MnDOT Central Traffic Signal Control Software
Systems Engineering Analysis
Concept of Operations
Version 4.0

Introduction and System Overview

Transportation agencies use a variety of localized and centralized signal control software to manage traffic operations. Such operations may include among other things signal timing, intersection monitoring, modifications to timing plans and maintenance. The Minnesota Department of Transportation (MnDOT) operates signal systems that require a combination of both localized and centralized control. Localized signal control may be managed in the field via the signal controller cabinet or remotely via a dial-up telephone connection to the controller. Localized control of this nature is cumbersome and limits automated monitoring and alert functions that can otherwise be performed on signal systems that are controlled centrally. Most of the signals operating under localized control are on lower volume, less critical routes. Most are also operated using Aries, a Windows-based data management and monitoring system for arterial control systems that is manufactured by Econolite.

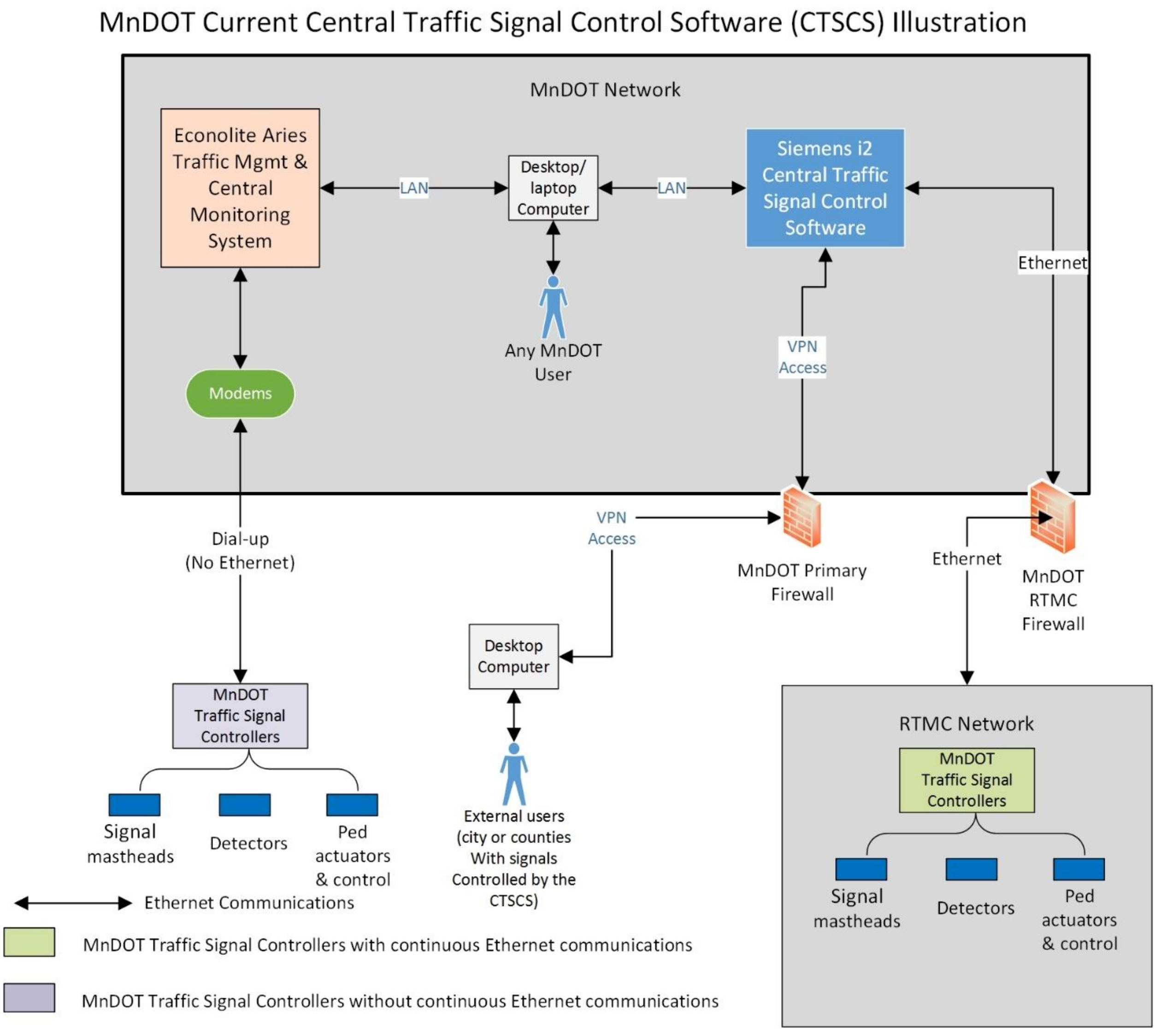
Centralized signal control allows MnDOT to manage operations remotely via higher speed, constant communications with the field. This type of control is used on approximately one-third of MnDOT's Metro District signal system, particularly those at high-volume, more critical routes. The current central control is i2 by Siemens. The i2 system is an integrated, interagency traffic management system that provided interfaces to multiple plug-in software modules and devices. It is designed to accommodate the multi-device, multi-jurisdiction expansion necessary for today's marketplace.

MnDOT maintains a variety of signal controllers for traffic operations, including the ASC/3, ASC/2S and ASC/2 AB3418 models manufactured by Econolite, and the Eagle NTCIP and Eagle ECOM models manufactured by Siemens.

The department also uses Synchro V7 (and soon V9) developed by Trafficware for traffic analysis, optimization and simulation applications. Data from active signal controllers is imported to Synchro for analysis and optimization, and once complete results are transferred from Synchro to the signal controller programming. Figure 1 provides an overview of the current system operated by MnDOT.

The Siemens i2 control system is no longer offered by Siemens and will no longer be supported. This is the primary driver behind MnDOT's procurement of a new Central Traffic Signal Control Software (CTSCS) system. This concept of operations is part of an overall systems engineering analysis being conducted to support MnDOT's procurement. The systems engineering analysis is required in 23 CFR 940 and it allows Intelligent Transportation Systems (ITS) projects such as this to move forward with proper consideration of interoperability and future expansion. Additionally, 23 CFR 940 also requires ITS projects to comply with national and regional ITS architectures. This fosters integration of the deployment of regional ITS systems and components. CTSCS is part of the Advanced Traffic Management Systems Service Package (ATMS03 Traffic Signal Control) in the Minnesota Statewide Regional ITS Architecture. Completing the systems engineering analysis will allow MnDOT to enhance its financial effectiveness while conforming to federal regulations and working cooperatively with its partners to achieve greater safety, mobility and efficiency. The concept of operations presents the fundamental needs that MnDOT has for the CTSCS, as well as the operational concepts that illustrate how the system will be used to control traffic signals operated by the department. The needs in this document serve as the basis for systems requirements that will be used to develop specifications for the procurement process.

Figure 1 Overview of Current CTSCS



Stakeholders

There are several stakeholders affected by the CTSCS procurement. Because the procurement is being led at this time by MnDOT's Metro District, the traffic staff who manages signal operations in the Twin Cities Metro Area are the primary stakeholders. MnDOT desires this procurement process to set the stage for further use of the same CTSCS throughout all MnDOT districts. The Office of Traffic, Safety and Technology also has vested interest in the CTSCS procurement as the software will be used to operate traffic signal hardware that is maintained by the office's Electrical Service Section throughout the state. The department has also invited local partners to participate in the process as many of them are also considering new control systems and in cases where traffic operations are shared across jurisdictions, having similar control systems would be beneficial. Finally, as a state agency, MnDOT also works with MN.IT in regard to any information technology services, including the procurement of new software such as CTSCS. MN.IT provides technical support to the State of Minnesota's executive branch and to other customers in Minnesota government. Their IT planning and investment oversight role includes portfolio management and contract approvals. They provide an enterprise view of state IT activity that highlights opportunities for collaboration and helps state leadership prioritize investments. Following is a list of the stakeholders who have expressed their needs for the new CTSCS.

- MnDOT Metro District Traffic Staff
- Other MnDOT District Traffic Staff
- MnDOT Office of Traffic, Safety and Technology-Electrical Services Section Staff
- MN.IT
- Local Partners

Needs

This section presents a series of needs that have been identified for the MnDOT CTSCS. Needs were identified through discussions with stakeholders. The needs are described below and numbered for identification and traceability purposes.

Need 1: MnDOT needs to control any department-operated traffic signal controller that is equipped with continuous communications (e.g. Ethernet) capabilities and also supports NTCIP 1202 Actuated Signal Controller (ASC) management information base (MIB) codes, from one central system.

Need 2: MnDOT needs central control software to be easy to use and convenient, supporting both regular operators who will work with it daily and occasional operators.

Need 3: MnDOT needs central control software to be compatible with MnDOT hardware and software environments, as well as the Minnesota Statewide Regional ITS Architecture.

Need 4: Operators need easy access to real-time signalized intersection information.

Need 5: Operators need to upload and download traffic control operations to traffic signal controllers, and perform quick and full compare functions.

Need 6: Operators need to use traffic synchronization tools in conjunction with the CTSCS to help develop signal timing plans.

Need 7: MnDOT needs to accommodate multiple operators with various privilege levels, who may access the system at any time, including simultaneous use.

Need 8: MnDOT needs the option to allow other jurisdictions the ability to view and/or control selected signalized intersections and the ability to view and/or control signalized intersections in neighboring jurisdictions.

Need 9: MnDOT needs the CTSCS to support multiple control modes to meet various conditions.

Need 10: MnDOT needs data describing signalized intersections to be saved in a manner that supports access by others and archiving capabilities.

Need 11: MnDOT needs the CTSCS to generate a variety of operations, maintenance, and performance reports in useful formats.

Need 12: MnDOT needs the CTSCS to operate reliably, with minimum downtime.

Need 13: MnDOT needs the CTSCS to have training, technical support and online help features to support operator questions about technical issues.

Need 14: MnDOT and partnering agencies need to access the CTSCS from various office locations throughout Minnesota.

Need 15: MnDOT staff needs to access the CTSCS from mobile devices, such as tablets or cell phones, although not all functionality needs to be available from mobile devices.

Need 16: MnDOT needs the CTSCS to support traffic signal performance measure calculations.

Need 17: MnDOT needs the CTSCS to allow customization and flexibility in the user interface, without requiring software code changes (e.g. the ability to select the parameters that appear when hovering the mouse over an object).

It is important to note that MnDOT is proposing a Connected Vehicle demonstration project to the Federal Highway Administration. If the project is awarded funding, the resulting deployment may create additional sources of traffic detection in the form of Connected Vehicles. MnDOT may desire an interface between such sources and the CTSCS. The needs listed above, as well as the operational concept described in the next section, do not currently address this interface because information about such an interface is not yet available. Any new needs resulting from the Connected Vehicles project will be identified and discussed with potential CTSCS vendors as the project progresses.

Operational Concept

This section describes the operational concept in relation to 18 areas of functionality that will be provided by the CTSCS. Each piece of the concept is further described in terms of how it will address the stakeholder needs identified in the previous section. The original needs identified in the previous section are noted in parentheses following each description of the operational concept. The operational concept is intended to help each stakeholder group see how their needs have been interpreted and how the system is expected to address their needs. Each piece of the description is also numbered for reference purposes.

1. Graphical User Interface

1.1. Operators will want to see and work with field devices located on a map in the central control software. (Need 2)

1.2. Operators may be simultaneously monitoring field device operations and controlling modifications to them. (Need 2)

1.3. Operators will use tools and features they are familiar with (e.g. pop-up windows, dialog boxes, menu icons). (Needs 2, 3, 17)

1.4. Operators will customize the user interface settings to suit their preferences. (Needs 2, 17)

1.5. Operators will use a map in the user interface to view all field devices connected to the CTSCS and require a map displaying their locations to do so. (Need 4)

1.6. Operators will use screen captures and annotated text to share information with other operators or jurisdictions. (Need 4)

1.7. Operators will view a map displaying of status for all signals controlled by their agency. (Need 4)

1.8. Operators will pan/zoom the map to view any of the intersections controlled by the system. (Need 4)

1.9. Operators will mouse over intersections to view detailed signal phase status. (Need 4)

1.10. As operators zoom to specific intersections or corridors, the map should present real-time intersection information. (Need 4)

1.11. Operators will view general signal status at higher zoom levels. (Need 4)

1.12. Operators needing additional information will zoom the map to examine closer views of the intersections, where additional information will be available. (Needs 2, 4, 17)

1.13. Operators may quickly access their specific area using zoom, pull down menus or individual operator settings. (Need 4)

1.14. Operators will save their preferred map area displayed for future access. (Need 4)

1.15. Operators will use one CTSCS to view the status of all traffic signals controlled by the system. (Need 1)

1.16. Operators will have the option of viewing background satellite images overlaid on the map to understand the geometries and other physical characteristics of the intersection. (Need 4)

1.17. Operators will use the CTSCS map display to select one or more intersections and view information about the current demand at the intersection and signal control plan in operation, including: (Need 4)

- The geographic layout of the intersection(s);
- The location of detectors;
- The location of signal controllers;
- The current signal plan and phasing in operation;
- The current green, yellow, red displays to travelers (including flashing yellow arrow); and
- The most recent detector data recorded.

1.18. Operators will use the interface to place a demand on one or more detectors, effectively replicating a vehicle crossing a detector, and the system will communicate this demand to the local controller. (Need 4)

1.19. The creation of the graphical map display will be supported by customized graphics that are used by MnDOT to diagram intersections. (Need 4)

1.20. Operators will have the option of selecting a group of intersections and be able to view the current green for all signalized intersections in the group. (Need 4)

1.21. Operators will have the capability of opening multiple windows, including multiple map displays and text displays. (Need 4)

1.22. The operator will always be viewing the most recent data that has been received by the CTSCS from field devices during the most recent data poll. (Need 4)

1.23. Operators will use the map interface to view ITS devices not controlled by the CTSCS (e.g. DMS, CCTV) located at intersections, including text descriptions of their capabilities. (Need 4)

2. Signal Timing Database Management

2.1. The operator will have the ability to select for the CTSCS to download data describing traffic signal control operations from the CTSCS to the field controller, or to upload data from the field controller to CTSCS. (Need 5)

2.2. Operators will have the option of archiving data related to signal timing plans and other control attributes for use later or by other intersections. (Need 5)

2.3. When operators use a database to generate traffic control operations, the CTSCS will include safeguards to avoid unacceptable operations. (Need 5)

2.4. Operators will have the option to copy traffic control operations implemented at one intersection and deploy it to other intersections. (Need 5)

2.5. Operators will have the option to schedule upload or download of traffic control operations parameters to intersection controllers. (Need 5)

2.6. Operators will have the ability initiate a process for Synchro to determine a new timing plan for one or more intersections and to incorporate the Synchro generated timing plan into the CTSCS and the intersection controllers. (Need 6)

3. Traffic Signal Controller Interface

3.1. Operators will execute a login process to gain access to the CTSCS, including specific access and control privileges. (Need 3)

4. Operator / User Access to CTSCS

4.1. Multiple operators will access and use the CTSCS simultaneously, with various levels of privileges. (Need 7)

4.2. Operators will execute a login process to gain access to the CTSCS, including specific access and control privileges. (Need 7)

4.3. MnDOT operators will use the CTSCS to view and/or control signalized intersections in neighboring jurisdictions. (Need 8)

4.4. The primary users will be traffic operations staff accessing the system from computers connected to the MnDOT Intranet. This will include the Metro District Traffic Staff who have responsibility for the traffic signals in the Twin Cities metro area, and traffic operations staff in other MnDOT district offices responsible for signal operations in their respective districts. (Need 14)

4.5. Operators will also access the CTSCS from locations outside MnDOT offices (including MnDOT employees and/or contractors, neighboring jurisdictions, or other authorized users with VPN access to the MnDOT network). (Needs 8, 14)

4.6. Operators will access the CTSCS from mobile devices. For example staff in the field may use an Internet accessible mobile tablet while at the intersection to access the CTSCS and download a signal timing plan rather than making a manual change directly to the field controller. (Need 15)

4.7. Operators within MnDOT facilities or off-site will access the CTSCS from laptop computers. (Needs 4, 5)

5. Control Modes

5.1. Operators will enter commands into the CTSCS to control one or more signalized intersections and the CTSCS will execute the commands. (Need 5)

5.2. Operators viewing information in the CTSCS will view real-time changes at the field controllers, with updates no less frequent than once per second. (Need 5)

5.3. In situations where a change is implemented to the signal timing plan by an operator manually adjusting the controller at the cabinet, the CTSCS will notify operators that a field change has been implemented. (Need 4)

5.4. The CTSCS will operate to control all connected traffic signal controllers 24 hours per day, seven days per week, regardless of whether any operators are logged in. (Need 5)

5.5. Operators will have the ability to control traffic signal controllers using ‘manual mode.’ (Need 5)

5.6. Operators will select to operate the CTSCS in Time-of-Day (TOD)/Day-of-Week (DOW) mode. (Need 5)

5.7. Operators will select to operate the CTSCS in Traffic Responsive Control Mode. (Need 5)

5.8. Traffic signal controllers connected to the CTSCS will support vehicle actuated signal priority operation and the CTSCS will enable and support this. (Need 5)

5.9. Operators will use the CTSCS to implement flash control (red flashing lights) to any individual intersection controlled by the CTSCS. (Need 5)

5.10. Operators may need to control select intersections outside normal coordination with other intersections. (Need 5)

5.11. Operators will predefine scheduled operations for intersections based on events. (Need 5)

5.12. Operators will rely on functionality of the CTSCS to enable them to define a series of actions that can be applied to various signal controllers and save these actions as ‘action sets’ to be implemented quickly when needed. (Need 5)

5.13. Unless prescribed otherwise by an operator, the CTSCS will operate in a default mode that is based on TOD/DOW. (Need 5)

5.14. Operators will maintain a schedule for appropriate timing plans based on time of year, week and day. (Need 5)

6. Traffic Adaptive Control

6.1. Some, but not all, of the MnDOT traffic signal controllers will operate in traffic adaptive control – to determine signal control and coordination parameters in response to current traffic as measured by intersection detectors. The architecture of the CTSCS will enable MnDOT to select these intersections and purchase a CTSCS module to support these. (Need 9)

7. Control Areas

7.1. Operators will have the option to control all signal controllers in the system. (Need 1)

7.2. Operators or administrators will organize traffic signals into logical groups to support more efficient control of multiple intersections. (Needs 2, 17)

8. Time/Date Synchronization

8.1. The time/date of the CTSCS will be synchronized with Universal Time automatically, without operator intervention. (Need 2)

8.2. The CTSCS will support system-wide clocks and local time clocks. (Need 2)

8.3. The CTSCS will perform checks on traffic signal controllers connected to the CTSCS to verify if the field clocks are within acceptable range of the system time. (Need 2)

9. System Schedules

9.1. Operators will create and implement schedules for the control of one more traffic signal controllers by specifying the begin/end time and date. (Need 2)

9.2. When creating and implementing schedules, operators will have the option to use either permanent or temporary schedules. (Need 2)

10. Timing Plan Compliance Monitoring

10.1. The CTSCS will support operators by performing remote monitoring of traffic signal controllers connected to the CTSCS to determine if the actual timing parameters match the current values scheduled to be operational at the selected time, based on the database stored in the CTSCS. Operators will receive alerts if these do not match. (Need 5)

11. Failure Monitoring

11.1. The CTSCS will support operators by detecting, alerting, and logging communications failures to traffic signal controllers. (Needs 4, 5)

12. CTSCS Database

12.1. The CTSCS will support a variety of users by maintaining a database that stores data describing traffic detected at signalized intersections and signal timing parameters executed at intersections. (Need 10)

13. Detectors

13.1. The CTSCS will accept and process detector data reported by connected traffic signal controllers, including system detectors (e.g. mid-block detectors reporting volume and occupancy) and local detectors near the intersection to support actuation, extensions, etc. (Need 1)

13.2. MnDOT will use data collected and processed by the CTSCS to support the creation of measures of effectiveness. (Need 5)

13.3. As MnDOT's involvement in Connected Vehicle deployments evolves, increased functionality may be required of the CTSCS that is not known at this time. (Need 3)

14. System Log

14.1. Operators will have access to a log reporting what was performed by the traffic signal controllers. (Need 10)

14.2. Operators viewing system logs will view the functions actually performed by the traffic signal controllers, the source of the functions, and the time they were performed, not solely what the scheduler requested. (Need 10)

14.3. The CTSCS will keep logs secure, unalterable, and accessible. (Need 10)

14.4. Operators with certain privileges will be able to view logs reporting what operators have logged into and out of the system, and activities performed by operators. (Need 7)

15. Reporting Requirements

15.1. Operators will have the ability to run, view, print, and save a variety of pre-defined or operator created reports from the CTSCS user interface. (Need 11)

15.2. Operators will have the ability to run, view, print, and save system status reports that describe to operational status of all equipment connected to the CTSCS. (Needs 11, 16)

15.3. Operators will have the ability to run, view, print, and save intersection operation reports on an individual intersection basis. (Needs 11, 16)

15.4. Operators will have the ability to run, view, print, and save real-time split monitor reports. (Needs 11, 16)

15.5. Operators will have the ability to run, view, print, and save time space diagram reports. (Needs 11, 16)

15.6. Operators will have the ability to run, view, print, and save intersection measure of effectiveness reports. (Needs 11, 16)

15.7. Operators will have the ability to run, view, print, and save database reports. (Needs 11, 16)

15.8. Operators will have the ability to run, view, print, and save real-time communications monitoring reports, describing all requests and replies to and from the intersection. (Needs 11, 16)

15.9. Operators will have the ability to run, view, print, and save communications statistics reports describing statistics for communications, including failures and successes. (Needs 11, 16)

15.10. Operators will have the ability to run, view, print, and save pre-emption / signal priority reports. (Needs 11, 16)

16. Automatic Alerting of Maintenance Personnel

16.1. The CTSCS will automatically create and send alerts to appropriate individuals or agencies when critical problems are detected within the system or within connections to other systems. (Need 12)

16.2. The CTSCS will automatically send email to designated individuals when changes to the database are implemented. (Need 7)

17. Failure Recovery

17.1. The CTSCS will monitor for failures and follow an organized procedure to shut-down and/or recover from failures. (Need 12)

18. Online Help

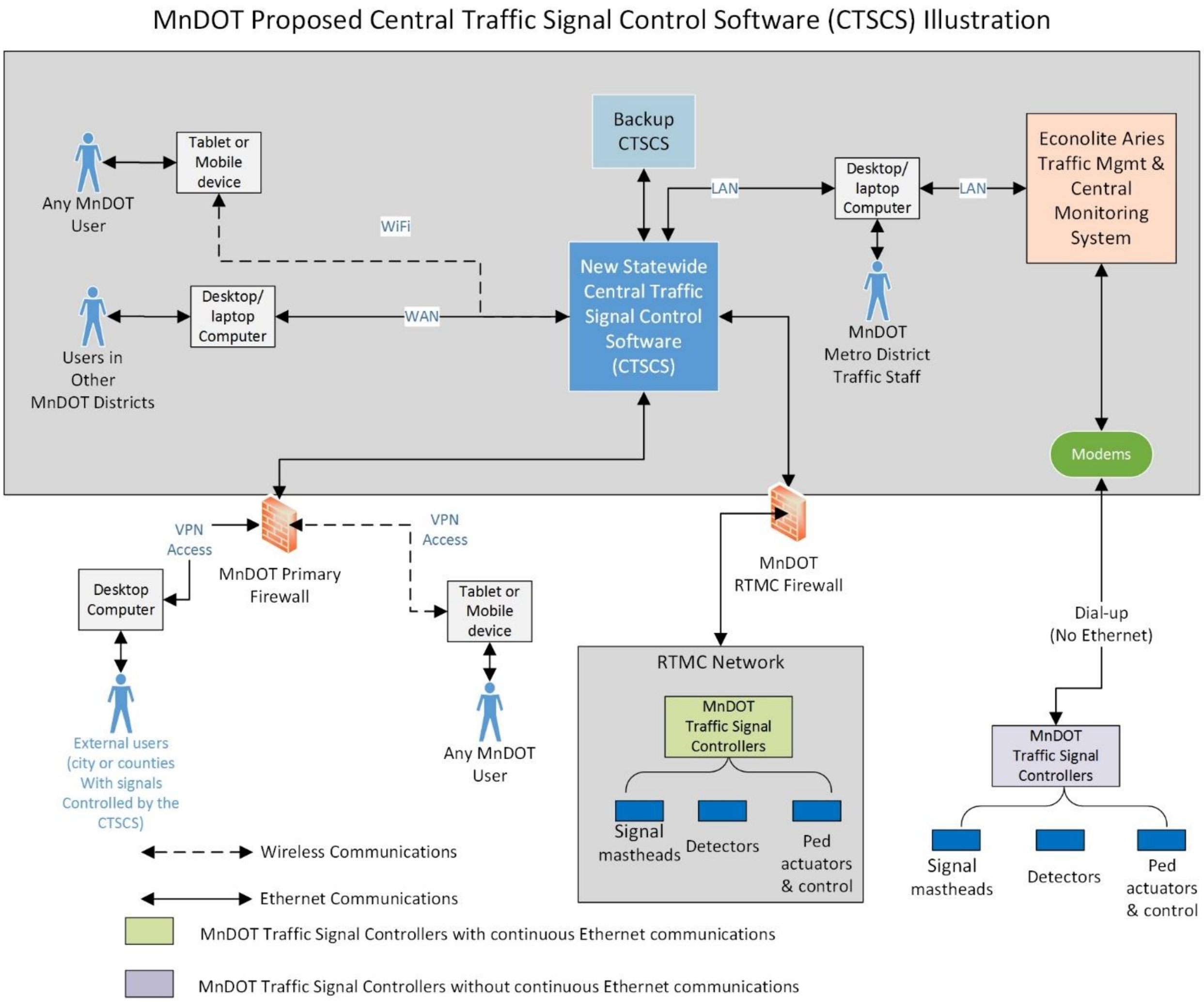
18.1. Operators will use an online help support tool to troubleshoot technical issues. (Need 13)

Proposed System

MnDOT will deploy a CTSCS that accomplishes the operational concepts and meets the stakeholder needs identified above. The proposed system components are described below and illustrated in Figure 2.

- **Primary CTSCS** – The software solution, together with associated databases that users throughout the state will access from their desktop computer, laptop computer, and mobile devices to manage the traffic signal controllers configured in the system.
- **Back-up CTSCS** – A mirror image software system to the primary CTSCS that MnDOT could utilize in situations where the primary CTSCS is not operational (either because the software is not operational, LAN/WAN/Internet connectivity or power to the primary CTSCS is not functioning). The back-up CTSCS will periodically synchronize with the primary CTSCS such that all the databases, login accounts, data, etc. are available to operators should they need to use the back-up system.
- **System Interconnects** – The interconnections that are needed to enable operators to access the CTSCS and to enable the CTSCS to communicate with the traffic signal controllers configured in the system.

Figure 2 Proposed CTSCS Components



Roles and Responsibilities

Building on the operational concept, this section describes suggested roles and responsibilities for the stakeholders who will operate and maintain the proposed CTSCS. The roles and responsibilities described in the following are based on those already in place for the current control software and traffic operations environment. This is intended to maintain consistency and familiarity among the stakeholders who will ultimately make the CTSCS operate efficiently. As the CTSCS is procured and different MnDOT districts begin using the new software, these roles and responsibilities may be discussed again and further modified. The suggested roles and responsibilities presented in Table 1 should be viewed as a starting point for that discussion.

Table 1 Suggested Roles and Responsibilities

Stakeholder	Role / Responsibility
MnDOT Metro District Traffic Staff	• Use CTSCS to monitor and maintain traffic signal operations on MnDOT operated roadways within the Metro District boundaries. • Use CTSCS to troubleshoot hardware issues with traffic signals. • Provide administrator for CTSCS to manage operator access and user rights. • Serve as in-house technical expert for MnDOT. • Serve as primary MnDOT contact with CTSCS vendor for training, technical support and warranty services.
Other MnDOT District Traffic Staff	• Use CTSCS to monitor and maintain traffic signal operations on MnDOT operated roadways within the District boundaries. • Use CTSCS to troubleshoot hardware issues with traffic signals.
MnDOT Office of Traffic, Safety and Technology-Electrical Services Section Staff	• Review CTSCS operational performance logs, identified by District traffic staff, to troubleshoot and repair (as needed) hardware issues with traffic signals.
MN.IT	• Maintain communication, server and computer infrastructure used by MnDOT to operate the CTSCS with traffic signals throughout the state.
Local Partners	• Use CTSCS, as per agreement with MnDOT, to monitor and maintain traffic signal operations on roadways with shared jurisdictional control and interests.
CTSCS Vendor[1]	• Provide training, technical support and warranty services as negotiated by MnDOT.

Operational Scenarios

Now that the needs have been identified and an operational concept has been described, along with the potential operational and maintenance roles and responsibilities, this final section presents operational scenarios that describe how the CTSCS will be used in actual situations that commonly occur during traffic signal operations. The scenarios generally describe the situation, how the system performs and who interacts with the system in response to the action it performs. The scenarios describe system performance only to the extent necessary for stakeholders to understand how the CTSCS will operate under various operational conditions.

[1] The CTSCS vendor serves in a limited capacity as a stakeholder, with their roles and responsibilities specified by MnDOT in agreements associated with procuring the CTSCS.

Scenario: Routine Operations

System Administration

A CTSCS administrator will establish user identification and password credentials for the traffic operations staff that will use the system. (4.1, 4.4) Credentials will be based on various levels of view and editing access to the CTSCS. (4.2) The administrator will establish user credentials to enable individuals from other jurisdictions or contractors to access the CTSCS to control signals controlled in the system. Similarly, credentials will be established for MnDOT operators to view and/or control intersections in neighboring jurisdictions as specified by interagency agreements. (4.3) For example, a Dakota County signal may be included in the MnDOT CTSCS because it is coordinated with other signals along the same route. The CTSCS administrator will maintain privileges for operators with rights to view logs for activities performed by operators. (14.4)

Operator Monitoring

MnDOT operates and manages traffic control signals at intersections along MnDOT operated highways. At the beginning of each day, traffic operations staff opens the CTSCS from their desktop or laptop computers using their individual user identification and password. (1.1, 1.2, 1.5, 3.1, 4.6, 4.7) Once logged in, staff checks the current status of traffic signals within their district boundaries that are accessible by Ethernet connections. The opening view of CTSCS will be displayed according to the operator's customized settings for zoom level and signal status information displayed. (1.3, 1.4, 1.14, 1.16, 1.21) The CTSCS map display allows the operator to quickly view the status of signal controllers and understand if any signals are malfunctioning. The CTSCS can then allow the operator to troubleshoot what may be causing the malfunction. (1.7) As the operator zooms to specific intersections, the CTSCS allows the operator to view the intersection layout, detector and controller locations, current signal phasing and timing and most recent detector data. (1.8, 1.9, 1.10, 1.11, 1.12, 1.13, 1.22, 13.1) The CTSCS map display will also note where cameras and DMS that have been entered into the CTSCS (to enable the operators to view the locations of the devices) but are **not controlled** by the CTSCS are located around the intersection. (1.23) The operator may also use the CTSCS to view multiple intersections operating in a corridor. (1.15, 1.17, 1.20) This allows the operator to determine if adjustments to timing plans are needed to accommodate traffic volumes within established measures of performance. (13.2)

Control

Operators will use the CTSCS to control various functions at signalized intersections and as such the CTSCS will allow them to view changes in real-time, 24 hours per day, seven days per week. (5.1, 5.2, 5.4) Operators will have the primary option to control signals within pre-defined logical groups or all controllers in the CTSCS. (7.1, 7.2) Many intersections will operate in a default mode based on time of day and day of week. (5.6, 5.13) The details of which will be maintained according to planned events and time of year/week/day by traffic operations staff. (5.11, 5.14) Time and date synchronization will be automatically maintained by the CTSCS, without operator intervention, based on Universal Time and the CTSCS will also support system-wide and local time clocks. (8.1, 8.2) In addition to default mode, operators may also choose one of several other modes to control an intersection – manual, traffic responsive, vehicle actuated and flash. (5.5, 5.7, 5.8, 5.9) Within these modes, operators may need to control select intersections outside normal coordination with other intersections or they may need to quickly enable specific actions to address unique traffic conditions. (5.10, 5.12) Operators may also have the option to operate signal control using adaptive control strategies based on current traffic measured by intersection detection. (6.1) The schedules for various control modes will be created and implemented by operators to specify begin/end times and dates. (9.1) Schedules may be considered temporary or permanent. (9.2)

Adjustments

If adjustments or additional signal timing plans are needed, the operator may use Synchro to develop a revised timing plan, import the new plan into CTSCS and download it to the signal controller. (2.1, 2.5, 2.6) Information for the revised timing plan may also be pulled from the CTSCS database based on previously used plans. (2.2) The revised timing plan will then be uploaded from Synchro to the CTSCS and placed into operation in the field controller. (2.3) If the revised plan for one intersection needs to be added to other intersections, the operator will copy and paste the timing plan from one to the other. (2.4) All changes will be documented in the CTSCS system log according to the operator who made them, when the change was made and what the change consisted of. (1.6) The logs will be secure and unalterable, but accessible to operators for viewing functions performed by the signal controller. (14.1, 14.2, 14.3)

Automated System Functions

The CTSCS will perform a series of automated system functions. The system will perform automatic checks on signal controller field clocks to verify they are within an acceptable range of system time. (8.3) It will monitor remotely to determine if actual timing parameters match the current values scheduled at the times specified by operators. (10.1) The CTSCS will detect, alert and log communication failures to signal controllers. (11.1) It will also monitor for system failures and follow a system recovery procedure. (17.1) When issues are detected by the CTSCS, the system will create and send alerts to traffic operations staff. (16.1, 16.2) The CTSCS will store in a database all information describing traffic detected and signal timing parameters at each intersection. (12.1)

Reporting

Operators will use the CTSCS to run, view, print and save a variety of reports associated with signal operations. (15.1, 15.7) Such reports may be associated with the operational status of equipment, intersections or corridors. (15.2, 15.3, 15.4) Operators may also run reports associated with real-time splits, time space diagrams, intersection performance, communication and pre-emption/signal priority functions. (15.5, 15.6, 15.8, 15.9. 15.10)

Troubleshooting

If technical issues arise with the CTSCS, operators will first use the online help resources available through the system as provided by the system vendor. (18.1) If the issues cannot be resolved through the online help resources, operators may reference training materials provided by the CTSCS vendor, contact fellow operators, or contact the CTSCS administrator.

Scenario: Intersection Modifications

Jurisdictional changes, construction and equipment upgrades are just some of the causes for intersection modifications in the CTSCS. When such changes occur, an operator will open the CTSCS from their desktop using their individual user identification and password. (1.1, 1.2, 1.5, 3.1, 4.6) Once logged in, the operator will zoom to the location impacted by the change. (1.8, 1.9, 1.10, 1.11, 1.12, 1.13, 1.22) Using the CTSCS map display and customized graphics, the operator will draw or modify the intersection to match the changes. (1.19)

Scenario: Intersection Changes Made in the Field

The CTSCS will allow changes to signal phase and timing to be made from the field. Such changes may be made by traffic operations staff using a mobile device such as a tablet or smartphone. (4.5) However, CTSCS functionality via mobile devices will likely be limited and therefore limit the extent to which changes can be made. Similarly, changes may also be made directly at the traffic signal controller in the field. If an operator manually makes a signal timing plan change at the field controller (not using the CTSCS), the CTSCS will detect this change and send messages to alert MnDOT operators that a field change has occurred. (5.3)

Scenario: Incident or Special Event

The CTSCS will allow operators to change signal phase and timing for incidents and special events. (5.11) Such changes may need to be executed by mobile device or laptop, or in the field. (4.6, 4.7, 5.3) Changes may be completed through existing action sets or operators may need to make specific changes to individual intersections based on the nature of the incident or special event. (5.9, 5.10, 5.12)