SYSTEMS ENGINEERING
CONCEPT OF OPERATIONS AND SYSTEM REQUIREMENTS

For

HENNEPIN COUNTY
CENTRAL TRAFFIC SIGNAL CONTORL SOFTWARE

SP 027-030-040
Minn Proj. No. HSIP 2717 (156)
County Project 1546

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1. Introduction

1.1 Introduction

Transportation agencies use a variety of localized and centralized traffic signal control software to manage traffic signal operations. Such operations may include among other things signal timing, intersection monitoring, modifications to timing plans and maintenance. Hennepin County Traffic Management Center (TMC), located in Hennepin County Public Works facility in the City of Medina, is responsible for operating most traffic signals (except for the signals within the City of Minneapolis) and managing day-to-day traffic operations along County roads within Hennepin County limits. On a daily basis, traffic professionals at Hennepin County TMC have been utilizing the traffic control software to monitor intersection signal operations and implement proper signal timing strategies to accommodate traffic needs for daily traffic operations, construction and work zone operations, special events, traffic incident response, weather conditions and traffic bottlenecks.

1.2 Purpose of Document

This Concept of Operations and System Requirements is for the procurement of an Advanced Traffic Management System (ATMS), which will be referred to in this document as the Central Traffic Signal Control System (CTSCS). This Concept of Operations and System Requirements is part of an overall systems engineering analysis being conducted to support Hennepin County's procurement of a CTSCS. It presents the fundamental needs that the Hennepin County 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 Hennepin County TMC. The needs in this document serve as the basis for systems requirements that will be used to develop specifications for the procurement process. As Minnesota Department of Transportation (MnDOT) and several other counties and cities are in the process of procuring and deploying new CTSCS, Hennepin County took part in a coordinated effort in identifying these needs as part of the Project Management Team.

1.3 System Overview

Currently, Hennepin County TMC operates traffic signal systems with localized control strategy. Localized signal control may be managed either directly in the field via the signal controller cabinet or remotely from the County TMC via a dial-up telephone connection to the local controller. Signal control decisions and actions are taken place by the controllers at intersections in the field. Time-of-Day (TOD) based signal timing plans are optimally designed and programmed in each controller to best accommodate different traffic patterns at the intersection, corridor and network levels. The controller unit programmed to select and implement a pre-specified signal timing plan and sequence (cycle/offset/split) based on the time of day, day of week, and/or time of year. At present, Hennepin County operates and maintains a total of 456 traffic signals, including 426 signals operating in coordination under 70 zone master controllers and 30 signals operating in free mode at isolated intersections. Each zone master controller connects to one of the central computers at the County TMC with a Plain Old Telephone Service (POTS) and to other coordinated controllers in the zone with twisted pair copper cables. In addition, Hennepin County owns another 333 traffic signals that are on County roadways within the City of Minneapolis jurisdiction. The County has been financing the City to operate and maintain these traffic signals.

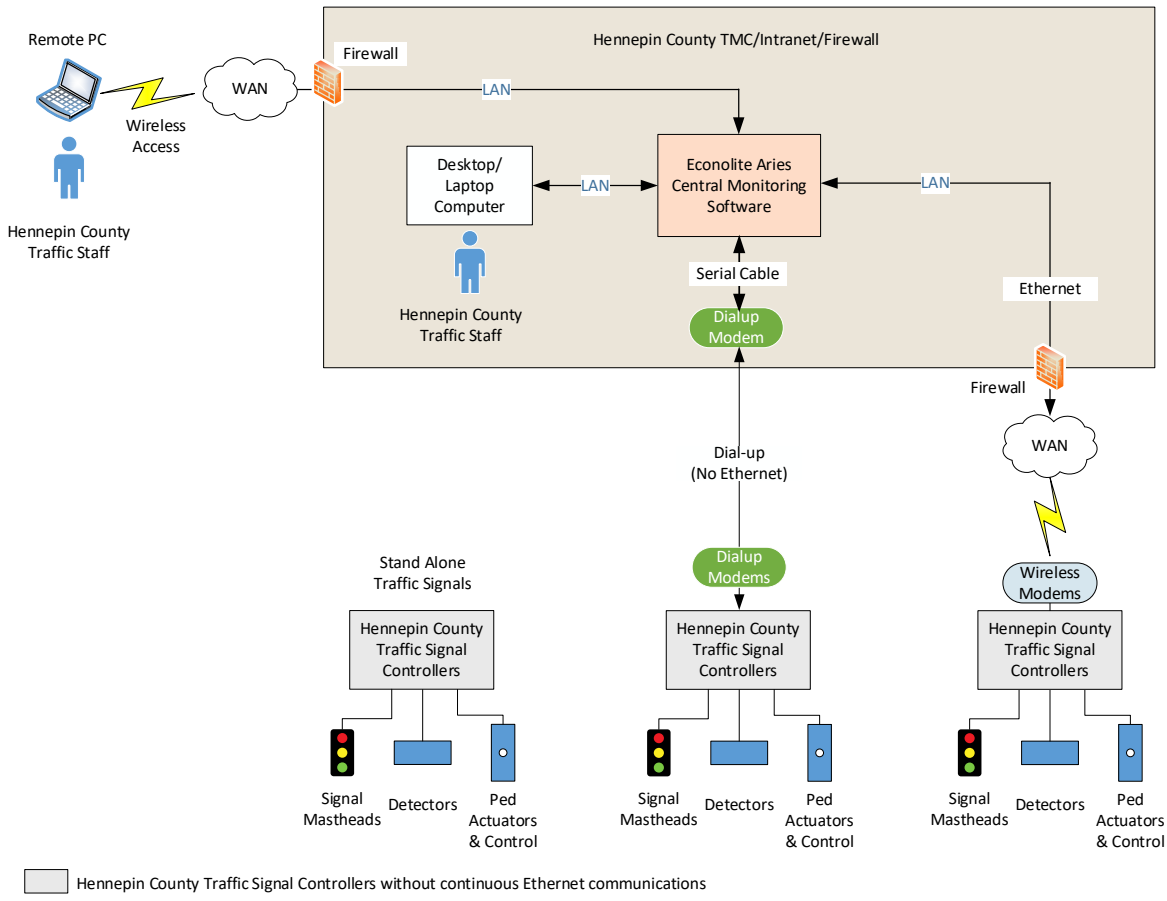
Signal controllers operated and maintained by the Hennepin County include the ASC/3, ASC/2, and ASC/8000 models manufactured by Econolite.

Hennepin County is currently using Aries, a Microsoft Windows-based data management and monitoring system developed by Econolite, to manage County traffic signal systems. This traffic control software package provides a platform that allows the County traffic staff and TMC operators to perform multiple traffic control tasks including creating schedule operations, monitoring intersection signal and detector operations, tracking traffic flow, managing a signal database, and generating signal operations and status reports.

In addition, Hennepin County uses standard traffic simulation and analytical software, Synchro V9 developed by Trafficware, for traffic analysis and signal timing plans development. Traffic signal data generated from active signal controllers is manually imported into Synchro for analysis and optimization, and the results are processed and manually transferred back from Synchro to the signal controllers.

Figure 1 shows the existing Hennepin County CTSCS system diagram.

Figure 1: Existing Hennepin County CTSCS System Diagram



1.4 Justifications for Change

Hennepin County has been using Econolite Aries to operate and manage County signal systems for about 20 years. However, the Aries software is no longer being enhanced and further developed by Econolite, and is no longer supported by the vendor. It is essential for the County to upgrade the existing Aries system with a state-of-art technology to maintain effective and reliable TMC operations and traffic signal control and management.

Secondly, the localized signal control is cumbersome and limits automated monitoring and alert functions that can otherwise be performed on signal systems that are controlled centrally. The current telephone based connections are not reliable and cannot meet the needs of performing real-time signal control operations. It often takes multiple attempts to establish a remote connection from the County TMC to the local controller. Such a connection often gets disconnected and interrupted during signal data transmission which significantly impacts real-time signal operations. Besides, the POTS based communications slow down the batch signal operations process such as backing up signal data from the local controllers and synchronizing clock times to the zone master controllers. The growing needs in real-time signal control and management require a more efficient and reliable central control software and faster communications infrastructure. Hennepin County is in the process of deploying a County-wide fiber optic based signal interconnect system. This will allow large scale real-time control commands to be transmitted between the CTSCS and local controllers. As a result, it is essential to deploy a new CTSCS to effectively support future signal operations and enable advanced signal control strategies (i.e. adaptive traffic signal control) that can be accomplished with the fiber optic communications techniques.

Furthermore, it is anticipated that the future centralized signal control would allow Hennepin County traffic staff and TMC operators to better manage signal operations remotely via higher speed connections, utilizing constant communications between the County TMC and the field controllers. The future CTSCS is expected to be an integrated traffic management system that provides interfaces and controls to multiple plug-in software modules and devices. It would be designed to accommodate the multi-device, multi-jurisdiction expansion necessary for today's technologies.

In summary, upgrading the existing signal control software to current technology becomes necessary and vital for the County since the existing signal control software and POTS based communication infrastructure have limited signal control and operations efficiency and created concerns for system interoperability and expandability in the long term.

In order to meet future needs, Hennepin County has applied for and been awarded Highway Safety Improvement Program (HSIP) funding for upgrade the existing traffic signal control system to an ATMS in different phases. The first phase is the 2017 HSIP project which will facilitate the purchase of a new traffic signal control software to monitor and coordinate 81 traffic signals along CSAH 17, CSAH 61, CSAH 81, CSAH 130, and CSAH 152 for a total of 25.3 miles, and deploy fiber optic communications with an additional 10.4 miles of roadway segments along CSAH 17, CSAH 130, and CSAH 152. The County is also advancing Capital Improvement Program (CIP) funding to expand ATMS implementation to a countywide level (2017-2021 CIP). The County has submitted multiple funding applications via the Regional Solicitation and HSIP to help facilitate system deployment.

1.5 Stakeholders

One important element in developing the Concept of Operations and System Requirements is to fully communicate with the involved stakeholders and capture their needs and expectations regarding system capabilities and operations. Several stakeholders inside and outside Hennepin County will be affected by the CTSCS procurement. Hennepin County TMC operators and traffic staff are considered as the primary stakeholders because they are responsible for operating and maintaining County signal operations supported by the current CTSCS. The County TMC operators and traffic staff were invited and participated in the stakeholders' meetings with partnered Cities and Counties when MnDOT and Dakota County conducted the systems engineering for their CTSCS procurement. The County TMC staff conducted additional stakeholders' meetings with MnDOT and City of Minneapolis in this effort to further identify the needs for these partnered agencies. Finally, Hennepin County IT department was involved in any information technology services, communications network architecture and security with respect to the new CTSCS procurement and deployment. Following is a list of the stakeholders who have expressed their needs for a new CTSCS.

- Hennepin County TMC Operators and Traffic Staff
- Hennepin County IT and Fiber Staff
- MnDOT Metro Traffic
- City of Minneapolis
- Other Local Agency Partner Counties and Cities

2. Referenced Documents

The following list of documents was used as supporting references and resources in developing this Concept of Operations and System Requirements.

- FHWA, "A Primer for Developing and Using a Concept of Operations in Transportation Management systems," September 2005.
- Hennepin County, "Hennepin County ITS Strategic Plan," June 2007.
- Hennepin County, "Intelligent Information Management Plan (IIMP)," December 2014.
- City of Minneapolis Road Maintenance Agreement PW 19-20-15
- Dakota County, "Dakota County CTSCS Systems Engineering Analysis - Concept of Operations", May 5, 2015

3. Needs

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

Need	Description
Need 1:	Hennepin County needs to control any County-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:	Hennepin County needs the CTSCS to be easy to use and convenient, supporting both regular operators who will work with it daily and occasional operators.
Need 3:	Hennepin County needs the CTSCS to be compatible with existing and future hardware and software environments, as well as, the Minnesota Statewide Regional ITS Architecture.
Need 4:	Hennepin County needs easy access to real-time signalized intersection information.
Need 5:	Hennepin County needs to upload and download traffic control operations to traffic signal controllers, and perform quick and full compare functions.
Need 6:	Hennepin County needs to use traffic signal optimization tools in conjunction with the CTSCS to help develop and program signal timing plans.
Need 7:	Hennepin County needs to accommodate multiple operators with various privilege levels, who may securely access the system at any time, including simultaneous use.
Need 8:	Hennepin County 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:	Hennepin County needs the CTSCS to support multiple control modes to meet various conditions, including time-of-day, traffic responsive, and compatibility with future adaptive control systems.
Need 10:	Hennepin County needs CTSCS data describing signalized intersections to be saved in a manner that supports secure access by others and having archiving capabilities.
Need 11:	Hennepin County needs the CTSCS to generate a variety of operations, maintenance, and performance reports in useful formats.
Need 12:	Hennepin County needs the CTSCS to operate reliably, with minimum downtime.

Need 13:	Hennepin County needs the CTSCS to be supported by the vendor through a combination of training, limited on-site visits, telephone help lines, and online help features to support operator questions about technical issues.
Need 14:	Hennepin County and partnering agencies need to access the CTSCS from various office locations throughout the metropolitan area.
Need 15:	Hennepin County staff needs to securely 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:	Hennepin County needs the CTSCS to support traffic signal performance measure calculations.
Need 17:	Hennepin County 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).
Need 18	Hennepin County needs the CTSCS to be expandable to include additional intersections in the future.
Need 19	Hennepin County Operators need to receive automated maintenance recognition and alerts including requirements for user-defined formats.
Need 20	Hennepin County Operators need to be able to remotely monitor transit signal priority (TSP) operations, and to be able to remotely upload/download TSP timing parameters from the CTSCS to the signal controllers.
Need 21	Hennepin County needs the CTSCS to interface with and operate current and future Intelligent Transportation System (ITS) devices (i.e. DMS and CCTV).

4. Operational and Evaluation

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. Each operational concept item can be tested and evaluated as system requirements during the system testing phase.

Category	Descriptions
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. (Needs 4, 21)
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 status of 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)

Category	Descriptions
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: (Needs 4, 20)
	• 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 operators 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. (Needs 4, 21)
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 21)
1.24.	Operators will have the capability to view current transit signal priority operations in real-time. (Need 20)
2. Signal Timing Database Management	
2.1.	The operator will have the ability for the CTSCS to select 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)

Category	Descriptions
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 by menu that allows to select portion of the database (i.e. system configuration, signal timing, detectors, and etc.). (Need 5)
2.5.	Operators will have the option to schedule upload or download of traffic control operations parameters from and to intersection controllers. (Need 5)
2.6.	Operators will have the ability to initiate a process for Synchro to determine a new signal timing plan for one or more intersections and to incorporate the Synchro generated timing plan into the CTSCS and the intersection controllers. (Need 6)
2.7.	Operators will have the ability to download TSP timing parameter data from the CTSCS to the field controllers, and to upload TSP timing parameter data from the field controller to the CTSCS. (Need 20)
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.	Hennepin County operators will use the CTSCS to view and/or control signalized intersections in neighboring jurisdictions. (Need 8)
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. (Needs 5, 9)
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)

Category	Descriptions
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. (Needs 5, 9)
5.5.	Operators will have the ability to control traffic signal controllers using 'manual mode.' (Needs 5, 9)
5.6.	Operators will select to operate the CTSCS in Time-of-Day (TOD)/Day-of-Week (DOW) mode. (Needs 5, 9)
5.7.	Operators will select to operate the CTSCS in Traffic Responsive Control Mode. (Needs 5, 9)
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 plans' 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. (Needs 5, 9)
5.14.	Operators will maintain a schedule for appropriate timing plans based on time of year, week and day. (Needs 5, 9)
6. Traffic Adaptive Control	
6.1.	At some point in the future Hennepin County may utilize a traffic adaptive control strategy. The architecture of the CTSCS will enable Hennepin County to implement the adaptive control strategy at selected intersections or corridors. (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)

Category	Descriptions
7.3.	Operators will have the option to add and delete signal controllers in the system. (Need 18)
8. Time/Date Synchronization	
8.1.	The time/date of the CTSCS will be synchronized using a scheduled command 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 or 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 communication failures to traffic signal controllers. (Needs 4, 5, 19)
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)

Category	Descriptions
13.2.	Hennepin County will use data collected and processed by the CTSCS to support the creation of measures of effectiveness (MOEs). (Needs 5, 16)
13.3.	As Hennepin County'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 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 measures 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)

Category	Descriptions
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 by email or text message when critical problems or communications failures are detected within the system or within connections to other systems. (Needs 12, 19)
16.2.	The CTSCS will automatically send emails 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)

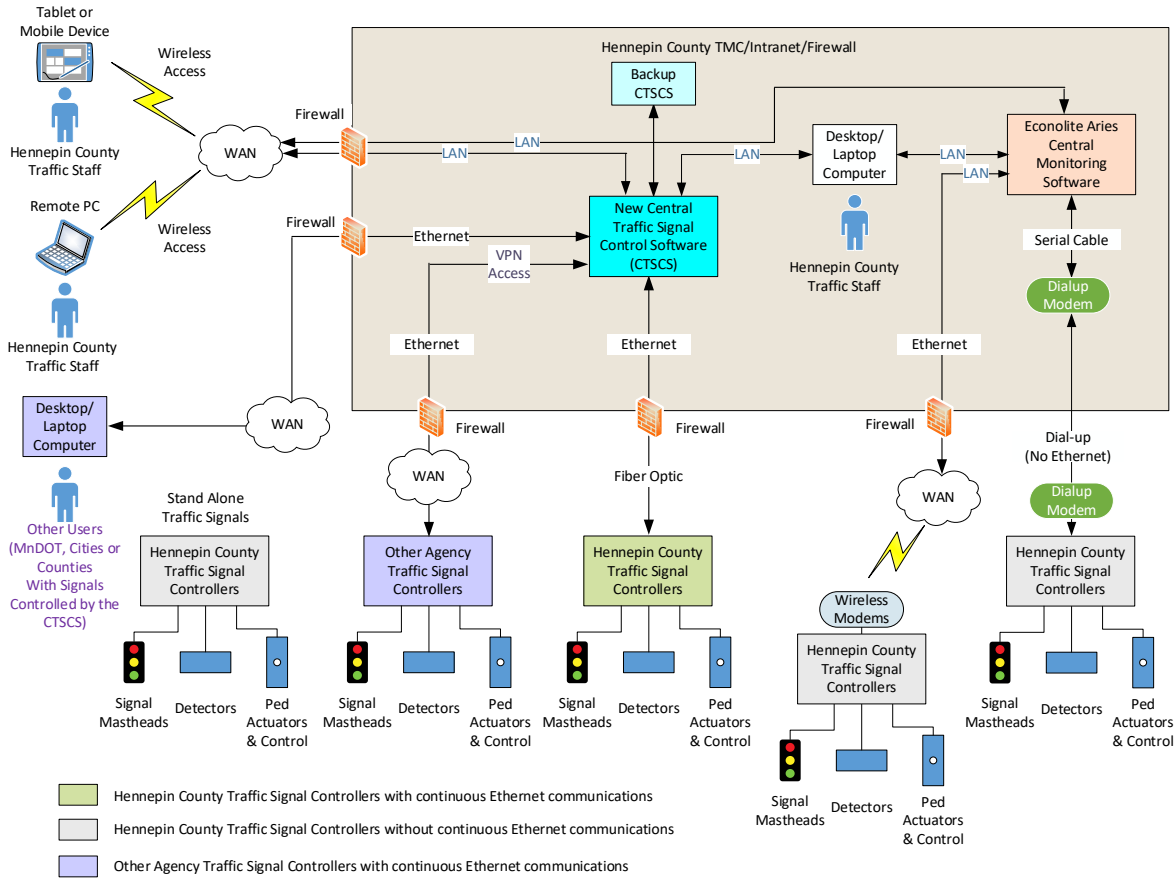
5. Proposed System

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

- **Primary CTSCS** – The software solution, together with associated databases that users throughout the County 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 the County 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 Hennepin County CTSCS System Diagram



6. 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.

Table 1 Suggested Roles and Responsibilities

Stakeholder	Roles / Responsibilities
Hennepin County TMC Traffic Engineering Staff	• Use CTSCS to monitor, manage, and maintain traffic signal operations on Hennepin County operated roadways. • Use CTSCS to help address traffic and signal operational requests from partner agencies and public. • Use CTSCS to troubleshoot hardware issues with traffic signals. • Serve as in-house technical expert for Hennepin County. • Serve as primary contact with CTSCS vendor for training, technical support and warranty services.
Hennepin County TMC Traffic Signal Staff Services	• Maintain signal and communications • Review CTSCS operational performance logs, identified by County traffic staff, to troubleshoot and repair (as needed) hardware issues with traffic signals.
Hennepin County IT Department	• Maintain server and computer infrastructure used by Hennepin County to operate the CTSCS with traffic signals throughout the County. • Provide administrator for CTSCS to manage operator access and user rights.
Local Partners	• Use CTSCS, as per agreement with Hennepin County, to monitor and maintain traffic signal operations of signals operated by the local partner. • Use CTSCS to troubleshoot hardware issues with traffic signals operated by local partner. • Use CTSCS to monitor Hennepin County operated traffic signals.

7. Operational Scenarios

This 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 following scenarios were developed:

- Scenario 1: Hennepin County Routine Operations – Signals operated by Hennepin County, all data housed on Hennepin County CTSCS.
- Scenario 2: Local Partner Operations – Signals operated by agency other than Hennepin County, Local Partner signal data is housed on Hennepin County data server. *This will require agency agreements and infrastructure improvements that are beyond the scope of this ConOps.*
- Scenario 3: Shared Operations on Hennepin County CTSCS – Hennepin County and another agency share operating responsibilities, all data from both Hennepin County and the other operating agency is housed on Hennepin County CTSCS. *This will require agency agreements and infrastructure improvements that are beyond the scope of this ConOps.*
- Scenario 4: Shared Operations on multiple CTSCS – Hennepin County and another agency share operating responsibilities, Hennepin County signals are housed on Hennepin County CTSCS, other agency's signals are housed on the Agency's unique CTSCS. *This will require agency agreements and infrastructure improvements that are beyond the scope of this ConOps.*
- Scenario 5: Incident or Special Events

Scenario 1: Hennepin County 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) Credentials will be based on various levels of view and editing access to the CTSCS. (4.2, 4.4) The CTSCS administrator will maintain privileges for operators with rights to view logs for activities performed by operators. (14.4)

Operator Monitoring

Hennepin County operates and manages traffic control signals at intersections along Hennepin County operated highways. At the beginning of each day, traffic operations staff opens the CTSCS from their desktop or laptop computers at County facilities or off-site 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 operated by Hennepin County 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, 11.1) 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) If the CTSCS application is not used for a user specified time, the application will be locked for security purposes. The application will be resumed when the operator logs in with user identification and password. (4.8)

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). Operators may also have the option to run a group of signals on a holiday or event plan by selecting or scheduling the plan once for the group of signals rather than having to enable the plan for each individual signal. (5.1, 5.10) Operators are able to view real-time transit signal priority (TSP) timing parameter data, upload from the controller to CTSCS and download from CTSCS to the controller as needed. (1.24, 2.7)

Modifications in the Office

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, 4.7) 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 and add or delete intersections as needed. (1.19, 7.3)

Modifications in the Field

The CTSCS will allow changes to signal phasing 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 operators that a field change has occurred. (5.3)

Adjustments

If adjustments or additional signal timing plans are needed, the operator may use Synchro or another traffic modeling program 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 or from the Measures of Effectiveness reports. (2.2, 15.6) The revised timing plan will then be uploaded from the traffic modeling program to the CTSCS and placed into operation in the field controller. (2.3, 2.6) 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 and maintenance 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). Operators may also run reports associated with real-time splits, time space diagrams, intersection performance, communication and pre-emption/transit signal priority functions. (15.4, 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.

Scenarios 2 and 3: Shared Operations on Hennepin County CTSCS

Operations will follow Hennepin County Routine Operational Scenario, with the following exceptions:

System Administration

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. For example, if Hennepin County and partner agency (i.e. MnDOT) decide to share operations of a corridor, with all data housed on Hennepin County's CTSCS.(4.2)

Operator Monitoring

Hennepin County is responsible for operating County owned traffic signals. Hennepin County can monitor operations for signalized intersections controlled by the other agency. The reverse would be true for the other partnering agency. (4.3)

Scenario 4: Shared Operations on Multiple CTSCS

Operations will follow Hennepin County Routine Operational Scenario, with the following exceptions:

System Administration

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. For example, if Hennepin County and partner agency (i.e. MnDOT) decide to share operations of a corridor, with Hennepin County owned signal data housed on Hennepin County's CTSCS, and MnDOT owned signal data housed on MnDOT's CTSCS. (4.2)

Operator Monitoring

Hennepin County, along with MnDOT or a Local Agency Partner, agree to jointly operate and manage traffic control signals along a corridor. Hennepin County would be responsible for operating County owned traffic signals. Hennepin County can monitor operations for signalized intersections controlled by the other agency. The reverse would be true for the other partnering agency. (4.3)

Automated System Functions

The time/date of the Hennepin County CTSCS and the partnering agency CTSCS will be synchronized with Universal Time automatically, without operator intervention. (8.1).

Scenario 5: 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)