send to individuals that have requested video in accordance with MnDOT data retention policies.
CAV Infrastructure Systems and CAVs	
18. Individuals responsible for operating CAV infrastructure systems need visual verification of infrastructure status (e.g. traffic signal phase, road	18.1 Selection of camera locations shall consider the use of video to monitor connected signalized intersections broadcasting SPaT/MAP messages to allow the use of video from cameras positioned to view current signal light displays to contrast with data received and displayed on monitoring devices.

Need	System Requirement
work lane closures) to validate messages broadcast to CAVs.	18.2 Selection of camera locations shall consider the use of video to monitor CAV infrastructure systems that are broadcasting work zone or lane closure data to view camera images to compare with data received and displayed on monitoring devices. 18.3 Selection of camera locations shall consider the use of video to monitor CAV infrastructure systems to rely on video or video processing to generate data to compare and assess operational status of systems.

Relationship to the National ARC-IT and Minnesota ITS Architecture

The Minnesota Statewide Regional ITS Architecture presents a vision for how ITS systems work together, share resources, and share information. The 2018 update to the ITS Architecture represents the latest status of Minnesota, as captured through outreach meetings and input from stakeholders statewide. As such, the Minnesota ITS Architecture was a valuable input to the development of this documents, supporting:

- Identification of stakeholders;
- Definition of needs for video;
- Concepts for the use of video; and
- Overall input to the requirements.

The Minnesota ITS Architecture enabled the Project Team to build upon the content of the architecture and clarify specifics for this document.

In addition to the role of supporting the development of this document, the Minnesota Statewide Regional ITS Architecture and the National Architecture Reference for Cooperative and Intelligent Transportation (ARC-IT) will continue to serve as a resource for the agencies that utilize this document as they prepare for deployment. Table 15 below identifies the needs/potential solutions included in the Minnesota ITS Architecture that are addressed through concepts for the use of video described in this document, as well as references to Service Packages and processes as defined in the ARC-IT. Finally, the far right column identifies the video stakeholder need(s) that were influenced or derived based on each service package.

Table 15: Summary of Local and National ITS and CAV Architecture References Mapped to Video Needs

MN Statewide Regional ITS Architecture: Need/Potential Solutions	ARC-IT: Service Packages	ARC-IT: Processes	Video Stakeholder Needs Influenced by each Service Package
• ATMS04 Provide cameras at locations with high incidents for incident identification and verification	• TM08 Traffic Incident Management System	• Process traffic images • Video surveillance control (information flow) • Process Video Data	• Need 6. Remote camera control and live viewing • Need 10. Minimum performance measures
• ATIS15 Make camera images available to travelers	• TM01 Infrastructure Based Traffic Surveillance	• Process Video Data	• Need 7. Block video access • Need 11. External access to high quality video • Need 12. External access to low or medium quality video
• ATMS25 Operate CCTV Cameras	• TM12 Dynamic Roadway Warning	• Process traffic images • Video surveillance control (information flow) • Process Video Data	• Need 6. Remote camera control and live viewing • Need 7. Block video access • Need 8. Buffer video • Need 9. Archive video • Need 10. Minimum performance measures

MN Statewide Regional ITS Architecture: Need/Potential Solutions	ARC-IT: Service Packages	ARC-IT: Processes	Video Stakeholder Needs Influenced by each Service Package
• ATMS39 Monitor queue length at ramps, incident scenes and work zones	• MC06 Work Zone Management	• Process traffic images • Operate Work Zone Devices	• Need 6. Remote camera control and live viewing • Need 7. Block video access • Need 8. Buffer video • Need 9. Archive video • Need 10. Minimum performance measures • Need 13. Remote access to video
• ATMS04 Provide cameras at locations with high incidents for incident identification and verification	• TM08 Traffic Incident Management System	• Process traffic images • Video surveillance control (information flow) • Process Video Data	• Need 6. Remote camera control and live viewing • Need 10. Minimum performance measures
• ATMS44 Provide incident detection systems	• TM08 Traffic Incident Management System	• Process traffic images • Video surveillance control (information flow) • Process Video Data	• Need 6. Remote camera control and live viewing • Need 10. Minimum performance measures
• ATMS29 Provide automated/remote control gate systems	• TM19 Roadway Closure Management	• Video surveillance control (information flow) • Process Video Data • Operate Work Zone Devices	• Need 6. Remote camera control and live viewing • Need 10. Minimum performance measures

MN Statewide Regional ITS Architecture: Need/Potential Solutions	ARC-IT: Service Packages	ARC-IT: Processes	Video Stakeholder Needs Influenced by each Service Package
• ATMS39 Monitor queue length at ramps, incident scenes and work zones	• TM12 Dynamic Roadway Warning	• Process traffic images • Video surveillance control (information flow) • Process Video Data	• Need 6. Remote camera control and live viewing • Need 7. Block video access • Need 8. Buffer video • Need 9. Archive video • Need 10. Minimum performance measures
• ATMS50 Keep drivers off the roads during winter storms	• TM01 Infrastructure Based Traffic Surveillance	• Process Video Data	• Need 7. Block video access • Need 11. External access to high quality video • Need 12. External access to low or medium quality video
• PSFT13 Provide real-time Digital Video Recordings (DVR)	• PS01 Emergency Call-Taking and Dispatch • PS02 Routing Support for Emergency Responders • PS06 Incident scene pre-arrival staging guidance for emergency responders	• Process Video Data	• Need 8. Buffer video • Need 9. Archive video

Model Test Plan

This section presents a model test plan to support testing and validation activities during the integration and deployment stages of video to confirm that the system is developed, installed and operating as specified by the system requirements.

Each video deployment will be different, and the testing and validation performed will likely vary depending upon the complexity of the system and the familiarity with the vendor products.

The table below provides a series of testing instructions related to the requirements presented above. The intent is that agencies using this model systems engineering document will incorporate these tests into their overall testing and validation plans, adapting them as needed.

Column 3 in the table below describes 'testing instructions' for each requirement. The video requirements include a range of requirement types and therefore the testing instructions vary. The following bullet list explains the approach to different testing instructions:

- *Advisory requirement – no testing required:* This is noted for requirements that are primarily operational advice (e.g. the locating and use of video) and therefore no formal testing is required;

- *Design:* these test instructions are used to describe testing in the form of design reviews or documentation reviews describing the video. These are typically not physical tests, but rather reviews of processes or documents;

- *Factory Acceptance Tests (FAT):* These represent recommendations for FATs to allow the agency deploying the video to verify the quality assurance / quality control and video operational parameters at the site of manufacturing and assembly. This can involve the procuring agency on-site at the vendor factory testing the actual equipment to be delivered or the reports of previous tests of components, software, or features;

- *Field:* These represent recommendations for tests to be conducted in MnDOT offices or the field to test the actual deployment and functionality of the video.

Table 16: Model Test Plan for Video

	System Requirement	Testing Instructions	Type of Result	Comments / Notes
1.1	The overall video application shall provide a mechanism for administrators to add and delete cameras such that the cameras can be controlled, and video captured by the overall application.	Design – Confirm that the design allows administrators to add and delete cameras for control and video capture by the overall application. Field – Confirm that administrators can add and delete cameras for control and video capture by the overall application.	Design - Content Review Field - Pass/Fail	
1.2	The overall video application shall support remote configuration of the cameras (i.e. not require administrators to be at the site of the cameras when configuring).	Design – Confirm that the design allows cameras to be configured remotely. Field – Confirm that the camera can be configured remotely.	Design - Content Review Field - Pass/Fail	
1.3	The overall video application shall provide a mechanism for administrators to add and delete temporary portable cameras that can be controlled by the video application.	Design – Confirm that the design allows administrators to add and delete temporary portable cameras that can be controlled by the overall application. Field – Confirm that administrators can add and delete temporary portable cameras that can be controlled by the overall application.	Design - Content Review Field -Pass/Fail	
2.1	The video application shall provide a mechanism for administrators to create and manage user groups for assigning access and privileges.	Design – Confirm that the design includes a mechanism for administrators to create and manage user groups for assigning access and privileges. Field – Confirm that administrators can create and manage user groups for assigning access and privileges.	Design - Content Review Field -Pass/Fail	
2.2	The video application shall provide a mechanism for administrators to assign unique privileges and functionality to support each user group that include	Design – Confirm that the design includes a mechanism for administrators to assign unique privileges and functionality to support each user group, including viewing only, adjusting view	Design - Content Review	

	viewing only, adjusting view (panning/zooming), turning off live streaming when necessary, adding new users and assigning groups, updating existing users' information, and deleting users.	(panning/zooming), turning off live streaming when necessary, adding new users and assigning groups, updating existing users' information, and deleting users. Field – Confirm that administrators can assign unique privileges and functionality to support each user group, including viewing only, adjusting view (panning/zooming), turning off live streaming when necessary, adding new users and assigning groups, updating existing users' information, and deleting users.	Field -Pass/Fail	
2.3	The video application may provide a mechanism for administrators to track number of simultaneous connections bandwidth usage by user group.	Design – Confirm that the design includes a mechanism for administrators to track number of simultaneous connections bandwidth usage by user group, if applicable. Field – Confirm that administrators can track the number of simultaneous connections bandwidth usage by user group, if applicable.	Design - Content Review Field -Pass/Fail	
2.4	The video management application shall provide a mechanism for administrators to manage system upgrades, testing, maintenance, and outages, including notifying operators and user groups of expected periods without access to video from one or more cameras.	Design – Confirm that the design includes a mechanism for administrators to manage system upgrades, testing, maintenance, and outages, including notifying operators and user groups of expected periods without access to video from one or more cameras. Field – Confirm that administrators can manage system upgrades, testing, maintenance, and outages, including notifying operators and user groups of expected periods without access to video from one or more cameras.	Design - Content Review Field -Pass/Fail	

3.1	Video cameras shall only be installed after design and deployment of a structure.	Design – Confirm that the camera field equipment designs include appropriate structure support designs and considerations.	Content Review	
3.2	Video camera installation design shall include the approach to mounting and housing the camera, considering external environmental factors.	Design – Confirm that the design includes the approach for mounting and housing the camera.	Content Review	
3.3	Video camera installation design shall be in accordance with requirements for roadway clearance and crashworthiness (e.g. breakaway structures or protected as needed).	Design – Confirm that the design is in accordance with requirements for roadway clearance and crashworthiness. FAT – Confirm that components meet current requirements for roadway clearance and crashworthiness.	Design - Content Review FAT - Pass/Fail	
3.4	Video camera installation design shall include power connections.	Design – Confirm that the design includes power connections.	Content Review	
3.5	Video camera installation design shall include communications connections.	Design – Confirm that the design includes communications connections.	Content Review	
3.6	Video camera installation design shall include electrical grounding and surge suppression.	Design – Confirm that the design includes electrical grounding and surge suppression.	Content Review	
3.7	Video camera installation design shall include site range considerations (including consideration of obstructions, solar glare, nearby ITS and CAV equipment, and seasonal aspects).	Design – Confirm that the design includes site range considerations, including consideration of obstructions, solar glare, nearby ITS and CAV equipment, and seasonal aspects.	Content Review	
3.8	Temporary video cameras shall be installed by technicians and installers in approved locations with power and communications.	Design – Approve appropriate locations for installing temporary video cameras. Field – Confirm that location is approved and includes power and communications.	Design - Content Review Field -Pass/Fail	
4.1	Video cameras shall be tested, certified, and labeled by NRTL as acceptable under	FAT – Confirm that components are acceptable under OSHA regulations in order to be installed by technicians and installers.	Pass/Fail Pass/Fail	

	OSHA regulations in order to be installed by technicians and installers.	Field – Confirm that video cameras are labelled as certified for OSHA regulations.		
4.2	Video cameras shall include installation instructions and guidelines from the camera vendor for technicians and installers to rely upon during installation.	FAT – Confirm that installation instructions and guidelines can be relied on by technicians and installers for safe installation. Field – Confirm instructions and guidelines for safe installation are available.	Pass/Fail	
4.3	Technicians and installers shall perform appropriate TTC in compliance with the MUTCD when installing or performing field work on cameras.	Design – Confirm that a TTC plan in compliance with the MUTCD is available for installing and maintaining the cameras.	Content Review	
5.1	Video cameras that are in-place shall continue to be used as new video cameras are added.	Advisory requirement – no testing required	N/A	
5.2	As new cameras are procured (either for new locations or to replace existing cameras) IP-based cameras shall be deployed unless external factors prevent their use.	Design – Confirm in the design that the new camera is IP-based, unless external factors prevent this.	Content Review	
5.3	Newly procured video cameras and housing units shall be consistent with in-place video cameras to the extent possible as technicians and installers are well-trained to install and repair these devices and can interchange parts.	Design – Confirm in the design that the new camera and housing unit are consistent with in-place video cameras to the extent possible.	Content Review	
5.4	Newly purchased and installed video cameras shall be compatible with existing equipment and systems such as communications (fiber, etc.) and the video management systems.	Design – Confirm in the design that the new camera is compatible with existing equipment and systems such as communications and the video management systems. Field – Confirm new camera is compatible with existing equipment and systems such as communications and the video management systems.	Design - Content Review Field -Pass/Fail	

5.5	New video cameras shall use appropriate protocols where needed and open standards when available.	Design – Confirm that the design uses available open standards and appropriate protocols for video cameras.

FAT – Confirm that available open standards and appropriate protocols for the video cameras are met. | Design - Content Review

FAT - Pass/Fail | |
| 6.1 | The video application shall provide a mechanism for authorized operators to control video cameras remotely. | Design – Confirm that the video application design includes a mechanism for authorized operators to control video cameras remotely.

Field – Confirm that authorized operators can control video cameras remotely. | Design - Content Review

Field -Pass/Fail | |
| 6.2 | The video application shall manage the control of cameras by multiple users and presets happening at scheduled times. | Design – Confirm that the video application design allows the video application to manage the control of cameras by multiple users and presets happening at scheduled times.

Field – Confirm that the video application can manage the control of cameras by multiple users and presets happening at scheduled times. | Design - Content Review

Field -Pass/Fail | |
| 6.3 | The video application shall provide a mechanism for operators to view real-time full motion video and to select the specific display location for viewing video from cameras. | Design – Confirm that the video application design includes a mechanism for operators to view real-time full motion video and to select the specific display location for viewing video from cameras.

Field – Confirm that operators can view real-time full motion video and to select the specific display location for viewing video from cameras. | Design - Content Review

Field -Pass/Fail | |
| 6.4 | The video application shall provide a mechanism for operators to view the geographic location of cameras in order to find the nearest video camera to a selected location. | Design – Confirm that the video application design includes a mechanism for operators to view the geographic location of cameras in order to find the nearest video camera to a selected location. | Design - Content Review | |

		Field – Confirm that operators can view the geographic location of cameras for finding the nearest video camera to a selected location.	Field -Pass/Fail	
6.5	The video application shall provide a mechanism for operators to configure selected video cameras to home/default pan/zoom positions for prominent display in the operations center.	Design – Confirm that the video application design includes a mechanism for operators to configure selected video cameras to home/default pan/zoom positions for prominent display in the operations center. Field – Confirm that operators can configure selected video cameras to home/default pan/zoom positions for prominent display in the operations center.	Design - Content Review Field -Pass/Fail	
6.6	The video application shall provide a mechanism for operators to have full 360 degree panning of the cameras.	Design – Confirm that the video application design includes a mechanism for operators to have full 360 degree panning of the cameras. Field – Confirm that operators have full 360 degree panning of the cameras.	Design - Content Review Field -Pass/Fail	
6.7	Video cameras shall be capable of panning a full 360 degrees.	Design – Confirm that the design includes video cameras capable of panning a full 360 degrees. Field – Confirm that video cameras can pan a full 360 degrees.	Design - Content Review Field -Pass/Fail	
6.8	The video application shall provide a mechanism for operators to view video from temporary cameras, installed at work zones or event locations.	Design – Confirm that the video application design includes a mechanism for operators to view video from temporary cameras, installed at work zones or event locations. Field – Confirm that operators can view video from temporary cameras, installed at work zones or event locations.	Design - Content Review Field -Pass/Fail	
6.9	The video application shall provide a mechanism for operators to understand	Design – Confirm that the video application design includes a mechanism for operators to understand if	Design - Content Review	

	if any video cameras are not functioning or have lost communications.	any video cameras are not functioning or have lost communications. Field – Confirm that operators can understand when video cameras are not functioning or have lost communications.	Field -Pass/Fail	
6.10	The video application shall provide a mechanism for users to restore connections and restart cameras that are not responding.	Field – Confirm that users can restore connections and restart cameras that are not responding.	Pass/Fail	
6.11	The video application shall use appropriate protocols where needed and open standards when available for camera control.	Design – Confirm that the video application design uses available open standards and appropriate protocols for camera control. FAT – Confirm that available open standards and appropriate protocols for camera control are met.	Design - Content Review FAT - Pass/Fail	
6.12	The video application shall support video switching with external 'consumers' of the video.	Field – Confirm that the video application supports video switching with external 'consumers' of the video.	Pass/Fail	
7.1	The video application shall provide a mechanism for operators to temporarily block the live video to outside organizations while still enabling viewing by the operators during situations where video cameras are capturing images of situations that are sensitive or a security risk.	Field – Confirm that the operators can temporarily block the live video to outside organizations while still enabling viewing by the operators.	Pass/Fail	
7.2	The video application shall provide a mechanism for operators to select the camera(s) to be blocked, while still allowing outside users to access video from other cameras.	Field – Confirm that operators can block select cameras for outside users, while allowing them to access video from other cameras.	Pass/Fail	

8.1	The video application shall provide a mechanism for operators to buffer video (i.e. temporarily store video to allow playback and archiving within the buffer period).	Field – Confirm that video from cameras is being buffered for a period of time, and that operators can select to archive video within the buffer period.	Pass/Fail	
8.2	The period of time video is buffered by the system shall be configurable by operators or administrators.	Field – Confirm that operators or administrators can configure the period of time video is buffered by the system.	Pass/Fail	
8.3	The video application shall provide a mechanism for operators to access and view video from cameras recorded recently (buffered video) to help understand recent activities regarding an event as they manage the event.	Design – Confirm that the video application design includes a mechanism for users to restore connections and restart cameras that are not responding. Field – Confirm that users can restore connections and restart cameras that are not responding.	Design - Content Review Field -Pass/Fail	
8.4	The video application shall provide a mechanism for users to search and retrieve recorded video using search criteria such as camera, time of day, day of year.	Design – Confirm that the video application design includes a mechanism for users to search and retrieve recorded video using search criteria like camera or day of year. Field – Confirm that users can search and retrieve recorded video using search criteria.	Design - Content Review Field -Pass/Fail	
8.5	The video application shall provide a mechanism for operators to permanently archive buffered video following a request from others in or outside of their organization to access the buffered video, as operators decide is appropriate.	Design – Confirm that the video application design includes a mechanism for operators to permanently archive buffered video. Field – Confirm that operators can permanently archive buffered video.	Design - Content Review Field -Pass/Fail	
9.1	The video application shall provide a mechanism for operators to select a time period and camera that they wish to archive video after events occur.	Design – Confirm that the video application design includes a mechanism for operators to select a time period and camera that they wish to archive video after events occur.	Design - Content Review	

		Field – Confirm that operators can select a time period and camera that they wish to archive video after events occur.	Field -Pass/Fail	
9.2	The video application shall provide a mechanism for operators to archive a time period of video from a specific camera following a request from others in or outside of their organization in order to support incident analyses, safety improvements, or training efforts, as operators decide is appropriate.	Design – Confirm that the video application design includes a mechanism for operators to archive a time period of video from a specific camera. Field – Confirm that operators can archive a time period of video from a specific camera.	Design - Content Review Field -Pass/Fail	
9.3	The video application shall provide a mechanism for operators to archive video during the time period that it is still available in the buffer.	Design – Confirm that the video application design includes a mechanism for operators to archive video during the time period that it is still available in the buffer. Field – Confirm that operators can archive video during the time period that it is still available in the buffer.	Design - Content Review Field -Pass/Fail	
9.4	The video application shall permanently save video that is specifically selected for archive.	Design – Confirm that the video application is designed to permanently save video that is specifically selected for archive. Field – Confirm that the video application permanently saves video that is specifically selected for archive.	Design - Content Review Field -Pass/Fail	
9.5	The video application shall remove all video that is buffered at the end of the buffer date, unless it is specifically selected for archive, in response to data practices considerations as well as storage requirements.	Design – Confirm that the video application is designed to remove all video that is buffered at the end of the buffer date, unless it is specifically selected for archive. Field – Confirm that the video application removes all video that is buffered at the end of the buffer date, unless it is specifically selected for archive.	Design - Content Review Field -Pass/Fail	

10.1	The video application shall provide a mechanism for operators to see immediate real-time impacts with unnoticeable delay between the pan/zoom request and camera reaction.	Field – Confirm that operators can see immediate real-time impacts with unnoticeable delay between the pan/zoom request and camera reaction.	Pass/Fail	
10.2	The video cameras shall be positioned and have sufficient zoom capabilities to enable operators to view details of vehicles and objects in the road and surrounding areas.	Design – Confirm that the procurement documents for video cameras includes specifications for sufficient zoom capabilities so operators can view details of vehicles and objects in the road and surrounding areas. Field – Confirm that operators can zoom cameras to view details of vehicles and objects in the road and surrounding areas.	Design - Content Review Field -Pass/Fail	
11.1	The video application shall provide a mechanism for media providers to view and display to their viewers video from MnDOT cameras during on-air broadcasts that is of sufficient quality for media use in all conditions.	Design – Confirm that the video application design includes sufficient bandwidth in outbound communications of video to enable transfer of video with sufficient quality for media display. Field – Confirm that media providers can view and display to their viewers video from MnDOT cameras during on-air broadcasts that is of sufficient quality for media use in all conditions.	Design - Content Review Field -Pass/Fail	
11.2	The video application shall provide a web interface for media to select the camera to stream.	Design – Confirm that the video application design includes a web interface for media to select the camera to stream. Field – Confirm that the web interface allows media to select the camera to stream.	Design - Content Review Field -Pass/Fail	
12.1	The video application shall provide a mechanism for media to view video to create reports that are verbally or textually relayed to travelers, in addition	Field – Confirm that media can view video to create reports that are verbally or textually relayed to travelers, in addition to broadcasting live video streams to viewers.	Pass/Fail	

	to broadcasting live video streams to viewers.			
13.1	The video application shall provide video access to public safety agencies (e.g. law enforcement and emergency responders) to view live video.	Design – Confirm that the video application design anticipates video access for public safety agencies to view live video. Field – Confirm that public safety agencies have video access to view live video.	Design - Content Review Field -Pass/Fail	
13.2	The video application shall provide a mechanism for emergency and maintenance response dispatchers to view video to assess response and resources needed during incidents.	Design – Confirm that the video application design includes a mechanism for emergency and maintenance response dispatchers to view video. Field – Confirm that emergency and maintenance response dispatchers can view video.	Design - Content Review Field -Pass/Fail	
14.1	MnDOT procedures shall allow for phone or email requests from partner public safety agencies to perform video camera panning and zooming such that public safety agencies can better view conditions.	Advisory requirement – no testing required	N/A	
15.1	The video application shall provide video feeds that can be accessed by traveler information service providers and researchers.	Design – Confirm that the video application design can provide video access to external systems. Field – Confirm that external systems can access video.	Design - Content Review Field -Pass/Fail	
15.2	The video application shall provide one or more optional ways for researchers and other information providers viewing the video to recognize the source as a MnDOT camera, such as the video overlay.	Design – Confirm that the video application design allows for one or more optional ways for the general public viewing the video to recognize the source as a MnDOT camera. Field – Confirm that public websites displaying video or still images are not blocking or preventing the public from viewing the source as a MnDOT camera.	Design - Content Review Field -Pass/Fail	

16.1	The video application shall provide a mechanism for MnDOT operated websites to display video to web site visitors.	Design – Confirm that the video application design includes a mechanism for MnDOT operated websites to display video to web site visitors. Field – Confirm that MnDOT operated websites can display video to web site visitors.	Design - Content Review Field -Pass/Fail	
16.2	The video application shall provide a mechanism for other third-party traveler information providers to access video and snapshot pictures generated by MnDOT video cameras..	Field – Confirm that other third-party traveler information websites can access video and still images from MnDOT video cameras.	Pass/Fail	
16.3	The video application shall provide one or more ways for the travelers viewing the video or still images to recognize the source as a MnDOT camera, such as the video layover, website branding, or other common display approaches.	Design – Confirm that MnDOT has an approach in place for those viewing video or still images from third party sites to know the source is MnDOT. Field – Confirm that other third-party traveler information websites are not blocking or preventing the display of MnDOT as the source of video and still images.	Design - Content Review Field -Pass/Fail	
17.1	The video application shall provide a mechanism for MnDOT to generate video clips of buffered or archived video to send to individuals that have requested video in accordance with MnDOT data retention policies.	Design – Confirm that the Video Application design includes a mechanism for MnDOT to Create video clips of buffered or archived video into a format that can be emailed. Field – Confirm that MnDOT can create video clips of video that is either buffered or archived.	Design - Content Review Field -Pass/Fail	

18.1	Selection of camera locations shall consider the use of video to monitor connected signalized intersections broadcasting SPaT/MAP messages to allow the use of video from cameras positioned to view current signal light displays to contrast with data received and displayed on monitoring devices.	Advisory requirement – no testing required	N/A	
18.2	Selection of camera locations shall consider the use of video to monitor CAV infrastructure systems that are broadcasting work zone or lane closure data to view camera images to compare with data received and displayed on monitoring devices.	Advisory requirement – no testing required	N/A	
18.3	Selection of camera locations shall consider the use of video to monitor CAV infrastructure systems to rely on video or video processing to generate data to compare and assess operational status of systems.	Advisory requirement – no testing required	N/A	