TASK 2: NEXT GENERATION TMC

NEXT GENERATION ITS

Prepared for:

SDOT

Seattle Department of Transportation

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Executive Summary

Seattle's transportation system is evolving and growing. As part of that process, multiple major construction projects will be underway simultaneously in the Center City over the next several years. Seattle is also enjoying an upswing in private development projects as a result of a strong economy, an increasing population density, and the creation of a more vibrant urban center.

These factors have the ability to create a more livable, sustainable and dynamic city in the long term. They can also place unprecedented pressure on the constrained transportation system, particularly while significant construction is underway. The City has identified the need to develop strategies to mitigate the cumulative impacts to the transportation system. It is imperative that strategies be implemented as soon as possible to avoid significant adverse impacts to the Center City from the projects that will be under construction until 2020. The identified major projects are:

- Alaskan Way Viaduct Replacement Program (including demolition of the existing viaduct);
- Elliott Bay Seawall Replacement;
- Waterfront Seattle (reconstruction of Alaskan Way and waterfront improvements); and
- Mercer West Corridor Project.

In order for the City to realize the full potential of these capital investments, there needs to be a Transportation Management Center capable of handling the additional systems and staff resources available with the technical and operational knowledge to support these systems. This task sets the requirements and develops a roadmap to transform the existing Traffic Management Center to become a fully effective multi-modal, multi-agency Transportation Management Center, operating 24/7.

In order to develop the roadmap, we conducted stakeholder meetings, identified systems, and conducted a complete Business Process Review. The team reviewed TMC functionality from an operational standpoint and evaluated back office systems based on current constraints. Some of the key findings through these activities include:

- The TMC video wall system has surpassed its useful lifespan, limiting the TMC's ability to effectively respond to events and incidents.
- TMC staff currently lack the experience in running more sophisticated ITS systems
- Some manual procedures can be streamlined and/or automated
- There is minimal integration between modes of transportation
- Hours of operation are not adequate to effectively manage the network
- Back office systems are not adequate to support new ITS initiatives and strategies

This report recommends what steps the City should take to update the existing TMC to Next Generation as defined by this project. As mentioned previously, these recommendations are essential to receive full return for the capital expenditures invested in construction impact mitigation. Not updating the TMC will impact traffic management potential and will reduce expected return from the implemented ITS strategies.

Section 1:
Existing Conditions

1. Existing Conditions

1.1 Existing Traffic Management Center

SDOT's current Traffic Management Center (TMC) is located on the 37th floor of the Seattle Municipal Tower in downtown Seattle. The TMC is responsible for managing the operations of signals and CCTV cameras. The CCTV network is all-digital while the signal interconnection is primarily through copper wiring. The TMC is currently staffed with at least one operator between the hours of 7 AM to 6 PM on Monday through Friday. Operators monitor traffic and respond to incidents that affect traffic flows. They also coordinate incident response with other agencies as required. A TMC supervisor is present in the TMC during operating hours to oversee the operators and coordinate TMC responsibilities with other City departments. Appendix A provides a flow chart for a TMC operator's day-to-day responsibilities.

The current layout of SDOT's TMC is shown in Figure 1, indicating a control room with one main desk in which two operators survey the eight rear projection displays that form the video wall. A small meeting area is also provided inside the TMC control room. There are two tables located to the left of the operators that are used for bench-testing and monitoring the communication network. The TMC Manager's office is also located within the control room, with a large window that overlooks the control room operations. A large conference room adjacent to the TMC provides a gathering area for emergency operations when SDOT is the lead responder, such as during winter snow removal response efforts or other severe weather warnings and alerts.

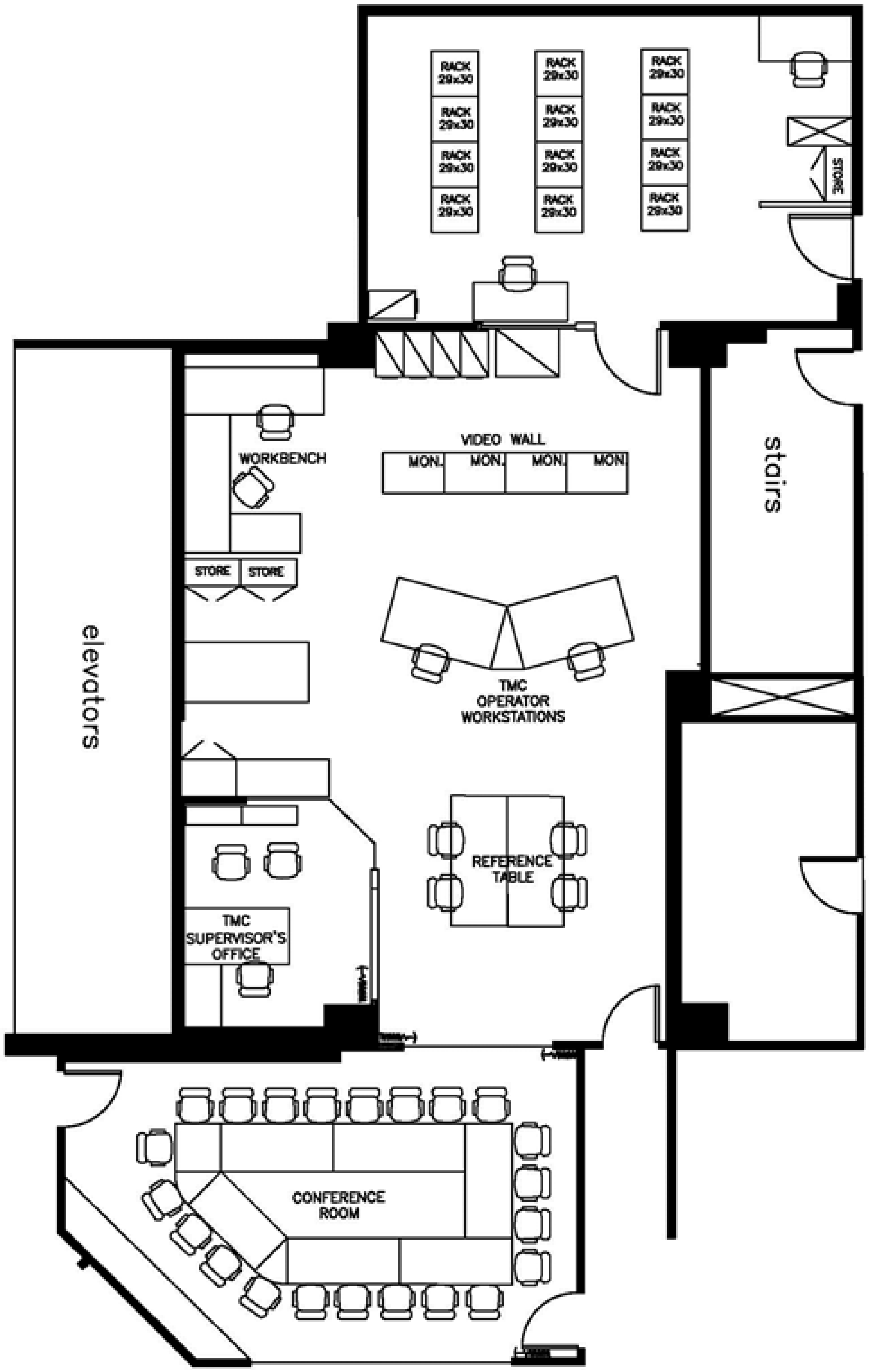
TMC Control Room Operator Workstations

TMC Equipment Room

Adjoining the TMC and behind the video wall is an equipment room housing 12 server racks where networking and server equipment is installed to communicate with field equipment and operate the TMC's critical application software platforms. Recent projects that have replaced many of the outdated point-to-point communication links to a redundant ring topology have helped to free up rack space for future use. Figure 3 provides a view inside the existing equipment room. The equipment room has additional dedicated workspace for bench testing.

The entire TMC control room and equipment room is built on a six inch raised platform. The raised flooring allows for access into the floor panels to run additional communication and electrical cables as the facility develops. The raised floor also provides better air circulation in the TMC to regulate temperatures.

Figure 1: Current TMC Layout



1.2 Existing ITS Field Devices

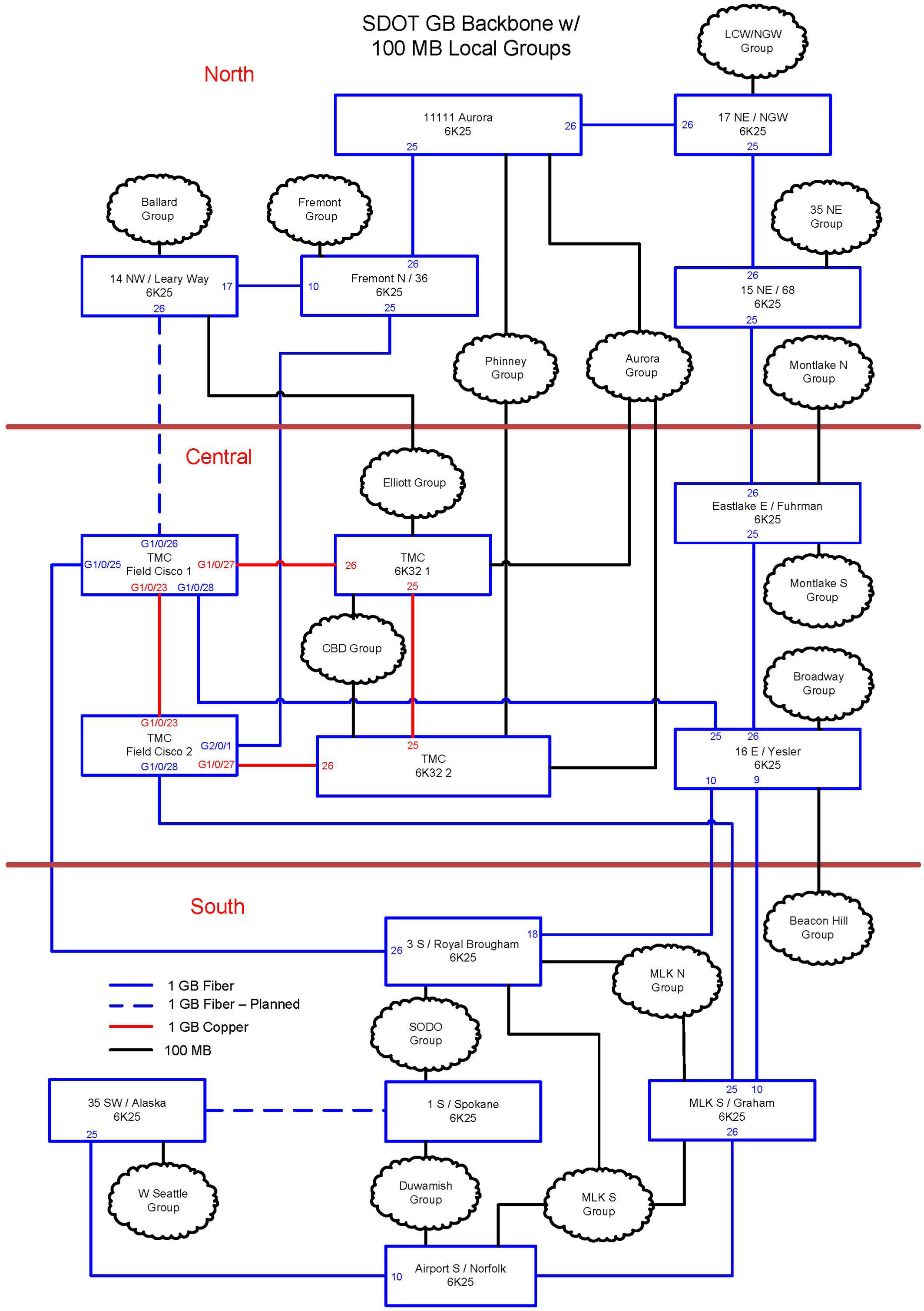
The TMC provides supervisory control of the City's signal and ITS system, which includes CCTV cameras, dynamic message signs (DMS), license plate readers (LPR), and data stations. SDOT is responsible for 1075 traffic signals, of which 700 have established communication links with the TMC. Communication is achieved via 1000 Mbps (Gigabit) fiber optic and 100Mbps serial network as illustrated in Figure 2. The main fiber communication backhauls are deployed in a ring topology to provide system redundancy. Many of the local 100 Mbps signal groups branch off from the ring topology as spurs. In addition to providing interconnectivity for the signal system, the communication system also serves as a backhaul for the City's ITS system. In locations where wired communications are not available, the City utilizes Wi-fi or GSM networks to communicate to field devices.

The City currently has a combination of approximately 150 analog and digital CCTV cameras. Video from analog cameras are digitally encoded in the field and transmitted over the Ethernet network using H.264 video compression. Streaming video is provided for internal department access and public viewing. Internal departments have access to streaming video for all 150 cameras over a 1Mbps link while the public facing video streams are limited to approximately 40 cameras transmitting over a 256Kbps link. The lower transmission rate of the public-facing video results in lower frame rates per second.

The TMC also operates the City's DMS and LPRs in tandem. The City's LPR system collects license plate data along key corridors to generate travel time information. The information is disseminated to the public through DMS. This data is also used to generate SDOT's traffic flow information on SDOT Traveler's Information Map (TIM). SDOT's Traveler Information Map (TIM) system is driven from a custom developed software solution called Data Manager. Operators may also provide inputs such as construction activity to Data Manager which will automatically update the SDOT website and provide appropriate updates through SDOT's Twitter account.

The TMC also provides ITS response for the City's five draw bridges: Ballard, Fremont, University, Montlake, and Spokane Street. At each of the bridges, a contact-closure indicating bridge opening status allows SDOT to disseminate information to the public through the use of DMS, social media, and the TIM. The TMC is also responsible for providing ITS response to the Battery Street Tunnel and unplanned emergency events. During these scenarios, messages are displayed on DMS to alert the public.

Figure 2: Fiber and Copper Ethernet Communications Network



1.3 Existing TMC Functions

Utilizing the field devices and back-end systems described, the current TMC's functions are summarized in Table 1:

Table 1. TMC Functions

Main Function	Description	Tasks
Congestion Management	To operate roadways effectively and efficiently and minimize delays caused by incidents	▶ Congestion monitoring and management ▶ Incident management and coordination ▶ Signal timing plan deployment ▶ Corridor Optimization ▶ Event monitoring, management and coordination ▶ System and Field Device Health Checks
Safety and Security	Coordinate response to incidents to enhance driver safety and reduce congestion	▶ Incident response ▶ Construction work zones management ▶ Rail Crossing management ▶ Emergency Management ▶ Monitor traffic conditions via CCTV cameras
Information Dissemination	Provide traveling public with up-to-date timely, reliable accurate information	▶ Management of Dynamic Message Signs (DMS) ▶ Management of Travelers Information Map (TIM) ▶ Road Closures ▶ Detours ▶ Travel Time ▶ Average Speeds ▶ Incident Alerts ▶ Broadcast public-facing video streams
Coordination	Coordinate with other agencies and internal SDOT divisions	▶ Seattle Police Department ▶ Seattle Fire Department ▶ WSDOT and Federal Agencies ▶ WSDOT Ferries ▶ Port of Seattle ▶ Adjacent public agencies

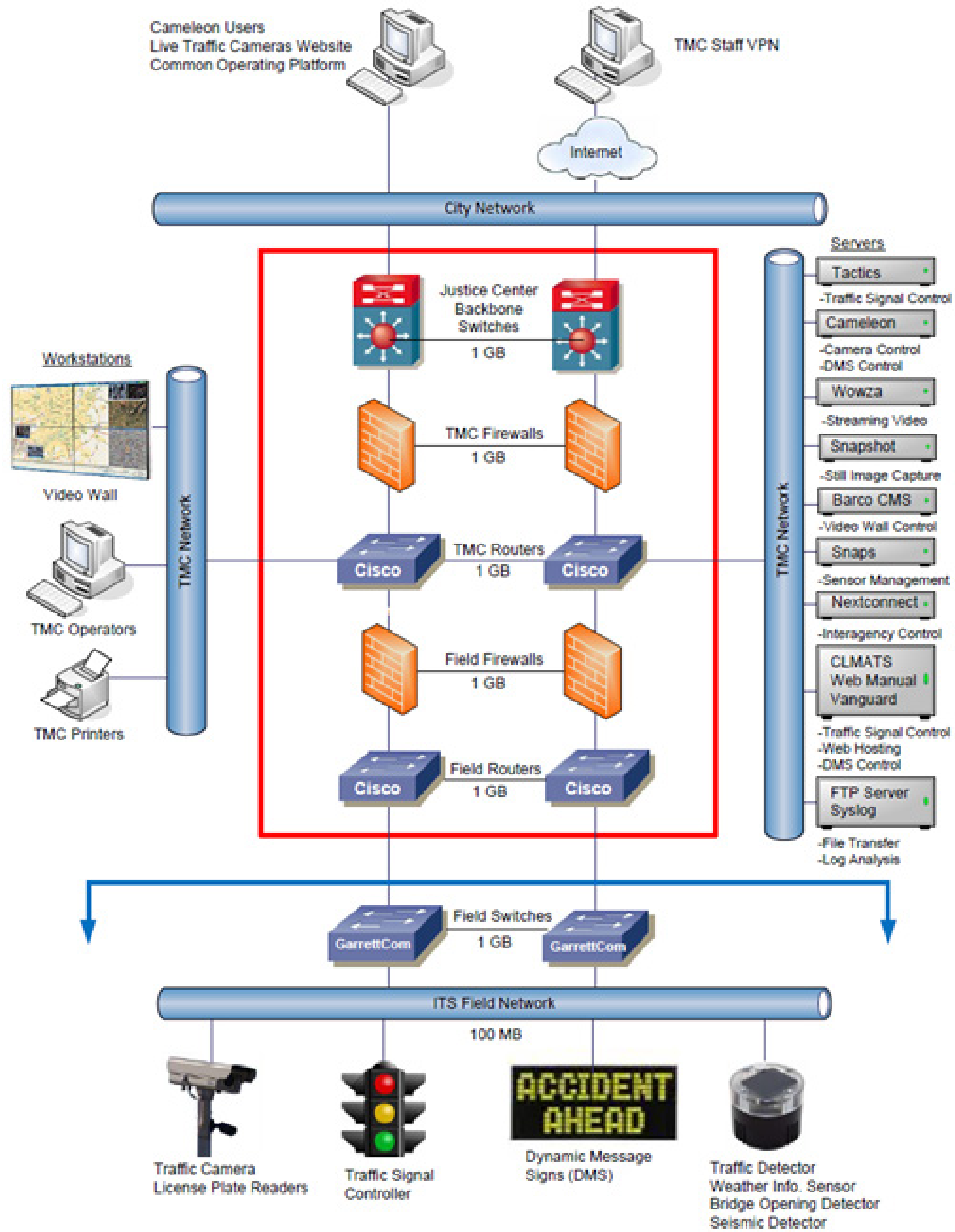
1.4 Existing System Architecture

To support the duties set out above, the existing TMC consists of various primary, secondary, and development servers with varying ranges of importance and reliance. The current servers support the following systems:

- Traffic Signal Operations
- Video Streaming
- Communication Network (copper and Fiber)
- System Health Monitoring
- CCTV Cameras
- Video Wall
- DMS Control Systems

The critical application back-end equipment is located in an equipment room adjacent to the control room and directly interfaces with field hardware. This room also houses networking hardware in which Ethernet and serial links terminate from field devices. TMC supervisors and operators have full access to the equipment room to provide server configurations, test new ITS deployments, and troubleshoot hardware. Additionally, SDOT's public-facing servers are located in a data center on the 26th floor in the Seattle Municipal Tower. These systems are jointly maintained by Central IT (DoIT) and TMC staff. The TMC staff has full access to these servers when necessary. Figure 3 shows the system architecture connecting the server components and field devices.

Figure 3. SDOT ITS System Architecture



Section 2:

Business Process Review

2. Business Process Review

2.1 Methodology

A Business Process Review was conducted to evaluate the existing TMC's capacity to support present and future ITS needs. The review was conducted between SDOT's TMC staff and stakeholders from other City departments to determine how the ITS system and TMC can better serve the City's transportation network and travelling public as part of the Access Seattle initiative.

Stakeholder interviews were held with the following SDOT departments:

- Signal Operations
- Traffic Management
- Major Projects
- Transit
- Freight
- Emergency Response
- IT

Representatives from each department were briefed on the Access Seattle initiative and were asked to describe their department's current interaction with the TMC as well as provide feedback on how they could leverage additional TMC support. Discussions were documented in the form of meeting minutes and information was evaluated to identify the key TMC challenges. Findings and key challenges were categorized under the following four main headings:

1) Operational challenges

2) Maintenance challenges

3) Equipment challenges

4) Setting challenges

Preliminary recommendations were developed to address each of the key challenges identified and presented in a collective stakeholder environment for further input. The proposed recommendations were confirmed and prioritized according to budgetary and institutional constraints, benefit, and importance.

2.2 TMC Key Challenges

The TMC's key challenges as it relates to the Access Seattle initiative and maintaining multi-modal accessibility into Seattle's CBD are detailed in the following sections. Each section is broken down into key findings, recommendations, and action items. The key findings, which represent the challenges that the current TMC is facing, were extracted from discussions with stakeholders and TMC staff regarding the Access Seattle initiative. The recommendations cover the challenges (Operational, Maintenance, Equipment, and Setting) that were acknowledged by the stakeholders and TMC staff through the Business Process Review (BPR) workshop.

Each section concludes with a set of action items that summarize the recommended approach to addressing each challenge. Each action item contains a unique identification, an action item title, a short summary, forecasted benefits, and ratings for relative cost and relative level of effort. These relative ratings establish the framework for prioritizing the TMC recommendations that will be discussed in section 2.3.

The following benchmarks were developed for estimated cost classes:

$	Little to no capital, operation or maintenance costs as these recommendations are expected to be accomplished through administrative efforts.
$$	Low capital, operations and maintenance costs.
$$$	Moderate capital, operations, and maintenance costs.
$$$$	High capital, operations and maintenance costs

A high-level cost class was assigned to each recommended action item as there are many uncertainties to substantiate an actual cost for implementation. External factors such as the level of interdepartmental cooperation have a significant bearing on the actual cost of implementing each action item. This benchmark is intended to provide a means of providing relative comparison to other recommended action items.

The following benchmarks were developed for level of effort classes:

Low	Implementation has low cost implications and can be implemented at the TMC level.
Medium	Implementation has some cost implications and requires the coordination with other SDOT and City departments.
High	Implementation has some cost implications and requires coordination with a larger within the City departments, partnering agencies, and/or the public.

Similarly, the benchmark developed for level of effort for implementation is also a high-level exercise that is susceptible to the same external factors that affect cost. This benchmark is also intended to provide a means of providing relative comparison to other recommended action items.

2.2.1 Operational Challenges

Operational challenges relate to the policies and procedures that govern the function of the City's signal and ITS systems. As it relates to the major construction projects identified, operational challenges involve multiple City departments such as the Department of Transportation, Capital Improvement Projects, Transit, Police, Fire, etc. Throughout the next 8 years, SDOT recognizes the importance of improving and streamlining TMC operations in coordination with other City departments to efficiently operate the roadway network and mitigate construction impacts. This section identifies key operational improvements that would help enhance ITS and signal operations.

2.2.1.1 Construction Coordination

In order to successfully manage traffic during major construction, SDOT needs to effectively share information internally within City departments and externally to the travelling public. Improved information sharing will allow SDOT staff to alleviate congestion on the transportation network. The TMC plays a key role in achieving this goal as TMC staff can disseminate information between City departments and to the public in order to influence travel plans, employ strategic traffic control strategies, and gain roadway situational awareness through CCTV cameras.

The City currently operates an internal network called Inweb. While information on construction activities may currently be available, there are minimal requirements and procedures in place for stakeholders to follow and proactively coordinate construction activities. TMC staff are often requested to respond to construction-related impacts as a reactive measure with minimal notice. Common requests include posting messages regarding delay times on DMS, adjusting signal timing parameters, and online outreach. On average, TMC personnel are given approximately two to three days' notice to provide ITS support for major construction activities. The lack of a forward outlook prevents TMC staff from proactively allocating staff resources and coordinating ITS equipment use with other major project groups. As major construction activities begin to coincide within the next 8 years, TMC staff will need to improve their forward-outlook related to construction activity in order to optimize the use of available ITS resources.

Recommendation

In order to facilitate improved communication between the major construction projects groups and the TMC, pre-construction requirements need to be implemented to outline the responsibilities of City staff and contractors. These requirements would promote the use of Inweb to provide long-term outlooks on upcoming construction activities and TMC support requests. This will require modifying the Inweb system to include a Construction Event Log and a TMC Support Request form where the needs of the construction management team are identified and the resources of the TMC can be appropriately allocated. TMC resources would include CCTV camera coverage, DMS advanced warning messages, public information dissemination via TIM, and TMC oversight from a dedicated signal timing engineer.

2.2.1.2 Incident Response Coordination

To facilitate with incident response, SDOT has developed a handbook with emergency TMC procedures. This resource identifies response tactics for major City emergencies and defines SDOT's role in various scenarios. Currently, this handbook assigns SDOT as the lead agency in winter weather response efforts. In addition to the handbook, the TMC operator flow map presented in Appendix A is another tool that provides guidance to TMC operators on the proper procedures when responding to incidents. One shortcoming is that TMC operators currently have no guidance on when to escalate incident response to senior staff and involve other departments as necessary. Operators escalate response efforts based on their job experience and best judgment. The absence of a defined standard in resource allocation results in response inefficiency and inconsistency.

One initiative that the Seattle Fire Department (SFD), Seattle Police Department (SPD), Seattle Public Utilities (SPU), Seattle City Lights (SCL) and SDOT have been developing is a Common Operating Picture (COP) for collaborative emergency response. COP enables the five major responding departments to collectively share incident-related information, such as real-time video and computer-aided dispatch (CAD) data, on a common system. The goal of COP is to decrease incident response times by optimizing the resources available from the five major incident response groups. Recognizing that this tool is currently under development, the five agencies should integrate the TMC operations into COP and leverage the support of ITS as much as possible.

Recommendation

In order to improve TMC resource management and assist operators in incident response scenarios, it is recommended that SDOT develop an Incident Severity Index (ISI) which would identify qualitative and quantitative thresholds in which additional support staff should be allocated to help TMC staff expeditiously respond to incidents. For example, if the travel time on a main arterial exceeds an established threshold due to a lane closure, a signal timing engineer can be assigned to help employ signal timing adjustments and corridor optimization to help relieve congestion. The ISI should also prompt TMC operators to notify applicable partnering agencies depending on the type and severity of incident.

Refined operational procedures in the emerging COP system will also help manage incident response efforts by defining how coordination is performed between the City's five main incident response departments. Consequently, it is recommended that SDOT update the TMC operator's flow map and emergency response handbook to include COP responsibilities. The previously discussed example of SDOT's lead role in winter weather response can be used to exemplify how current incident response practices might be used to improve the COP. As an example, the information gathered by SDOT Street Maintenance's snowplow AVL/GPS system could be implemented in COP to dispatch emergency responders to the most problematic areas of the city. Under direction of the COP, the same information should also be shared between the Street Maintenance division and TMC staff to alert drivers of the safest and clearest routes.

Similarly, in order to encourage additional coordination and information exchange between the TMC and other incident responders, the SDOT TMC should develop an Incident Response Protocol where ITS devices and TMC systems that contribute to incident response (i.e. TIM, DMS, Access Seattle mobile application) should be considered for shared use in COP. Additionally, pertinent data such as status of bridge openings, rail crossing blockages, CCTV camera video, and travel time information should also be shared in COP. The protocol should establish user credentials to safeguard the proper use of the ITS system.

2.2.1.3 Dynamic Message Sign Usage

Findings

Dynamic message signs (DMS) have been a proven and effective technology in providing information to roadway users on key city corridors. As it relates to major construction, SDOT's permanent and portable DMS provide alternate routing, delays, detours and construction activity information. DMS are intended to provide information relating to construction impacts at key decision points to help the travelling public make informed decisions and route plans. Currently there are 24 permanent DMS installed within the city limits. SDOT also operates and maintains portable DMS that can be temporarily deployed for construction use.

Feedback from TMC staff indicates that the current procedure for posting construction-related DMS messages is arduous as messages are custom-developed and require the TMC supervisor's approval for each request. As mentioned in the construction coordination findings, as more of the major construction project activities coincide within the next 8 years, TMC staff resources will be limited and TMC processes should be streamlined to improve efficiency.

Portable DMS provide flexible deployment; however, many of the portable DMS lack the ability to communicate with the TMC and the Cameleon device management platform. This has hindered the TMC's involvement in utilizing these signs. As a result, most of the portable DMS are managed solely within the major project groups who have a limited understanding about the transportation network. Consequently, it would be challenging for the major project groups to deploy strategic messages to facilitate system-wide congestion mitigation strategies.

Recommendation

Recognizing that construction activity for several major CBD projects will coincide within the next 8 years, there will be an unprecedented need to provide dynamic messaging support from the TMC. Consequently, improving TMC operational efficiencies will be paramount. In order to improve operation efficiencies, it is recommended that TMC staff develop a list of standardized pre-approved construction-related messages. The list will then be incorporated into a Cameleon ITS system library to reduce the level of effort needed for posting and streamline the process to devise construction-related messages, allowing TMC staff to direct their attention on other tasks. While the expectation is that the pre-approved messages will be suitable for many typical scenarios, custom-message will still be required for unique applications.

Due to the limited number of permanent and portable DMS available and the anticipated demand for DMS messaging needs, it is also recommended that SDOT implement a DMS Messaging Priority Index (MPI). The priority index will establish importance and post messages to a DMS in accordance with a pre-defined hierarchy. In conjunction with SDOT's existing Message Priority Policy, the MPI will compare the construction impacts for different links in the transportation network and allocate DMS resources where the most benefit is anticipated. This will increase the distribution of relevant travel information and produce a more efficient network during construction.

To improve the effectiveness of portable DMS usage, the major projects groups and TMC staff need to engage in a combined effort to integrate the portable DMS with the TMC's central systems. Integration will require a means of communication to the field device which could rely on a satellite or cellular network similar to the communication for SDOT's e-Park system. This will allow the TMC staff to manage a portable message sign with the same degree of flexibility as permanent message sign. Portable DMS integration into the TMC's central systems will result in a more efficient use of the portable DMS as City staff will have a more complete understanding of the roadway operations compared to the construction management team of the specific project.

2.2.1.4 Maintaining ITS Devices

Findings

The reliability of ITS infrastructure and devices is critical to the successful implementation of traffic mitigation strategies. Currently, the City of Seattle does not have an established maintenance plan for routine evaluations of ITS and signal systems. Routine maintenance minimizes the frequency of equipment failures, resulting in increased lifespans for ITS and signal equipment. The current lack of preventative maintenance negatively affects the longevity of the signal and ITS systems, resulting in more frequent malfunctions and service disruptions. The lack of routine maintenance plans, or preventative maintenance, is largely due to a shortage of funding and staff resources that would be required to improve system reliability.

Recommendation

A comprehensive Preventative Maintenance Plan (PMP) should be developed for all ITS and signal systems. These maintenance plans should be developed based on current best practices and should also include procedures for routine diagnostic tests to assess equipment replacement needs. Examples of these PMP procedures can be found for CCTV Cameras, DMS, and Signals in Appendix B. To ensure that the preventative maintenance logs are thorough and current, it is recommended that SDOT provide field preventative maintenance crews with mobile access to the maintenance log. This will enable field maintenance crews to enter maintenance information to the central database in real-time. Without a comprehensive PMP in place, SDOT will continue to be challenged by unresolved system malfunctions and service disruptions.

In addition to maintaining existing ITS and signal infrastructure, in order to minimize the level of resources that SDOT will need to dedicate towards troubleshooting the initial errors in any new ITS and signal system, it is recommended that SDOT implement a five-year technical support requirement for new projects. Through this support requirement, contractors and vendors will be obligated to provide system support for new ITS operations, such as Bluetooth data collection technologies, through the burn-in period to absorb initial maintenance costs. This requirement will require contractors and vendors to maintain system operability for a 5-year timespan. After 5-years, it is expected that the new ITS and signal system will reach maturity and SDOT staff will take-over future maintenance.

2.2.2.2 IT Support

Findings

Currently, many of the TMC's IT functions are managed by the City of Seattle's centralized Department of IT (DoIT). IT support is critical to operating an effective and reliable TMC system. DoIT is responsible for telephone support, data center management, intranet / internet, TMC router and firewall support, and providing operating system updates and patching for TMC workstations and servers. In addition to supporting these systems, DoIT is also responsible for maintaining the SDOT's physical fiber optic infrastructure through the Fiber One agreement. IT support on the network-level of the fiber optic infrastructure is managed by SDOT. Additionally, SDOT's TMC staff is also responsible for managing communication hardware such as switches, routers, networking hubs and wireless access points.

The TMC's IT functions are divided into two categories: critical-application / command & control and public-facing. Critical application functions are comprised of the TMC components that are directly related to the operations of the field hardware. Failure of these components will impact the ability of TMC staff to effectively manage the transportation system. Public-facing functions are TMC components that are responsible for disseminating information to the public. Failures of these components will only impact the public's ability to access SDOT information since they are not a result of field hardware failure.

Critical applications are expected to have a high level of availability and low tolerances for downtimes. To meet these strict requirements, SDOT has established a comprehensive Service Level Agreements (SLA) with DoIT to define the roles and responsibilities that the two parties should adhere to with respect to maintaining the TMC's workstations and servers.

Recommendation

In reviewing the April 2013 draft SLA that was established between the SDOT TMC and DoIT, the scope and responsibilities assigned to DoIT and the SDOT TMC should be adequate to support the existing and proposed ITS system presented in Task 1. To strengthen network support the following three recommendations should be implemented into the draft SLA:

1. Increase the availability of IT support beyond the regular DoIT Monday to Friday operating hours of 7 am to 5 pm. DoIT will need to identify an on-call team that is responsible for responding to TMC operation critical application needs after regular operating hours. Physical and remote IT support beyond the regular operating hours is critical because major construction work is anticipated to occur around the clock. One of the most common construction impacts to an ITS and signal system is damage to the communication infrastructure (fiber optic and copper links), which limits the TMC staff's ability to manage field devices. Outside of the regular operating hours, DoIT should still adhere to the same agreed-upon system service metrics outlined in the SLA.
2. The current service metric presented in the draft SLA allows up to 1 hour for DoIT staff to notify SDOT after receipt of the Trouble Ticket. A 1 hour allowance for acknowledgement may not provide DoIT with the capacity to resolve the issue in time to meet the allowable downtime service metrics. It is recommended that DoIT notify and acknowledge SDOT's Trouble Ticket within 30 minutes of receiving the request. This is especially important for operation critical applications considering the low tolerance for system downtimes.
3. Consistent with best practices from many other TMCs in the US, the availability of the operation critical production servers should be revised to 99.9%. For an ITS systems that is expected to operate 24 hours of the day and 7 days a week, this standard amounts to 8.75 hours of downtime in a year or 10 minutes of downtime per week. These TMC system standards have been adopted by many other regions across the country.

Action Items

O1.A: TMC Operational Enhancements	
To counter the operational challenges identified, this project will implement one key recommendation from each of the operational challenge categories for short-term implementation as part of the Next Generation ITS Strategy. Selective improvements from each category will enable SDOT to realize benefits in TMC operational efficiencies.	
Benefits: Improves TMC Operational Efficiencies, Improves Public Information Dissemination, Congestion Reduction.	
Level of Effort: Medium	**Costs:** $$

O2.A: Integrating Portable Message Signs into the TMC	
This project integrates the portable dynamic message signs used for roadway construction projects with SDOT's communication and device management systems in the TMC. This will allow TMC staff to manage portable message signs with the same degree of flexibility as permanent signs. It will also result in a more efficient use of portable message signs.	
Benefits: Improves TMC Operational Efficiencies, Improves Public Information Dissemination, Congestion Reduction.	
Level of Effort: Medium	**Costs:** $$

2.2.3 Equipment Challenges

Equipment challenges relate to functionality of hardware and software components used to manage the City's ITS and signal system. As it relates to major construction, ITS and signal equipment are key components which directly influence effectiveness of traffic management strategies. ITS and signal equipment also provides TMC staff with the capability to dynamically monitor roadway conditions and proactively respond to incidents.

2.2.3.1 ITS Device Control

Findings

SDOT currently operates a system containing 148 CCTV cameras, 24 DMS and 90 License Plate Readers (LPR) on key arterial streets, and approximately 1075 traffic signals. Most devices are centrally managed from the SDOT TMC utilizing an extensive fiber optic Ethernet, serial, and wireless communication network. Consistent with the construction mitigation strategies presented in Task 1, additional ITS devices will be implemented to manage the impacts to the transportation system. With the expansion of field-devices, additional back-end system upgrades are also necessary to accommodate for system growth.

Presently, hardware selection has been a challenge for SDOT due to the combined limitations of the City's existing video management software, Cameleon, and video wall system, Barco Transform A. The Cameleon ITS platform, which manages the majority of SDOT's ITS field devices, is compatible with hardware identified on the software developer's 3rd party support list. Additionally, the existing Barco video wall processor system limits the models of CCTV camera that are compatible with this processor. The combined limitation of the two systems significantly limits the selection of CCTV cameras that SDOT can choose from. Both the software and video wall components will be discussed in more detail in the subsequent sections.

In many instances, limiting the number of deployed products has maintenance advantages as it minimizes the necessary spare equipment inventory; however, selecting equivalent products can help SDOT avoid pervasive problems when a hardware deficiency is detected. SDOT has experienced some of these common deficiencies in their existing CCTV camera system, resulting in frequently recurring troubleshooting efforts and added expenditure in staff resources.

Recommendation

When selecting ITS hardware, it is recommended that SDOT revise procurement specifications to include provisions for deploying forward compatible ITS technologies in order to maximize the life cycle of the installed hardware. Additionally, the specifications should also include ITS devices from two or three comparable vendors that are compatible with the existing systems. While compatibility with existing systems is a major consideration when selecting hardware, SDOT should allocate reserve funding for software development costs in the event that a superior product requires integration with the TMC's central systems. In order to effectively support an expanded ITS system, SDOT will also need to allocate additional funding to account for any increases in O&M and asset management costs.

2.2.3.2 Software

Findings

SDOT currently operates several software platforms independently to manage field equipment and disseminate information to the public. The functions of each software platform that has direct interaction with field devices are outlined in the table below:

Software	Developer	Function
Cameleon ITS	Flir	Provides command and control functionality for the City's ITS devices including DMS and CCTV cameras
Tactics	Siemens	Enables remote management and operations of traffic signal controllers
Data Manager	City of Seattle	Processes datasets from the City's data collection devices for use on the City's Traveler Information Map (TIM) and Twitter posts

Currently Data Manager is only integrated with the City's License Plate Recognition (LPR) as a data source. While the City has access to a wider variety of transportation data including transit, cycling and parking data, this information is not available for Data Manager and subsequently, TIM. The BPR recognized a need to integrate these additional data sources to improve multi-modal operations. Through the BPR, SDOT also recognizes a need to implement a software solution that is capable of archiving or reporting device performance and reliability. This tool would allow TMC staff to better understand the reliability of existing CCTV cameras and DMS through key performance indicators (KPI). Important KPIs would include device availability, history of communication failures and outages.

Additionally, SDOT utilizes the Cameleon ITS software platform to manage DMS and CCTV cameras. While Cameleon ITS is capable of communicating with all the permanent DMS and CCTV cameras installations in the city, SDOT has been experiencing ongoing difficulties with certain Cameleon functionalities including the restoration preconfigured software settings, system recovery from power outages, and DMS message confirmation through the user interface.

Recommendation

In order to maximize usage and public benefit of all the SDOT data sources, it is recommended that Data Manager incorporate a wider-range of data sources including parking (e-Park), bicycle-count information, transit data, and real-time traffic data from outside sources. The multiple data sources will allow TIM to evolve into a multi-modal tool for the public to assess travel options. Also, recognizing that King County Metro and Sound Transit have plans to implement AVL technology with One Bus Away in the near future, further integration of transit data will benefit the public with more accurate and reliable data to assess transit alternatives. With the integration of the additional data sources identified, Data Manager will become the gateway for data entry and information dissemination. It is recommended that SDOT implement a Data Warehousing function that operates in parallel with Data Manager. The Data Warehousing system will enable SDOT to archive information for all modes of traffic that will be useful for other SDOT assignments including traffic studies, planning studies, parking studies, etc.

In order to support the ITS system improvements proposed in Task 1, it is also recommended that SDOT upgrade the Cameleon ITS system to support both existing and future ITS devices. The introduction of new devices to the existing Cameleon ITS platform will inherently require configuration and possibly device driver upgrades. Recognizing that the current Cameleon ITS system is missing several key functionalities outlined in the findings, SDOT will need to work with the Cameleon ITS developer, Flir, under their existing service agreement to resolve missing features that are essential to the TMC operations.

In addition to resolving the missing features identified, SDOT should also cooperate with Flir to integrate Cameleon DMS control with Data Manager. This development will further expand Data Manager's effectiveness in providing useful real-time information for all modes of traffic.

Action Items

E2.A: Expand Data Manager Data Sources	
Summary: SDOT's Traveler Information Map (TIM) provides congestion information, travel times, and incident and event information. This project will allow SDOT to incorporate travel information from outside agencies and data sources to provide parking, bicycle, transit and additional traffic data. Enhancements may include: ► Providing real-time information related to transit alternatives. ► Supplementing existing vehicle detector information with real-time data from outside sources to provide traffic flow information on additional corridors. ► Providing bicycle count data on major bicycle facilities to highlight other travel options. ► Integrating the e-Park data to TIM to provide information on parking availability.	
Benefits: Promotes Multi-Modal Transportation, Improves Public Information Dissemination, Congestion Reduction.	
Level of Effort: Medium	**Costs:** $$

E2.B: Integrate Data Warehousing feature with Data Manager	
Summary: this project will implement data storage and warehousing capabilities that will operate in parallel with SDOT's data management system. The data warehousing system will enable SDOT to archive information for all modes of traffic, which will be useful for traffic evaluations, planning studies, parking studies, signal retiming initiatives, etc.	
Benefits: Develops additional tools for SDOT use.	
Level of Effort: Medium	**Costs:** $$

E2.C: Cameleon ITS Upgrades and Feature Enhancements	
Summary: this project will expand and upgrade SDOT's current ITS management system to operate existing and new ITS devices installed as part of Next Generation ITS. Upgrades to the TMC operating systems will include automated system recovery features to reduce device or system downtime, and enhanced system performance reporting capabilities.	
Benefits: Improves Public Information Dissemination, Improves TMC Operational Efficiencies, Supports Expanding ITS Infrastructure.	
Level of Effort: Medium	**Costs:** $$$

2.2.3.3 Video Wall System

Findings

Video wall systems are critical to TMCs because they allow operators to visualize traffic flows and incidents through the use of real-time video streams, mapping features, and on-screen alerts. Additionally, they also allow TMC staff to display contents from multiple sources that are pertinent to understanding the transportation network and respond to traffic incidents. SDOT's existing Barco Transform A video wall processor system is operating beyond its useful service life and is in urgent need of replacement. The video expansion cards that are used on the existing video wall processor have been discontinued, preventing SDOT from expanding the video wall to include additional camera streams. More concerning is that replacement expansion cards will not be available when in the event of system malfunction. Another limitation of the existing system is the dependency on Barco to develop custom configuration files to support specific camera models. Currently, the manufacturer has been unsuccessful in developing configuration files for IP cameras which are becoming a standard in the traffic management industry.

In addition to the video wall processor, TMC staff expressed that the video wall display units are also operating beyond their critical life cycles. Maintenance of the existing rear projection cube displays have been costly because this technology is obsolete and replacement parts are difficult to source.

Recommendation

In order to address the current issues with the outdated video wall system and subsequent high maintenance costs, it is recommended that SDOT procure new video wall display units and a new video wall processor system that allows for future compatibility. Within the procurement package, the following minimal requirements should be required to provide the TMC staff with a flexible and robust video wall system that is capable of supporting the future ITS system and allow for growth:

Video Wall Displays:

- LED-based display cube technology
- Front-access maintenance
- Capable of 1080p HD resolution
- Minimum 60,000 hours lifetime
- Minimum 3 Year Warranty

Video Wall Processing System:

- Capable of supporting up to 9 operator workstations
- Capable of supporting an ITS system with 400 cameras with up to 40 simultaneous streams on the video wall at 50% system utilization
- Fully compatible with SDOT's existing Cameleon ITS video management system
- Fully supports existing CCTV camera system and future IP camera deployment
- Decodes digital video including H.264 format.
- Capable of remote video wall management
- Minimum 2 Year Warranty

LED-based display cube technology have been recommended for the video wall displays over flat panel technology as they have a longer life cycle than flat panel displays, minimizing frequent replacement costs and the need to re-integrate the display panels after the unit's useful service life. Under 24/7 operations, LED cube displays offer a lifespan of approximately 9 years while many flat panel technology typically have a useful lifespan of approximate 3 years. The life cycle of the displays is an important consideration since the frequent release of newer display models and discontinuation of older models creates a challenge when sourcing replacement displays to match the existing configuration and layout. It is recommended that SDOT deploy a 4x2 matrix to match or exceed the current size. The selection of display sizes shall be selected to maximize the area allocated for the video wall. Additional video wall surface area will enhance TMC operations by allowing operators to display and share more content.

Action Items

E3.A: Video Wall Replacement Upgrade	
Summary: this project will purchase and install new video wall displays and a new video wall processor system to replace outdated equipment as well as provide compatibility with a wider range of ITS devices. IT will also add flexibility in how content is displayed, and increase the number of sources that are supported. This project includes a video wall system that meets the minimum requirements specified in this section.	
Benefits: Improves Public Information Dissemination, Improves TMC Operational Efficiencies, Supports Expanding ITS Infrastructure.	
Level of Effort: Medium	**Costs:** $$$

2.2.3.4 ITS Communication Network

Findings

SDOT currently operates an Ethernet and serial based communication network that is dedicated for signal and ITS use. The street-level network consists of multiple redundant ring structures that serve as the communication backbone. There are also older copper point-to-point links that connect to the upgraded fiber optic infrastructure to maintain interconnectivity. It is anticipated that these older copper connections will be replaced when they surpass their useful service life.

All the devices currently route to the Seattle Municipal Towers 37th floor where the communication links terminate inside the TMC equipment room's back-end switches and serial modems. The network devices in the equipment room are jointly managed by TMC staff and Seattle's central IT (DoIT). Between the two departments, a comprehensive Service Level Agreement (SLA) has been developed to outline responsibilities and define commitments to maintaining system availability.

With the anticipated expansion of the ITS system as proposed in Task 1, the existing communication system capacity (i.e. fiber availability and bandwidth capacities) will need to be reviewed to determine if the network expansion is necessary. If additional fiber is needed or communication links are necessary to implement the construction mitigation strategies outlined, SDOT will also need to evaluate the capacity of field and back-end network equipment to support the additional infrastructure.

Recommendation

The installation of additional communication links is typically the most costly component of an ITS system, especially if major civil work is required. It is recommended that SDOT develop an evaluation criteria that will help assess future communication upgrade needs, especially with the ITS system expansion that is anticipated in the upcoming years.

1. Assess fiber availability and bandwidth capacities on the proposed ITS corridors and seek opportunities to leverage existing fiber partnerships through SDOT's Fiber One agreement.
2. If fiber is not available, SDOT should evaluate the practicality of using SPD's existing, dormant wireless mesh network. This will require negotiations with SPD to understand factors such as network security, network maintenance, and available bandwidth.
3. Expand SDOT's fiber sharing agreements with other departments and partnering agencies to meet the data throughput requirements necessary to support the added ITS infrastructure. Fiber agreements with private networks should also be evaluated and compared against the costs associated with expanding the communication system.
4. If an agreement is not feasible or available, it is recommended that SDOT include communications upgrades within the scope of the Task 1 ITS mitigation projects considering the using of fiber, copper, or wireless technologies.

It will also be advantageous for the City to explore the opportunity of the development of a private Wi-Fi Mesh Network. This is a relatively quick deployment activity, requires minimal construction. and is a cost effective means of communication.

Within the Seattle CBD, line of sight will be a major concern for wireless Ethernet radio deployment due to the steep terrain. Acknowledging the topographical challenges, a wireless access survey is recommended to measure the physical data rate and signal strength associated with each access point installation. The wireless mesh system shall conform to the following standards:

- Maintain a consistent and reliable data rate capable of supporting full functionality of the connected ITS devices.
- Maintain a secure communication network using industry encryption standards (i.e WPA2 and AES).
- Interoperable with the existing networking infrastructure and equipment.

A fundamental component to supporting the ITS system is a reliable and communication infrastructure. Without an available communication system or deployment plan to establish additional communication links, SDOT will not be able to support additional ITS device deployment that are vital to mitigating construction impacts.

2.2.3.5 Internet Service Provider

Findings

At the present, the City of Seattle's network bandwidth cap is limited to 1 Gbps imposed by the City's internet service provider (ISP). Although a 1 Gbps physical connection is provided, the City is only contracted for 500 Mbps worth of outbound data traffic. This connection is shared with all departments within the City of Seattle including SDOT's TMC.

Understanding that the most data intensive component of an ITS system is typically CCTV video streaming, SDOT is limited to the volume and quality of video content that can be made publicly available through the TIM system. Although the City has 150 CCTV cameras deployed citywide, only 40 cameras are available to the public due to this data throughput limitation. SDOT currently utilizes the Google Analytics feature to determine which cameras receive the most Internet hits as a means to prioritize the 40 cameras that are disseminated through the TIM. With significant anticipated increase in CCTV camera deployment to support the major construction projects, there will be increased public demand to access CCTV cameras. SPD has recently initiated a project to replace several of the City's firewalls which are expected to increase the number of cameras that SDOT will be able to stream over the TIM; however, it is uncertain as to how many additional cameras this upgrade will support.

Recommendation

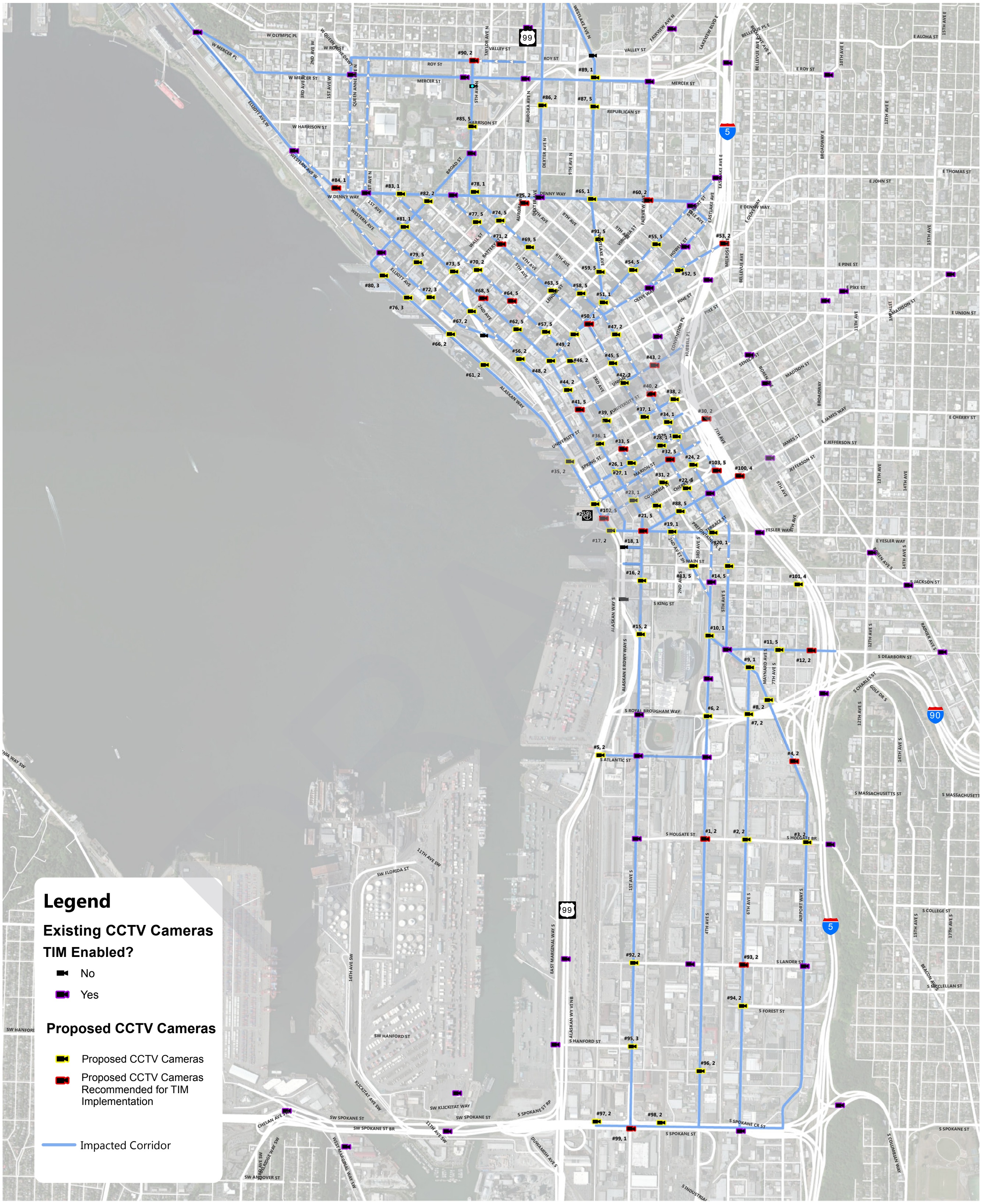
In addition to the 40 existing video streams that are currently available on SDOT's TIM, it is anticipated that the public would benefit from additional streams to gain situational awareness of the major construction impacts to the transportation system. Figure 4 suggests some of the additional Task 1 cameras that will likely be useful for public viewing.

In order to support an expanded camera system with up to 100 additional cameras (recommendation provided in Task 1), and increased public video streaming demands, it is recommended that SDOT review the network capacities after the SPD firewall upgrades. While a complete understanding of the data needs for all City of Seattle departments is necessary, SDOT should also coordinate with DoIT to determine if additional network capacity could be allocated for TMC use. If, after evaluating all these considerations, the system is still insufficient to meet the ITS data needs, additional capacity will need to be negotiated with the ISP with the primary intent of providing additional CCTV video to the public.

Action Item

E5.A: Network Bandwidth Improvement Plan	
Summary: the Next Generation ITS substantially increases the number of devices that will be communicating with the TMC. Video cameras that support streaming video in particular require a lot of bandwidth. This project will review SDOT's network bandwidth capacities. This project will be conducted in collaboration with DoIT since the network bandwidth is shared between all departments at the City of Seattle.	
Benefits: Supports Expanding ITS Infrastructure, Improves Public Information Dissemination.	
Level of Effort: High	**Costs:** $$$$

Figure 4. TIM Enabled CCTV Cameras



2.2.4 Setting Challenges

Setting challenges relate to the issues regarding the environment, staffing, and hours of operation for SDOT's TMC. As it relates to the major construction projects identified in Task 1, the following challenges for the TMC become increasingly important as the TMC will be the major hub responsible for monitoring the city's roadway network and operating ITS and signal systems. The availability and adaptability of TMC support will be an important consideration for managing construction impacts that are expected to occur around the clock.

2.2.4.1 TMC Operational Hours

Findings

The Traffic Management Center (TMC) is responsible for ensuring that the city's roadways are operating efficiently and the roadway system is optimized. According to the Seattle Municipal Code, construction activity is permitted between 7 am to 10pm on weekdays and 9 am to 10 pm on weekends. Occasionally, the City of Seattle also grants variances outside the allowable construction hours to account for special circumstances. Currently, the TMC provides coverage from 7 am to 6 pm on weekdays. The current TMC operational hours result in limited response capabilities in the evenings and weekends. Consequently, incidents that occur outside of the TMC's operating hours do not receive TMC support, resulting in potential response time delays.

Recommendation

In order to address the increasing demands placed on TMC operations during times of major construction, it is imperative that the City increase hours of operation and coverage. At a minimum, it is recommended that normal hours of operation be extended from 6 am to 8 pm 7 days a week in order to improve incident response and recovery times for incidents and construction impacts that may develop before and after peak periods. Active monitoring by TMC staff should be provided one hour before the anticipated AM peak hour and one hour after the expected PM peak hour to account for variability. Providing extended AM operations at the TMC will result in decreased congestion variability during commuting time. Similarly, extending TMC operating hours into the evening ensures that all incidents occurring during the PM peak hours will be properly resolved by the time of TMC shut down. Irregular construction impacts outside of normal TMC operating hours (such as overnight paving) that cause partial or full roadway closures on any major arterial, highway or freeway should also require a TMC operator on duty to support construction closures. These requests need to be coordinated with the TMC well in advance to enable the TMC to adequately allocate resources.

2.2.4.2 TMC Staffing

Findings

According to standard TMC staffing best practices, one full-time operator per 250 traffic signals controlled by a central system is typically suggested for arterial signal management. SDOT currently allocates 1 full-time operator for all of the City's 1075 signals. SDOT has also traditionally used student interns to fulfill the full responsibility of a TMC Operator, which has been an operational challenge due to the lack of experience and the ability to retain staff. SDOT has not been able to hire dedicated TMC Operators due to funding constraints.

As Seattle has already entered an 8-year span of major construction, the TMC will need to maximize operating efficiencies, reduce incident response times, and be capable of responding to multiple incidents that may occur simultaneously. This need will be heightened as more construction activities begin to coincide, requiring increased attention from TMC staff and a more proactive approach to managing congestion. The capabilities and qualifications of TMC staff will be fundamental to accomplishing these objectives.

Recommendation

In order for the SDOT to hire qualified TMC staff, it is recommended that job descriptions be developed to convey the minimum expectations and responsibilities associated with TMC positions. Job description should be developed for TMC Operators and Senior ITS Technicians. Recognizing that the TMC Supervisor is often away from the control room coordinating with other department staff, it is also recommended that SDOT introduce of a new Senior ITS Technician position to provide an additional oversight to support signal timing operations and maintenance. The Senior ITS Technician would be responsible for providing Operator support, implementing advanced operational procedures and mitigation techniques, and liaising maintenance needs with the Signal Maintenance department. In addition to these tasks, the Senior ITS Technician will work alongside the TMC supervisor to ensure the successful deployment and maintenance of ITS system. This Senior ITS Technician would require a dedicated workstation in the TMC.

At the very minimum, the TMC also needs to have one entry-level TMC Operator and one experienced TMC Operator during the AM and PM Peaks (6 – 10 AM) and (4 – 8 PM) working under the supervision of the Senior ITS Technician and the TMC Supervisor. Entry-level operators should be expected to work a minimum of 20 hours per week over five rotating shifts to provide the coverage that is recommended. In some cases, operators will need to cover weekday and potential weekend shifts for special events and construction closures. Depending on the level of experience, entry-level operators will generally perform basic TMC functions such as monitoring CCTV cameras for incidents, posting preset DMS messages, and coordinating with other SDOT departments and partnering agencies. Once proficiency has been demonstrated, it is recommended that entry-level operators be advanced to work on special projects assigned by the Senior ITS Technician in addition to daily routine monitoring.

Overall, TMC operators should have working knowledge of ITS devices and signal systems, while the Senior ITS Technician should have an extensive understanding of these systems. Providing qualified staff in the TMC optimizes the use the deployed ITS systems as the field device are often useful when managed properly. Sample job descriptions based on example FHWA TMC job descriptions can be found in Appendix C.

2.3 Prioritization of Recommended Action Items

With many of the major construction projects already underway, there is an immediate need to develop a prioritized implementation plan to address the TMC's BPR findings as part of the Access Seattle initiative. Proposed implementation strategies were prioritized during the final stakeholder meeting with input and consensus from the participants. The prioritization structure accounts for the following considerations:

- Implementation complexities
- Cost
- Implementation prerequisites
- Organizational challenges

Organizational challenges are more difficult to gauge as they often involve interaction with other departments and/or partnering agencies where there is uncertainty on the level of cooperation. The prioritization of recommended TMC action items are presented by arranging the action item summaries presented in Section 2.2.

Recommended action items are categorized in terms of the short-term (<12 Months), medium-term (12-24 months), and long-term (>24 month) time frames represented by the green, yellow and orange colors respectively. Recommended action items that have other specific considerations influencing the prioritization scheme that are beyond the four mentioned above will include an explanation as necessary.

Section 3:
TMC Functional Layout

3. TMC Functional Layout

As mentioned in the Business Process Review, the TMC functions as the heart of the City's ITS and signal systems. Its functionality and effectiveness in providing the tools for operators to carry out transportation management responsibilities is essential to the City operating an efficient transportation network. With many major construction projects already under way, Task 1 presents a set of ITS mitigation strategies that are expected to alleviate many of these concerns through the deployment of additional ITS equipment. In order to effectively manage the additional signal and ITS equipment proposed, a new TMC layout is recommended to provide an enhanced operating environment while providing room for future growth and capability to coordinate with other departments and agencies. Two concepts were prepared for a new TMC layout following these criteria:

- Maintain the core TMC components which include an equipment room, control room, and Emergency Operations Center;
- Allow for future growth;
- Maximize the available lines of sight to the video wall;
- Provide dedicated workstation consoles for TMC Operators with individual access to the core ITS system platforms;
- Replace obsolete TMC components;
- Adhere to TMC design best practices;
- Maintain full TMC operations during construction; and
- Include a comprehensive cutover plan to include a phased migration to the new facilities.

Figures 5 and 6 present the optimal TMC layout in plan view format and 3D visualization. This option considers a full remodel that attempts to resolve some of the key challenges identified in the BPR study. It is important to note that the layouts presented in this report are preliminary concepts. A professional architect and structural engineer should be consulted to further refine the concept plans and identify the structural constraints that may exist.

As seen in Figures 5 and 6, the most significant change in the TMC is attributed to the main control room. The operator workstations and video wall is rearranged to optimize visibility of at each operator console. Figure 9 indicates the spatial layout of the workstations and the view from the control room floor. Three rows or workstations are recommended as shown in Figure 8. By using three rows of workstations, additional TMC operators, maintenance, and signal staff, as well as police or fire representative could be assigned designated workstations as needed. In addition to the workstations, a new video wall layout using LED-based cube displays is proposed to replace the existing legacy system. The video wall shares a wall with the equipment room to simplify connections to the video wall controller system and optimize the space in the control room.

Another significant modification to the existing layout is the relocation of the emergency operations center (EOC) along with a reduction in size. The new EOC allows all participants to have a clear line of sight to the operations in the control room, a feature that was not available in the existing layout. Although roughly half the size of

Figure 5. Conceptual TMC Layout (Plan View)

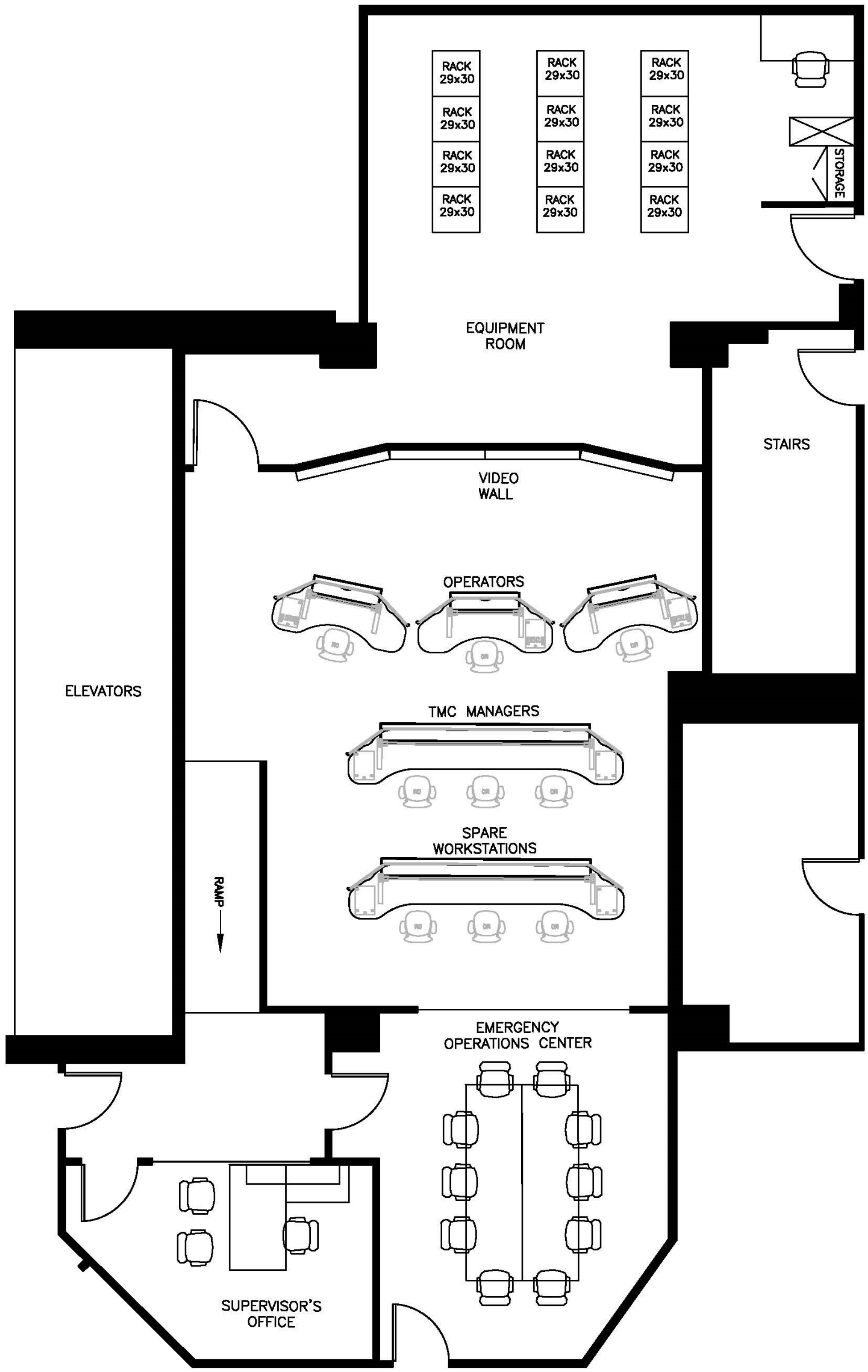


Figure 6. Conceptual TMC Layout (3D Visualization)

the existing EOC, the proposed TMC layout incorporates a full height sliding glass between the control room and the EOC to create additional room for more participants as necessary. Recognizing that the five major incident responders are implementing a COP system for incident management, the need for a large EOC is reduced as most of the response efforts can be managed by agencies remotely through COP. Modern video conferencing systems have also been an effective means of coordinating efforts remotely. However, the proposed EOC is equipped to accommodate up to 10 participants as needed.

Consistent with the existing layout, the proposed layout maintains a clear line of sight from the supervisor's office allowing the supervisor to oversee the operations in the control room.

Another recommendation not evident in the figures shown above is the need for a higher raised floor. Consistent with the US Department of Energy's "Best Practices Guide for Energy-Efficient Data Center Design", the raised flooring in the TMC's control room and equipment room should be a minimum of 24" to allow room for cable management and achieve uniform air circulation. To adhere to these best practices, it is recommended that SDOT provide a minimum raised floor height of 24".

Understanding that the proposed layout is a costly improvement for SDOT, the proposed layout has been developed in a scalable approach. Modular workstations have been recommended so they may be installed in phases as needed. Additionally, the main separating partition between the existing control room and conference room is in the same location, allowing the work in the control room and EOC to be phased as well if needed.

Figure 7. Conceptual TMC Workstation Layout

Alternative Option

An alternative option was considered to provide a more cost-conscious layout that effectively utilizes most of the existing partitions, minimizing costs associated with major construction. Partitions that are impacted include:

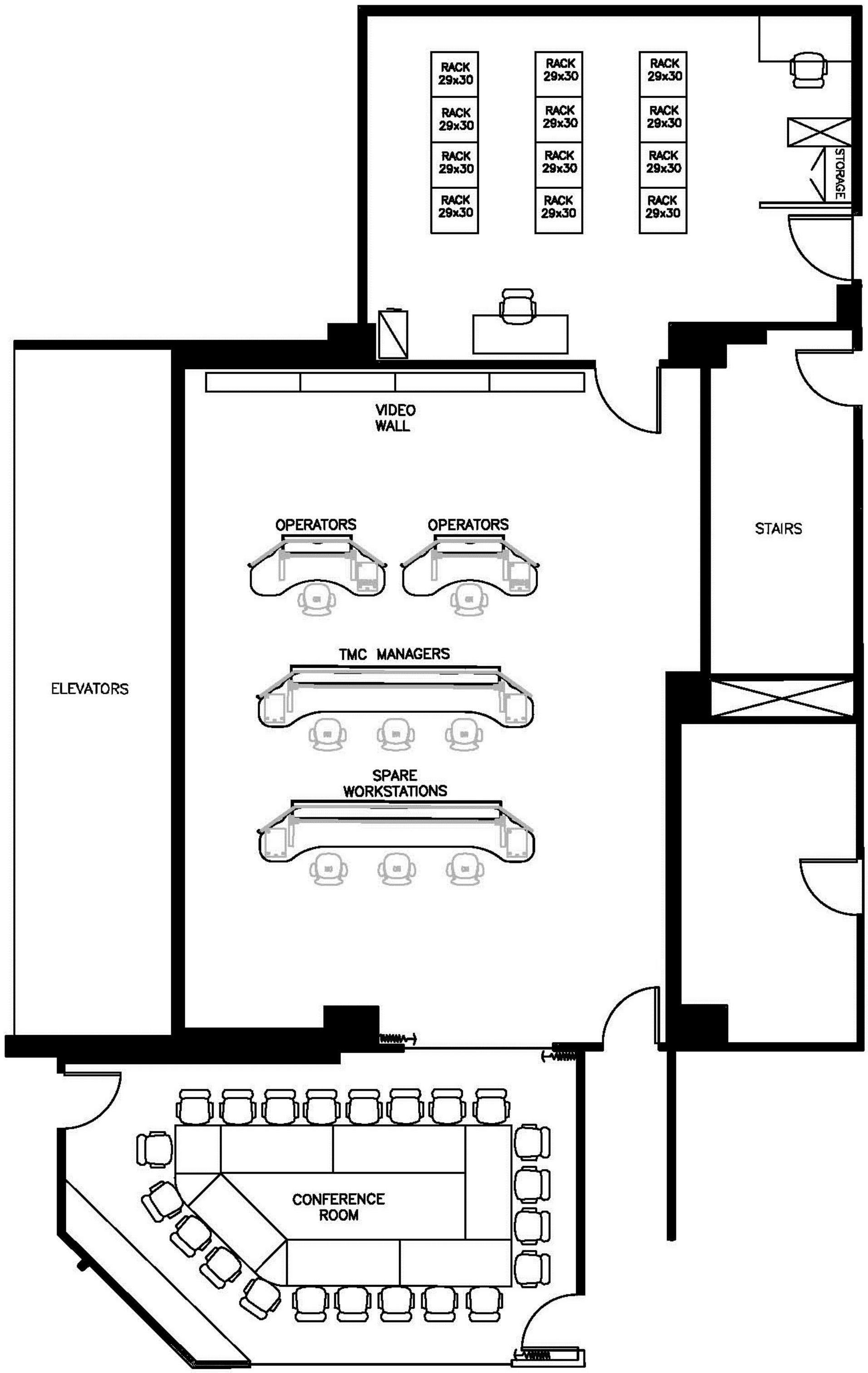
1. The separating glass and wall components between the equipment room and control room
2. The existing TMC Supervisor's office

This modification was necessary to maximize the space in the control room and accommodate the new video wall and workstation consoles (shown in Figure 7).

This option also includes modular workstations, allowing SDOT to phase the construction within the allocated budget constraints. Important to note is that this design relocates the TMC Supervisor's office outside of the control room with the other SDOT offices areas adjacent to the TMC in order to create additional space for the workstations without impacting the existing EOC. Although relocating the TMC supervisor away from the TMC is not an ideal setup, a real-time video and intercom system can be provided between the control room and the TMC supervisor's office to satisfy any communication.

Realizing that this option will most likely maintain the existing raised floor system and require very little structural, electrical, and HVAC upgrades, the cost is expected to be significantly less than the optimal layout. Cost estimates are provided in section 4 of this report to highlight the magnitude of cost difference between the two options.

Figure 8. Alternative TMC Layout (Plan View)



Section 4:

Cost Estimates
Conceptual TMC Layout

4. Cost Estimates Conceptual TMC Layout

A cost estimate has been prepared for the preferred TMC option to give SDOT a rough order of magnitude (ROM) idea of the costs associated with remodeling the TMC. Costs are broken into separate line items to enable SDOT to phase the implementation of the conceptual plan according to funding constraints. Tables 2 and 3 present the cost estimate associated with the optimal TMC layout and alternative TMC layout respectively. The estimate also includes the cost for a new video wall.

Table 2. Cost Estimates for Optimal TMC Layout

Item Description	Quantity	Unit	Per Unit	Cost
Installation				
Raised floor (server & control rooms)	1350	SF	$192	$259,200
Video Wall Monitor	8	EA	$7,000	$56,000
Video Wall Processor Upgrade	1	EA	$60,000	$60,000
TMC Operator Consoles	9	EA	$15,000	$135,000
TMC Operator Workstations	9	EA	$4,000	$36,000
Automatic Sliding Door	1	EA	$5,000	$5,000
Interior partition framing and finishing	300	SF	$40	$12,000
Ramps	2	EA	$10,000	$20,000
Secure Entry Doors	1	EA	$2,000	$2,000
Communication and phone upgrades	1	LS	$50,000	$50,000
HVAC upgrades	1450	SF	$60	$87,000
Power and lighting upgrades	1450	SF	$50	$72,500
Fire protection system upgrades	1450	SF	$6	$8,700
Demolition				
Existing partitions	250	SF	$8	$2,000
			Subtotal	$805,500
			Design Costs (35%)	$282,000
			Construction Management Costs (10%)	$80,500
			Contingency (10%)	$80,500
			Total	**$1,248,500**

Table 3.Cost Estimates for Alternative TMC Layout

Item Description	Quantity	Unit	Per Unit	Cost
Installation				
Video Wall Monitor	8	EA	$7,000	$56,000
Video Wall Processor Upgrade	1	EA	$60,000	$60,000
TMC Operator Consoles	9	EA	$15,000	$135,000
TMC Operator Workstations	9	EA	$4,000	$36,000
Interior partition framing and finishing	100	SF	$40	$4,000
Demolition				
Existing partitions	200	SF	$8	$1,600
			Subtotal	$292,500
			Design Costs (35%)	$102,500
			Construction Management Costs (10%)	$29,500
			Contingency (10%)	$29,500
			Total	**$454,000**

Section 5:
Conclusion

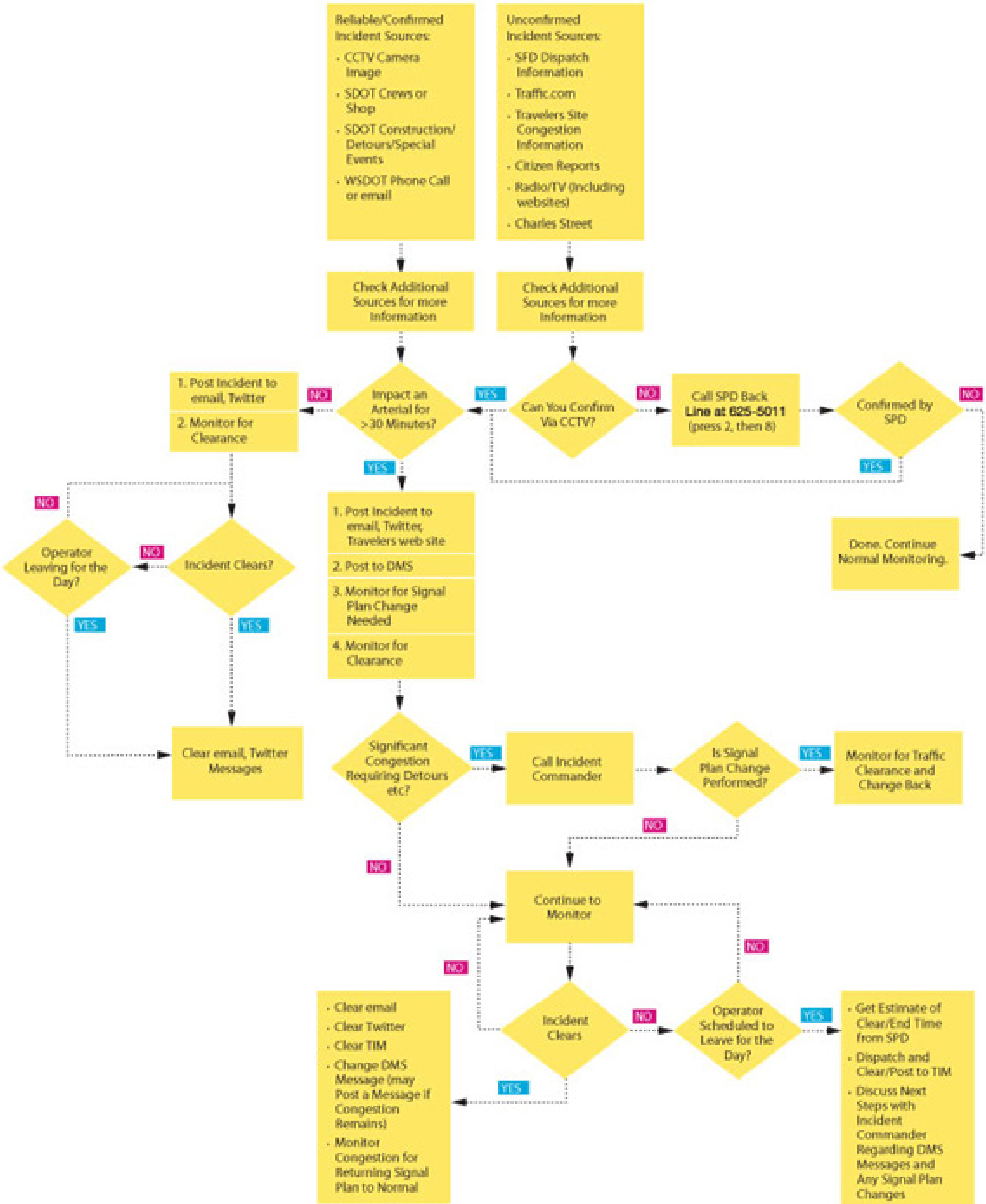
5. Conclusion

In order to meet the challenges of managing the traffic of multiple modes of transportation for the next eight years of major construction, the Access Seattle initiative will depend heavily on the functions of the SDOT TMC. The Business Process Review conducted with stakeholders from various SDOT departments identified the current needs of the TMC. Improvement areas related to operations, maintenance, equipment, and setting were identified and recommended to enable City staff to best manage ITS and signal systems. It is anticipated that these improvements will help SDOT mitigate the demands and constraints imposed by the cumulative effects of major construction activities. Through this study, stakeholders were given the opportunity to actively participate in developing proposed improvement strategy sets with TMC staff. Improvements were prioritized in terms of short term (<12 months), medium term (12-24 months), and long term (>24 month) time frames. It is important to understand that successful execution of each recommendation requires an implementation plan, which is presented as part of Task 5. The implementation plan will combine the BPR recommendations with the Next Generation ITS improvements from other tasks and serve as a roadmap to implementing system-wide ITS enhancements.

Consistent with the recommendations presented in the BPR study and the need to support a significant increase in field equipment, a new TMC layout was conceptualized within this report to provide a more efficient environment for TMC personnel and City staff. The revised layout rearranges the TMC to improve future expandability and functionality, while updating TMC components to current standards and accepted best practices. The TMC conceptualized in this report factors in the need for additional support staff in the TMC and establishes an improved functional relationship between adjacent workspaces, improving coordination effort between City departments. While the TMC upgrade is anticipated to be a costly project, the conceptualized layout allows for phased implementation to suit the City's budgetary constraints.

The successful implementation of the proposed BPR improvements will not only optimize the investments made in field equipment, but it will ultimately meet the objective of maintaining accessibility into Seattle and provide a transportation system that will best serve the travelling public during the most involved construction periods and beyond.

Appendix A:
TMC Operator Flow Map


Reliable/Confirmed Incident Sources:
· CCTV Camera Image
· SDOT Crews or Shop
· SDOT Construction/ Detours/Special Events
· WSDOT Phone Call or email
Unconfirmed Incident Sources:
· SFD Dispatch Information
· Traffic.com
· Travelers Site Congestion Information
· Citizen Reports
· Radio/TV (including websites)
· Charles Street
Check Additional Sources for more Information
Check Additional Sources for more Information
1. Post Incident to email, Twitter
2. Monitor for Clearance
NO
Impact an Arterial for >30 Minutes?
YES
Can You Confirm Via CCTV?
NO
Call SPD Back Line at 625-5011 (press 2, then 8)
Confirmed by SPD
NO
YES
YES
Done. Continue Normal Monitoring.
NO
Operator Leaving for the Day?
NO
Incident Clears?
YES
YES
1. Post Incident to email, Twitter, Travelers web site
2. Post to DMS
3. Monitor for Signal Plan Change Needed
4. Monitor for Clearance
Clear email, Twitter Messages
Significant Congestion Requiring Detours etc?
YES
Call Incident Commander
Is Signal Plan Change Performed?
YES
Monitor for Traffic Clearance and Change Back
NO
NO
Continue to Monitor
NO
NO
Incident Clears
NO
Operator Scheduled to Leave for the Day?
YES
YES
· Clear email
· Clear Twitter
· Clear TIM
· Change DMS Message (may Post a Message if Congestion Remains)
· Monitor Congestion for Returning Signal Plan to Normal
· Get Estimate of Clear/End Time from SPD
· Dispatch and Clear/Post to TIM
· Discuss Next Steps with Incident Commander Regarding DMS Messages and Any Signal Plan Changes

Appendix B:
Example Preventative Maintenance Forms

CCTV Preventative Maintenance

Activity Description:

This activity includes the routine inspection and repair of closed circuit television cameras and related equipment. All preventative maintenance checklists and the Preventative Maintenance Report Form must be completed and reported to the District ITS manager for this work to be considered complete.

How to complete this document:

Please use the following guidelines when filling in the preventative maintenance checklists:
Task: Description of task to be completed
Completed- Yes/No: Select the option that best describes the status of the task, i.e. if the task was completed select yes. If the task does not apply, please leave blank.
Condition: Choose the option that best describes the status of the task.

- **Excellent –** Like new condition, no repairs needed
- **Good –** Few minor repairs (tightening, etc.)
- **Fair –** In need of many minor repairs
- **Poor –** In need of major repairs

Scheduling:

Preventative maintenance is to be completed a minimum of twice per year for each device, prior to and after the winter season of each year (unless the manufacturer suggests more); the District ITS Manager may request more as needed. Maintenance activities may require lane closures; this must be considered while scheduling work.

CCTV Preventative Maintenance

Seattle Department of Transportation

General Checklist:

Task Number	Task	Completed?	Condition (choose one)			
G001	Check clearance of tree branches or brush around power and communication lines. Report required tree trimming and/or brush clearing work.	Yes/No	Excellent	Good	Fair*	Poor*
G002	Check that CCTV system is adequately protected by guardrail or fence. Report damaged guardrail or fence.	Yes/No	Excellent	Good	Fair*	Poor*
G003	Check for damage (lightning, leaning, car impacts, vandalism, etc.). Repair as necessary.	Yes/No	Excellent	Good	Fair*	Poor*
G004	Verify that ITS site plans, ITS system block diagrams, electrical details/wiring diagram, and any other necessary records are located in the cabinet.	Yes/No	Excellent	Good	Fair*	Poor*

*Document all Fair or Poor conditions in the Preventative Maintenance Report Form. Repair when possible.

CCTV Preventative Maintenance

Device Checklist:

Task Number	Task	Completed?	Condition (choose one)			
D001	Perform preventative maintenance in accordance with the manufactures recommendations and as follows:					
D002	Check for proper clearance of tree branches or brush; schedule any required trim work.	Yes/No	Excellent	Good	Fair*	Poor*
D003	Inspect for general condition, wear, rust, cracks, loose connections, frayed cables, and any other damage. Repair as necessary	Yes/No	Excellent	Good	Fair*	Poor*
D004	Inspect camera housing for wear, rust, cracks, loose connections, and frayed cables. Repair/replace as necessary	Yes/No	Excellent	Good	Fair*	Poor*
D005	Note and replace any missing, damaged, rusted, cracked or bent parts.	Yes/No	Excellent	Good	Fair*	Poor*
D006	Inspect mounting hardware (anchor bolts, pole attachment) for rust, cracks, etc. Repair/replace as necessary	Yes/No	Excellent	Good	Fair*	Poor*
D007	Check camera alignment (for barrel cameras only)	Yes/No	Excellent	Good	Fair*	Poor*
D008	Visually inspect all camera equipment for wear and corrosion. Replace substandard equipment.	Yes/No	Excellent	Good	Fair*	Poor*
D009	Inspect enclosure window and lens. Clean glass with suitable glass cleaning agent.	Yes/No	Excellent	Good	Fair*	Poor*
D010	Operate PTZ (Pan-Tilt-Zoom) for all functions to their extreme limits to ensure full operation and proper focus / zoom.	Yes/No	Excellent	Good	Fair*	Poor*
D011	Check operation of auto-iris and adjust for correct operation per operational and maintenance manual.	Yes/No	Excellent	Good	Fair*	Poor*
D012	Check for tightness of al internal hardware.	Yes/No	Excellent	Good	Fair*	Poor*

CCTV Preventative Maintenance

D013	Inspect all wiring harnesses and interconnecting cable assemblies / connectors for tightness, wear, and corrosion. Correct as required.	Yes/No	Excellent	Good	Fair*	Poor*
D014	Check camera housing pressure (typically 5 +/- 1 psi). Pressurize per Manufacturer's Instructions if not within limits and document readings on the maintenance report form.	Yes/No	Excellent	Good	Fair*	Poor*
D015	Visually inspect all exposed grounding systems at the device for corrosion and damage.	Yes/No	Excellent	Good	Fair*	Poor*

*Document all Fair or Poor conditions in the Preventative Maintenance Report Form. Repair when possible.

CCTV Preventative Maintenance

Cabinet Checklist:

Task Number	Task	Completed?	Condition (choose one)			
C001	Check the condition of surface and general cabinet appearance for damage (paint, damage, graffiti).	Yes/No	Excellent	Good	Fair*	Poor*
C002	Check cabinet door and locking mechanism for proper closure. Adjust or repair if needed. Lubricate hinges and lock.	Yes/No	Excellent	Good	Fair*	Poor*
C003	Inspect and change filters where applicable.	Yes/No	Excellent	Good	Fair*	Poor*
C004	Check weatherproof seal (gasket).	Yes/No	Excellent	Good	Fair*	Poor*
C005	Remove any snow or brush from doorway opening or area surrounding cabinet.	Yes/No	Excellent	Good	Fair*	Poor*
C006	Inspect cabinet mounting hardware (anchor bolts, pole attachment) for rust, cracks, etc. Tighten if necessary.	Yes/No	Excellent	Good	Fair*	Poor*
C007	Check for water accumulations and duct sealant.	Yes/No	Excellent	Good	Fair*	Poor*
C008	Clean and vacuum inside of cabinet and equipment to remove dust.	Yes/No	Excellent	Good	Fair*	Poor*
C009	Check light bulbs and replace where applicable.	Yes/No	Excellent	Good	Fair*	Poor*
C010	Check and inspect equipment racks/shelves (tighten any loose hardware).	Yes/No	Excellent	Good	Fair*	Poor*
C011	Check operation of fain/air conditioner unit and heater. Replace where applicable.	Yes/No	Excellent	Good	Fair*	Poor*
C012	Check lightning arrestor.	Yes/No	Excellent	Good	Fair*	Poor*
C013	Check circuit breaker and fuses	Yes/No	Excellent	Good	Fair*	Poor*
C014	Check ground fault receptacle	Yes/No	Excellent	Good	Fair*	Poor*
C015	Check environmental systems.	Yes/No	Excellent	Good	Fair*	Poor*
C016	Check the controller and associated units, indicator lights.	Yes/No	Excellent	Good	Fair*	Poor*

CCTV Preventative Maintenance

C017	Inspect all connections, cabling and physical appearance of any equipment within cabinets.	Yes/No	Excellent	Good	Fair*	Poor*
C018	Ensure that cables are not stressed.	Yes/No	Excellent	Good	Fair*	Poor*
C019	Hand-tighten all electrical terminations as necessary.	Yes/No	Excellent	Good	Fair*	Poor*
C020	Check and inspect controller. Run and save controller diagnostics according to manufacturer's specifications.	Yes/No	Excellent	Good	Fair*	Poor*
C021	Inspect all wires for loose connections, frayed wires, rodent damage, etc. Repair as necessary	Yes/No	Excellent	Good	Fair*	Poor*
C022	Check incoming power for proper voltage and correct if not within tolerances.	Yes/No	Excellent	Good	Fair*	Poor*
C023	Check function and communication (modem).	Yes/No	Excellent	Good	Fair*	Poor*
C024	Visually inspect all exposed grounding systems at the device for corrosion and damage.	Yes/No	Excellent	Good	Fair*	Poor*
C025	Check conduit entry to cabinet. Provide duct sealant (or another means) to prevent rodent entry if not already present.	Yes/No	Excellent	Good	Fair*	Poor*
	Preform the following for locations with uninterruptible power supply (UPS):					
C026	Visually inspect general condition of UPS for corrosion, wear, and any other damage. Repair as needed.	Yes/No	Excellent	Good	Fair*	Poor*
C027	Clean UPS and battery.	Yes/No	Excellent	Good	Fair*	Poor*
C028	Check all battery terminal connections for security and apply corrosion preventative compound. Tighten as necessary.	Yes/No	Excellent	Good	Fair*	Poor*
C029	Verify functionality of UPS by disconnecting power at breaker. Verify that all UPS maintains operation.	Yes/No	Excellent	Good	Fair*	Poor*

*Document all Fair or Poor conditions in the Preventative Maintenance Report Form. Repair when possible.

CCTV Preventative Maintenance

Communications and Electrical Service Checklist:

Task Number	Task	Completed?	Condition (choose one)			
E001	Check to be sure hand hole covers are secure. Tighten if necessary	Yes/No	Excellent	Good	Fair*	Poor*
E002	Check pull boxes (damage, covers missing, or damaged). Repair if necessary	Yes/No	Excellent	Good	Fair*	Poor*
E003	Check conduit entry to junction box. Repair if necessary.	Yes/No	Excellent	Good	Fair*	Poor*
E004	Check conduit runs for settling of trench.	Yes/No	Excellent	Good	Fair*	Poor*
E005	Pump junction box dry if water is present.	Yes/No	Excellent	Good	Fair*	Poor*
E006	Clean garbage from junction box.	Yes/No	Excellent	Good	Fair*	Poor*
E007	Visually inspect lugs for burning corrosion, water infiltration and rodent damage.	Yes/No	Excellent	Good	Fair*	Poor*
E008	Visually inspect cable tags. Replace or reattach if needed.	Yes/No	Excellent	Good	Fair*	Poor*
E009	Visually inspect bushings for rust or damage.	Yes/No	Excellent	Good	Fair*	Poor*
E010	Visually inspect splice kit for integrity and water infiltration. Repair or replace if necessary.	Yes/No	Excellent	Good	Fair*	Poor*
E011	Inspect all equipment grounding conductors and connections for integrity.	Yes/No	Excellent	Good	Fair*	Poor*
E012	Check antenna for proper communications.	Yes/No	Excellent	Good	Fair*	Poor*
E013	Verify communications by having a message displayed remotely from the Traffic Operations Center.	Yes/No	Excellent	Good	Fair*	Poor*
	Perform the following for locations with direct electrical connection:					
E014	Check meter cabinet/pole/pedestal for damage (lightning, leaning, vehicle damage, vandalism, corrosion, etc).	Yes/No	Excellent	Good	Fair*	Poor*
E015	Check service pole base. Replace base cover and clean out if necessary.	Yes/No	Excellent	Good	Fair*	Poor*

CCTV Preventative Maintenance

E016	Check cabinet/conduit mounting hardware. Replace bolt cover and tighten if necessary.	Yes/No	Excellent	Good	Fair*	Poor*
E017	Check pole base splices for damage, water infiltration, and rodent damage.	Yes/No	Excellent	Good	Fair*	Poor*
E018	Visually inspect all exposed grounding systems at the device for corrosion and damage.	Yes/No	Excellent	Good	Fair*	Poor*
E019	Visually inspect the meter socket and disconnect for damage, vandalism, and missing hardware.	Yes/No	Excellent	Good	Fair*	Poor*
E020	Check anchor bolts for tightness and corrosion.	Yes/No	Excellent	Good	Fair*	Poor*
E021	Check breakers.	Yes/No	Excellent	Good	Fair*	Poor*
E022	Check meter cabinet for damage.	Yes/No	Excellent	Good	Fair*	Poor*
E023	Check meter cabinet locking mechanism. Adjust or repair if needed.	Yes/No	Excellent	Good	Fair*	Poor*

*Document all Fair or Poor conditions in the Preventative Maintenance Report Form. Repair when possible.

CCTV Preventative Maintenance

Preventative Maintenance Report Form

Device Type: ______________ District ID: _____________ Statewide ID______________
Date / Time: _________________________
County:_______________ Serial / RFID Number: __________________
Roadway:______________ Direction: ___________________
Location (mile post): _________________________
Latitude/Longitude:______________________ (Verify at site)
Time arriving at site:________________ Time Leaving site:________________
Description of Problem(s): ____

____

____

____

Corrective Actions Taken: ____

____

____

____

All problems corrected? (Yes / No)

Parts: ____

____

____

Labor / equipment / traffic control: ____

____

____

____

ADDITIONAL COMMENTS (Use back if necessary)

By signing below, the signee confirms that all four preventative maintenance checklists (General, Device, Cabinet, and Communications and Electrical) have been completed and that all tasks marked “fair” or “poor” have been documented above.

Name:_____________________ Signature:______________________ Date:________________

Company:____________________________

Dynamic Message Sign Preventative Maintenance

SDOT
Seattle Department of Transportation

<u>Activity Description</u>:

This activity includes the routine inspection and repair of Dynamic Message Signs and related equipment. All preventative maintenance checklists and the Preventative Maintenance Report Form must be completed and reported to the District ITS manager for this work to be considered complete.

<u>How to complete this document</u>:

Please use the following guidelines when filling in the preventative maintenance checklists:
Task: Description of task to be completed
Completed- Yes/No: Select the option that best describes the status of the task, i.e. if the task was completed select yes. If the task does not apply, please leave blank.
Condition: Choose the option that best describes the status of the task.

- **Excellent –** Like new condition, no repairs needed
- **Good –** Few minor repairs (tightening, etc.)
- **Fair –** In need of many minor repairs
- **Poor –** In need of major repairs

<u>Scheduling</u>:

Preventative maintenance is to be completed a minimum of twice per year for each device, prior to and after the winter season of each year (unless the manufacturer suggests more); the District ITS Manager may request more as needed. Maintenance activities may require lane closures; this must be considered while scheduling work.

Dynamic Message Sign Preventative Maintenance

SDOT
Seattle Department of Transportation

General Checklist:

Task Number	Task	Completed?	Condition (choose one)			
G001	Check clearance of tree branches or brush around power lines. Report required tree trimming and/or brush clearing work.	Yes/No	Excellent	Good	Fair*	Poor*
G002	Report damaged guardrail or fence around DMS system.	Yes/No	Excellent	Good	Fair*	Poor*
G003	Check for damage (lighting, leaning, car impacts, vandalism, etc). Repair if necessary.	Yes/No	Excellent	Good	Fair*	Poor*
G004	Verify that the ITS site plans, ITS system block diagram, electrical details/wiring diagram, and any other necessary records are located in the cabinet.	Yes/No	Excellent	Good	Fair*	Poor*

*Document all Fair or Poor conditions in the Preventative Maintenance Report Form. Repair when possible.

Dynamic Message Sign Preventative Maintenance

Device Checklist:

Task Number	Task	Completed?	Condition (choose one)			
D001	Perform preventative maintenance in accordance with the manufactures recommendations and as follows:					
D002	Inspect for general condition, wear, rust, cracks, loose connections, frayed cables, and any other damage. Repair as necessary	Yes/No	Excellent	Good	Fair*	Poor*
D003	Note and replace any missing, damaged, rusted, cracked or bent parts.	Yes/No	Excellent	Good	Fair*	Poor*
D004	Check gaskets for water filtration and deterioration.	Yes/No	Excellent	Good	Fair*	Poor*
D005	Lube latches, locks and hinges.	Yes/No	Excellent	Good	Fair*	Poor*
D006	Check hoods, wing nuts and hinges.	Yes/No	Excellent	Good	Fair*	Poor*
D007	Clean display boards.	Yes/No	Excellent	Good	Fair*	Poor*
D008	Check sign alignment.	Yes/No	Excellent	Good	Fair*	Poor*
D009	Inspect maintenance walkway/mounting hardware, if applicable (tighten hardware if necessary).	Yes/No	Excellent	Good	Fair*	Poor*
D010	Inspect and vacuum the interior of the DMS enclosure.	Yes/No	Excellent	Good	Fair*	Poor*
D011	Check for tightness of all internal hardware.	Yes/No	Excellent	Good	Fair*	Poor*
D012	Inspect air vents and weep holes.	Yes/No	Excellent	Good	Fair*	Poor*
D013	Inspect all wiring harnesses and interconnecting cable assemblies for tightness, wear and corrosion. Correct as required.	Yes/No	Excellent	Good	Fair*	Poor*
D014	Check enclosure locking device. Repair / replace as required.	Yes/No	Excellent	Good	Fair*	Poor*
D015	Clean/replace ventilation filters as needed.	Yes/No	Excellent	Good	Fair*	Poor*
D016	Inspect power distribution unit.	Yes/No	Excellent	Good	Fair*	Poor*
D017	Visually inspect surge suppression systems to confirm it is operating.	Yes/No	Excellent	Good	Fair*	Poor*

Dynamic Message Sign Preventative Maintenance

D018	Clean dimming/brightness sensor and verify that the sensor functions correctly.	Yes/No	Excellent	Good	Fair*	Poor*
D019	Run test message. Verify full message is displayed.	Yes/No	Excellent	Good	Fair*	Poor*
D020	Run diagnostic (per manufacturer's instructions) to verify all pixels function correctly, replace LEDs if needed.	Yes/No	Excellent	Good	Fair*	Poor*
D021	Visually inspect all exposed grounding systems at the device for corrosion and damage.	Yes/No	Excellent	Good	Fair*	Poor*
D022	Inspect environmental systems.	Yes/No	Excellent	Good	Fair*	Poor*

*Document all Fair or Poor conditions in the Preventative Maintenance Report Form. Repair when possible.

Dynamic Message Sign Preventative Maintenance

SDOT
Seattle Department of Transportation

Cabinet Checklist:

Task Number	Task	Completed?	Condition (choose one)			
C001	Check the condition of surface and general cabinet appearance for damage (paint, damage, graffiti).	Yes/No	Excellent	Good	Fair*	Poor*
C002	Check cabinet door and locking mechanism for proper closure. Adjust or repair if needed. Lubricate hinges and lock.	Yes/No	Excellent	Good	Fair*	Poor*
C003	Inspect and change filters where applicable.	Yes/No	Excellent	Good	Fair*	Poor*
C004	Check weatherproof seal of main cabinet door.	Yes/No	Excellent	Good	Fair*	Poor*
C005	Remove any snow or brush from doorway opening or area surrounding cabinet.	Yes/No	Excellent	Good	Fair*	Poor*
C006	Inspect cabinet mounting hardware (anchor bolts, pole attachment) for rust, cracks, etc. Tighten if necessary.	Yes/No	Excellent	Good	Fair*	Poor*
C007	Check for water accumulations and duct sealant.	Yes/No	Excellent	Good	Fair*	Poor*
C008	Clean and vacuum inside of cabinet and equipment to remove dust.	Yes/No	Excellent	Good	Fair*	Poor*
C009	Check light bulbs and replace where applicable.	Yes/No	Excellent	Good	Fair*	Poor*
C010	Check and inspect equipment racks/shelves (tighten any loose hardware).	Yes/No	Excellent	Good	Fair*	Poor*
C011	Check operation of fain/air conditioner unit and heater. Replace where applicable.	Yes/No	Excellent	Good	Fair*	Poor*
C012	Check lightning arrestor.	Yes/No	Excellent	Good	Fair*	Poor*
C013	Check circuit breaker and fuses	Yes/No	Excellent	Good	Fair*	Poor*
C014	Check ground fault receptacle	Yes/No	Excellent	Good	Fair*	Poor*
C015	Check environmental systems.	Yes/No	Excellent	Good	Fair*	Poor*

C016	Check the controller and associated units, indicator lights.	Yes/No	Excellent	Good	Fair*	Poor*
C017	Inspect all connections, cabling and physical appearance of any equipment within cabinets.	Yes/No	Excellent	Good	Fair*	Poor*
C018	Ensure that cables are not stressed.	Yes/No	Excellent	Good	Fair*	Poor*
C019	Hand-tighten all electrical terminations as necessary.	Yes/No	Excellent	Good	Fair*	Poor*
C020	Check and inspect controller. Run and save controller diagnostics according to manufacturer's specifications.	Yes/No	Excellent	Good	Fair*	Poor*
C021	Inspect all wires for loose connections, frayed wires, rodent damage, etc. Repair as necessary	Yes/No	Excellent	Good	Fair*	Poor*
C022	Check incoming power for proper voltage and correct if not within tolerances.	Yes/No	Excellent	Good	Fair*	Poor*
C023	Check function and communication (modem).	Yes/No	Excellent	Good	Fair*	Poor*
C024	Visually inspect all exposed grounding systems at the device for corrosion and damage.	Yes/No	Excellent	Good	Fair*	Poor*
C025	Check conduit entry to cabinet. Provide duct sealant (or another means) to prevent rodent entry if not already present.	Yes/No	Excellent	Good	Fair*	Poor*
	Preform the following for locations with uninterruptible power supply (UPS):					
C026	Visually inspect general condition of UPS for corrosion, wear, and any other damage. Repair as needed.	Yes/No	Excellent	Good	Fair*	Poor*
C027	Clean UPS and battery.	Yes/No	Excellent	Good	Fair*	Poor*
C028	Check all battery terminal connections for security and apply corrosion preventative compound. Tighten as necessary.	Yes/No	Excellent	Good	Fair*	Poor*
C029	Verify functionality of UPS by disconnecting power at breaker. Verify that all UPS maintains operation.	Yes/No	Excellent	Good	Fair*	Poor*

*Document all Fair or Poor conditions in the Preventative Maintenance Report Form. Repair when possible.

Dynamic Message Sign Preventative Maintenance

SDOT
Seattle Department of Transportation

Communications and Electrical Service Checklist:

Task Number	Task	Completed?	Condition (choose one)			
E001	Check to be sure hand hole covers are secure. Tighten if necessary	Yes/No	Excellent	Good	Fair*	Poor*
E002	Check pull boxes (damage, covers missing, or damaged). Repair if necessary	Yes/No	Excellent	Good	Fair*	Poor*
E003	Check conduit entry to junction box. Repair if necessary.	Yes/No	Excellent	Good	Fair*	Poor*
E004	Check conduit runs for settling of trench.	Yes/No	Excellent	Good	Fair*	Poor*
E005	Pump junction box dry if water is present.	Yes/No	Excellent	Good	Fair*	Poor*
E006	Clean garbage from junction box.	Yes/No	Excellent	Good	Fair*	Poor*
E007	Visually inspect lugs for burning corrosion, water infiltration and rodent damage.	Yes/No	Excellent	Good	Fair*	Poor*
E008	Visually inspect cable tags. Replace or reattach if needed.	Yes/No	Excellent	Good	Fair*	Poor*
E009	Visually inspect bushings for rust or damage.	Yes/No	Excellent	Good	Fair*	Poor*
E010	Visually inspect splice kit for integrity and water infiltration. Repair or replace if necessary.	Yes/No	Excellent	Good	Fair*	Poor*
E011	Inspect all equipment grounding conductors and connections for integrity.	Yes/No	Excellent	Good	Fair*	Poor*
E012	Check antenna for proper communications.	Yes/No	Excellent	Good	Fair*	Poor*
E013	Verify communications by having a message displayed remotely from the Traffic Operations Center.	Yes/No	Excellent	Good	Fair*	Poor*
	Perform the following for locations with direct electrical connection:					
E014	Check meter cabinet/pole/pedestal for damage (lightning, leaning, vehicle damage, vandalism, corrosion, etc).	Yes/No	Excellent	Good	Fair*	Poor*
E015	Check service pole base. Replace base cover and clean out if necessary.	Yes/No	Excellent	Good	Fair*	Poor*

E016	Check cabinet/conduit mounting hardware. Replace bolt cover and tighten if necessary.	Yes/No	Excellent	Good	Fair*	Poor*
E017	Check pole base splices for damage, water infiltration, and rodent damage.	Yes/No	Excellent	Good	Fair*	Poor*
E018	Visually inspect all exposed grounding systems at the device for corrosion and damage.	Yes/No	Excellent	Good	Fair*	Poor*
E019	Visually inspect the meter socket and disconnect for damage, vandalism, and missing hardware.	Yes/No	Excellent	Good	Fair*	Poor*
E020	Check anchor bolts for tightness and corrosion.	Yes/No	Excellent	Good	Fair*	Poor*
E021	Check breakers.	Yes/No	Excellent	Good	Fair*	Poor*
E022	Check meter cabinet for damage.	Yes/No	Excellent	Good	Fair*	Poor*
E023	Check meter cabinet locking mechanism. Adjust or repair if needed.	Yes/No	Excellent	Good	Fair*	Poor*

*Document all Fair or Poor conditions in the Preventative Maintenance Report Form. Repair when possible.

Dynamic Message Sign Preventative Maintenance

Preventative Maintenance Report Form

Device Type: _____________ District ID: ____________ Statewide ID_____________
Date / Time: ________________________
County:______________ Serial / RFID Number: _________________
Roadway:_____________ Direction: __________________
Location (mile post): ________________________
Latitude/Longitude:_____________________ (Verify at site)
Time arriving at site:_______________ Time Leaving site:_______________
Description of Problem(s): ____
____
____
____

Corrective Actions Taken: ____
____
____
____

All problems corrected? (Yes / No)

Parts: ____
____
____

Labor / equipment / traffic control: ____
____
____
____

ADDITIONAL COMMENTS (Use back if necessary)

By signing below, the signee confirms that all four preventative maintenance checklists (General, Device, Cabinet, and Communications and Electrical) have been completed and that all tasks marked “fair” or “poor” have been documented above.

Name:____________________ Signature:_____________________ Date:_______________

Company:__________________________

Appendix C:
Sample Job Descriptions

Position: Entry-Level TMC Operator (Operator I)

General Function

The Operator I will be responsible for efficiently responding to all incident and operational needs that occur within the Traffic Management Center (TMC). This person shall possess a thorough understanding of the various system tools and operational procedures utilized within the TOC. The Operator I shall report directly to the TMC Head Operator.

Individuals holding this position shall be capable of performing routine TMC functions, including but not limited to: the dissemination of information regarding active incidents, coordination with emergency response units, maintaining a working knowledge of all system applications, continuous monitoring of system devices, and light office work (e.g., word processing, spreadsheets, etc.).

This position will require flexible work hours, rotating shifts, and on-call support work to meet the demands of the TMC operation. This individual must be able to pass an exam and demonstrate proficiency for this position, which may include a subjective analysis of the ability to use good common sense under adverse and stressful situations.

Minimum Qualifications

Education: Graduation from an accredited high school or possession of a high school equivalency certificate. Passage of the Operator I proficiency exam.

Experience: Hands on training in all aspects of the TOC operations, with a demonstrated knowledge of the TOC operating procedures and policies.

Skills: Must have ability to cope with some job stress resulting from unusual work schedules, limited interaction with other people, and must be capable of working closely with co-workers. Must be dedicated and capable of performing duties with minimum supervision.

Specific Functions

All traffic and safety related operations and record keeping duties associated with the smooth operations of the TOC. Examples of duties include:

- All qualities and duties required of an Operator Trainee
- Monitor system resources to quickly detect and identify incident or hazardous conditions
- Monitor Roadway Weather Information System (RWIS)
- Prepare incident and construction event information for subsequent dissemination
- Display library or template based variable message sign messages in accordance with TOC guidelines
- Record template based audio messages in accordance with TOC guidelines
- Monitor system performance and generate work order reports as required
- Perform record keeping tasks such as daily communication logs and incident reports
- Coordinate with other agency and construction staff

Position: Senior ITS Technician

Class specifications are intended to present a descriptive list of the range of duties performed by employees in the class. Specifications are not intended to reflect all duties performed within the job.

Definition

To lead, oversee, and participate in the most complex and difficult work of staff responsible for installing, maintaining, and repairing ITS control devices; to assist in the ITS design review and the development of standard operating procedures; and to perform a variety of technical tasks related to assigned area of responsibility.

Distinguishing Characteristics

This is the advanced journey level class in the ITS Technician series. Positions at this level are distinguished from other classes by the level of responsibility assumed, the complexity of duties assigned, and the level of independence with which employees are expected to perform. Employees perform the most difficult and responsible types of duties assigned to classes within the series. Employees at this level are required to be fully trained in all procedures related to assigned area of responsibility.

Supervision Received and Exercised

- Receives general supervision from the ITS supervisor and higher level management staff.
- Exercises functional and technical supervision over technical staff.
- Essential and Marginal Function Statements
- Essential and other important responsibilities and duties may include, but are not limited to, the following:

Essential Functions:

1. Lead, plan, and review the work of staff responsible for installing and maintaining a wide variety of ITS devices such as video detection systems, vehicle induction loops, ramp meters, dynamic message signs, solid state equipment, fiber optic equipment, trailblazers, computerized communication cables, light emitting diode lamps, and related devices and equipment for freeway and arterial roadways; troubleshoot malfunctions, isolate defects and repair devices and equipment using a bucket truck on high speed, high volume roads and freeways; verify proper device and system operation; conduct inspections and periodic preventive maintenance.
2. Monitor ITS device operation through the use of a laptop computer in the field or a desktop computer in the TMC; use sophisticated ITS software, both proprietary and non-proprietary; recommend and safely complete appropriate changes for effective system operation.
3. Evaluate, plan, direct, and perform repair, removal, and replacement of poles, cabinets, controllers, and other equipment; repair conduit and pull wires and cable, as needed; perform emergency repairs as needed.
4. Modify or update existing ITS devices and equipment to improve traffic flow.
5. Participate in the design, layout, modification, and fabrication of the ITS components used in the Las Vegas valley's freeway and arterial transportation infrastructure; recommend ITS equipment specifications; assist in developing operating procedures for ITS devices; read diagrams, blueprints, manuals, and specifications for new installations and continual maintenance of ITS devices; make corrections to schematics and blueprints; assist contractors and other agencies with installation of new devices and system expansion.
6. Estimate materials and repair parts, equipment, and tools required to work at a remote or central location; make independent technical decisions in the course of day to day maintenance activities.
7. Direct and participate in a wide range of functional electrical tasks on ITS components; isolate prime power malfunctions and coordinate repairs with power company; replace power service points as needed.
8. Lead and participate in complex field and bench testing procedures on a variety of ITS equipment, such as closed circuit television systems, traffic system control units, trailblazer signs, dynamic message signs, radio communication

facilities, conflict monitors, incident detection systems, load switches, inductive vehicle detection systems, power service assemblies, and others; test, troubleshoot, and repair ITS equipment to component level of micro processing systems; maintain and service a variety of test and repair equipment.

9. Train assigned staff in proper work methods and techniques and in the set up and use of equipment.
10. Document work performed on all ITS devices in the freeway and arterial infrastructure.
11. Assist TMC staff within the center as needed with the operation of the ITS facilities.

Marginal Functions:

1. Assist communications technicians with repairs and connection of intercommunication cable and related equipment.
2. Lead other related technical staff as required.
3. Stay abreast of new control devices in the field of ITS.
4. Perform related duties and responsibilities as required.

Minimum Qualifications

Knowledge of:

- Principles and techniques of lead supervision and training.
- Principles and practices of the use of diagnostic and utility software to locate problems and repair system equipment.
- Principles and practices of state and local traffic control guidelines.
- Advanced principles and practices of the use of a computerized system for coordinating traffic movement.
- Cable and component color coding.
- Tools, equipment, practices, and methods used in installing, maintaining, and repairing electronic solid state traffic signals and associated equipment.
- Practices and techniques of field and bench testing of electronic devices and components.
- The relationship of the various components of a computer-controlled traffic control system.
- Interpretation of design schematics, site plans, maps, and engineering drawings.
- Advanced mathematical principles.
- Techniques and methods of record keeping.
- Pertinent federal, state, and local laws, codes, and regulations.

Ability to:

- Work independently without direct supervision.
- Communicate clearly and concisely, both orally and in writing.
- Establish and maintain effective working relationships with those contacted in the course of work.
- Maintain effective audio-visual discrimination and perception needed for:
    - Making observations;
    - Communicating with others;
    - Reading and writing; and
    - Operating assigned equipment.
- Maintain mental capacity which allows the capability of:
    - Making sound decisions;

- Effective interaction and communication with others; and
  - Demonstrating intellectual capabilities.
- Maintain physical condition appropriate to the performance of assigned duties and responsibilities which may include the following:
  - Sitting for extended periods of time; and
  - Operating assigned equipment.

Experience and Training Requirements:

Experience:

Three years of increasing responsibility and experience in ITS or traffic control system installation, repair, and maintenance.

Training:

Equivalent to graduation from high schoo, plus additional specialized training in electronics.

License or Certificate:

Possession of a valid Class B commercial driver's license on the date of application.

Possession of a Traffic Signal Technician Level II or Traffic Signal Electrician Level II certification from the International Municipal Signal Association on the date of application.

Working Conditions

Environmental Conditions:

Office, shop, and field environments; travel from site to site; exposure to electrical energy, high voltage, computer screens, heat, cold, noise, dust, fumes, inclement weather conditions; work in high speed and high volume traffic; work at heights on ladders or other elevating device.

Physical Conditions:

Essential and marginal functions may require maintaining physical condition necessary for light to moderate lifting, bending, stooping, kneeling, climbing, and standing for prolonged periods of time; operating motorized equipment and vehicles; the ability to distinguish color.