Concept Of Operations:
Fargo-Moorhead Traffic Operations Center

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FINAL REPORT

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1.0 PURPOSE

A regional traffic operations center (TOC) serves as a focal point for coordinating and supporting transportation system operations by bringing together various jurisdictions and agencies to focus on the common goal of optimizing the performance of the system and maximizing its safety and service to the traveling public. A TOC provides the infrastructure, mechanism, and agreements for sharing and directing information related to traffic control, traffic management, traveler information, and traffic incident/emergency management.

The Fargo-Moorhead (F-M) metropolitan area consists of several jurisdictions in two states, and therefore, transportation system operations involve several transportation, planning, and emergency management agencies. In addition, the continued growth of the metropolitan area poses several challenges to effectively operate and manage the transportation system during recurring events (e.g., peak-hour traffic conditions), and non-recurring events (e.g., crashes and special events). Transportation agencies in the F-M metro area support a vision for centralized regional operations through the creation of a FM TOC for actively monitoring and managing the transportation system. In order to achieve the goal of centralized operations, and under leadership from the Fargo-Moorhead Metropolitan Council of Governments (Metro COG), a concept of operations (ConOps) for a hybrid and centralized TOC was developed in 2010. Several conditions have changed since 2010, some of the major changes include:

- The procurement of centralized traffic control software by several agencies;
- Increased interconnect between NDDOT and the city of Fargo;
- Signal and communications upgrades by MnDOT on the TH10 and TH75 corridors;
- Signal and communications upgrades by city of Moorhead with specialized signal controllers and control software for improved performance with rail preemption; and
- West Fargo signal interconnect and communications upgrade through the deployment of a fiber optic network.

This document will discuss the operational aspects of a future FM TOC under these updated conditions as of 2014.

2.0 SCOPE

The TOC will serve as a focal point for coordinating and managing the transportation activities within the metropolitan area. The primary goals of the FM TOC include the following:

- Enhancing the coordination among agencies responsible for transportation system operations;
- Improving transportation system safety and efficiency;
- Enhancing training and technical expertise of agencies/staff involved in traffic operations;
- Increasing coordination with emergency management and transit agencies; and
- Enhancing the transportation system to meet the rapid challenges of continued growth.

To achieve these regional goals, several functions and activities will be performed by the FM TOC. The intended functions of the FM TOC are as follows:

1. Collect and share information among agencies about:
    a. Traffic and performance measures
    b. Road condition information (pavement condition and environmental data)
    c. Incidents
    d. Traffic congestion (special events)
    e. Construction/road work
    f. Real-time video monitoring
2. Provide information to travelers using some of these options:
    a. DMS
    b. Internet and mobile devices
    c. Media
3. Implement traffic control strategies in response to special traffic conditions/incidents
    a. Modify traffic signal timing
    b. Coordinate incident response
4. Implement inter-jurisdictional traffic control plans on major corridors
    a. Coordinate traffic signal timing on major corridors
    b. Coordinate traffic signal timing at freeway interchanges

While the F-M area transportation agencies have a varying degree of intelligent transportation systems (ITS) deployment, the last four years have seen a rapid increase in installations specifically in the areas of communication: fiber optic cable network; video surveillance equipment: PTZ cameras; and traffic signal central control software. These deployments represent important improvements in the infrastructure necessary for the establishment of a TOC.

In addition to traffic operator agencies, it is important to identify all potential stakeholders that may have immediate or future involvement with the FM TOC. The following jurisdictions may be involved in the TOC:

1. Transportation agencies with operating and control responsibilities:
    a. NDDOT
    b. MnDOT
    c. City of Fargo
    d. City of Moorhead
    e. City of West Fargo

f. Cass County Highway Department
g. Clay County Highway Department
h. Metro Area Transit (MAT) of Fargo Moorhead

2. Law enforcement agencies responsible for enforcement functions and event response:
   a. Fargo Police
   b. Moorhead Police
   c. West Fargo Police
   d. Cass County Sheriff
   e. Clay County Sheriff
   f. North Dakota Highway Patrol
   g. Minnesota State Patrol
3. Emergency management agencies for incident and event response:
   a. Fargo Fire
   b. Moorhead Fire
   c. West Fargo Fire
   d. F-M Ambulance
   e. Cass County Emergency Management
   f. Clay County Emergency Management
   g. Red River Regional Dispatch Center
4. Supporting agencies/organizations:
   a. Metro COG
   b. NDSU-UGPTI
   c. FHWA

3.0 REFERENCE DOCUMENTS

The regional TOC effort and the information contained in this document is the product of several stakeholder meetings and various supporting projects and documents. The information in this document is primarily based on the following sources:

1. Discussions with stakeholders (Metro COG, NDDOT, MnDOT, Fargo, Moorhead, West Fargo)
2. ITS Deployment Plan
3. F-M Metropolitan Traffic Operations Action Plan (2009)
4. Fargo-Moorhead Regional ITS Architecture (2014)
5. Fargo-Moorhead Metro ITS Plan (2014)
6. Assessment of Fargo-Moorhead Traffic Signal Operations Program, FHWA-HOP-09-013, January 2009
7. Fargo-Moorhead Traffic Operations Center: Operational Concept (2007, 2009)
8. Fargo-Moorhead Traffic Operations Center ITS Project Architecture (2010)
9. Available literature on other TOCs
10. FHWA's Systems Engineering Guidebook for ITS – Concept of Operations Template

4.0 BACKGROUND

The growth experienced in the F-M area has resulted in additional burdens on its transportation system. Although the system functions satisfactorily for the most part, the high demand levels during peak periods, traffic incidents, special events, and inclement weather can result in significant traffic congestion. In addition, most major and minor arterials cross at least two transportation agency and jurisdictional boundaries and at least one corridor (Main Ave.) involves five transportation agencies.

Although traffic operations have seen improvements in the F-M area over the past several years, greater enhancements can be achieved through integrated and centralized operations. Several activities over the past year have reenergized the importance of this effort. Additionally, in 2007, the F-M Metro ITS Plan and F-M Regional ITS Architecture were updated, which identified several TOC components as being desired by numerous transportation agencies [*1,2*]. The traffic signal operations assessment conducted in November of 2008 by the Federal Highway Administration (FHWA) reinforced the importance of performing effective traffic operations rather than focusing on maintenance activities [*3*]. Shortly after the FHWA assessment, Metro COG formed a traffic operations working group to develop a F-M Traffic Operations Action Plan, which focuses on signal operations, system performance, incident management, and creating a traffic operations center [*4*]. A significant portion of the tasks/projects identified in the plan relate to TOC functions.

The current operation of the F-M transportation system has several limitations and drawbacks. While most of these issue are jurisdictional related, some are related to technology. A summary of the regional limitations and shortcoming include the following:

1. Limited coordination on inter-jurisdictional corridors
2. Different agencies have varying levels of resources in terms of training and number of staff dedicated to traffic operations
3. Different agencies have different software and hardware (field devices) that might hinder integration and information sharing (traffic data and traffic images)
4. Lack of established regional practices for traffic control and dealing with incidents, special events, and large-scale emergencies (e.g. flooding)

4.1 Infrastructure/Network

Traffic operations functions/tasks are performed by using various traffic and ITS devices, such as traffic signals, vehicle detection systems, video surveillance systems, communication infrastructure, and various management software systems. Several transportation agencies in the F-M area have traffic signal systems, as well as vehicle detection and video surveillance systems (Figure 1). It should be noted that the traffic signal systems of each jurisdiction are primarily independent from neighboring jurisdictions. A TOC will allow the various jurisdictions to share information through a communication connection.

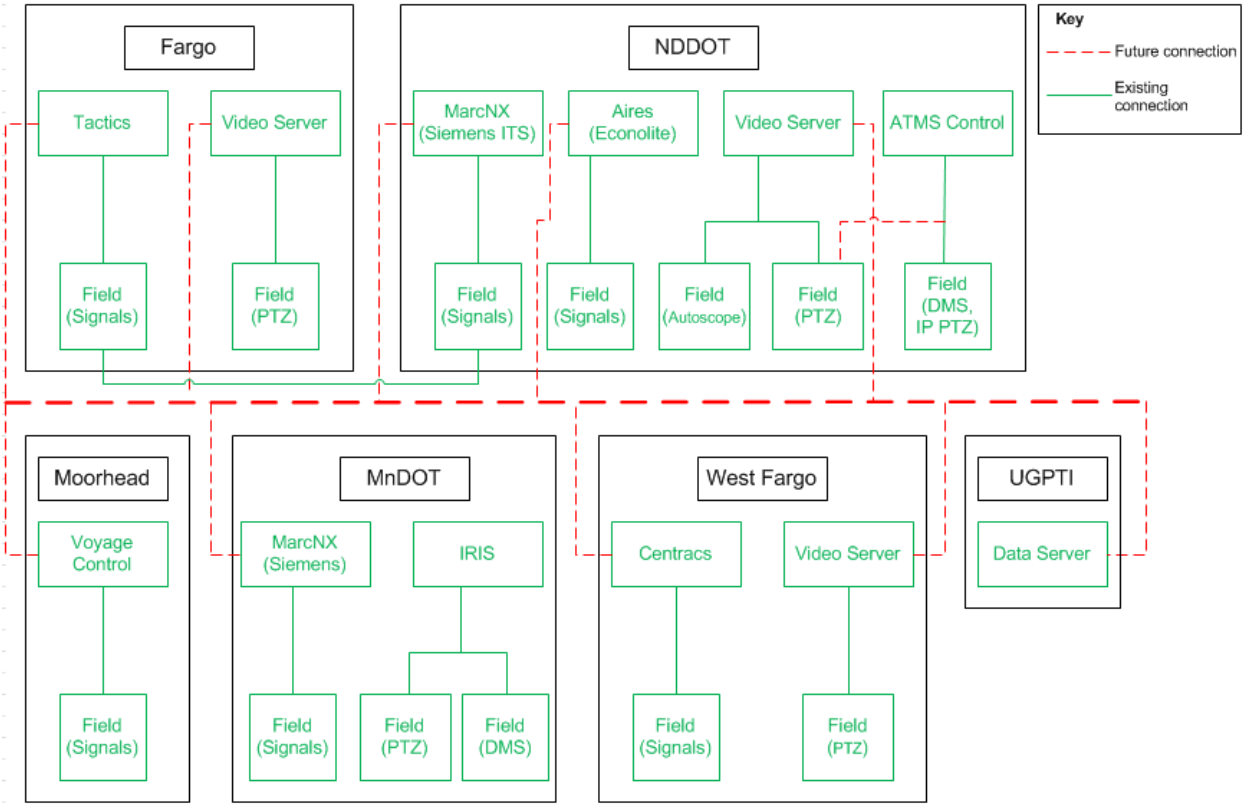


Figure 4.1 Fargo-Moorhead traffic operations agencies: existing and potential connections.

Traffic signals comprise a majority of the traffic devices and have the largest impact in effective traffic operations. The F-M area will have approximately 239 signalized intersections by the end of the 2014 construction season (Table 4.1). The city of Fargo has the most traffic signals with 160 or 67% of the metro total.

Table 4.1. F-M Signalized Intersections

F-M Jurisdiction	Number of Traffic Signals*	Percent of F-M Metro	Traffic Signal Controller Brand
Fargo	154	63%	154 - Eagle
MnDOT	25	10%	25 - Eagle/Voyage
NDDOT	23	10%	21 - Eagle, 2 - Econolite
Moorhead	21	9%	21 - Eagle/Voyage
West Fargo	19	8%	19 - Econolite
F-M Metro	243	100%	220 - Eagle, 23 - Econolite,

* Maintained by jurisdiction. Information based on December 2013 data.

Issues with system compatibility may arise with existing hardware and software. Equipment compatibility is required to interconnect the various traffic signals. Of the five jurisdictions that operate/maintain traffic signals, four traffic signal controller brands are used. However, most of the F-M arterials, which are the primary focus of signal interconnects, are equipped with Eagle traffic controllers which are managed by the MarcNX closed-loop traffic management software (Table 4.2).

Table 4.2. F-M Traffic Signal Controllers

Traffic Controller Brand	Percent of F-M Metro
Eagle (Siemens ITS)/Voyage	91%
Econolite	9%

To obtain an integrated transportation system, communication infrastructure and supporting devices must be installed. Communication to local and master traffic signal controllers in the field allows technicians and engineers to effectively operate, maintain, and monitor the traffic signal system. Signal coordination can be achieved since system-wide controller clock uniformity becomes possible, which currently occurs on a limited basis.

Connecting existing transportation communication systems and extending/installing new systems are critical for effective traffic operation and management. These connections allow various types of data to be shared between various field devices and agencies. The City of Fargo and NDDOT have extensive fiber-optic systems for communicating to their transportation field devices; additionally the City of West Fargo, City of Moorhead, and MnDOT have all added to their communications network. NDDOT and the City of Fargo have been working on interconnecting their signal systems, these connections currently exist at: 13th Ave S, University Drive S, 25th St S, and 45th St S. Furthermore, the NDDOT's signals that have been interconnected are available on the City of Fargo's central control software Tactics. In addition, establishing network connections would allow almost all of the F-M traffic monitoring camera data (using pan/tilt/zoom – PTZ cameras) to be shared.

Although creating the network connections will allow traffic signal data and video monitoring data to be shared, additional management software will be required for other agencies to access the data. For example, the City of Fargo has a Pelco system (41 PTZ cameras), while the NDDOT uses a Cameleon traffic management system for accessing their devices (11 PTZ cameras). In 2014 the NDDOT Central Office has procured an advanced transportation management software (ATMS) for controlling all their ITS devices, surveillance video can be shared via this software. At least one new IP-based PTZ camera is planned on the tri-level at the I-94/I-29 interchange in addition to upgrading some of the other NDDOT PTZ cameras in Fargo so they are sharable.

5.0 CONCEPT

Several categories or types of TOCs exist and the type adopted depends on the stakeholders' needs and resources. A staged development approach is common for TOCs since significant funding and interest from partnering agencies may not be available or realized during the initial planning or deployment stage. A description of these categories is as follows:

- Centralized: a single physical location that houses all traffic operations staff and functions;
- Distributed: several centers exist but have unique roles based on operational role or function;
- Virtual: no physical location exists as a point of activity, all functions exist as network applications and can be accessed in a variety of physical locations; and
- Hybrid: combining a central facility and some remote functionality across network links.

Since the City of Fargo and NDDOT already have agency specific TOCs, a short-term (Phase I) TOC would consist of a hybrid TOC that would connect the existing centers together along with other agencies and devices as they became available. The hybrid TOC would not require significant resources (depending on functional requirements) and would serve the F-M area until funding for a long-term center is identified.

The long-term (Phase II) TOC would be classified as a centralized TOC that includes dedicated physical space for performing all transportation operations and management activities. The centralized TOC could be a portion of an existing transportation agency/entity or a standalone facility. Options discussed and documented in the F-M Metro ITS Plan included the Red River Regional Dispatch Center (RRRDC) and the Metro Area Transit expansion (future).

Regardless of the TOC phase, several general functions/activities will be performed by the FM TOC. These intended functions include the following:

- Collect and share traffic data and information among agencies;
- Provide information to travelers;
- Implement traffic control strategies in response to special traffic conditions/incidents; and
- Implement inter-jurisdictional traffic control plans on major corridors.

5.1 Phase I: Operational Concept

The initial TOC phase would connect the existing centers together along with other agencies and devices as they became available. The hybrid TOC would establish a communication link among the partnering agencies and ITS devices. One major benefit of the communication link is that the agencies will able to perform more efficient traffic signal operations since the traffic signal controller clocks will be synced together. A second major benefit allows the agencies to share traffic video from the various pan-tilt-zoom cameras and traffic volume information.

The hybrid TOC would provide operational improvements to the metro area by combining operations of signals in Moorhead that are under the jurisdiction of both MnDOT and the City of Moorhead, this would create a Minnesota traffic operations center in the F-M areas (MnTOC). Under this scenario NDDOT, City of Fargo, and City of West Fargo would operate their own traffic signals, communication links will provide more efficient signal coordination between the

signals operated by both cities and signals operated by NDDOT at Interstate ramp termini. Under the MnTOC umbrella, some aspects of signal maintenance can be shared between MnDOT and City of Moorhead while MnDOT will continue to use ESS for specific portions of maintenance activities via an arrangement with MnDOT central office.

5.2 Phase II: Operational Concept

The long-term TOC or Phase II would consist of a centralized TOC. The communication connections established in Phase I would still be used to provide access to the available devices/data. However, this phase would create a centralized facility to serve as the focal point for collecting, processing, and sharing operational information in the metropolitan area, including coordination among the various jurisdictions and agencies. The traffic signal operations of the City of Fargo, City of Moorhead, NDDOT, and MnDOT would be conducted at the centralized facility. The City of West Fargo might decide to join in the centralized TOC, otherwise data and video sharing between FM TOC and West Fargo TOC will be performed via the established communication connects. The traffic signal maintenance activities would primarily be performed by TOC staff while the equipment would be provided by its respective owner.

6.0 OPERATIONAL DESCRIPTION

The growth experienced in the F-M metropolitan area has resulted in additional burdens on its transportation system. Although the system functions satisfactorily for the most part, the high demand levels during peak periods, traffic incidents, special events, and inclement weather can result in significant traffic congestion. Limitations of the current transportation system in terms of traffic operations include the following:

- Limited coordination on inter-jurisdictional corridors;
- Agencies have varying levels of resources in terms of training and number of staff dedicated to traffic operations;
- Agencies have different software and hardware (field devices) that might hinder integration and information sharing (traffic data and traffic images); and
- No established regional practices for traffic control and dealing with large-scale special events, incidents, or emergencies (e.g., flooding).

6.1 City of Fargo, ND

The City of Fargo has the most traffic operations resources in the region in terms of staff, training, and equipment. In addition, the city has the most technical expertise related to traffic signals. The city has one professional traffic operations engineer (PTOE) and one traffic operations engineer. However, most of their time is spent on activities unrelated to traffic operations, such as day-to-day management of consulting engineers working on environmental documents, corridor studies or final design for future road construction projects, day-to-day correspondence with traffic control contractors dealing with road closures, sitting on various committees, corresponding with the general public on transportation related items, etc. In addition, the city has four traffic signal technicians that maintain the city's traffic signals (154) and traffic signs (~22,000). The chief signal maintenance technician receives training and certification from the International Municipal Signal Association (IMSA).

The City of Fargo exclusively uses Eagle traffic signal controllers along with the Tactics central control traffic management software. This is to ensure system capability and more efficient signal operation. The city has a traffic signal maintenance plan which is followed on a continuous basis. Traffic signal operational improvements are performed on an as needed basis and no policy exists for discussing update priorities or methods. The city performs signal coordination along all major and minor arterials. Typically three timing plans are developed for a corridor during weekdays (AM Peak: 6:30 am to 9:00 am, Midday or Off-Peak: 9:00 am to 3:30 pm and 6:30 pm to 10:30 pm, and PM peak: 3:30 pm to 6:30 pm), while one coordination plan is typically developed for weekends (6:30 am to 10:30 pm). The highly commercial corridors in the city run a Midday plan from 11:00 am to 7:00 pm. Actuated signals run uncoordinated (free) when not under coordination operation.

Due to compatible equipment and a good working relationship with the NDDOT - Fargo District, several arterials are coordinated that include signals owned by both the City of Fargo and NDDOT. However, this process is not seamless for a couple of reasons. First, the city may propose signal timings along a corridor but may have to wait for a significant amount of time before the NDDOT approves the timings for their ramp terminals. This issue has significantly improved in the past few years. Secondly, since the two agencies have different system (master) clocks for the traffic controllers, the offsets for the coordination plans may not be accurate. This

problem exists since the City of Fargo currently does not use an atomic clock for updating the system clock.

The City of Fargo has numerous PTZ devices to monitor traffic operations along the arterial system. The cameras are used periodically to assess recurring congestion and the impacts of road construction. Signal timing updates may be performed based on observing existing traffic conditions. Currently, only the city's traffic engineering staff (engineers and technicians) has access to the video images. In the near future, the city's street and police department will have access to the video images.

To assist in improving traffic signal operations, the City of Fargo and Metro COG have installed additional vehicle detection equipment. This equipment is needed to provide continuous traffic volume data, which will assist in identifying temporal traffic patterns and determining appropriate signal timing durations. Although approximately 12 intersections have had some updates, several of these intersections are missing one or more turning movements.

6.2 NDDOT – Fargo District

The NDDOT – Fargo District has one traffic engineer (professional engineer) who spends approximately 25% of their time on traffic signal operations. In addition, the district has two maintenance technicians that spend approximately 5% of their time performing traffic signal maintenance activities. Most of traffic engineer's time is spent on activities unrelated to traffic operations, such as maintaining traffic signs, roadway lighting, pavement markings, etc.

The NDDOT– Fargo District primarily uses Eagle traffic signal controllers (21 of the 23 signals) along with the MarcNX closed-loop traffic management software. One reason for using Eagle controllers is to provide system capability with the City of Fargo. The NDDOT – Traffic Operations section performs annual traffic signal maintenance on all of the state's traffic signals in accordance with an NDDOT statewide maintenance plan. Traffic signal operational improvements are performed on an as needed basis. The district performs signal coordination per requests of the local jurisdictions. The local jurisdictions (primarily the City of Fargo) provide the district with the proposed timing plans to review and implement.

Due to compatible equipment and a good working relationship with the City of Fargo, several arterials are coordinated that include signals from NDDOT and City of Fargo. This process is not completely seamless since the two agencies have different system (master) clocks for the traffic controllers, the offsets for the coordination plans may not be accurate. This problem exists since the City of Fargo currently does not use an atomic clock for updating the system clock. The clocks are currently synced manually when significant drift has occurred. With the inclusion of NDDOT signals that are interconnected into the City of Fargo's Tactics central control software, clock syncing could be more easily achieved.

The NDDOT – Fargo District has several PTZ devices to monitor traffic operations along the freeway system. The cameras are used periodically to assess recurring congestion, as well as monitoring road construction and adverse weather conditions. In addition, the devices are valuable for verifying freeway incidents and deploying appropriate personnel and equipment to clear the incident. Currently, only the traffic engineering office at the district has access to the

video images.

To assist in improving traffic signal operations, several of the vehicle detection cameras (Autoscope) were set up to collect volume information on a continuous basis. However, due to the placement of the cameras, the ramp counts are not very accurate compared to the arterial counts but the data could be used for trend analysis. Currently, no traffic sensors are located on the freeway system for traffic management purposes.

6.3 MnDOT – District 4

The MnDOT – District 4 has one traffic engineer (professional engineer) who spends approximately 10% of their time on traffic signal operations within Moorhead, MN. Most of traffic engineer's time is spent on activities unrelated to traffic operations, such as reviewing construction plans, inspecting construction activities, etc. In addition, the district has one signal maintenance technician covering a 12-county area. The signal technician spends about 40% of their time in Moorhead, MN; however, most of that time is related to performing traffic signal and street lighting locates.

MnDOT – District 4 has 25 traffic signals in Moorhead, MN, (all Eagle/Voyage) and the MarcNX closed-loop traffic management software for communicating with the traffic signals. Recently, MnDOT has completed a major project on TH75 and US10 that included upgrading signals and installing fiber optic communication. The project also has a data collection component utilizing the University of Minnesota's SMART Signal. Signals on US10 that are adjacent to railroad lines have been equipped with the Voyage controller to better handle rail preemption. The district performs annual traffic signal maintenance on all of the MnDOT owned traffic signals. Traffic signal operational improvements are performed on an as needed basis and no policy exists for discussing update priorities or methods. The district performs signal coordination with the local jurisdiction (City of Moorhead), and is performed along portions of the state routes. When signal coordination is performed, various numbers of timing plans may be used, ranging from one to five time plans.

It should be pointed out that MnDOT's Electrical Services Section (ESS) provides the traffic signal equipment for all of MnDOT's districts. In addition, ESS staff performs the major signal maintenance activities for the districts. If a significant signal problem occurs, the district will contact ESS for assistance.

MnDOT – District 4 and the City of Moorhead perform signal coordination together for portions of the downtown arterials. The coordination efforts can be enhanced with the recent equipment and communication network upgrades by both agencies and with establishing a joint TOC for Moorhead signals (MnTOC).

Currently, the district has 9 PTZ cameras for traffic surveillance and data collection utilizing the SMART signal system is performed. There are currently no traffic sensors on the freeway system for traffic management purposes.

6.4 City of Moorhead, MN

The City of Moorhead's assistant city engineer (professional engineer) spends approximately 10% of their time on traffic signal operations. Recently, the city hired a traffic engineer (PTOE) which brings the available traffic signal operations staff to 0.8 full time equivalents (FTE). In addition, the city has one engineering technician that spends about 10% of their time working on signal related issues. The City of Moorhead contracts with Moorhead Electric to perform its signal maintenance activities.

The City of Moorhead has 21 traffic signals. Since rail preemption is one of the main issues affecting traffic in Moorhead, the city is upgrading their signal system with controllers that have specialized software for handling rail preemption; Voyage. Communication to these signals will be achieved utilizing Peek's Spinnaker central control software. Since rail preemption affects the majority of signalized intersections in the city, and for the purpose of simplifying operations, all City of Moorhead signals will have Voyage controllers and utilize the Spinnaker central control software.

Currently, the city performs coordination on 1st Ave. N. in the downtown area. The city does not perform scheduled annual traffic signal maintenance on the traffic signals.
Traffic signal operational improvements are performed on an as needed basis and no policy exists for discussing update priorities or methods. When signal coordination is performed, various numbers of timing plans may be used, ranging from one to five time plans.

The City of Moorhead and MnDOT – District 4 perform signal coordination together for the downtown arterials. The coordination efforts can be enhanced with the recent equipment and communication network upgrades by both agencies and with establishing a joint TOC for Moorhead signals (MnTOC). Currently, the City of Moorhead does not have any PTZ devices for monitoring arterial operations. In terms of traffic data collection, traffic volume and turning movement counts are possible with the updated signal and communications system.

6.5 City of West Fargo, ND

The City of West Fargo's assistant public works director performs most of the traffic signal operations activities, while the public works director (professional engineer) reviews all traffic signal improvements. About 5%-10% of their time is related to traffic signal systems.

The City of West Fargo has 18 traffic signals (Econolite) and uses the Centracs central control software for communicating with the Econolite traffic signals. The city analyzes traffic signal timing parameters (actuated-uncoordinated) on about one third of the signals each year and performs annual traffic signal maintenance on all traffic signals. In addition, the city follows an inspection checklist during the maintenance process.

Currently, the city operates 1 PTZ devices for monitoring arterial operations. In addition, the city does not have any continuous counting locations within its city limits although there is interest in setting up the existing Autoscope detection equipment for data collection.

7.0 OPERATIONAL NEEDS

It is envisioned that the TOC will be the focal point for coordinating and managing the transportation activities within the metropolitan area. Specifically, the TOC will enhance agency coordination, improve transportation safety and operations, and enhance training and technical expertise to meet the rapid challenges of continued growth. Typical city and state transportation agency budgets focus on project development and little attention goes to operating and maintaining the facility after construction.

To accomplish the TOC goals, several functions/activities need to be implemented and performed. The functions can be grouped into traffic signal control, traffic video, traveler information, and traffic data. A description of each of the functional areas and how a TOC can address these areas will be discussed in the following sections.

7.1 Traffic Signal Control

The F-M metro area has 5 jurisdictions that perform traffic signal operations and maintenance activities. As previously discussed, each jurisdiction performs various levels of operations and maintenance activities. Some agencies perform signal coordination, while others do not perform coordination. Traditionally, multi-jurisdictional signal coordination was limited due to equipment and/or communication issues however this has changes especially between NDDOT and the City of Fargo, and MnDOT and the City of Moorhead. In addition, the experience and time allocated for traffic signal control activities varies among the jurisdictions.

7.1.1 Traffic Signal Operations

Although some traffic signal coordination occurs within the F-M metro area, there is little evidence of performing active traffic management. Several steps need to be taken to provide more effective and efficient traffic signal operations, which would be included in the TOC design. First, the various jurisdictions must be able to share traffic signal information to provide signal coordination. Therefore, the transportation agencies must be connected (physically or virtually) to allow traffic signal data to be exchanged. The communication connections would need to be between the various centers and field devices (traffic signals).

Currently, no local or regional policies exist for identifying priority corridors, traffic signal timing practices, and performance standards. Several major corridors cross several jurisdictional boundaries. Some portions of the corridors may provide signal coordination; however, signal coordination at a regional level among all signal operators is not provided or feasible under the current technical and political arrangements. Related to signal timing practices, agencies use various methods for establishing clearance, change, pedestrians, and green intervals; use various vehicle detection methods and settings; and incorporate various signal coordination timing plans and durations.

The FM TOC will assist traffic signal operations by establishing communication links between key agencies and field devices and ensuring that signal timing coordination can occur by purchasing compatible traffic signal equipment. In addition, the TOC will establish regional traffic signal timing procedures, performance standards, and signal timing plans for corridors across several jurisdictional boundaries. These tasks and functions will allow the metro area to actively manage the traffic signal system.

7.1.2 Traffic Signal Maintenance

Traffic signal maintenance practices vary significantly among the F-M transportation agencies. Some agencies inspect and document all of their traffic signals on an annual basis while other agencies perform inspections only when issues arise. Most agencies do not have comprehensive documentation about signal maintenance activities and they do not have established protocols/priorities documented to address signal issues. In addition, the level of expertise and certification varies for maintenance staff. Some signal technicians have basic knowledge of traffic signal systems, while others are master electricians.

The FM TOC will assist in the preventative maintenance and responsive activities related to traffic signal maintenance. This can be performed by establishing protocols and priorities for addressing signal issues as well as annual maintenance practices. The TOC will help relay maintenance or service request by informing or dispatching the proper signal technicians.

7.2 Traffic Video

Although a number of traffic cameras are currently deployed or are planned in the near future, only the owning agency (sometimes only one computer) can view the images. The FM TOC will allow the partnering agencies to view the available video cameras once a communication link is established. The images will benefits the traffic engineers since they can monitor and evaluate the operation of their transportation system. In addition, the emergency management agencies will be able to use the devices during emergency situations (hazmat, terrorism, etc.) and transit operators will be able to monitor roadway conditions along their routes. Collectively, the video data will assist traffic incident detection and response, which will improve safety and efficiency.

7.3 Traveler Information

Traveler information within the F-M metro area is provided in the form of dynamic message signs (DMS) and the local media. The NDDOT has five permanent DMS along I-29 and I-94 for providing information related to major traffic events (road construction, road closures, special events, and AMBER alerts). In addition, MnDOT has four permanent DMS that are along I-94 and US10. The state DOTs and some of the local agencies have several portable DMS signs that can be deployed. Although some inter-jurisdictional coordination exists for major events (e.g., flooding), regional coordination for using DMS does not exist. Some local radio stations provide information related to traffic congestion and incidents during the morning and afternoon peak periods, the source of information is personal observation and it does not come from the traffic operators.

The FM TOC would assist in coordinating DMS use for the region, which would be based on DMS guidelines for using these devices and establishing the availability of the devices. The FM TOC could provide other traveler information methods, including traffic information video, traffic condition website and mobile application, and highway advisory radio (HAR). These systems can provide both pre-trip and en-route traveler information related to crashes, adverse road conditions, and traffic congestion.

7.4 Traffic Data

Collecting and processing traffic data is critical for performing active traffic management. These

data are important for evaluating the operations of the transportation system, as well as for updating traffic signal control plans. Currently, the metro area collects some turning movement data at a handful of signalized intersections. In addition, no traffic sensors are located on the freeway system for traffic management purposes. The FM TOC would assist in the coordination of installing, collecting, processing, and archiving the arterial and freeway traffic data, which can be used for signal timing, performance measures, and traveler information.

7.5 Incident Management

Incident management includes the detection, response, clearing, and traffic management related to traffic events (crashes, special events, etc.). Currently, the F-M metro area has limited incident management strategies or procedures that integrate response among emergency management and transportation agencies. A TOC will allow for policies and protocols to be developed to more efficiently and effectively response to incidents that occur on the freeway and local arterials. For example, if an incident occurs on the freeway, incident management would include detecting and verifying the incident (traffic data, traffic video, etc.), deploying the proper personnel and equipment, providing traveler information to notify the motorists, diverting traffic to avoid the incident location, and managing diverted traffic by using specialized incident signal timing plans. Several protocols and procedures must be developed and implemented for various types and severities of incidents. Efforts in this area would need to be closely coordinated with the RRRDC, emergency responders, and law enforcement agencies in the F-M area.

7.6 Traffic Operations/Maintenance Staff

To provide an effective and efficient transportation system, having knowledgeable and qualified staff is essential. The Institute of Transportation Engineers (ITE) has provided labor requirements for traffic operations and maintenance (*1*). As a rule of thumb, one traffic engineer is needed to properly operate and maintain every 75 to 100 signals and one technician to operate and maintain every 40 to 50 signals. Although most local agencies have traffic/transportation engineering staff, this staff spends a small amount of their time working on traffic signal operations and maintenance activities. Using 100 signal devices for engineering staff and 60 signal devices for signal technicians, the F-M area would be deficient of four FTE.

Table 7.1. F-M Traffic Signal Operations and Maintenance Staff

Transportation Agency	Staff Time Operations	Staff Time Maintenance	ITE Operations Recommendation	ITE Maintenance Recommendation†
City of Fargo	2.5	2	3.1	3.4
City of Moorhead	0.8	0.05	0.42	0.36
City of W. Fargo	0.2	0.12	0.32	0.27
MnDOT	0.06	0.3	0.5	0.61
NDDOT	0.5	0.0	0.46	0.55
Total	4.06	2.47	4.8	5.19

† Maintenance recommendations cover devices other than signals including flashing signs, and speed warning sign.

Additional staff required for F-M signal operations: **0.74** traffic operations and **2.72** traffic maintenance.

In addition to having enough staff, the FHWA signal assessment of the metro area recommended that staff are adequately trained and certified related to traffic signal systems. Currently, most of the traffic engineer positions are professional engineers and two are certified as Professional Traffic Operations Engineers (PTOE). In addition, one of the signal technicians is International Municipal Signal Association (IMSA) certified as a Traffic Signal Technician.

8.0 SYSTEM OVERVIEW

The FM TOC will serve as a focal point for coordinating and managing the transportation activities within the metropolitan area. The primary functions include collecting and sharing information among agencies, implementing inter-jurisdictional traffic control plans on major corridors, providing traveler information, and implementing traffic control strategies in response to special traffic conditions/incidents.

8.1 System Users

Since the focus of the FM TOC is to improve traffic safety and operations, the local traffic/transportation engineering agencies will serve as the primary partners. The primary users of the TOC include traffic engineering departments, emergency management departments, and transit agencies. Although additional agencies may be involved in the TOC, the following agencies will have the main stake in this endeavor:

- City of Fargo
- City of Moorhead
- City of West Fargo
- NDDOT - Fargo District
- MnDOT District 4
- Metro Area Transit (MAT)
- Red River Regional Dispatch Center (RRRDC) and the following partners:
    - Fargo Police
    - Fargo Fire
    - Moorhead Police
    - Moorhead Fire
    - FM Ambulance
    - West Fargo Police
    - West Fargo Fire
- North Dakota Highway Patrol - Fargo District
- Minnesota State Patrol - Detroit Lakes District
- Metropolitan Council of Governments (Metro COG)
- Upper Great Plains Transportation Institute (UGPTI) – NDSU

8.2 System Functions/Interfaces

The FM TOC will perform a variety of traffic operations, management, and maintenance activities. A critical component of these functions is communication between the agencies and field devices. The major functions of the TOC can be grouped into the following categories:

- Traffic signal control;
- Traffic signal maintenance;
- Video sharing;
- Dynamic message signs (DMS); and
- Traffic data.

Stakeholder meetings were conducted to determine the level of involvement of each agency as it relates to TOC functions. Table 8.1 illustrates the initial level of involvement for both a hybrid and centralized TOCs, while the following sections will discuss each function in more detail.

Table 8.1. Agency Level of Interest Related to Regional TOC Functions/Activities.

		FM TOC Functions										
		Traffic Signal Control		Traffic Signal Maintenance		Video Sharing*			Dynamic Message Signs*		Traffic Data*	
Agency		Relinquish to MnTOC (Hybrid)	Relinquish to FM TOC (Central)	Relinquish to MnTOC (Hybrid)	Relinquish to FM TOC (Central)	Allow Control	Allow View	Receive	Direct Control	Via Request	Send	Rec-eive
Traffic Management	Fargo	N/A	Yes	N/A	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes
	Moorhead	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	N/A	Yes	Yes
	MnDOT	Yes	Yes	Yes†	Yes†	Yes	Yes	Yes	Yes	Yes	Yes	Yes
	NDDOT	N/A	Yes	N/A	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes
	West Fargo	N/A	No	N/A	Maybe	Yes	Yes	Yes	N/A	N/A	Yes	Yes
Emergency Management	Minnesota State Patrol	N/A		N/A		N/A	N/A	Yes	Yes	Yes	N/A	Yes
	North Dakota Highway Patrol	N/A		N/A		N/A	N/A	Yes	Yes	Yes	N/A	Yes
	RRRDC	N/A		N/A		N/A	N/A	Yes	Yes	Yes	N/A	Yes
Transit	Metro Area Transit	N/A		N/A		N/A	N/A	Yes	N/A	N/A	Yes	Yes

* Applies to both Hybrid TOC and Centralized TOC

† MnDOT maintains service agreement with ESS for specific tasks

8.2.1 Traffic Signal Control

The system will be designed to allow the City of Fargo, NDDOT, City of West Fargo, City of Moorhead, and MnDOT to access and update traffic signal timing parameters to perform traffic signal coordination. The agencies will be physically or virtually connected to each other through existing or enhanced traffic signal management software. Near-term signal control will be conducted by each agency's staff, while long-term signal control will be conducted by FM TOC staff.

8.2.2 Traffic Signal Maintenance

In the near term (hybrid), the traffic signal maintenance activities for Moorhead and MnDOT signals will be combined with MnDOT, while NDDOT, City of Fargo, and City of West Fargo will continue to maintain equipment they own. Under centralized control, it is envisioned that the equipment will be provided by the appropriate jurisdiction but installed and maintained by TOC staff. MnDOT's ESS will continue to perform their major signal maintenance activities under both hybrid and centralized TOCs.

8.2.3 Video Sharing

The system will be designed to allow the traffic management agencies to view and control other jurisdiction's traffic monitoring cameras. All of the stakeholders would like to have access to the video images based on various traffic conditions/events. In addition, priorities must be allowed so critical staff can take control and lock out other agencies from using the device. Partnering agencies will still be allowed to view the video images during this operation.

8.2.4 Dynamic Message Signs (DMS)

Dynamic message signs (DMS) provide traveler information based on various road conditions or events. Although not all agencies own these devices, all of the traffic management agencies would like direct access to them or to be able to request the owning agency display messages when needed. Policies and procedures for the proper use of DMS devices during various types of situations must be developed and implemented.

8.2.5 Traffic Data

The system will be designed to collect and disseminate traffic data among the various traffic sensors and agencies. These data will be processed and analyzed to monitor, evaluate, and optimize the transportation system. The types of traffic data to be collected include volume, speed, and classification.

8.3 ITS Architecture Service Packages

Based on the desired functions of the FM TOC, several service packages were identified for the TOC. The transportation agencies and information flows for each service package are provided in the FM TOC Architecture (Hybrid) and FM TOC Centralized Architecture (Centralized) documents. The applicable Market Packages are listed below along with their deployment status (i.e., existing or planned). Service packages with an *Existing* followed by the * indicates there are portions of the Market Package already deployed but additional portions are planned for deployment.

- ATMS01: Network Surveillance (Existing)
- ATMS03: Traffic Signal Control (Existing)

- ATMS04: Traffic Metering (Planned)
- ATMS06: Traffic Information Dissemination (Planned)
- ATMS07: Regional Traffic Management (Existing*)
- ATMS08: Traffic Incident Management (Planned)
- ATMS13: Standard Railroad Grade Crossing (Existing)
- APTS09: Transit Signal Priority (Existing*)
- EM02: Emergency Routing (Existing)
- AD2: Archived Data Warehouse (Planned)

9.0 OPERATIONAL ENVIRONMENT

The operational environment for the TOC will differ between the hybrid and centralized architectures as outlined in the sections below.

9.1 Hybrid

Under the hybrid implementation of the TOC MnDOT and the City of Moorhead would combine operations under MnTOC umbrella. The NDDOT, the City of Fargo, and the City of West Fargo will operate separate, cooperative TOCs from their respective facilities. Currently, all five traffic operators have equipment at their offices that communicate with their field devices. Staffing analysis for the needs of MnTOC is covered in Table 7.1, section 7.6. It is not anticipated that the remaining agencies will add additional staff for the hybrid TOC.

In terms of additional equipment and field devices needs, the completion of communication network interconnect between the City of Moorhead and MnDOT is needed for MnTOC. Further, interconnect between the NDDOT and City of Fargo signal systems will be completed on all shared corridors, and interconnect between the NDDOT and City of West Fargo will take place. A connection between MnTOC and the signal system on the North Dakota side can be established either through a link between MnDOT and NDDOT, or between the City of Moorhead and City of Fargo. Additional linkages will be created from the TOCs to other regional partners, namely RRRDC, MSP, NDHP, and MAT to provide video images from the TOCs to non-traffic agencies.

9.2 Centralized

Under the centralized implementation, all traffic operation activities in the region would be combined under one TOC. This will involve the co-location of TOC equipment and staff in one facility. Communication links will be establish from this centralized location to all field devices in the area of operations, field devices include signals, sensors, surveillance cameras, and DMS. Additionally, the linkages with non-traffic agencies outlined above will also be maintained.

10.0 SUPPORT ENVIRONMENT

The support environment for the TOC will differ between the hybrid and centralized TOCs. However, in both implementations the TOC will have the support from the following external agencies/organizations:

1. Metro COG
2. NDSU-UGPTI
3. FHWA

10.1 Hybrid

No changes are expected in the support environment in the hybrid implementation as that calls for the use of existing facilities and equipment. Support personnel including information technology (IT), and maintenance staff at all agencies will continue to perform their roles as they normally do.

10.2 Centralized

Under a centralized TOC, participating agencies will decide if they will hire IT and maintenance staff or their existing staff will contribute a portion of their time towards TOC support. Utilities and facility upkeep will be handled on a cost sharing basis that will be further detailed in future TOC agreements.

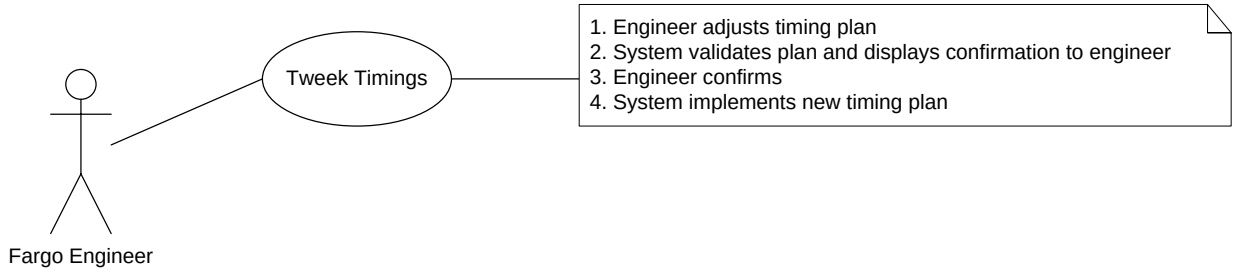
11.0 OPERATIONAL SCENARIOS

Operational scenarios for both a hybrid and centralized TOC will be presented below using Use Case diagrams. A use case diagram will show Actors (engineer, technician, dispatcher, etc.) and how they interact with the system (TOC) to perform a task in a particular scenario.

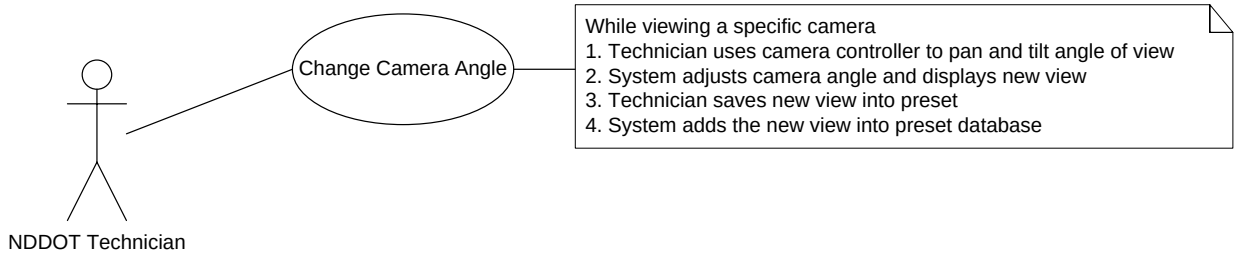
11.1 Normal System Conditions (Sunny Day Scenarios)

These scenarios reflect day-to-day tasks performed within the TOC:

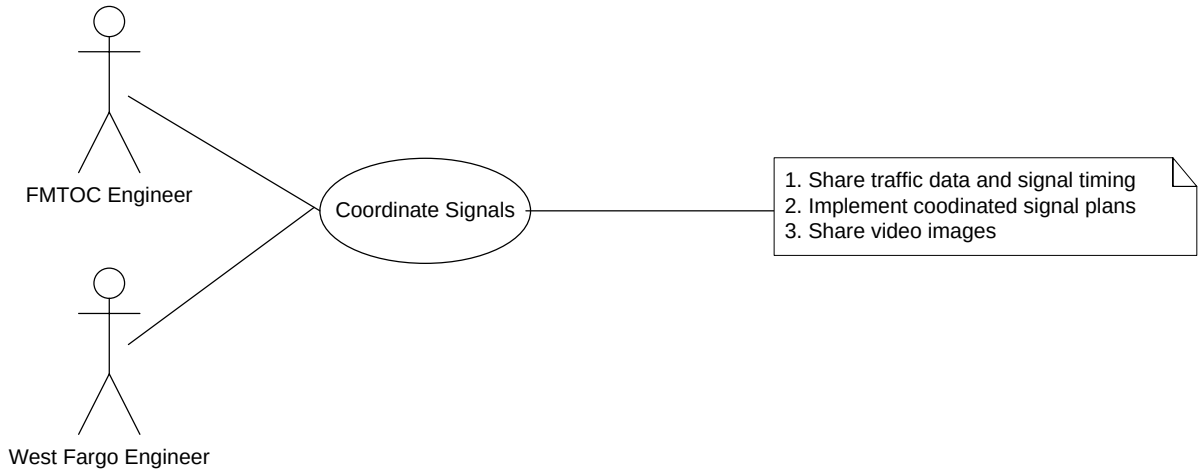
11.1.1 Tweaking signal timing (Hybrid)



11.1.2 Change camera angle (Hybrid)



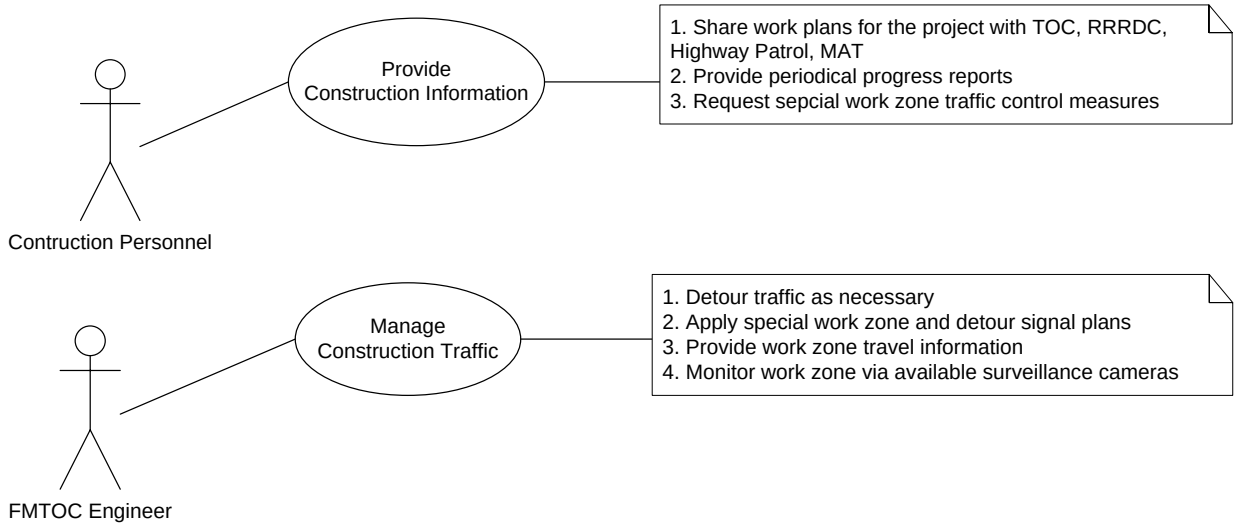
11.1.3 Coordinate signal operations (Centralized)



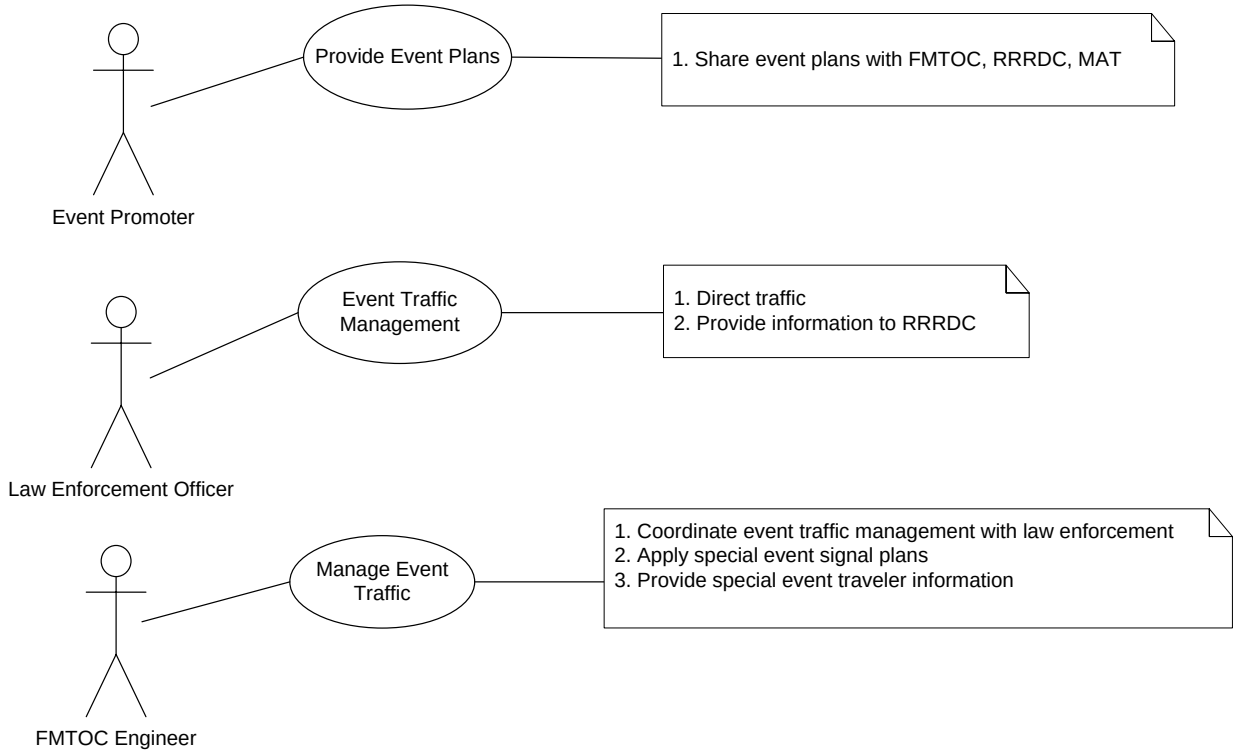
11.2 Fault-and-Failure Scenarios

These scenarios reflect extraordinary conditions:

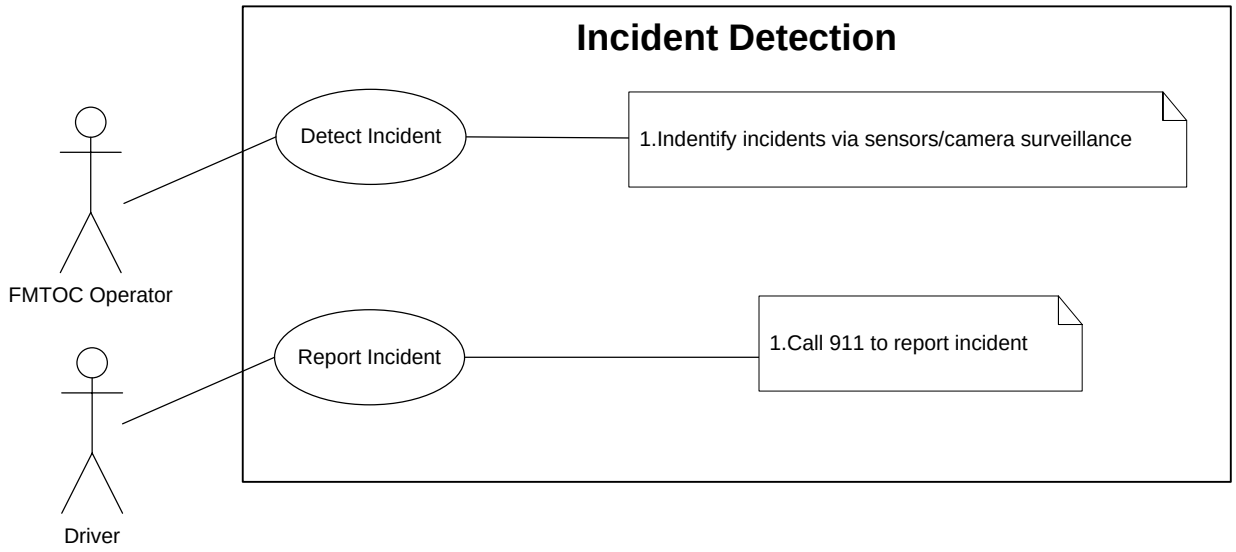
11.2.1 Work Zone (Centralized)

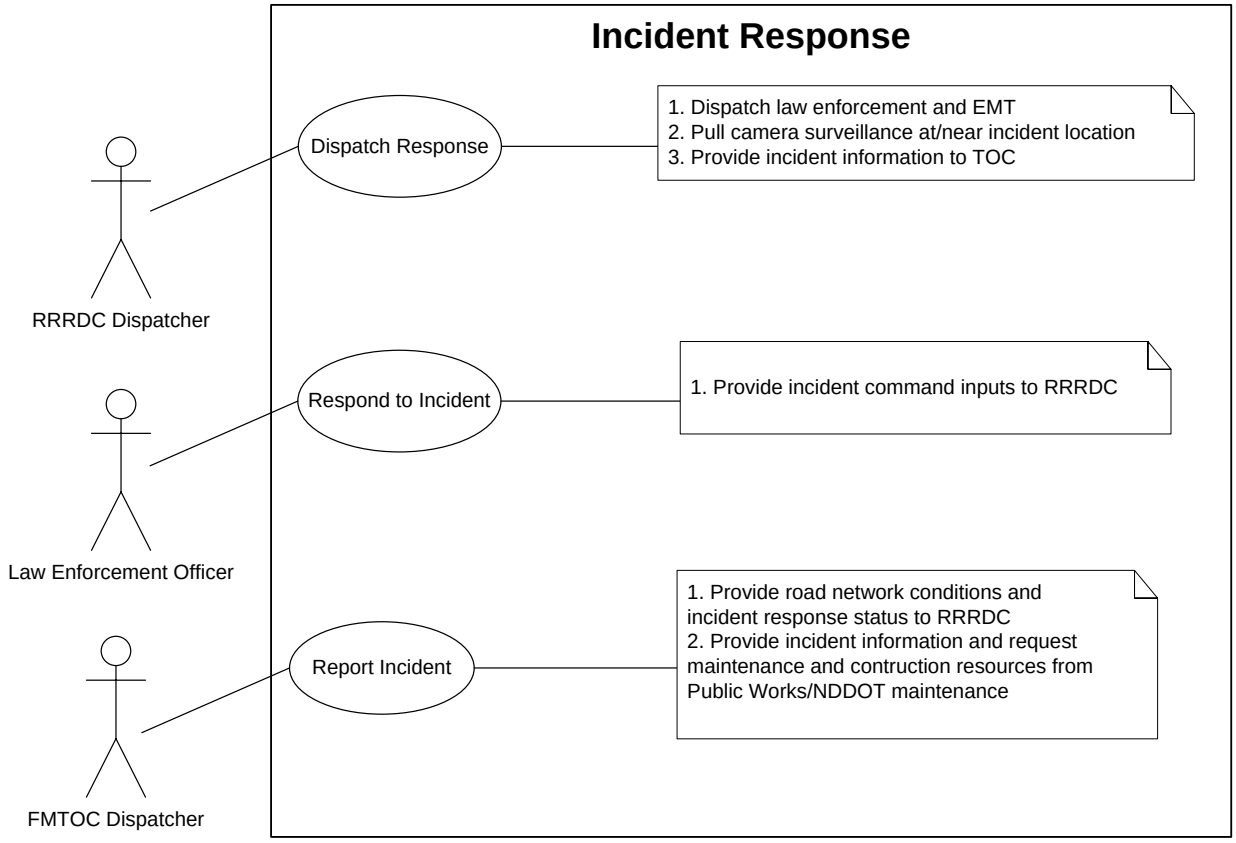


11.2.2 Fargodome Event (Centralized)



11.2.3 Major Incident (Centralized)




Incident Response
Dispatch Response
1. Dispatch law enforcement and EMT
2. Pull camera surveillance at/near incident location
3. Provide incident information to TOC
RRRDC Dispatcher
Respond to Incident
1. Provide incident command inputs to RRRDC
Law Enforcement Officer
Report Incident
1. Provide road network conditions and incident response status to RRRDC
2. Provide incident information and request maintenance and contruction resources from Public Works/NDDOT maintenance
FMTOC Dispatcher

12.0 SUMMARY OF IMPACTS

The establishment of a TOC will serve to have improved traffic management and resource sharing between area agencies. Performance measures of delay, queue length, and travel time on major corridors will be used to quantify improvements. In terms of specific impacts on each stakeholder they will be as follows.

12.1 Hybrid

In a hybrid TOC environment the following impacts will take place:

- NDDOT: no major impact on operations, will gain access to City of Fargo and City of West Fargo surveillance cameras and signal data. NDDOT will provide access to own video images to other agencies.
- Fargo: no major impact on operations, will gain access to NDDOT surveillance cameras and signal data.
- MnDOT: will combine signal operations and a portion of signal maintenance activities with Moorhead, MnDOT will continue to handle the locate service portion of their maintenance activities.
- Moorhead: will combine signal operations and maintenance with MnDOT.
- West Fargo: no change on signal operations and maintenance activities. West Fargo will coordinate with NDDOT appropriate intersections and will gain access to NDDOT surveillance cameras.

12.2 Centralized

In the centralized TOC environment, a single entity (FM TOC) will operate and maintain the traffic system in the entire area. The following impacts are anticipated:

- NDDOT: arterial and freeway management will be handled by FM TOC.
- Fargo: entire signal system handled by FM TOC.
- MnDOT: entire signal system handled by FM TOC.
- Moorhead: entire signal system handled by FM TOC.
- West Fargo: either the signal system will be handled by FM TOC or West Fargo will coordinate with FM TOC where needed.
- RRRDC: will have access to camera images from FM TOC.
- MAT: will have access to camera images from FM TOC.
- MSP: will have access to camera images from FM TOC.
- NDHP: will have access to camera images from FM TOC.

13.0 STATUS/ACTION PLAN

The deployment of a TOC within the FM Metropolitan area is seen as a gradual and iterative process. This section outlines the steps that must be undertaken for continuing towards the implementation of a TOC within the FM Metropolitan area.

13.1 Next steps

The following is a preliminary list of steps necessary to proceed with the development of the TOC:

1. Establish Joint Powers Agreement (JPA) between MnDOT and the City of Moorhead for

creating Minnesota signals TOC (MnTOC)

2. Through Traffic Operations MOU, establish Metropolitan Traffic Operations Committee (MTOC) to guide deployment of hybrid TOC and coordinate traffic operations within the FM Metropolitan area
3. Establish a specific MOU/JPA between MnTOC and City of Fargo for connecting TOCs on both sides of the river
4. Complete development of Memorandum of Understand (MOU) between MnDOT, NDDOT, Fargo, Moorhead, and West Fargo regarding Traffic Operations for the FM Metropolitan area
5. Assess progress towards implementation of a hybrid TOC and develop action plan to guide continued implementation and functionality of the hybrid TOC as part of Metro COG future ITS Deployment Plans and ITS Architecture
6. Identify, analyze and select a preferred alternative regarding a centralized TOC as part of Metro COG future ITS Deployment Plans and ITS Architecture.

References

Traffic Signal Operations and Maintenance Staffing Guidelines, FHWA-HOP-09-006, Federal Highway Administration, Washington D.C., Mach 2009

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