DELAWARE VALLEY
REGIONAL
PLANNING COMMISSION

Philadelphia Traffic Operations Center: Concept of Operations

December 2010

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Executive Summary

Philadelphia is the only city among the 10 largest cities in the country without a Traffic Operations Center (TOC). It owns and operates 2,924 traffic signals, the third largest municipal signal system in the country, and represents over 21 percent of the signals in Pennsylvania. As part of the reconstruction of I-95 in Philadelphia, the Pennsylvania Department of Transportation (PennDOT) is constructing signal improvements and traffic surveillance systems on parallel arterials to handle an anticipated surge in traffic. To operate these signals, PennDOT is purchasing new traffic signal system software for the city. By spring 2011, an interim TOC will be co-located in the city's Office of Emergency Management (OEM), constructed as part of the redesign of OEM. The objective of this document is to identify TOC goals, features, physical attributes, costs, and outstanding issues to be addressed.

TOC Goals

A Steering Committee composed of key stakeholders identified the following TOC goals:

- Provide capability to actively manage traffic signals.
- Provide situational information about the city's arterial system.
- Enhance incident management capability.
- Promote corridor management.
- Improve interagency coordination

TOC Capabilities

Below are the more significant opening day capabilities envisioned for the TOC:

- Operate advanced traffic signal control using centralized signal system software and a centralized database storing multiple signal timing plans.
- Monitor arterial traffic with Closed Circuit Television (CCTV) cameras.
- Detect and verify incidents using CCTV cameras.
- Dispatch emergency routing of police and fire vehicles.

Organizational Structure

An organizational chart shows how the TOC will be integrated into the City of Philadelphia's Streets Department Traffic and Lighting Unit. An analysis was conducted comparing Philadelphia traffic signal engineering and maintenance personnel levels to national standards and staffing in other major cities. Staffing needs for the TOC, signal engineering, and maintenance are documented.

Hours of Operation

Initially the interim Philadelphia TOC will operate 16/5. Recommendations for after-hours operations and emergency situations are discussed. PennDOT District 6-0's Traffic Management Center (TMC) will provide limited after-hours support.

Procedures

An operations manual is critical to successful management of a TOC. Using PennDOT District 6-0 TMC Manual and information from various Federal Highway Administration (FHWA) publications, the report identifies items to incorporate into a TOC operations manual:

- types of logs to document TOC activities;
- shift change procedures;
- hand-off procedures between Philadelphia the TOC and PennDOT District 6-0 TMC;
- procedures to respond to requests for signal timing changes and Streets Department resources; and
- trouble shooting and maintenance procedures.

Systems Architecture and Support Environment

The systems architecture consists of an Ethernet-based fiber network connecting central system software to local field units. A combination of Streets Department, PennDOT, and City of Philadelphia Division of Technology (DOT) fiber assets will be used to communicate with field equipment and to distribute traffic information to multiple hubs throughout the city.

Funding Requirements

TOC capital cost and annual operation and maintenance costs are documented. Personnel costs represent the largest component of yearly operating costs. Since less than 10 percent of the city's signals are currently on the signal system, options to buildout the system in a more systematic manner are presented.

TOC Best Practices

Best practices of TOCs in other major cities are documented. Information was gathered from FHWA's Intelligent Transportation System (ITS) deployment statistics database. Items documented include:

- TOC role and responsibilities;
- integration with other agencies;
- incident management functions and capabilities;
- traveler information functions and capabilities;
- types of information displayed on Variable Message Signs (VMS); and
- start-up issues encountered.

1 Scope

1.1 Introduction

Philadelphia is the only city among the 10 largest cities in the country without a TOC. It owns and operates 2,924 traffic signals, the third largest municipal signal system in the country, and represents over 21 percent of the signals in Pennsylvania. The Streets Department has completed four traffic signal system projects in Center City and on Broad Street, placing approximately 235 signals on the signal system. PennDOT, as part of the reconstruction of I-95, is upgrading traffic signals and deploying ITS devices on parallel arterials to manage overflow traffic in the event of an I-95 detour. To support their operation, PennDOT is funding an interim TOC and the acquisition of new signal system software for the city. Long-term plans call for incorporating the TOC into a larger fusion center with police and fire dispatchers, and with OEM.

The purpose of this study is to develop a Concept of Operations (ConOps) for the Philadelphia TOC and to document TOC best practices. A ConOps describes the desires and expectations of the TOC. It documents current conditions, operational needs, TOC characteristics, priority features, and how it will interface with other entities.

The city intends to migrate from passive management of the street system to a more proactive approach. This involves expanding the signal system, installing CCTV cameras to monitor arterial streets, and installing VMS to disseminate traveler information. The ConOps identifies how these elements will be integrated into the TOC.

Constructing a TOC does not just involve technical issues. Logistics, procedures, and institutional policies can often determine the success of a TOC. Many other cities have struggled with these issues. Consequently, this document also presents best practices from other cities.

This effort identified an extensive list of TOC needs, far exceeding the city's capability to implement and maintain them, given current staffing and funding limitations. Therefore, a central theme of this report is to document what needs to be in place on opening day and potential medium-term enhancements.

1.2 Traffic Operations Center Goals

The ConOps Steering Committee collaboratively developed the following five goals for the TOC:

1.2.1 Goal 1: Provide Capability to Actively Manage Traffic Signals

Most of the city's traffic signals, regardless of whether they are on or off the signal system, essentially operate as fixed time signals. With a few exceptions, rarely do the signal controllers employ multiple signal timings programs to account for peak versus off-peak conditions or weekday versus weekend conditions. In the current situation, adjusting signal timings is an onerous process. Timings must be manually programmed, there is no mechanism to monitor how effective the new timing plans are, and minor adjustments must be manually reprogrammed.

Alternative pre-planned signal timing plans will be developed for a wide range of traffic conditions and emergency situations, whether the situation is an expressway closure, emergency evacuation, or an event at the Sports Complex. The objective is to store alternate signal timing plans in a database and have the signal system automatically select the most appropriate timing plan, based on time of day or traffic conditions. Alternately, the TOC operator will be able to override the timing plan based on visual observation.

1.2.2 Goal 2: Provide Situational Information about the City's Arterial System

Situational information pertains to roadway conditions, including traffic congestion, traffic accidents, illegally parked vehicles, construction activity, and traffic at special events. During normal operating conditions, the Philadelphia TOC will utilize situational information to manage traffic, inform motorists about congestion, adjust traffic signal timings based on observed traffic conditions, and notify Philadelphia Police about traffic crashes and other conditions that require remediation. Situational information will be obtained from CCTV cameras.

In emergencies, the Philadelphia Police Department (PPD), Philadelphia Fire Department's Fire Communications Center (FCC), and OEM will use video feeds to view the situation and determine the appropriate assets to dispatch. Video will also be used to route emergency vehicles, trying to avoid traffic congestion and other bottlenecks. OEM intends to use CCTV video to monitor the integrity of its emergency evacuation routes; PennDOT wants to monitor its detour routes. This monitoring involves whether they are free flowing; whether they can handle a surge in traffic; where police officers are needed for traffic control; and whether any construction jobs, illegally parked vehicles, or other obstructions have to be removed.

1.2.3 Goal 3: Enhance Incident Management Capability

While the Streets Department provides limited support for major pre-planned events, like events at the Sports Complex, it currently has minimal capability to support more minor pre-planned events and unplanned events like road closures due to vehicular crashes, emergency construction projects, or police and fire activity.

Police and fire dispatchers will use TOC video feeds to confirm 911 traffic accident reports and to determine the appropriate resources to dispatch. Dispatchers can use video feeds to route emergency vehicles, bypassing traffic congestion. If needed, the TOC will temporarily adjust signal timings to manage traffic. Using VMS signs and 511PA, the TOC will issue travel advisories to reroute traffic around the impacted area.

1.2.4 Goal 4: Promote Corridor Management

Philadelphia's arterial highways do not operate in a vacuum. Many of them parallel PennDOT expressways, function as a feeder-distributor to the expressway system, or are extensions of suburban arterials leading into the city. Corridor management involves working with PennDOT's TMC to balance traffic on highway facilities, expressways-arterials, or arterials-arterials; and adjusting traffic signals for heavy traffic congestion, construction activity, or expressway detours.

In a similar manner, corridor management will foster greater highway-transit coordination with the Southeastern Pennsylvania Transportation Authority (SEPTA). Transit priority treatment has been deployed along trolley lines and a limited number of bus routes. Deploying ITS infrastructure can improve SEPTA's situational awareness of traffic conditions, and ultimately enable SEPTA to deploy smart bus stops and other advanced technology using the Streets Department's fiber communication network.

1.2.5 Goal 5: Improve Interagency Coordination

The road network in and around Philadelphia is managed by many entities. On the highway side, PennDOT, the Delaware River Port Authority (DRPA), and Burlington County Bridge Commission (BCBC) manage highways and bridges into and out of the city. Pennsylvania State Police (PSP) on expressways, and PPD on city arterials, are responsible for law enforcement and incident management. Others like the Philadelphia International Airport, Philadelphia Parking Authority (PPA), Sports Complex Special Services District (SCSSD), and SEPTA also have an interest in traffic operations.

These organizations routinely communicate with each other to manage incidents and plan for major events or construction projects. PennDOT shares its video feeds, DRPA reconfigures the number of lanes on its bridges based on activity at the Sports Complex, and PSP routinely requests maintenance resources from PennDOT to close highways or remove debris from crashes. The Delaware Valley Regional Planning Commission (DVRPC) is funding a regional information exchange network called Regional Integrated Multi-modal Information Sharing System (RIMIS) to share incident, construction, and special events information. Constructing a TOC and deploying ITS devices will strengthen the Streets Department's relationship with regional partners by institutionalizing a formal point of contact and enabling it to more readily respond to requests from other agencies.

1.3 Stakeholders

Many stakeholders have an interest in the design and operation of the Philadelphia TOC, because they will interact with it on a daily basis. A Steering Committee, composed of key stakeholders, was formed to provide policy and technical guidance. Steering Committee member agencies are listed below:

- Delaware River Port Authority;

- Delaware Valley Regional Planning Commission;
- Federal Highway Administration – Philadelphia Metropolitan Office;
- Mayor's Office of Transportation and Utilities;
- Pennsylvania Department of Transportation District 6-0 – Traffic Engineering;
- Philadelphia Office of Emergency Management;
- Philadelphia Police Department – Traffic Police;
- Philadelphia Streets Department – Traffic and Lighting Unit; and
- Southeastern Pennsylvania Transportation Authority.

1.4 How This Document Is Organized

The first five sections of this document are organized in conformance with the Institute of Electrical and Electronic Engineers (IEEE) Standard 1362-1998, the standard for developing a ConOps. Sections pertaining to funding needs and TOC best practices are found toward the end of the document. The remainder of this document contains the following:

- **Chapter 2 —** Lists the documents that were used to support the development of the ConOps.
- **Chapter 3 —** Describes the current situation, including the signal system, its support environment, and organizations the Streets Department currently interfaces with.
- **Chapter 4 —** Provides justification for the proposed TOC. It describes desired TOC capabilities and features. Due to budgetary constraints, it is not feasible to implement all the desired capabilities at this time; therefore, emphasis is placed on opening day capabilities and medium-term enhancements.
- **Chapter 5 —** Describes the TOC from several different perspectives including its physical attributes, operational polices, support environment, and how it will interface with other entities.
- **Chapter 6 —** Sets forth funding needs to construct, operate, and maintain the TOC.
- **Chapter 7 —** Describes TOC best practices derived from other major cities.

2 Referenced Documents

The following documents were used to support development of the Philadelphia TOC ConOps:

- Delaware Valley Regional Planning Commission

  ———. *Interactive Detour Route Mapping*, DVRPC, http://www.dvrpc.org/idrum.htm

  ———. *ITS Regional Architecture for the Delaware Valley*, *Version 2.0*, DVRPC, Fall 2009

  ———. *Transportation Operations Master Plan*, DVRPC, July 2009, Publication Number 09049

- Federal Highway Administration

  ———. *ITS Deployment Statistics Database*, Arterial Management, Characteristics of Signalized Intersections, 2006 and 2007 Metropolitan Surveys, FHWA, http://www.itsdeployment.its.dot.gov/SurveyOutline1.asp?SID=am

  ———. *Handbook for Developing a Traffic Management Center Operations Manual*, FHWA, FHWA-HOP-06-015, November 2005

  ———. *Metropolitan Transportation Management Center Concepts of Operation: A Cross-Cutting Study*, FHWA, FHWA-JPO-99-020, October 1999

  ———. *Traffic Control Systems Handbook*, FHWA, FHWA-HOP-06-006, October 2005

  ———. *Traffic Signal Operations and Maintenance Staffing Guidelines*, FHWA, FHWA-HOP-09006, March 2009

  ———. *Traffic Signal Timing Manual*, FHWA, FHWA-HOP-08-024, June 2008

  ———. *Transportation Management Center Business Planning and Plans Handbook*, FHWA, December 2005 http://tmcpfs.ops.fhwa.dot.gov/cfprojects/uploaded_files/TMC_BPG _Final.pdf

  ———. *Transportation Management Center Concepts of Operation: Implementation Guide,* FHWA, FHWA-OP-1999-029, December 1999

- Institute of Electrical and Electronics Engineers, *IEEE Guide for Information Technology – System Definition – Concept of Operations (ConOps) Document*, IEEE Standard 1362-1998. December 1998

- Pennsylvania Department of Transportation, *PennDOT District 6-0 RTMC Manual*, (internal PennDOT database; accessed May 6, 2009)

- Philadelphia Department of Emergency Management, *Emergency Evacuation Routes*, http://oem.readyphiladelphia.org/ evacuation

3 Current Situation

3.1 Existing Traffic Equipment and Devices

3.1.1 Existing Traffic Signals

The City of Philadelphia owns and operates 2,924 traffic signals, representing 21 percent of all traffic signals in Pennsylvania. **Figure 1** displays the location of all traffic signals in the city.

Of the 2,924 signals, only 235 (8 percent) currently operate on the signal system. That is, the signals are controlled by centralized signal software via a fiber optic communications network. As highlighted in the figure, the majority of these signals are located in Center City, constructed as part of the Southwest Quadrant Project, Southeast Quadrant Project, or the Convention Center Project.

In addition to the signals currently on the system, approximately another 500 signals (17 percent) are on the city's fiber network but are not yet programmed into the centralized signal system software. A combination of software issues, lack of resources, and gaps in the fiber network are responsible for delaying their addition to the signal system.

In addition to the city's centralized system, between 1990 and 2005 the Streets Department constructed a number of closed loop systems. These signals operate via dial-up communications from a computer, with master on-street controllers controlling local intersections. Approximately 300 intersections operate as closed loop systems.

As part of PennDOT's I-95 Cottman Princeton Interchange (CP1) and Girard Interchange (GR1) projects, PennDOT will be adding approximately 130 of the existing signals to the city's signal system. Some of these signals are already on the city's fiber network; for others, fiber will be installed as part of the project. The design for GR1 is not complete, so the exact number of signals is not yet known. Roads to be added include parts of Columbus Boulevard, Delaware Avenue, and Aramingo Avenue.

3.1.2 CCTV and VMS Signs

The two I-95 projects also include placing 20 CCTV cameras and one VMS sign on Aramingo Avenue, State Road, and Torresdale Avenue. The Philadelphia TOC will be responsible for co-managing these devices with PennDOT District 6-0 TMC.

Existing Signal Hardware and Systems Software

All system and system-enabled traffic signals use Type 170 controllers. Generally, most other signals in the city, except for the closed loop systems, have electromechanical controllers. As additional signals are placed on the system, the city intends to upgrade them to Type 170 controllers.

Traffic signals in Philadelphia, regardless of whether they are part of the signal system or are off the system, operate as fixed time signals. With only a few exceptions, the signals do not operate on a time of day schedule.

When the city began designing its first signal system project in the late 1990s, Kimley-Horn's Escort Advanced Traffic Management System (ATMS) software was selected to manage the signal system. Shortly after the software was installed with an Oracle database platform the city switched to SQL Server making it difficult to program additional signals onto the system. Escort also uses Windows NT as its operating software. Due to these and other shortcomings, and subsequent vendor software enhancements, Philadelphia intends to migrate to Kimley-Horn Integrated Transportation System (KITS) software as the TOC ATMS software platform. KITS, purchased by PennDOT using I-95 Section GR0 monies, was installed and has been operating since spring 2010.

3.2 Support Environment

3.2.1 Existing Fiber Network

The Streets Department fiber communications network is shown in **Figure 2**. Fiber assets owned by PennDOT, DOT, or SEPTA are not shown on the map.

All signals on the signal system are connected by fiber to the basement of the Municipal Services Building (MSB) where signal system servers are located. There are ten servers, five of which serve the signal system. Plans call for relocating one of the five servers to the Streets Department's Traffic Signal/Sign Shop. Four other servers manage the closed loop system signals.

3.2.2 System Architecture

The signal system architecture is undergoing transition. In the past, servers communicated with controllers via point-to-point communications. As the city migrates to KITS, it is implementing Internet Protocol (IP) addressable communications. At that time, on-street master controllers will be phased out, and centralized servers will generate signal coordination timing plans. **Figure 3** shows the system architecture that will be in effect later this year.

Figure 1

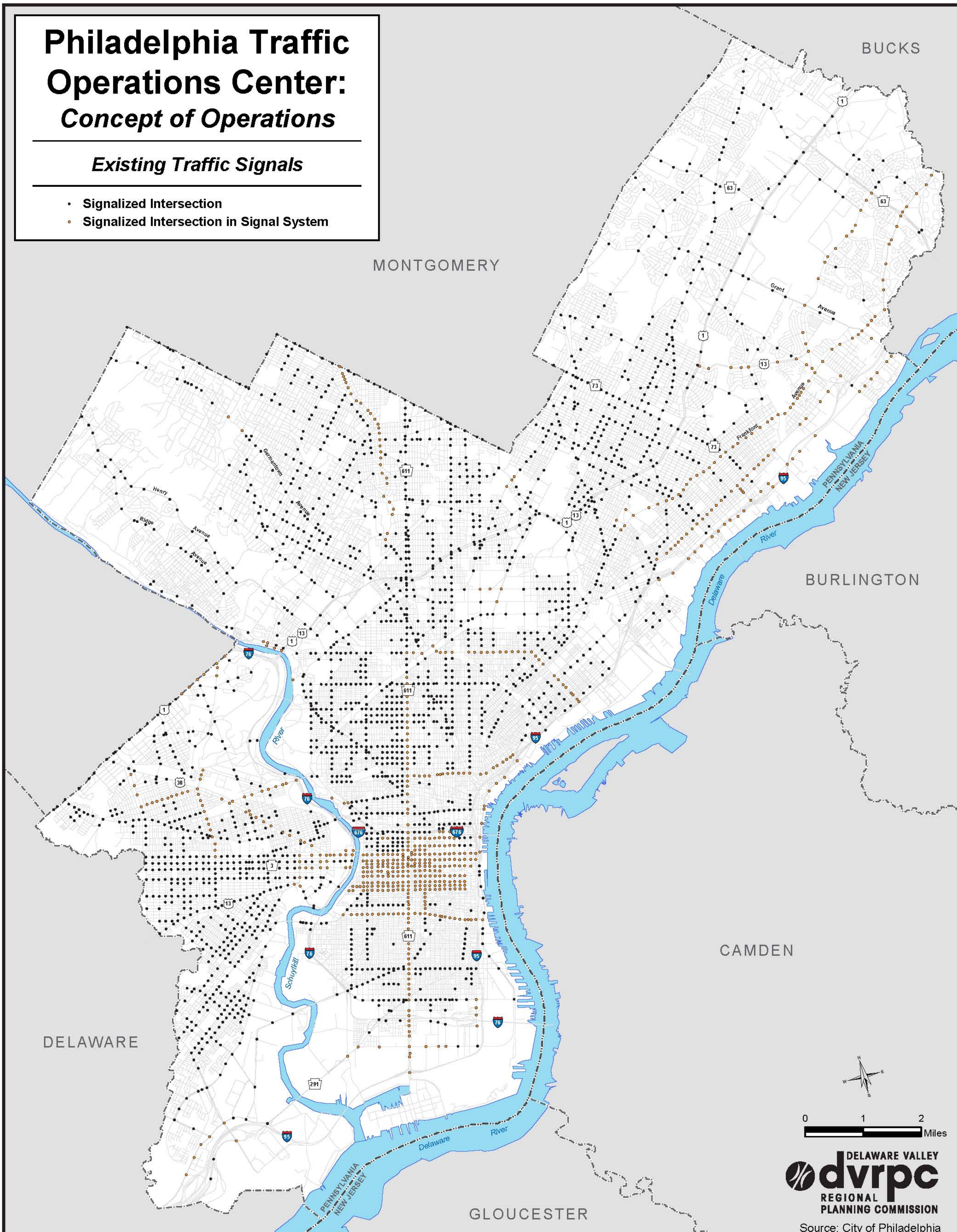

Philadelphia Traffic Operations Center:
Concept of Operations
Existing Traffic Signals
Signalized Intersection
Signalized Intersection in Signal System
MONTGOMERY
BUCKS
BURLINGTON
CAMDEN
DELAWARE
GLOUCESTER
PENNSYLVANIA
NEW JERSEY
Delaware River
Schuylkill River
Grant Avenue
Frankford Avenue
Germantown Avenue
Henry Avenue
Ridge Avenue
0 1 2 Miles
DELAWARE VALLEY
dvrpc
REGIONAL PLANNING COMMISSION
Source: City of Philadelphia

Figure 2

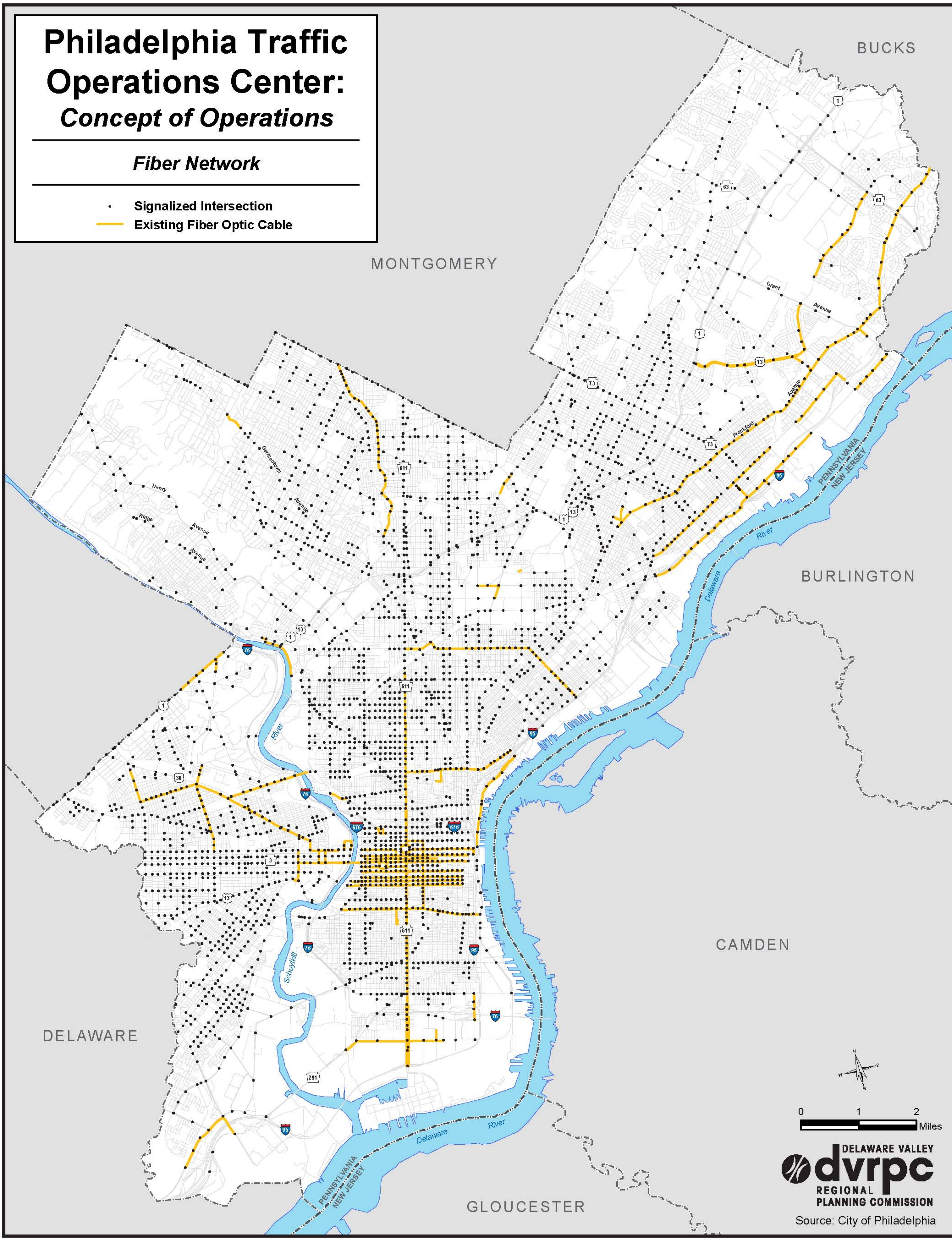
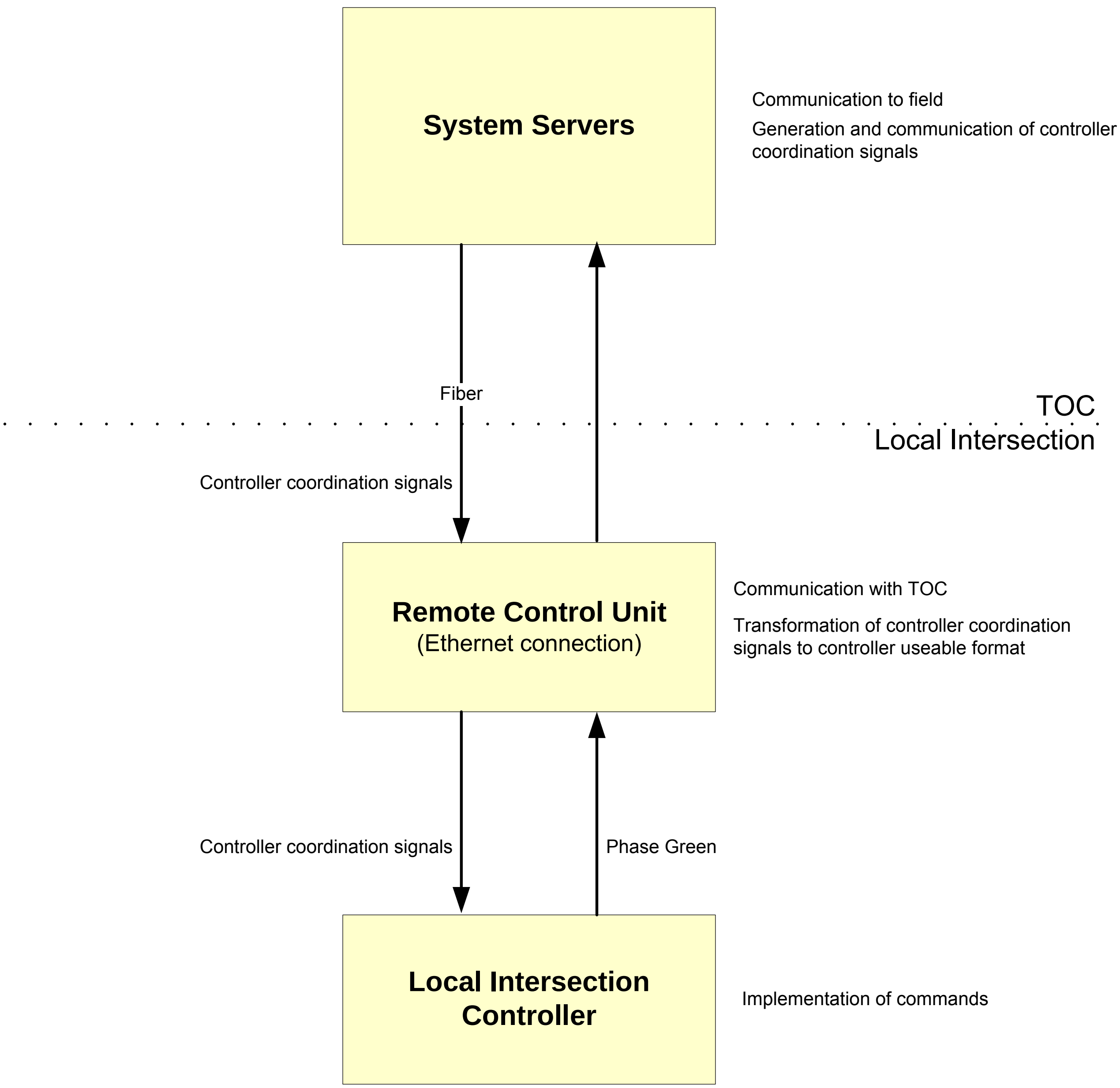

Philadelphia Traffic Operations Center:
Concept of Operations
Fiber Network
Signalized Intersection
Existing Fiber Optic Cable
BUCKS
MONTGOMERY
BURLINGTON
CAMDEN
DELAWARE
GLOUCESTER
PENNSYLVANIA
NEW JERSEY
Delaware River
Schuylkill River
Grant Avenue
Frankford Avenue
Germantown Avenue
Henry Avenue
Ridge Avenue
0 1 2 Miles
DELAWARE VALLEY
dvrpc
REGIONAL PLANNING COMMISSION
Source: City of Philadelphia

Figure 3: Signal System Architecture, 2010



3.3 User Classes

User classes distinguish the way different users interact with a system. There are several ways to look at users. One is from a personnel perspective: the type of work activities and skills needed to design, operate, and maintain a TOC and associated field and communications equipment. The second is from an organization perspective: the type of information passed back and forth among agencies.

3.3.1 Personnel Perspective

The objective of examining personnel is to ultimately identify the organizational changes needed to support TOC operations. While this analysis primarily focuses on the Streets Department, other agencies, inside and outside of city government, may have to modify job assignments or work responsibilities to better integrate the Philadelphia TOC into their normal operating procedures.

Below are the different types of categories of employees currently involved in traffic signal operations. Because job titles can cross agency lines, generic job descriptions are used to reflect the typical positions employed by TOCs throughout the country. As can be observed from the analysis, the city currently dedicates minimal resources to traffic signal operations.

- **Administrator —** This user class represents Traffic and Lighting's Assist Chief Engineer for Operations, who is responsible for planning, designing, and managing the traffic signal system. Work activities include supervising consultants, software vendors, contractors, traffic signal maintenance crews, and the Traffic Signal/Sign Shop. Currently, one person in the city performs this role on a part-time basis. Other duties include street closure permits, capital construction projects, and snow removal duties.

- **Supervisor —** This user class represents managers who oversee major organizational sub-entities involved in signal operations. Currently a Maintenance Supervisor II, who oversees the city's traffic maintenance crews, fills this level of responsibility.

- **Traffic Engineers —** Three traffic engineers are assigned to Traffic and Lighting. Their primary role is to respond to citizen complaints and City Council requests, and conduct traffic engineering studies. Traffic signal analyses, pertaining to developing or modifying traffic signal timing plans, are incidental to their primary responsibilities. Essentially, Philadelphia has no resources dedicated to an ongoing program of timing traffic signals.

- **Information Technology (IT) Engineers —** Within the Signal Unit of Traffic and Lighting, an engineer and technician are responsible for maintaining the fiber system, servers, and signal system software.

- **Operators —** This user class represents personnel directly responsible for interfacing with the KITS software to operate the signal system, monitor traffic conditions, implement alternative signal timing plans, and respond to signal fault reports. Currently no city employee performs this role. The traffic signal system administrator periodically monitors the system to ensure it is properly functioning, but takes no active role in operating it.

Plans call for PennDOT District 6-0 TMC operators to assume after-hours responsibility for managing TOC assets. How active PennDOT operators will be in terms of monitoring traffic signals and responding to situations has yet to be defined. While PennDOT TMC operators are familiar with PennDOT's software to control CCTV and VMS signs, they will need training to manage KITS software.

- **Traffic Signal Maintenance Crews —** Traffic signal maintenance crews are responsible for repairing signal knockdowns, fixing conflicting signal indications, replacing burned-out bulbs, performing routine maintenance, and addressing other signal maintenance issues that may arise. Maintenance crews are divided by light and heavy work maintenance responsibilities. Light work crews replace bulbs, repair controllers, and perform routine maintenance. Construction crews perform heavy work duties including signal knockdowns and ITS devices. They maintain the city's CCTV cameras.

3.3.2 Interaction among Agencies

Even though the city does not currently operate a TOC, the Traffic and Lighting Unit with the Streets Department emulates some of the functions of a TOC by managing traffic signals and interfacing with other organizations, both within the city and external to it. This section identifies these organizations, the roles they perform, and the type of information shared.

Table 1 summarizes existing information shared between Traffic and Lighting and other entities. Because there is no TOC, and no dedicated staff to manage traffic, very little information is currently shared. The limited information being shared largely pertains to traffic signal maintenance activities.

Philadelphia Streets Department

- **Traffic and Lighting Operations —** Traffic and Lighting is responsible for the traffic signal system, traffic signal maintenance crews, Traffic Signal/Sign Shop, and traffic management. Traffic signal system supervision includes managing consultants, software vendors, contractors, and working with PennDOT and FHWA to fulfill their design requirements. It also entails working with ITS personnel to make sure the servers and fiber communications system are properly functioning. As a point of contact with other agencies, this entity is responsible for traffic management at special events and work zones, construction coordination, and traffic signal retiming.

- **Highway Right-of-Way Unit —** Right-of-Way Unit is responsible for issuing Street Closure Permits and Block Party Permits. Street closure permits are required to be filed, either by mail or fax, at least 10 days in advance of the closure. The unit populates all street closure information in a database. A weekly street closure activity report is disseminated to select organizations. Emergency street closures are recorded in a separate database, which is not disseminated to other organizations.

Philadelphia DOT

DOT is responsible for managing Philadelphia's technology assets including databases, communications networks, and website; ensuring data security; and maintaining continuous operations in event of a disruption. It supports PPD, OEM, the Fire Department, and the Streets Department IT systems and databases. Key units within DOT include:

- **Municipal Radio Room —** Municipal Radio centralizes radio communications for all city agencies with the exception of police and fire who operate on separate communication networks. Streets-Band is dedicated for use by Streets Department vehicles and personnel.

- **311 Contact Center —** The Contact Center is responsible for receiving citizen complaints, including malfunctioning traffic signals and damaged traffic signs.

Table 1: Interaction with Traffic and Lighting Operations

Entity	Signal Operations	Signal Maintenance	CCTV and VMS Operations	511 Traveler Information	Construction Coordination
Highway Right-of-Way Unit					●
Municipal Radio Room		●			
311 Contact Center		●			
911		○	○		
Traffic Police	○		●		●
OEM			○		●
PennDOT District 6-0 TMC	○	○	○	○	●
SEPTA					●

● Existing interface ○ Opening day interface

Source: DVRPC , 2010

PPD

- **911 —** PPD operates the Philadelphia public safety call center. They dispatch all police responders. Fire and medical emergencies are passed off to the Fire Department FCC. Police officers report signal malfunctions and damaged traffic signals and signs to 911 dispatchers.

- **Traffic Police —** The Traffic Police are responsible for developing and implementing traffic control measures for road closures, special events, and incidents. For minor incidents or events, one or two officers are typically sent out to close a street or provide safety for construction crews. Officers frequently manually operate traffic signals. For large-scale events, Traffic Police will establish a temporary command center to manage field assets. For major events, PPD may request the Streets Department to modify signal timings or provide assistance to erect barriers to close a street. Traffic Police use T-Band for radio communications its officers.

Philadelphia OEM

OEM is responsible for planning for large-scale emergencies and disasters, coordinating and supporting responses to emergencies, conducting exercises and training programs, and educating the public on preparedness. OEM's operations center is located in the basement of the Fire Administration Building (FAB); a duty office is on call 24/7. Plans call for co-locating the Philadelphia TOC in the OEM operations center. Currently there is minimal contact between OEM and the Streets Department on a daily basis.

Figure 4: San Francisco Traffic Management Center

Source: San Francisco Municipal Transportation Agency, 2010

PennDOT District 6-0 TMC

PennDOT District 6-0 TMC is responsible for managing PennDOT's expressways in the region. By the anticipated opening of the interim Philadelphia TOC, PennDOT will be operating 63 CCTV cameras and over 18 VMS signs on expressways within the city limits. It also manages highway emergency service patrol vehicles and coordinates PennDOT's response to expressway incidents. Travel times from TRANSMIT and Remote Traffic Microwave Sensors (RTMS) and incident information from PennDOT's Roadway Condition Reporting System (RCRS) are pushed into 511PA's Interactive Voice Response (IVR) telephone system and website.

PennDOT does not own, or operate, traffic signals. However, when the Philadelphia TOC becomes operational, District 6-0 will assume responsibility of after-hours operation of Philadelphia's traffic signal system from its TMC. PennDOT TMC and Philadelphia's TOC will also co-manage CCTV and VMS signs deployed on I-95 diversion routes as part of the I-95 reconstruction project.

SEPTA

SEPTA operates buses, subway-elevated lines, regional rail, trolleys, and paratransit services within the City of Philadelphia. The Streets Department has implemented transit priority treatment on a limited number of transit corridors. However, on a daily basis, there is minimal coordination or communication between SEPTA and the Streets Department.

4 Nature of Changes

This chapter outlines changes necessitating development of the Philadelphia TOC. While expansion of the signal system is the primary justification, new roles and responsibilities set forth in the TOC's goals are just as important. This chapter establishes TOC priorities, with emphasis given to functionalities that can be in place on opening day. It also identifies short-term enhancements that can be in-place 2-3 years after the TOC opens. Lastly, it identifies constraints that will affect TOC operations, and therefore should be accounted for its design.

4.1 Justification for the Proposed Philadelphia TOC

4.1.1 Expansion of Traffic Signal System

Only 235 traffic signals - eight percent of all the signals - are currently on the city's signal system. Later this year the Section CP1 project will add 61 signals to the system; and by fall 2011, the Section GR1 project will add an additional 130 intersections. Another 503 traffic signals that are on the fiber network will be integrated into the system shortly after construction of the TOC. Therefore, by the end of 2011, close to 800 traffic signals - 27 percent of all the signals - will be on the signal system.

This considerable investment in upgrading traffic signal technology raises expectations. These expectations are mirrored in the TOC goals set forth by key agencies. PennDOT and FHWA, who funded the improvements, anticipate the city will undertake a more proactive management of the signal system. PPD, the Philadelphia Fire Department, and OEM have unanimously expressed interest in use of alternative signal timing plans during emergencies.

4.1.2 ITS Devices

The Streets Department has developed an unofficial list of close to 450 locations where it would like to install CCTV cameras to monitor the arterial street system. Generally, the CCTV cameras will be strategically located at the intersection of major arterials, allowing them to monitor traffic on both roads. On the most critical arterials, such as Broad Street or Roosevelt Boulevard, there would be some infill to increase video coverage.

Similarly, long-term plans call for the construction of VMS signs at the Sports Complex and other major special events/traffic generators. PennDOT is constructing VMS signs on I-95 detour routes as part of the I-95 reconstruction project. PennDOT expects Philadelphia will co-manage these ITS assets.

The Philadelphia TOC will be responsible for monitoring the CCTV video, identifying traffic congestion, crashes, road construction, and other impediments to traffic flow. When an incident is identified, it will implement procedures to minimize its traffic impact, including notifying PPD, PPA, or the Philadelphia Fire Department and/or implementing alternative signal timing plans. The TOC will be responsible for disseminating traveler information, including posting traffic alerts on VMS signs.

4.1.3 Expanded Incident and Traffic Management Capabilities

Philadelphia is the only city among the 10 largest cities in the country without a TOC. As documented in **Chapter 7 Traffic Operations Center Best Practices**, in the other cities TOCs routinely perform roadway surveillance, incident management, special events traffic management, and corridor traffic management. To a lesser extent they disseminate traveler information and assist in emergency evacuations. These capabilities are largely nonexistent in Philadelphia. A key objective is to raise Philadelphia's traffic management capabilities to levels comparable to those of other major cities.

PennDOT's long-term vision is to enhance traffic management on detour routes in expressway corridors. They are investing in closed loop traffic signal systems and are beginning to construct CCTV cameras and VMS signs on the detour routes. In suburban counties PennDOT will assume control over signals in emergency situations to move traffic. In Philadelphia, they will rely upon the TOC to perform this role.

Much of the region is improving interagency cooperation. RIMIS became operational in the summer of 2010. At that time, with the exception of Philadelphia, all key highway agencies in the region became able to share incident, construction, and special events information. Agencies participating in RIMIS include PennDOT, the New Jersey Department of Transportation (NJDOT), the Pennsylvania Turnpike Commission, the New Jersey Turnpike Authority, and the South Jersey Transportation Authority. DRPA is anticipated to become a participant within the next year.

4.2 TOC Capabilities

As the city's signal system expands, and ITS devices are deployed, it will fundamentally change the way the city manages the arterial street system. This section documents capabilities envisioned for the TOC. They were derived from the TOC goals and Steering Committee discussions. The relationship between TOC goals, capabilities, and features are documented in **Tables 2-6**. In the tables, TOC capabilities are grouped by goal. TOC features, a high-level description of specific TOC functionalities that supports TOC capabilities, are described in **Section 4.3**.

4.2.1 Provide Capability to Actively Manage Traffic Signals

- **Time of Day Plans —** Construction of the TOC will result in the expanded use of time of day plans. Signals that operate with fixed signal timings will now operate with time of day plans

Table 2: Provide Capability to Actively Manage Traffic Signals — Capabilities, Features, and Implementation Timeframe

Capabilities	Features	Implementation Timeframe			
		Existing	Opening Day	0-5 Years	5+ Years
Time of Day Plans	Fixed time of day signal plans	■	■		
Advanced Traffic Signal Control	Central control of traffic signals		■		
	Central database stores signal timng plans		■		
	System automatically implements time of day plans		■		
	Operator selects signal timing plan from database		■		
	Operator modifies signal timing plan		■		
	Generate and test new signal timing plans		■		
	Display signal status, signal timing plan		■		
	Traffic sensors monitor arterial traffic patterns			■	
	System selects signal timing plan based on traffic patterns			■	
	Traffic signal coordination with signals outside city limit				■
Create Traffic Signal Timing Plan Database	Utilize traffic signal optimization and simulation software			■	
	Retrieve archive traffic data			■	
	Central database stores signal timing plans			■	
Adaptive Traffic Signal Control	System software automatically manages traffic signals				■
	Change cycle length, timing splits to reflect traffic conditions				■
	Intersection level traffic flow information				■
	Display traffic volume and speed data for each intersection				■

Table 2: Provide Capability to Actively Manage Traffic Signals — Capabilities, Features, and Implementation Timeframe (continued)

Capabilities	Features	Implementation Timeframe			
		Existing	Opening Day	0-5 Years	5+ Years
Remote Traffic Signal Control	PennDOT District 6-0 TMC operates city's traffic signals (after hours)		■		
	Remote signal control from different city hubs		■		
	Remote signal control from the field			■	
Traffic Signal Maintenance	Receive signal malfunction reports from public via 311	■	■		
	System automatically generates fault alerts		■		
	Display traffic equipment status		■		
	Municipal Radio dispatches traffic signal maintenance crews	■			
	Operator dispatches maintenance crews		■		
	Generate maintenance activity reports		■		
Archive Traffic Signal Data	System generates traffic signal timing reports		■		
	System generates malfunction reports		■		
	Generate maintenance activity reports	■	■		
	System generates traffic flow data reports			■	

Source: DVRPC, 2010

triggered by centralized traffic signal software. Time of day plans will also be customized for more time periods and recurring events, not just for A.M., P.M., and mid-day traffic conditions.

- **Advanced Traffic Signal Control —** Stakeholders universally agree that the primary goal of the Philadelphia TOC is to actively manage traffic. The city needs to migrate from fixed time traffic signals to a more dynamic signal system that varies signal timings to match traffic conditions.

  To accomplish this objective, the TOC needs the capability to modify and test alternative traffic signal timings on a systematic basis, and store timing plans in a database. Centralized traffic signal software will implement the most appropriate timing plan based on time of day, network traffic conditions, and TOC operator input. TOC operators monitoring traffic conditions with CCTV cameras will have the capability to override the system and manually implement specific signal timings. Ultimately, traffic detectors will generate information on network traffic conditions, which will be used by the operator and software to determine the appropriate signal plan.

- **Create Traffic Signal Timing Plan Database —** KITS traffic signal software is capable of storing up to 30 traffic signal timing plans. In expressway corridors, PennDOT and the city mutually agreed to reserve 18 plans for everyday operations, 7 for expressway diversions, and 5 for emergencies. The 18 everyday plans cover recurring special events such as Phillies and Eagles games at the Sports Complex.

- **Adaptive Traffic Signal Control —** Adaptive traffic control, a technique that uses an algorithm to automatically compute cycle length and splits based on real-time individual intersection approach volumes, is a long-term objective. It is dependent upon real-time intersection level traffic data.

- **Remote Traffic Signal Control —** This capability will enable Streets Department personnel to operate the traffic signal system from various points on the city's communications network. It provides flexibility for TOC operators to temporarily co-locate with other agencies as they develop and test traffic control strategies, or manage events. This type of control also permits after-hours operation of the signal system and ITS assets by PennDOT District 6-0 TMC.

- **Traffic Signal Maintenance —** Municipal Radio is currently responsible for dispatching emergency work, repairing malfunctioning traffic signals, or replacing burned-out bulbs. Crews are dispatched in response to PPD reports or public calls to Philly311. During TOC business hours, emergency dispatching responsibility will be transferred from Municipal Radio to TOC operators. Centralized signal system software will detect signal malfunctions and alert TOC operators more rapidly than the existing notification process. Responsibility for dispatching heavy work, involving replacing signal poles or mast arms, will shift from traffic engineering staff to TOC operators.

  TOC software will improve traffic signal asset management, tracking signal repair and maintenance activities, scheduling routine maintenance, and storing design and regulatory approval documentation.

- **Archive Traffic Signal Data —** TOC software will automatically compile, generate, and archive reports including traffic signal timings, timing plans, operator overrides, equipment malfunctions, traffic volumes and travel speeds, and other measures of effectiveness. TOC operator activities, including incident logs, TOC notifications, and media contact, will also be archived.

4.2.2 Provide Situational Information about the City's Arterial System

- **Monitor Arterials with CCTV Cameras —** With the use of CCTV, TOC operators will have the ability to visually observe traffic on the city's arterial network and identify bottlenecks and incidents. They will be able to dispatch police officers or tow trucks to handle situations, and change signal timings based upon observed conditions. In emergencies, PPD and OEM will also be able to observe traffic flow and modify traffic control measures based on observed conditions.

- **Traffic Flow Data —** Gathering traffic flow data has multiple purposes. First, it will generate traffic condition metrics for the centralized traffic signal system software to select the appropriate timing plan. Under advanced traffic control, system detectors will produce network traffic data for the software to select the appropriate timing plan based on traffic conditions. For adaptive traffic signal control, local detectors will supply approach volumes for the software to calculate signal timings. Traffic engineers will use historic traffic flow data to develop and/or modify traffic signal timing plans. Lastly, this data will generate travel time information for 511 systems and information service providers.

- **Traveler Information —** The Philadelphia TOC will use VMS signs, 511PA, and information service providers to disseminate traveler information. VMS signs will display traffic delays, incidents, and construction alerts. Motorist information will be posted during expressway detours and emergency evacuations. Pre-defined messages will be stored in a library. TOC operators will use the system to automatically implement a series of pre-defined messages. Otherwise, the operator can select an individual pre-defined message, or manually write one as needed. At select locations, PennDOT expressway travel times will be displayed, giving motorists information about expressway congestion levels prior to them entering the highway.

  511PA has recently become operational, offering motorists travel information via an IVR system, text messaging, and a website. Presently, 511PA data is only being populated by PennDOT district offices and its 511 contractor. Traffic conditions on city streets are missing from 511PA. At this time, it is somewhat premature to envision how PennDOT will want to incorporate Philadelphia traveler information. One potential approach is for Philadelphia to use DVRPC's RIMIS system to notify PennDOT District 6-0 about traffic conditions on city streets. District 6-0 would in turn be responsible for manually inputting the information into 511. If, in the future, PennDOT Central Office allows construction of a two-way data interface, RIMIS would then be able to populate traveler information directly into 511PA.

  PennDOT District 6-0 TMC routinely supplies CCTV video images, construction alerts, and incident information to local traffic reporting services. Current plans call for giving all city video feeds to PennDOT. PennDOT would then be responsible for disseminating the video in accordance with PennDOT video sharing policies.

  Lastly, the TOC will function as a media point of contact for traffic information. Detailed guidelines will have to be developed specifying what information the TOC can divulge versus what information must come through the Streets Department Planning and Public Affairs office.

Table 3: Provide Situational Information about the City's Arterial System — Capabilities, Features, and Implementation Timeframe

		Implementation Timeframe			
Capabilities	**Features**	**Existing**	**Opening Day**	**0-5 Years**	**5+ Years**
Monitor Arterials with CCTV Cameras	Operate CCTV cameras from TOC		■		
	Display video feeds on video wall, at workstations		■		
	Distribute CCTV video feeds to other entities		■		
	Remote CCTV control		■		
Traffic Flow Data	Traffic sensors monitor arterial traffic patterns			■	
	Intersection level traffic flow information				■
	Obtain traffic speeds from vehicle probes				■
	Display traffic volume and speed data			■	
	Distribute road network data to other entities			■	
Traveler Information	Operator composes VMS messages			■	
	Central database stores VMS messages			■	
	Operator selects and displays VMS messages from database			■	
	Remote control of VMS signs by PennDOT District 6-0 TMC			■	
	Display VMS status and message			■	
Traffic Monitoring Equipment Maintenance	Display traffic equipment status		■		
	System automatically generates fault alerts		■		
	Operator dispatches maintenance crews		■		
	Generate maintenance activty reports		■		

Source: DVRPC, 2010

- **Traffic Monitoring Equipment Maintenance —** In a similar manner to traffic signal maintenance, system software will diagnose CCTV and VMS sign malfunctions and automatically alert TOC operators. TOC operators will be responsible for dispatching maintenance crews. TOC software will improve equipment asset management, tracking equipment repair and maintenance activities, and scheduling routine maintenance.

4.2.3 Enhance Incident Management Capability

- **Incident Detection and Verification —** TOC operators will routinely monitor CCTV video of the arterial network, identifying traffic crashes and other bottlenecks that impede traffic flow. When traffic crashes are detected, the TOC will notify PPD, who will use the video to verify its location, severity, and determine the appropriate resources to dispatch. PPD will also use the video to verify 911 traffic accident reports.

  When bottlenecks result from construction activity, illegally parked vehicles, or other conditions, operators will have the ability to request PPD or PPA assistance to control traffic and/or help remove the bottleneck.

- **Modify Traffic Signal Timings —** TOC operators will have the ability to override the current signal timing plan and implement a pre-defined signal timing plan in response to incident conditions. While operators will also be able to manually adjust signal splits in real-time, this practice should be discouraged. TOC operating policies should specify when operators are permitted to manually modify signal timing in real-time, and how the adjustments are to be enacted.

- **Emergency Routing —** There are several alternative mechanisms to expedite the routing of emergency vehicles. Initially, PPD, FCC, and OEM dispatchers will rely upon CCTV video feeds to determine which streets are open with traffic moving; or conversely which streets to avoid. In the medium-term, TOC operators will manually implement emergency signal timing plans that extend green times on arterials. Long-term, emergency vehicles will be equipped with optical devices to trigger emergency preemptions at upcoming traffic signals. Vehicles will also be able to receive video feeds showing surrounding traffic conditions.

- **Traveler Information —** See description under **Section 4.2.2 Provide Situational Information about the City's Arterial System**

- **Communications —** The Philadelphia TOC will communicate with other entities using several tiers of communication. Landline telephones, cell phones, e-mail, and wireless text messages will provide basic voice and information communications. Street-Band and T-Band radio will be used to communicate with Streets Department maintenance crews and Traffic Police, respectively. On a more advanced level, RIMIS will be used to broadcast situational information to multiple entities through a web-based application. Video conferencing capabilities will reduce the need for on-site meetings during emergencies. For redundancy and security purposes, communication will be carried over public networks and agency fiber assets.

Table 4: Enhance Incident Management Capability — Capabilities, Features, and Implementation Timeframe

		Implementation Timeframe			
Capabilities	**Features**	**Existing**	**Opening Day**	**0-5 Years**	**5+ Years**
Incident Detection and Verification	Operator monitors CCTV video		■		
	Distribute CCTV video feeds to other entities (PPD, FCC, OEM)		■		
	Remote CCTV control (PPD, FCC, OEM)		■		
	Monitor and talk on T-Band, Steet-Band		■		
Modify Traffic Signal Timings	Operator selects traffic signal timing plan from database		■		
	Operator modifies signal timing plan			■	
Emergency Vehicle Routing	Emergency vehicles optically trigger right-of-way				■
	Operator implements emergency vehicle pre-emption			■	
	Distribute CCTV video feeds to other entities (PPD/FCC dispatch)		■		
	Distribute traffic data to other entities (PPD/FCC dispatch)				■
	Stream CCTV video/traffic conditions to emergency vehicles				■
Traveler Information	Operator selects and displays VMS messages from database			■	
	Operator composes VMS messages			■	
	Media point of contact	■	■		
Communications	Monitor and talk on T-Band, Streets-Band		■		
	Monitor PSP, PennDOT, SEPTA radio			■	
Emergency Evacuation	Central database stores traffic signal timing plans (emergency evacuation)		■	■	
	Central database stores VMS messages (emergency evacuation)			■	
	System implements signal timing plans and VMS messages from database		■	■	
	Operator modifies signal timing plan and VMS messages (as per OEM)		■	■	

Table 4: Enhance Incident Management Capability — Capabilities, Features, and Implementation Timeframe (continued)

Capabilities	Features	Implementation Timeframe			
		Existing	Opening Day	0-5 Years	5+ Years
Special Events	Database of special events		■		
	Central database stores signal timing plans (special events)		■		
	Central database stores VMS messages (special events)			■	
	System implements signal timing plans and VMS messages from database		■	■	
	Operator modifies signal timing plan		■		
	Operator composes VMS messages			■	
	Remote signal control from the field			■	

Source: DVRPC, 2010

- **Emergency Evacuation —** Even though the location, time, and extent of an evacuation is not known until it is triggered, emergency evacuations can be treated as pre-planned incidents. OEM, working with many stakeholders, has pre-defined emergency evacuation routes, traffic control points, and emergency transit services. TOC staff will work with OEM and PPD to develop signal timing plans and VMS messages that support OEM's plans. Based on guidance received from OEM, TOC operators will implement and/or modify their pre-defined plans.

- **Special Events —** Special events are another pre-planned incident where TOC staff will develop pre-planned traffic signal timings and VMS messages that support PPD's traffic control strategy. Because many special events reoccur, their timing plans can be stored in a database and periodically refined. TOC operators will implement and modify the traffic control plan in cooperation with PPD officers in the field. For major events, remote control of traffic signals from the field is desirable.

4.2.4 Promote Corridor Management

- **Corridor Traffic Management —** PennDOT has developed official detour routes for all of its expressways. For each highway segment, there are designated primary and secondary detour routes. With the reconstruction of I-95, traffic diversions are anticipated to occur on a more regular basis. To successfully manage detours, PennDOT ultimately plans to place all signals on the detours on traffic signal systems, and install CCTV cameras and VMS signs. When a diversion is triggered, PennDOT District 6-0 TMC will visually ensure the detour route is able to handle the surge in traffic, prior to implementing the pre-defined detour timing. In Philadelphia, the Philadelphia TOC will be responsible for managing the detour routes.

- **Transit Operations Support —** The Philadelphia TOC will provide real-time traffic information and planned construction activity to SEPTA so that SEPTA will be able to adjust bus routes and schedules to reflect traffic conditions. Transit vehicle priority treatment will become feasible on a bus-by-bus basis by means of an optically triggered priority at specific intersections, or more systematically on a route segment by the TOC.

- **Traveler Information —** See description under **Section 4.2.2 Provide Situational Information about the City's Arterial System**

4.2.5 Improve Interagency Coordination

- **Populate Regional Notification Software —** This capability will allow the Philadelphia TOC to share real-time traffic information with other operations centers. Information to be shared includes incidents, traffic speeds and volumes, traffic signal timing plans, traffic signal plans in use, messages posted on VMS signs, and construction/road closure permits. RIMIS, an information exchange network created by DVRPC, is designed to fulfill this role. Initially, TOC operators will have to manually input data into RIMIS. An Application Program Interface (API) may be constructed in the future to automatically pick data from the TOC's ATMS software. Recipients of this information would include PennDOT, PPD, OEM, SEPTA, DRPA, the Pennsylvania Turnpike Commission, NJDOT, and 911s in adjoining counties.

- **Communications —** See description under **Section 4.2.3 Enhance Incident Management Capability**

- **Share Video with Other Agencies —** As described in **Section 4.2.2 Provide Situational Information about the City's Arterial System**, the city's video will be shared with other agencies so that operational decisions can be based on visual observations. Some external agencies will be allowed to have operational control over the CCTV cameras. To avoid potential conflicts among these agencies, a hierarchy needs to be established to set video control priorities.

- **Resource Coordination Point of Contact —** Agencies will be looking at the Philadelphia TOC as the point of contact to obtain traffic information and request resources from the Streets Department.

- **Maintenance and Construction Alerts —** Maintenance and construction activity covers Streets Department construction projects, maintenance crews, and road closure permits issued to utilities and other contractors. Philadelphia Police and Fire Departments need this information to route their emergency vehicles. Construction activity can cause SEPTA to reroute its buses. Prior to implementing a detour or evacuation, PennDOT and OEM need to assess the capacity of the emergency route and its ability to handle a surge in traffic, because maintenance and construction activity could significantly affect arterial capacity.

  Construction coordination and permitting functions should be centralized in the Philadelphia TOC. TOC operators should have the authority to schedule construction work to minimize traffic impacts, and to close jobs when emergency conditions, like incidents or detours, unexpectedly occur.

4.3 TOC Features — Implementation Timeframe

This section establishes implementation priorities for the Philadelphia TOC. It describes the most essential features that need to be in place by opening day. Desirable features that are not critical, or have a longer implementation timeframe, are also listed. TOC features were classified as follows:

- **Opening day —** Features that must be in place for the TOC to be operative on opening day. Generally, these features are fairly easy to implement. Functionalities that somewhat currently exist are also included.

- **0-5 years —** Features which, while desirable, are not considered essential for opening day. The objective is to defer implementation of nonessential features so as not to overwhelm TOC staff during the initial rollout period. Also included in this category are features that are more technically difficult and/or more costly to implement, and consequently require a longer timeframe.

- **5+ years —** Features which, while useful, are ultimately contingent for their implementation upon cost, ease of implementation, and perceived benefits. Given the magnitude of the list of potential features, these less critical items are not likely to be implemented within the next five years.

Table 5: Promote Corridor Management — Capabilities, Features, and Implementation Timeframe

		Implementation Timeframe			
Capabilities	**Features**	**Existing**	**Opening Day**	**0-5 Years**	**5+ Years**
Corridor Traffic Management	Share road network conditions (arterial and expressway) with other entities		■		
	Operator monitors CCTV video		■		
	Provide construction databases to other entities				■
	Maintain database of alternative diversion plans			■	
	System implements signal timing plan		■	■	
	System implements VMS message from database			■	
Transit Operations Support	Distribute road network conditions to other entities (SEPTA)		■		
	Provide construction databases to other entities (SEPTA)				■
	Transit vehicle priority optical capability	■	■		
	Transit vehicle priority treatment system based capability				■
	Operator selects or composes VMS messages (transit alerts)			■	
Traveler Information	Distribute road network conditions to other entities (511 systems)		■		
	System generates travel times on VMS signs				■
	Distribute road network conditions to other entities (info service providers)		■		
	System Implements VMS messages from database			■	
	Operator selects and displays VMS messages from database			■	
	Display parking information on VMS signs (special events)				■

Source: DVRPC, 2010

Table 6: Improve Interagency Coordination — Capabilities, Features, and Implementation Timeframe

Capabilities	Features	Implementation Timeframe			
		Existing	Opening Day	0-5 Years	5+ Years
Populate Regional Notification Software	Operator enters road network conditions into RIMIS		■		
	API populates RIMIS			■	
	TOC receives situational information from other entities		■		
	Situational map displaying incidents, construction, traffic conditions		■		
Communications	Phone, e-mail, wireless communication	■	■		
	Video conferencing			■	
	Monitor and talk on T-Band, Street-Band		■		
Share Video with Other Agencies	Distribute CCTV video feeds to other entities		■		
	Receive CCTV video feeds from other entities		■		
Resource Coordination Point of Contact	Operator receives request for Streets Department resources		■		
	Operator logs requests into a database		■		
	Operator dispatches maintenance crews		■		
Maintenance and Construction Alerts	Maintain database of street closure permits	■	■	■	
	Maintain database of emergency street closures			■	
	Maintain database of construction and work zone status			■	
	Provide construction databases to other entities				■

Source: DVRPC, 2010

The features listed below generally follow the order established in **Tables 2–6**. Many features or functionalities cut across several goals and capabilities. In these instances, the feature is described only once.

4.3.1 Opening Day Features

- **Fixed Time of Day Signal Plans —** For the first several years after the TOC opens, traffic signals on the system will essentially operate on fixed time of day plans. The only significant changes will be the use of central software, instead of local controllers, implementing the timing plans; and greater use of timing plans for specific time periods or events.
- **Central Control of Traffic Signals —** Traffic signal control will migrate from local controllers to the central system software. Signal timing plans, and the decision of which one to implement, will be made at the TOC level. Intersection equipment will function as local Ethernet nodes to receive instructions from central software and implement instructions via the local controller.
- **Central Database Stores Signal Timing Plans —** The central system software package, KITS, has the capability to store up to 30 timing plans for each intersection. In expressway corridors, an agreement between the Streets Department and PennDOT has allocated the number of timing plans for everyday operations, expressway detours, and emergencies. In other areas of the city, pre-defined signal plans for every-day operations and incidents will need to be developed by city traffic engineers.
- **System Automatically Implements Time of Day Plans —** Under normal operating conditions, the system software will automatically implement timing plans based on time of day and day of week.
- **Operator Selects Signal Timing Plan from Database —** TOC operators will have the capability to override the system software and implement an alternate pre-planned traffic signal timing plan.
- **Operator Modifies Signal Timing Plan —** TOC operators will have the capability to manually modify the existing signal timing plan, and implement new cycle lengths, splits, and offsets.
- **Generate and Test New Signal Timing Plans —** The TOC will have the ability to upload a new timing plan, implement it, and visually observe its effectiveness with CCTV cameras. Based on visual observation, the timing plan can either be stored in the central database, adjusted to reflect field conditions, or discarded.
- **Display Signal Status, Signal Timing Plan —** Workstation monitors and video wall display will display a map of the signal system, graphically showing signal locations, current signal phasing, and malfunctioning traffic signals. TOC operators will have the ability to zoom in and query individual signals regarding signal timing plans, signal status, and maintenance history.
- **PennDOT District 6-0 TMC Operates City's Traffic Signals (After Hours) —** Plans call for the Philadelphia TOC to initially operate only 16 hours on weekdays. PennDOT District 6-0

TMC will be responsible for operating traffic signals and CCTV cameras overnight and on weekends.

- **Remote Signal Control from Different City Hubs —** Streets Department personnel will have the capability to program and operate traffic signals from any hub on the traffic or DOT fiber communication networks. This will permit TOC staff to temporarily co-locate with other city personnel to plan and/or manage incidents.

- **Receive Signal Malfunction Reports from Public via 311 —** The TOC will receive traffic signal malfunction reports from the city's 311 Contact Center.

- **System Automatically Generates Fault Alerts —** Traffic signal software will notify TOC operators when a signal malfunction is detected. System software also has the capability to automatically detect CCTV camera and VMS sign failures. In addition to issuing alerts, equipment status will be graphically displayed on system maps. KITS is also capable of generating detailed logs of equipment failures, repair and maintenance activity, and routine maintenance schedules.

- **Display Traffic Equipment Status —** The system software will display the status of all field equipment including traffic signals, CCTV cameras, VMS signs, and traffic detectors. Information will include equipment identification, location details, current operating status, and mode of operation.

- **Operator Dispatches Maintenance Crews —** The TOC will take over responsibility for dispatching emergency work from Municipal Radio. Based on system malfunction alerts, 311 complaints, or PPD reports, TOC operators will use Streets-Band radio to dispatch signal maintenance crews to repair traffic signals and other field equipment. TOC operators will also be responsible for scheduling and dispatching maintenance crews for heavy work and routine signal maintenance. Outside requests for maintenance crews – from PPD, FCC, or other agencies – will come through the TOC.

- **Generate Maintenance Activity Reports —** Currently, maintenance activity reports are manually generated. The system will be capable of generating detailed reports documenting equipment failures and repair and maintenance activity. These reports will cover traffic signal equipment, CCTV and VMS devices, the communications network, and TOC software and equipment. Reports should form the basis of an asset management system, keeping track of equipment and software, upgrades, warranties, and repairs.

- **System Generates Traffic Signal Timing Reports —** The system will be capable of generating reports to document signal timing history, all system and operator commands to traffic signals, and all operator commands to signal software.

- **System Generates Malfunction Reports —** The TOC will maintain a log of all equipment malfunctions reported to the TOC and remedial actions taken by TOC operators to fix the problems.

- **Operate CCTV Cameras from TOC —** TOC operators will have the ability to operate CCTV assets, including full pan, tilt, and zoom (PTZ) capability. Because the cameras will be connected to the city's Ethernet fiber network, they should be IP addressable, facilitating distribution of video feeds to other entities.

- **Display Video Feeds on Video Wall, and at Workstations —** CCTV video feeds from Philadelphia CCTV cameras, as well as CCTV video from other agencies, should be capable of being displayed on a video wall and at individual workstations. The TOC operator will be capable of organizing video tours.

- **Distribute CCTV Video Feeds to Other Entities —** Stakeholders have expressed a strong interest in obtaining high-resolution full-streaming video of traffic conditions on the city's arterial network. This does not necessitate wall-to-wall coverage; rather, agencies want access to video from all cameras with the ability to select which cameras they wish to view. Video will be used for incident detection and verification, emergency vehicle routing, and monitoring detour and emergency evacuation routes.

- **Remote CCTV Control —** Due to the limited hours of TOC operation and the number of entities wanting access to video feeds for their own purposes, remote control of CCTV cameras with full PTZ capability is a necessity. To avoid conflicts among agencies, and not to overwhelm TOC staff with requests for control hand-off, protocols are needed to establish a CCTV control hierarchy. TOC staff should have the capability to override the protocols.

- **Operator Monitors CCTV Video —** Operators shall be able to organize video tours, allowing them to efficiently monitor the arterial highway network and identify conditions that require actions.

- **Monitor and Talk on T-Band, Street-Band —** The operator will have the capability to monitor T-Band and Street-Band radio communications. PPD's Traffic Police use T-Band; the Streets Department personnel use Street-Band. Access to these two radio bands will facilitate two-way communications to dispatch to field crews and/or respond to Traffic Police supervisors.

- **Media Point of Contact —** The TOC will respond to media requests about traffic conditions. All other media requests will go through the Streets Department Planning and Public Affairs office.

- **System Implements Signal Timing Plans —** The system will implement emergency signal, special events, or traffic diversion timing plans selected by the operator. Until these plans are developed the operator can implement an alternative time of day plan.

- **Database of Special Events —** The TOC will maintain a database of special events that might potentially impact traffic. The database should be able to be imported into a Geographic Information System (GIS) and correlated with construction activity and other street closures.

- **Share Road Network Conditions with Other Entities —** The Philadelphia TOC will share incident and traffic condition information with other TOCs throughout the region using RIMIS. The Philadelphia TOC will receive traffic conditions from PennDOT, DRPA, BCBC, NJDOT and other transportation agencies. In return, the Philadelphia TOC will be sharing information on the city's arterials network.

- **Transit Vehicle Priority Optical Capability —** The system shall have the capability to extend a green phase when intersection detectors receive a call from a transit vehicle.

- **Operator Enters Road Network Condtions into RIMIS —** In the short-term, road network conditions will primarily pertain to incident information, which includes information about the location, incident type, severity, and impact on traffic flow. The TOC operator will manually input incidents into RIMIS through a series of pull-down menus. They will also have the ability to update information and close out the event.

- **TOC Receives Situational Information from Other Entities —** The TOC will receive situational information from other agencies. Information will come from a variety of sources including radio communications, RIMIS, CCTV video feeds, and other modes of communication. RIMIS will provide situation information from other transportation agencies concerning traffic incidents, road construction activity, special events, and traffic speed data. The TOC will need to integrate external information into its situational mapping.
- **Situational Map Displaying Incidents, Construction, Traffic Conditions —** The TOC will have a situational map, displayed on a video wall and at individual workstations, showing incidents, construction, special events, incident status, field equipment location and status; traffic signal system status, and traffic flow data. Situational information not only pertains to TOC assets but also other entities such as PennDOT and DRPA.
- **Phone, E-mail, Wireless Communication —** The TOC shall be able to receive oral and text communications from other entities over several modes of communication, including telephone, e-mail, or other wireless communications.
- **Receive CCTV Video Feeds from Other Entities —** The TOC will have the capability to receive streaming video from other agencies, and be able to view the video at workstations or on a video wall. Video will be available over an interagency fiber network or a public communications network.
- **Operator Receives Request for Streets Department Resources —** The TOC will function as a point of contact for other agencies to request information or resource assistance from the Streets Department. Resource assistance can include changing signal timing patterns, posting messages on VMS signs, or for the TOC to dispatch maintenance crews to assist in an emergency.
- **Operator Logs Requests into a Database —** The operator will log all requests for assistance and all follow-up actions to respond to that request.
- **Maintain Database of Street Closure Permits —** Separate databases currently store street closure permits for utility work, equipment placement, block parties, and emergency road closures. Each type of road closure has its own permitting process. Eventually they should all be consolidated into a single database. The TOC should eventually have the capability to plot street closures in GIS in order to identify potential conflicts among applicants or with planned special events. In the event of a conflict, the TOC should have the authority to reschedule a street closure. In emergencies, the TOC, using GIS capabilities, should be able to quickly identify active street work, and have the authority to close any job that impedes traffic flow.

4.3.2 Medium-Term TOC Features

- **Traffic Sensors Monitor Arterial Traffic Patterns —** Network traffic sensors will be dispersed throughout the arterial network to generate traffic flow data, including traffic volumes, speeds, and vehicle classification. This information will be used to develop time of day traffic characteristics. Traffic data will be archived for future use to develop signal timing patterns for special events planning, to evaluate system performance, and to analyze long-term traffic trends.

- **System Selects Signal Timing Plan Based on Traffic Patterns —** Network traffic sensors will generate traffic flow data that will be used by the signal system and TOC operator to determine the appropriate signal timing plan to implement based on the timing plan that matches actual traffic conditions.

- **Utilize Traffic Signal Optimization and Simulation Software —** The TOC will use traffic engineering software, such as Synchro and VISSIM, to analytically optimize signal timing plans. They can optimize isolated intersections, arterials, and grid networks. KITS signal system software has the ability to import traffic signal timing plans from traffic engineering software.

- **Retrieve Archived Traffic Data —** The TOC operator will have the ability to retrieve archived traffic flow data, including traffic volumes and speeds, for input into traffic signal optimization software. The data will also be used to evaluate system performance.

- **Remote Signal Control from the Field —** Because TOC personnel may be co-located in the field with Traffic Police and/or OEM during a major special event, they require the capability to operate traffic signals remotely via wireless communications.

- **System Generates Traffic Flow Data Reports —** The system will have the capability to generate traffic flow reports for both network traffic sensors and intersection level data. Users will be able to aggregate data for different time periods. Traffic data includes traffic counts, speeds, vehicle classification, and vehicle presence.

Figure 5:   Seminole County Traffic Management Center

Source: Seminole County Florida, 2010

- **Display Traffic Volume and Speed Data —** Real-time traffic flow data will be graphically displayed on the video wall and at operator workstations. Operators should be able to observe traffic speeds and volumes, and deviation from typical conditions by day of week and time of day. If intersection level traffic data is collected, this information should be displayed in a similar manner.

- **Distribute Road Network Conditions to Other Entities —** In the short- to medium-term, real-time incident information, road closures, traffic congestion, and traffic speed data will be distributed to other agencies by means of RIMIS. Data may be entered manually or through an API. Other agencies may need this information to evaluate travel conditions on bus routes, detour and evacuation routes, and on approaches to special events venues.

- **Operator Composes VMS Messages —** The TOC operator will have to ability to manually compose and display messages. The system will be capable of formatting the message for each sign type.

- **Central Database Stores VMS Messages —** The TOC operator will be able to store pre-defined messages in a message library. The messages will cover generic congestion conditions, and messages targeted to specific construction projects, special events, and emergency evacuations. A series of messages can be grouped together to be implemented simultaneously on multiple VMS signs.

- **Operator Selects and Displays VMS Messages from Database —** The operator will be able to select the appropriate message and have it displayed on a VMS sign. The operator will have the capability to modify pre-defined messages to fit the situation, either based on visual observation or based on a request from an outside agency. Messages can be implemented on an individual basis or as a group.

- **Remote Control of VMS Signs by PennDOT District 6-0 TMC —** PennDOT District 6-0 TMC will have the capability to fully operate city-owned VMS signs, including sharing the message library and the ability to monitor the signs' status. Protocols are needed to avoid conflicts when the Philadelphia TOC and PennDOT want to post different messages concurrently on the same sign.

- **Display VMS Status and Message —** VMS status, its operating condition and whether a message is posted, as well as the actual message, will be capable of being displayed on a video wall display and at operator workstations.

- **System Implements VMS Messages from Database —** The system will be able to store a comprehensive VMS signing plan in the database so that when the operator triggers a pre-defined plan it automatically populates messages on signs in accordance to the plan. This is especially applicable for recurring congestion, traffic detours, special events, and emergency evacuations.

- **Operator Implements Emergency Vehicle Pre-emption —** TOC operators will have the capability to manually implement a signal timing plan that provides additional right-of-way on an arterial for emergency vehicles by extending green times.

- **Monitor PSP, PennDOT, SEPTA Radio —** TOC operators will have to capability to monitor radio communications of outside agencies to mine situational information. Presently, two-way communications is not envisioned.

- **Maintain Database of Alternative Diversion Plans —** PennDOT and OEM have respectively developed official detour routes and emergency evacuation routes. The Philadelphia TOC will maintain in GIS, and associated databases, procedures to implement these routes, including depictions of the routes, traffic control points, and pre-defined traffic signal timing plans and VMS messages.

- **API Populates RIMIS —** The TOC will have an API that automatically populates traffic speeds and VMS sign information from system software into RIMIS.

- **Video Conferencing —** The Philadelphia TOC will have the capability to conduct video conferences with other TOCs. Video conferencing includes the use of two-way video communications and common Smart Board technology. PennDOT plans to implement video conferencing over its regional fiber network. In emergencies, virtual conferencing is an efficient means for agencies to gather and develop a common response.

- **Maintain Database of Emergency Street Closures —** Because different units within the Streets Department currently handle street closure permits and emergency road closures, they are kept in separate databases. As the Philadelphia TOC becomes responsible for managing both types of permits, they will need to be integrated into a unified database. Using GIS to plot road closure activity will enable the TOC to better evaluate the applicant's impact on traffic and improve construction coordination.

- **Maintain Database of Construction and Work Zone Status —** TOC operators will maintain a database of active construction work zones, as distinguished from scheduled street closures and maintenance activities.

4.3.3 Long-Term TOC Features

- **Traffic Signal Coordination with Signals Outside City Limit —** Centralized traffic signal software will have the capability to receive traffic signal timing plans, in real-time, from PennDOT or adjoining municipalities, and use those plans in evaluating which signal plans to implement.

- **System Software Automatically Manages Traffic Signals —** Central traffic signal software utilizes traffic responsive algorithms to select the most appropriate signal timing plan. Using real-time intersection traffic flow information, the central software will select the most appropriate signal timing plan.

- **Change Cycle Length, Timing Splits to Reflect Traffic Conditions —** Initially, traffic signal timings will be based on time of day plans, where cycle length and phasing splits are pre-defined based on traffic engineering analyses. Under adaptive traffic signal control, cycle lengths, splits, and offsets will be calculated based on real-time traffic volumes from detectors. The timing changes can be accomplished either offline, downloaded for use next day, or online in real-time.

- **Intersection Level Traffic Flow Information —** The TOC will collect intersection level traffic flow information from sensors positioned on intersection approaches. Signal timing algorithms will use the data to calculate signal timing plans based on real-time traffic conditions. The data will also be used to generate intersection level measures of effectiveness.

- **Obtain Traffic Speeds from Vehicle Probes —** This is an optional long-term feature. Vehicle probe data may be obtained either from city-owned traffic detectors or outsourcing to private information providers who collect the data for commercial use. The information can be used to measure traffic system effectiveness and to provide traveler information.

- **Emergency Vehicles Optically Trigger Right-of-Way —** Emergency vehicles will have the capability to pre-empt signal timings to give themselves right-of-way through the intersection. Optical pre-emption devices will be used to accomplish this.

- **Distribute Traffic Data to Other Entities —** In the short- to medium-term, incident information, road closures, traffic congestion, and traffic speed data will be distributed to other agencies by means of RIMIS. In the long-term, direct communications links, using Private Virtual Networks (PVN) or wireless assets, may allow the TOC to directly feed data to PPD and FCC dispatchers as well as to emergency vehicles.

- **Stream CCTV Video/Traffic Conditions to Emergency Vehicles —** Wireless technology will be used to stream real-time traffic conditions to emergency vehicles. This will provide warning to the vehicle driver about traffic conditions he will encounter.

- **Provide Construction Databases to Other Entities —** The TOC will provide other agencies with scheduled permitted street closures and other construction and maintenance activities. This can be accomplished by inputting the information into RIMIS, either manually or though an API, or by the TOC sending out weekly construction alerts. RIMIS is the preferred option because it is tied to a GIS database that incorporates other incident information.

- **Transit Vehicle Priority Treatment System Based Capability —** The system will receive bus on-time performance information from SEPTA, and based on pre-established criteria determine whether priority treatment is required for a specific bus route. Centralized traffic signal software will extend green times along the bus corridor.

- **System Generates Travel Times on VMS Signs —** The system will receive expressway travel times from PennDOT TMC and automatically display them on Philadelphia VMS signs.

- **Display Parking Information on VMS Signs —** The TOC will receive parking lot status information including facility occupancy and which entrances are open. The TOC operator will be able to use pre-existing messages from the database or compose a new message imparting parking status information. This is applicable to parking facilities in the vicinity of special events venues.

4.4 Assumptions and Constraints

4.4.1 TOC Will Be Co-located with OEM

Plans call for co-locating the Philadelphia TOC with OEM in the basement of the FAB. Planning is underway for a Delaware Valley Intelligence Center (DVIC) that will house Philadelphia's 911 operations, 311 Contact Center, OEM, the TOC, and potentially other assets. There is no timetable for constructing the DVIC.

Co-locating the Philadelphia TOC with OEM offers many advantages:

- FAB is a 24/7 facility, offering continuous power, heating and air conditioning, security, and parking for employees.
- FAB offers uninterruptible power supply, backup power, redundant communications links, facilities for personnel, and conference rooms.
- FAB has existing communication access to the traffic signal system servers at MSB and the backup server at the Traffic Signal/Sign Shop. DOT's fiber communications network links FAB and MSB. PennDOT recently installed fiber between the FAB and the Traffic Signal/Sign Shop.
- OEM will share their video wall and video conferencing capabilities with the TOC.
- OEM has personnel on duty 24/7. While OEM staff is not trained to operate traffic signal systems, they can complement PennDOT District 6-0 TMC operators to manage the city's arterials during off-hours. OEM staff can dispatch city maintenance crews to handle signal malfunctions, monitor arterials outside expressway corridors, or coordinate with PPD/FCC.
- While not as quantifiable as the above, experiences in other cities have demonstrated that co-locating a TOC with other entities has resulted in stronger interpersonal relationships, making it easier to manage traffic in emergencies. Nearby success stories include New Jersey's Statewide Traffic Management Center (STMC) which co-locates personnel from NJDOT, the New Jersey Turnpike, the Garden State Parkway, and New Jersey State Police; and New York City's TMC which is composed of the New York City Department of Transportation's TMC and the New York Police Department TOC.

4.4.2 Phased Deployment of TOC, Traffic Signal System, and ITS Devices

Unlike many TOCs that are constructed as a single unified project, the Philadelphia TOC will be constructed in an incremental manner. In early 2010, KITS software became operational and the signal system migrated to the new ATMS software. Later in 2010, CP1 will add 61 signals to the signal system; and by fall 2011, GR1 will add an additional 130 signals to the system. The anticipated date for co-locating the TOC in the OEM Operations Center is spring 2011. Adding all other remaining signals on the fiber network to the signal system is contingent upon additional financial resources and staff support.

The incremental nature of this process presents the city several opportunities and constraints:

Opportunities

- Develop and test TOC policies and procedures during the interim TOC period when there are a minimum number of on-system signals and ITS devices to manage. Policies and procedures will be tested prior to the TOC becoming fully operational.
- Train TOC staff (operators and traffic signal engineers) during the interim TOC operation period.

- Expand the number of signals on the system and build up a critical mass prior to the TOC becoming part of the city's proposed fusion center.
- Incrementally implement KITS software features during the rollout period as staff develops expertise in the software.

Constraints

- Limited cohesion because the TOC would not be fully operational.
- Manpower and operational limitations may reduce the TOC's effectiveness. This is especially true in emergency situations.
- Given the city's financial situation and current allocation of personnel, it is unclear whether the TOC will ever be fully staffed. As a consequence, the TOC should be designed in a manner to automate as many functions as possible, thus minimizing manpower needs.
- For the foreseeable future, traffic signals will essentially operate with time of day signal plans. While this is a significant improvement over today's fixed time operations, it is not the most effective use of ATMS software and TOC capabilities.

4.4.3 After-Hours Operations by PennDOT District 6-0 TMC

Initially, the Philadelphia TOC will operate 16/5, with PennDOT District 6-0 TMC managing traffic signals and VMS signs overnight and on weekends. Due to this requirement, TOC capabilities and features include:

- PennDOT District 6-0 TMC operation of the city's traffic signals (after hours);
- remote CCTV control; and
- remote control of VMS signs by PennDOT District 6-0 TMC.

PennDOT will not actively manage the city's signal system. PennDOT District 6-0 TMC's primary responsibility is the expressway system; therefore, they will tend to focus on arterials in expressway corridors to the detriment of other signals in the city. The remaining signals on the signal system must be capable of functioning in automatic mode during off hours, without TOC operator input.

Protocols to facilitate the hand-off in operations between the Philadelphia TOC and District 6-0 TMC are required. It should provide for notification of active incidents, existing equipment malfunctions, and current timing plans and VMS messages. The protocols must also address maintenance procedures, who is responsible for alerting maintenance crews, and what assistance OEM can provide to PennDOT.

4.4.4 Insufficient Resources Dedicated to Traffic Signal Operations

Successful operation of the Philadelphia TOC is contingent upon adequate staffing. The goals set forth by the Steering Committee create a proactive environment where staff not only respond to events, but also dedicate considerable resources to routinely developing and refining signal timing plans for a wide range of conditions and contingencies. Because only one employee is currently assigned to manage the traffic signal system, provision of sufficient TOC staff is a critical issue.

A number of studies conducted by FHWA and the Institute of Transportation Engineers (ITE) were consulted to ascertain desirable staffing levels for the traffic signal operations. As described in the next chapter, based on staffing ratios from larger cities, Philadelphia should have at least seven full-time traffic engineers dedicated to preparing and modifying signal timing plans, and 49 technicians to maintain the city's traffic signals. These numbers do not include TOC operators dedicated to monitoring CCTV cameras and KITS software, or day-to-day interactions with outside agencies. Given current staffing levels and financial constraints, the city will not likely meet minimal staffing requirements in the foreseeable future. Philadelphia will need to evaluate the reallocation of existing personnel, outsource some functions, or prioritize what the TOC can realistically accomplish.

As a consequence of lack of resources, except at the most critical intersections, the city's signal system will have to continue to run in fixed time mode, and implementation of time of day signal plans will be a long-term process. Design of the TOC should automate as many functions as possible to free up TOC operators to perform other functions.

5 Operational Policies

5.1 Organizational Structure

This section outlines staffing requirements. It describes staff roles, responsibilities, and qualifications. It also presents staffing levels and a proposed organization chart.

5.1.1 Duties and Responsibilities

Based upon a review of various studies sponsored by FHWA and ITE, below are the typical categories of personnel associated with TOCs and signal operations. Accompanying each category is a set of recommended qualifications.

- **Administrator —** Responsible for supervising TOC staff, traffic signal engineers, maintenance crews, consultants, and outside vendors. Qualifications include a degree in civil or electrical engineering and supervisory experience in traffic signal operations. Most medium to large TOCs are structured with an administrator and multiple supervisors to oversee organizational units within traffic signal operations.
- **Supervisors —** Two supervisory positions are envisioned. One will be responsible for supervising traffic signal engineers and TOC operators. The second will be responsible for supervising maintenance crews. The former's qualifications should include a degree in civil or electrical engineering and experience with computerized signal systems. The latter's qualifications should include experience supervising traffic signal technicians.
- **Traffic Signal Engineers —** Responsible for developing, modifying, and maintaining traffic signal timing plans, databases, and systems checks. Qualifications include a degree in civil engineering and experience in traffic signal timings. While various studies call for one engineer per 75-00 traffic signals, in reality larger cities typically employ one engineer per 300-400 signals.
- **ITS Engineers —** Responsible for designing and maintaining ITS devices, fiber communications networks, software systems, workstations, server systems, video board; supervise consultants and maintenance service contracts. Qualifications include a degree in electrical engineering, systems engineering, or IT, with experience in communication systems or ITS. While an ITS Engineer is not required, and most other cities utilize shared IT personnel with other agencies to maintain software and communications, given the size of the city's traffic signal system, its underlying communications network, and the number of ITS devices envisioned, it is desirable to have ITS engineers dedicated to the TOC.
- **TOC Operators —** Responsibilities include monitoring CCTV cameras and traffic signal operations, manually changing traffic signal timing patterns, handling telephone calls from other agencies, and maintaining TOC databases. Qualifications include graduation from a high school, thorough working knowledge of basic PC computer programs, and the ability to

work flexible schedules. Other TOCs reported that a flexible schedule is a critical factor in hiring personnel. Most agencies employ two operators per shift.

- **Signal Technicians —** Responsible for preventative maintenance, troubleshooting, equipment repair, and installation of traffic signals, controllers, conflict monitors, CCTV cameras, and communication devices. As traffic signals migrate onto the signal system, it becomes increasingly important that the technicians have electronics and electrical training and International Municipal Signal Association (IMSA) certification. National standards recommend between 30-61signals per technician.

5.1.2 Staffing Levels

Philadelphia TOC staffing needs are presented in **Table 7**. The first two columns represent minimal and desired staffing requirements. The former is derived from staffing levels observed in other large cities; the latter is based on FHWA/ITE recommended staffing levels. FHWA/ITE standards represent an ideal staffing level that few cities can afford to achieve. The last two columns show opening day staffing needs and existing staffing levels.

It is recommended that a single administrator oversee all traffic signal operations including TOC operators, maintenance crews, traffic signal engineers, and the Traffic Signal/Sign Shop. Under the administrator there will be two supervisors, one managing the TOC and traffic signal engineers, and the other managing maintenance crews. All three supervisory staff are envisioned to be in place on opening day.

While national guidelines call for 75-100 signals per traffic signal engineer, based on the city's financial constraints and the fact that many cities get by with 300-400 signals per engineer, seven traffic signal engineers is a more realistic ultimate goal. The seven engineers are based on the full complement of 2,900 traffic signals. Only two traffic signal engineers are needed on opening day because only 800 traffic signals are expected to be on the system.   Even though the Streets Department currently has three district engineers and one project engineer, none of them dedicates any substantial time to traffic signal operations. The two traffic signal engineering positions will have to be filled either by new hires or through contracting of engineering services.

The number of TOC operators is a function of the number of shifts that need to be staffed. With the TOC initially operating for only 16 hours per day, only four TOC operators are required. When needed, the TOC supervisor or one of the traffic signal engineers can fill in for a missing TOC operator.

Many of the ITS engineering functions are currently shared by two engineers. As both assume more administrative responsibilities, one as head of traffic operations and the other as signal administrator, they will have to be replaced.

Maintenance technicians are currently divided into light work and heavy work crews. The former are responsible for controller repairs, replacing burned-out bulbs, and if time permits routine maintenance activities. The latter, also called construction crews, are responsible for traffic signal knockdowns, CCTV cameras, communication links, and jobs requiring more extensive resources. Based upon national standards of 30-61 signals per maintenance technician, 49-99 light work maintenance workers are needed. Only 12 signal technicians are assigned to light work. As a result, there is a backlog of signal repairs and routine maintenance work is rarely performed. Adding an additional 14 workers will begin to bridge this gap. However, even with 26 technicians, the city will still be operating below minimum staffing thresholds.

Table 7: TOC Staffing Requirements

Position	Minimum Staffing	Desired Staffing	Opening Day Staffing	Existing Staff Levels
Administrator	1	1	1	1*
Supervisors	2	2	2	1
Traffic Signal Engineers	7	40	2	0**
ITS Engineers	0	3	2	1***
TOC Operators	2	9	4	0
Signal Technicians	49	99	26	12

* Currently staffed by Assistant Chief Engineer – Operations   ** No current traffic engineer is substantially involved with signal operations   *** ITS engineer will be promoted to Signal Administrator

Source: DVRPC, 2010

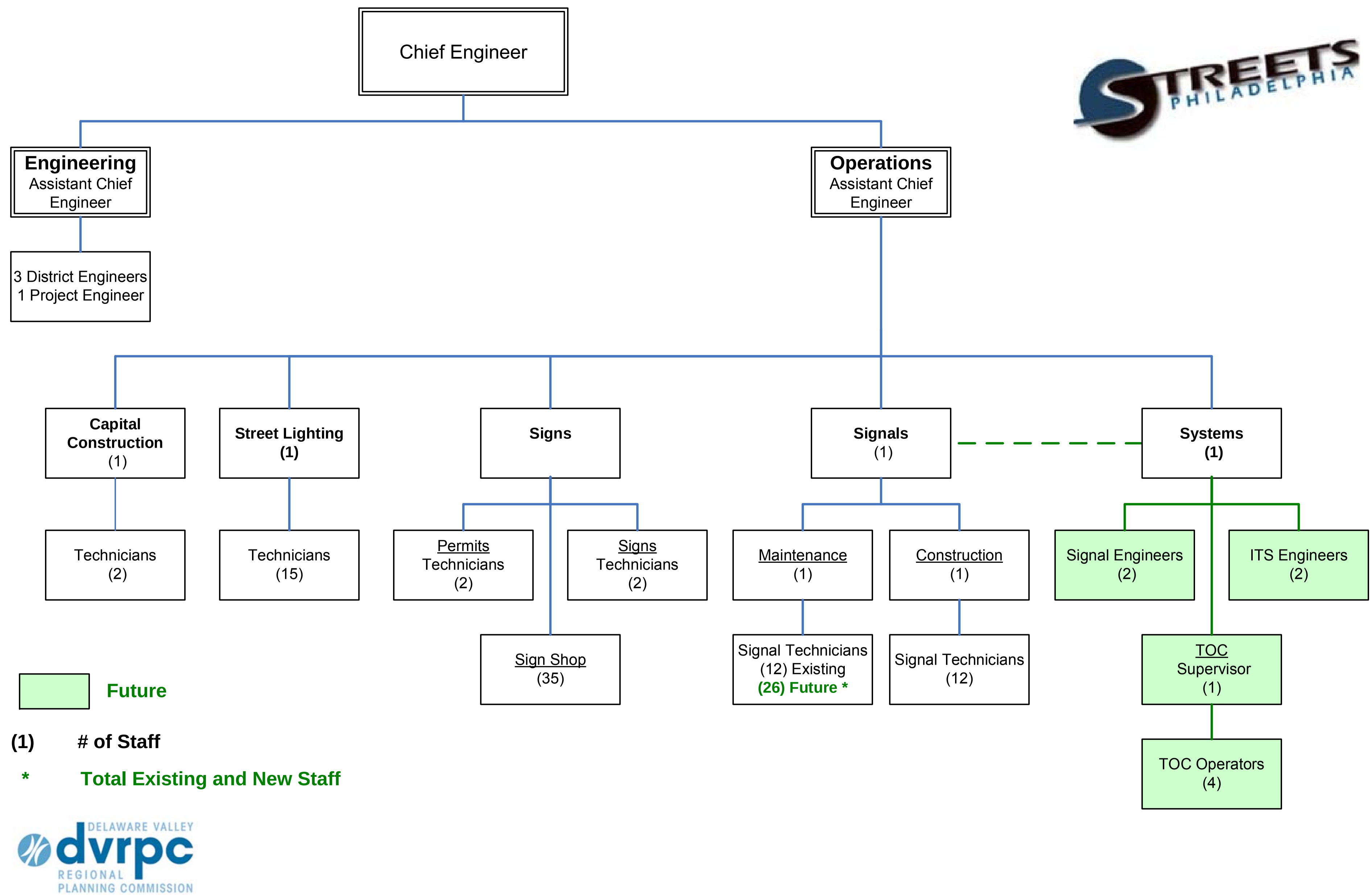
5.1.3 Staffing Options

Two issues that will eventually need to be addressed by Philadelphia are how to recruit TOC staff and whether to co-locate traffic signal engineers in the TOC.

Each year FHWA conducts a survey to determine the level of ITS deployment across the country and various attributes associated with ITS programs. In 2006, one of the questions dealt with methods used to recruit TOC staff. The most effective techniques employed by other cities to recruit staff are outreach to local colleges and advertising in local media. Recruiting services and advertising in trade publications do not appear to be as effective. It is interesting to note, that even though it was not listed in the survey as a potential response, two cities stated that in-house recruiting/training was their most effective means to obtain TOC staff. More information about TOC staff recruitment is available in **Chapter 7, Traffic Operations Center Best Practices**.

Another key issue is where to locate the traffic signal engineers. Experiences from other cities do not offer any clear guidance. In some cities, traffic signal engineers are an integral component of the TOC; in others, they are just another unit within traffic engineering. Development and maintenance of traffic signals timing plans was a major theme identified by the Steering Committee. Philadelphia is not devoting sufficient resources to developing and maintaining traffic signal plans. Existing Traffic and Lighting Unit engineers are largely dedicated to responding to citizen complaints and conducting traffic engineering studies. Traffic signal timing improvements are incidental, usually an outcome of their other responsibilities. Committing additional existing staff resources, or hiring additional traffic engineers, does not guarantee traffic engineers will be dedicated to signal operations. The only way to achieve this goal is to both organizationally and physically isolate traffic signal engineers from the rest of traffic engineering by co-locating them in the TOC and organizationally having them report to the TOC supervisor.

Figure 6: Philadelphia Streets Department – Proposed Traffic and Lighting Organizational Chart



Source: Philadelphia Streets Department, 2010

5.1.4 Organization Chart

Proposed reorganization of the Traffic and Lighting Unit is shown in **Figure 6**. Capital Construction, Street Lighting, and Signs would essentially remain unchanged.

Responsibilities of the existing Systems Unit would expand to cover TOC and signal operations. The Civil Engineer (CE) II who currently heads the Systems Unit would become the traffic signal administrator, reporting to the Assist Chief Engineer – Operations. Reporting to the signal administrator — that is, the CE II — would be the signal engineers, ITS engineers, and TOC supervisor. The TOC supervisor would supervise the TOC operators.

Signals Unit, which oversees the signal maintenance forces, would largely remain unchanged. Under the Signals supervisor, supervisors would oversee light maintenance work and heavy maintenance work. The major substantive change is that the Signal Unit Supervisor would indirectly report to the CE II. This change is required to integrate signals maintenance with signals operation.

5.2 Hours of Operation

5.2.1 Normal Hours

In 2010 after KITS software is installed and fiber connections are completed, the Philadelphia TOC will have limited operational capabilities. During this period an unofficial TOC could be activated at the Traffic Signal/Sign Shop if a situation warranted it.

An interim TOC will formally open in spring 2011, constructed as part of the redesign of OEM's operations center and after provision of staffing. Initial hours of operation will be 16 hours per weekday. There will two eight-hour shifts, probably from 6 A.M. to 2 P.M., and from 2 P.M. to 10 P.M. Ultimately, the TOC may operate 24/7, with three eight-hour shifts. There is no timetable as to when this will occur.

5.2.2 After Hours

Until the TOC goes 24/7, after-hours operations will be managed by PennDOT District 6-0 TMC with assistance from OEM. PennDOT will have full capability to operate KITS software, monitor traffic signal operations, and implement alternative time of day plans. PennDOT will also have CCTV PTZ capability and authority to post VMS messages.

PennDOT will not deliver the same level of operations as a fully functional Philadelphia TOC. PennDOT TMC's primary focus is managing District 6-0's expressways. As a Regional TMC, it is also responsible for after-hours TMC operations of PennDOT Districts 4 and 5 in Allentown and Wilkes-Barre. Consequently, PennDOT District 6-0 will have limited resources available to monitor the city's traffic signal system and manage incidents. PennDOT's emphasis will be on signals located in expressway corridors, leaving most of the city unmonitored. As an outside agency, PennDOT is not empowered to dispatch Streets Department maintenance crews or PPD resources.

With the TOC co-located in OEM, OEM personnel can supplement PennDOT staff and fill in some of the operations gap. Like PennDOT, OEM will have limited resources available after hours. OEM's duty officer will be responsible for monitoring PPD, FCC, Pennsylvania Emergency Management Agency (PEMA), and other data sources to identify conditions that will trigger an OEM response or operations center activation. Nor will OEM personnel be trained to manage ATMS software. Given OEM's focus, a natural role for them involves situational awareness. OEM will have access to CCTV video. Any traffic crashes or other incidents observed will be reported to PPD; signal malfunctions will be relayed to Municipal Radio. OEM can also function as an intermediary between PPD and PennDOT TMC.

It is recommended that a Memo of Understanding (MOU) be developed to define PennDOT's role and responsibilities, standard operating procedures, and actions to be undertaken in emergency situations. OEM's role and responsibilities should also be defined, and they should be a party to the MOU. The MOU should incorporate procedures to resolve any problems that might arise. A fuller discussion of after-hours procedures is included latter in this document.

5.2.3 Emergency Situations

How after-hours incidents will be handled depends on whether they are planned or unexpected events and their impact on traffic. The potential responses to after-hours situations are outlined in **Table 8**.

For major planned events, such as an Eagles game or Fourth of July festivities, TOC hours of operation will likely be extended. For more minor events, such as a Flyers game or a street closure due to construction activity, the Philadelphia TOC can develop a pre-planned response plan that will be forwarded to PennDOT District 6-0 TMC to implement. The Streets Department and PennDOT should periodically meet to review planned events, responsibilities, and the response plans.

For major unexpected events, PennDOT will implement standard agreed-upon incident management protocols and notify city personnel via a call down list. Based upon the anticipated duration of the event, and the magnitude of its impact on traffic, TOC staff will decide whether to activate the Philadelphia TOC. For minor or routine unplanned events, such as traffic crashes or water main breaks, PennDOT will implement standard incident management protocols.

Equipment malfunctions reports and equipment alerts received by PennDOT TMC operators will be logged and forwarded to OEM and/or Municipal Radio to dispatch maintenance crews.

5.3 Procedures

This section will review typical contents of a TOC operations manual and then address specific issues of interest to the Philadelphia TOC.

Table 8: After-Hours Situation Procedures

Type of Event	Major Event	Minor Event
Planned Event	■ Philadelphia TOC hours of operation extended	■ Philadelphia TOC prepares response plan – signal timings, VMS signs ■ Stores plan in database ■ PennDOT implements response plan
Unplanned Event	■ PennDOT implements incident management protocols ■ PennDOT notifies Philadelphia TOC staff ■ Philadelphia TOC staff decide whether to activate TOC	■ PennDOT implements incident management protocols

Source: DVRPC, 2010

5.3.1 TOC Operations Manual

An operations manual is just as critical to the TOC as the ATMS software. It defines roles, responsibilities, and procedures. There are several approaches to developing TOC procedures. FHWA has a publication, listed in **Chapter 2 Referenced Documents**, documenting best practices for developing an operations manual. Other references recommend the operations manual should be built on a TOC's ConOps. PennDOT has a set of policies that can serve as a starting point for the Philadelphia TOC, especially since PennDOT will be responsible for its after-hours operation. No matter which approach Philadelphia adopts, TOC procedures will change over time as the TOC's role evolves.

Table 9 presents the contents for a TOC manual as recommended by FHWA, and **Table 10** summarizes PennDOT District 6-0's operators manual. PennDOT's manual is actually a web browser application rather than a paper document. A review of both documents reveals common themes that should be incorporated into the Philadelphia TOC manual:

- identification of TOC goals, services provided, and coverage area;
- location of field devices;
- stakeholders, role and responsibilities, contact names, and telephone numbers;
- hours of operation, standard procedures, staff contact information;

- routine operation procedures including shift change, equipment malfunctions, citizen complaints;
- incident procedures, emergency response plans;
- equipment and software user guides and documentation; documentation of field devices should include identification number, manufacturer, and model number; and
- TOC forms and logs.

5.3.2 TOC Logs

Examples of forms employed by PennDOT to document TMC activities are located in **Appendix A**, and summarized below. In aggregate, they can serve as a staring point when Philadelphia begins developing a TOC manual.

- **Incident Reporting —** PennDOT operators primarily enter incidents on the state highway system directly into RCRS, occasionally Form TMC-100 is used. Both templates are very similar, containing date and time, road name, roadway limits, cause of incident, incident description, impact on traffic, estimated duration, and the name of the operator who prepared the report.
- **ITS Device Activation —** PennDOT has two forms dealing with activating ITS devices. One form is a simple check box indicating which VMS signs were activated and the incident's RCRS number. It does not record when the devices were activated, deactivated, or what message(s) were posted. A second form, which may have been discontinued, is for planned events. However, it may be more applicable to the Philadelphia TOC because it records the event, device number, location, messages posted, and start and end times.
- **Incident Response Plan —** PennDOT's incident response plans take two forms. For planned events, such as construction activity or special events, TMC operators, using PennDOT Form TMC-111, can specify pre-planned VMS messages to be displayed. The operator can record start and end display times. While not technically a log, PennDOT has for each expressway, by segment between interchanges, detailed road closure plans that document VMS signs to activate, messages to be posed, identification of CCTV cameras monitoring that particular expressway segment, and contact names for the TMC to contact.
- **Shift Passdown Report —** At shift change, the outgoing operators are required to record all active incidents and equipment issues. The form also records shift start times, and outgoing and incoming operators.
- **ITS Device Malfunction/Monitoring Reports —** ITS malfunctions are reported on PennDOT Form TCM-120. It logs device type, device identification number, location, description of the problem, date, time, and the operator that recorded the information. PennDOT also requires TMC operators to daily document VMS sign status during the overnight shift. At midnight, operators record if the device is operating properly, in use, not deployed, or offline.

Table 9: Range of Content for a TOC Operations Manual

Category		Handbook Section
Inventory		■ Area of coverage ■ Functions ■ Services provided ■ Traffic control devices in field ■ TOC components ■ Stakeholders
Daily Operations		■ Emergency and other contact names ■ TOC emergency plan ■ General policies ■ General system operation
Traffic Management System	Operational Concepts	■ Goals of the traffic signal management system ■ Interagency and interjurisdictional coordination ■ Control area ■ Traffic signal operations ■ Agency responsibility in developing signal timing ■ Field devices traffic signal systems
	Operational Procedures	■ System start-up procedures ■ System shut down procedures ■ Operator interface ■ Incident management procedures
TOC Maintenance Procedures		■ Routine maintenance ■ Preventative maintenance ■ Spare/backup equipment ■ Emergency ■ Agency maintenance ■ Contract maintenance
System Operation Logs		■ Incidents and events ■ Operations ■ Maintenance ■ Citizen reports
		■ System reports
		■ Traffic data collection and storage
		■ Risk management
		■ System documentation
Other Organizations	Context	■ Agreements, contracts, MOUs ■ Advisory functions of other organizations
	In the TOC	■ Agencies co-located with TOC ■ Operating agreements ■ Roles and responsibilities
Performance		■ Performance measures ■ Other aspects of performance measurement

Source: *Handbook for Developing a Traffic Management Center Operations Manual*, FHWA, 2005

- **ITS Device/Software Documentation —** All equipment and software should be documented with manufacturer, model number, software version number, drivers, date installed, updates, and service contact numbers. An example of PennDOT VMS software documentation is contained in **Appendix A**.

5.3.3 RIMIS

RIMIS is based on the same software platform that NJDOT currently uses in its STMC. NJDOT embedded some of the TMC reporting requirements directly into the center-to-center software. After an operator inputs an incident into the software, there is an additional input screen to log who was notified, agency resources dispatched to the scene, and ITS resources activated. Using the software, NJDOT routinely generates reports for upper management documenting incidents, TMC activity, and various performance measures.

Because RIMIS was developed by DVRPC using federal funds, it is available at no cost to the City of Philadelphia for its own use and customization. Sample screen shots showing the incident input screen, user actions, and situational map are displayed in **Appendix B.**

Incident Input Screen — By means of a series of pull-down menus, the TOC operator can select the impacted route, segment, direction, incident type, number of lanes impacted, and incident duration. For each road there are pre-defined road segments, the purpose of which is to minimize use of free text. There are also pull-down menus for weather and pavement condition. As the operator makes his selection, a Traffic Management Data Dictionary (TMDD) compliant message is generated. RIMIS automatically attaches identifier information, including operator identity, operator contact information, and a time stamp. As conditions change, and the operator updates incident information, the changes are recorded in the incident log.

User Action Screen — After inputting an incident, TOC operators can go to the user action screen. As currently configured, the operator can fill in when an incident was verified, who was notified by the TOC, what VMS signs were used, which crews were dispatched, and whether the police were notified. TOC notification can cover external agencies as well as internal agency staff. It provides additional documentation for fatal accidents, work zone crashes, and Hazardous Material (HAZMAT) incidents. A special feature, not shown in **Appendix B**, is that potential actions can be pre-defined to minimize operator typing. For example, a list of all traffic signal maintenance crews or VMS signs can be pre-defined, and then all the operator needs to do is select which ones were employed during the incident.

Reports — Monthly and event reports can easily be created. All the user needs to do is filter type of incidents, begin and end dates, and time of day. Reports can cross tabulate incident information and user actions. Reports are generated in both PDF and Excel formats.

Table 10: PennDOT District 6-0 TMC Operators Manual

Manual Contents
▪ General – TMC overview, objectives, coverage and scope, participants, operations
▪ Incident management procedures – accidents, disabled vehicles blocking a lane, debris, other, ending an incident
▪ Incident management – incident form, media contact, accidents in work zones, traffic/congestion management
▪ Roadwork procedures – what to do when maintenance or construction activity is spotted
▪ Radio communications – radio call signs for District 6 supervisors/trucks, ESP Nextel phone numbers
▪ ATMS software user guide – screen layouts, alarms and processing incidents, data retrieval and creating reports
▪ ATMS software tutorial video
▪ VMS signs – guidelines, messages, acceptable words/messages procedures for putting up messages with ATMS software, VMS IDs and locations
▪ CCTV – guidelines, basics, CCTV IDs and locations
▪ PennDOT Road Conditions Reporting System
▪ RSAN instructions
▪ TMC responsibilities – daily procedures, night shift, calls from police and other responders, calls from citizens
▪ ESP – coverage area, operating procedures, equipment list
▪ AMBER Alert – PennDOT policy, standard VMS message set, AMBER Alert activation log
▪ Inclement weather procedures
▪ Winter weather operations – RCRS, winter maintenance guide, road closure protocols
▪ Special events/Sports Complex procedures
▪ Contact numbers – TMC staff, District 6-0 press office, building maintenance, District 6 maintenance offices, maintenance office supervisors, road permits, PennDOT construction, resident engineers, Police and Fire Departments, other control centers, county 911 centers, utility call tree
▪ Appendix – maintenance responsibility area maps, equipment list and description, TMC UPS panel details
▪ Forms: ▪ Shift passdown form ▪ RCRS reporting form ▪ Camera request form (media partners) ▪ Daily sign report form (document VMS sign status) ▪ ESP log ▪ Fatal accident information form ▪ Off-hours maintenance report form

Source: DVRPC derived from *PennDOT District 6-0 TMC Operators Manual*, 2009

5.3.4 Shift Change Procedures

During normal shift change, the outgoing shift should fill out a Shift Passdown Report, and complete all incident reporting forms and ITS device activation forms. A sample Shift Passdown Report used by PennDOT District 6-0 is included in **Appendix A**. Outgoing shift operators should review the forms with the incoming shift operators, focusing on all active incidents and equipment malfunctions. If a major incident is still active, both sets of operators should hold an incident briefing, reviewing the incident location, traffic impacts, anticipated duration, ITS devices activated, and who was notified. It should be noted that the District uses slightly different versions of the Shift Passdown Report for its own internal TMC shift change and hand-off between Districts 4 and 5 with District 6.

5.3.5 Hand-Off Procedures between Philadelphia TOC and PennDOT 6-0 TMC

PennDOT has developed an Eastern Regional TMC operations manual for after-hours operation of Districts 4 and 5 ITS assets by District 6. An outline of the manual's contents is presented in **Table 11**. The Streets Department should work with PennDOT to develop a manual that emulates the eastern regional manual but focuses on the Philadelphia TOC requirements.

The manual should cover the purpose and role of the Philadelphia TOC, TOC coverage area showing arterials managed by the Philadelphia TOC, location of signals on the signal system, and location of CCTV cameras and VMS signs. Hand-off and equipment malfunction procedures should be documented. The manual should include software logon information, passwords, and user guides; incident response plans, and ITS equipment activation documentation. Contact information for TOC employee(s) on call in case of a major emergency should also be included. The manual should provide procedures to manage signal malfunctions, criteria on when signal timing plans should be overridden, incident procedures, and incident notification procedures.

Hand-off procedures between the Streets Department and PennDOT should emulate PennDOT's eastern regional policies. Within 15 minutes prior to a hand-off, the two TOCs should conduct an operations briefing reviewing the incident log, ITS device activation, and ITS device malfunction forms. If there is an active incident, they should have an incident briefing discussing its location, status, actions undertaken, and notifications. Depending on the situation, Philadelphia TOC operators might extend their shift until a planned event ends or the situation stabilizes. After all briefings are completed, the incoming TMC should logon to the system, verifying communications and functionality to complete the hand-off.

5.3.6 Notification Procedures

The TOC manual should describe all stakeholders, their relationship to the TOC, and contact information. This will provide TOC operators guidance on whom to call, and alternative means to contact them.

Two alternative technologies are available for the TOC to broadcast information to a wide array of stakeholders with minimal effort. RIMIS is a web-based application that distributes incident, construction, and special events information. Using a series of pull-down menus, an operator can create a message that specifies location, direction, event type, impact on traffic, expected duration, and other information that is National Transportation Communications for ITS Protocol (NTCIP) and TMDD compliant. RIMIS member organizations will eventually include virtually all transportation agencies in the region, county 911s/emergency management agencies, and many major municipalities. Alternatively, since the TOC will be co-located with OEM, it could establish a separate Roam Secure Alert Network (RSAN) channel to broadcast emergency transportation alerts. It should be noted that RIMIS's software developer successfully tested integrating RSAN messaging into RIMIS.

Table 11: PennDOT Eastern Regional TMC Operations

Manual Contents
■ District TMC descriptions
■ Roles and responsibilities – district TMCs, Regional Traffic Management Center (RTMC)
■ Business hours – hours of operation, support during normal hours, post incident briefings
■ Hand-off procedures – start of business day, end of business day
■ Incident management procedures – incident verification and notification, ITS device activation, incident closeout
■ Notification to other agencies
■ Emergency Preparedness Liaison
■ System operations logs – Incident reporting form, ITS activation form, ITS device maintanence malfunctioning reporting form
■ Appendices: ▪ ATMS software operations manuals ▪ ITS device inventory ▪ Incident reponse plans by highway segment – VMS messages, CCTV locations, instructions ▪ ITS device creditentials – ID and passwords ▪ Shift-passdown report ▪ County-level highway maps

Source: DVRPC derived from *PennDOT Eastern Regional TMC Operations Manual*, 2009

5.3.7 Requests for Signal Timing Changes and Resources

Requests by PPD, FCC, PennDOT, and other entities for the Philadelphia TOC to modify signal timing plans, post VMS messages, or deploy Streets Department resources should be documented by TOC operators. The TOC manual should provide direction to TOC operators on how to evaluate these requests. For example, the manual might establish a hierarchy to determine which categories of VMS messages will receive priority consideration, or provide guidance for the operators to evaluate the proposed action's applicability to the traffic situation. All replies to other agencies and any actions the TOC undertakes in response to a request should be documented.

5.3.8 Trouble Shooting and Maintenance Procedures

Detailed procedures for equipment and software failures are needed. Procedures should cover the following conditions: signal malfunctions during TOC business hours, signal malfunctions outside normal TOC business hours, VMS and CCTV malfunctions during business and after hours, disruptions to communication equipment/fiber network, signal system server malfunctions, and TOC equipment/software failures. A flow chart is a tool used by many TOCs to spell out the appropriate response under different conditions.

A call down list of ITS engineers, traffic signal technicians, and DOT personnel should be incorporated into the operations manual. When a situation cannot be remedied by city personnel, outside contractors may be necessary. A list of on-call outside contractors should be available to the TOC.

The TOC should maintain an asset inventory for all equipment and software that lists the item, manufacturer, supplier, model number, version number, warranty period, and contact numbers for customer service and/or service repair. A sample form used by PennDOT is included in **Appendix A**.

5.3.9 Start-Up and Shut-Down Procedures

Until the TOC goes 24/7, elements of the TOC may be powered down during nonbusiness hours. Start-up and shut-down procedures are necessary.

In rare circumstances, such as a massive power failure or computer virus, TOC operators may need to shut down the signal system servers and reboot the system software. Procedures should to be in place to guide this process.

5.3.10 Data Archiving

All ATMS and TOC operator-generated logs should automatically be backed-up on a daily basis. On a weekly or monthly basis, data should be archived and removed from the system. Analysts and planners should have access to the archived data.

5.3.11 Training

Because periodic changes to TOC staff and ATMS software upgrades are to be expected, a mechanism to conduct operator training should be in place. At a minimum, ATMS user manuals and vendor training materials should be incorporated into the TOC operations manual. A spare workstation with offline access to ATMS software can provide TOC operators an opportunity to practice with the software without effecting any changes to field devices. Hardcopy and online version of the operations manual should be available to TOC staff.

5.4 Systems Architecture and Communications

5.4.1 Systems Architecture

Figure 7 schematically depicts the proposed systems architecture for central control of the signal system. Systems software will store signal timing plans, which will be implemented based on time of day or operator override. As the TOC migrates toward more advanced traffic signal control, the software will smooth system-level traffic detector data and use simple traffic responsive algorithms to select the appropriate signal timing plan.

Communication with field equipment will be via an Ethernet connection over a fiber network. Remote processors will collect and encode traffic signal and other field equipment data for transmission to the TOC. Local Type 170 controllers will drive traffic signals, CCTV cameras, VMS signs, and traffic detectors.

Within the TOC, processors will decode all field data including CCTV images. Besides CCTV, the servers will manage communications to/from agencies, including PennDOT video, RIMIS API, and video conferencing. TOC software will also drive a wall-size video display as well as individual operator workstations. At each individual workstation, the operator will be able to manage KITS software including monitoring traffic signal equipment status, current timing plan(s), signal phasing, and traffic conditions; override timing plan; and generate new timing plans. Operators will similarly be able to manage CCTV cameras, VMS signs, and traffic detectors.

5.4.2 Fiber Communications Network

Figure 8 schematically shows the proposed communications network linking field equipment, signal system servers, other city agencies, and PennDOT District 6-0 TMC. All traffic signals and CCTV and VMS equipment will be connected to servers either in the basement of MSB or at the Traffic Signal/Sign Shop. These connections will be over fiber owned by the Philadelphia Streets Department and by PennDOT. The TOC, located in FAB, will be linked to MSB by DOT's fiber network, and to the Traffic Signal/Sign Shop by PennDOT-owned fiber. Key entities on the DOT network, such as City Hall, Police Headquarters, or the Traffic Police located in the Philadelphia Naval Business Center, will have access to the servers and signal and video data.

Fiber connectivity from the Signal Shop/Sign Shop to District 6-0 will be via PennDOT's backbone communications network. Other regional stakeholders such as DRPA, BCBC, or the Philadelphia International Airport will have indirect access to the Philadelphia TOC through PennDOT's fiber network.

Besides carrying data, the fiber can function as a secure backup communications network for center-to-center communications. This includes Voice Over Internet Protocol (VOIP), e-mail, instant messaging, and video conferencing.

5.4.3 Center to Center Communications

The Philadelphia TOC will share information and coordinate actions with other entities, both within and outside city government, using a combination of different communications media. Some communication channels will be used for agency-to-agency communication, while others will broadcast information to a wide array of entities.

- **Telephone —** Telephone will function as the primary agency-to-agency communications channel. Telephone represents both landline and cellular technology.
- **E-mail —** E-mail will backup telephone communications and RIMIS; it will also function as a conduit for less time-critical communications.
- **Text Messaging —** Text messaging will complement e-mail as backup communications.
- **Video Conferencing —** Video conferencing will permit TOC staff to participate in virtual meetings with other agencies during emergencies.
- **Smart Board Technology —** Enhances video conferencing capabilities by enabling different operations centers to strategize using the common maps and reference resources.
- **RIMIS —** RIMIS is a web-based application intended to distribute transportation situation information to multiple agencies, including incident and construction information, CCTV video, VMS messages, and travel time data.

5.4.4 Field Personnel to Center Communications

Two-way radio will enable voice communications between the TOC and traffic signal maintenance crews and other Streets Department field personnel. The TOC will also have access to T-Band, allowing operators to passively monitor Traffic Police communications. Whether TOC operators will be permitted to communicate with the Traffic Police dispatcher, or with supervisors in the field, is unclear at this time.

5.5 User Classes – Agencies Interacting with the TOC

Agencies that interface with the TOC and the type of information shared with them are documented in **Table 12**. A brief description of the agencies and their relationship with the TOC is presented in **Section 5.5.1**. A description of the type of information to be shared with the TOC is documented in **Section 5.5.2**.

It should be noted that information sharing could be either a one-way or a two-way flow. Under the former, the TOC will either just broadcast or receive information. With two-way information, one agency will typically request information or an action from another; the latter then responds with the information or indicates what actions it undertook in response to the request.

Figure 7: Systems Architecture: Central Control

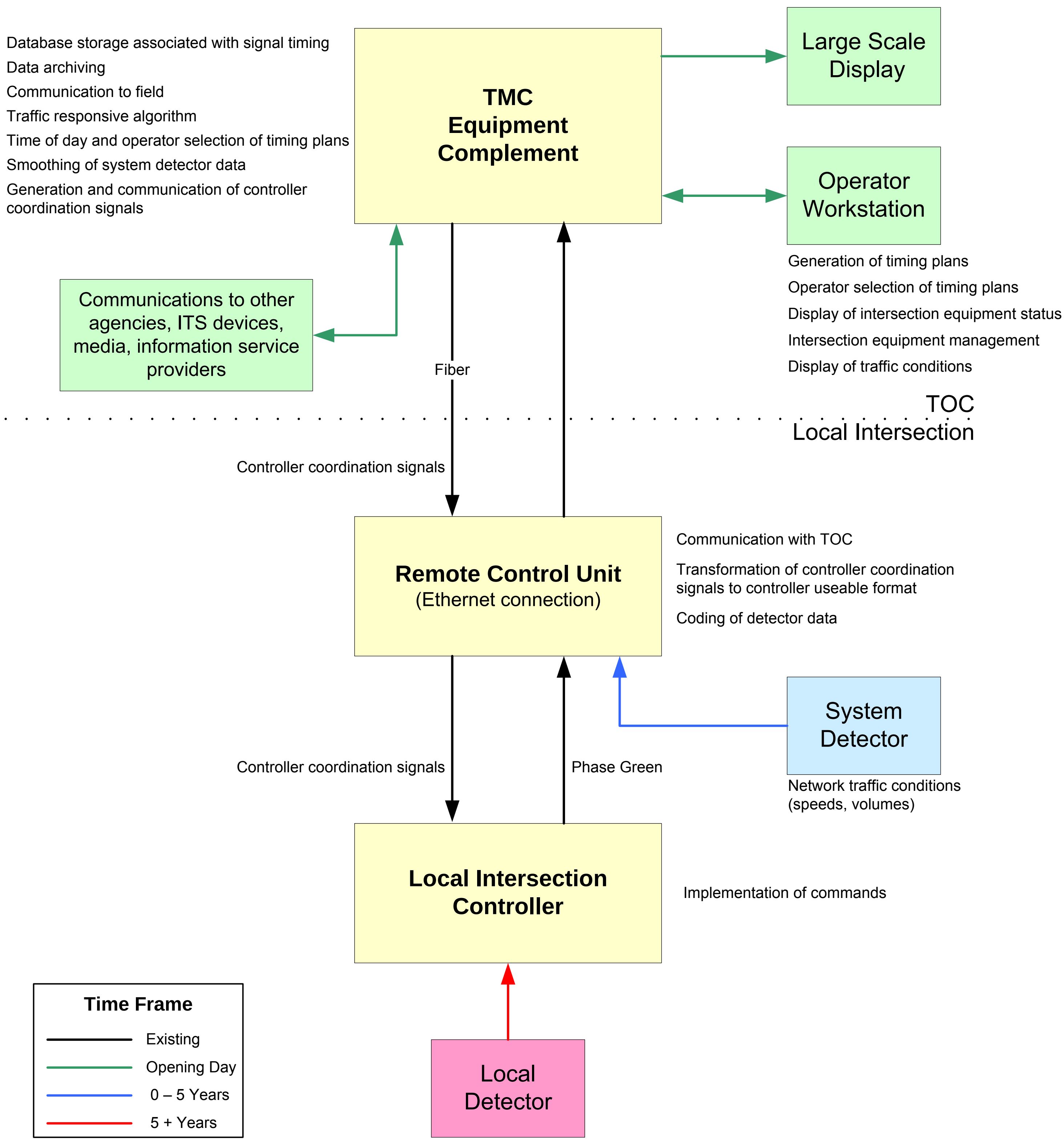
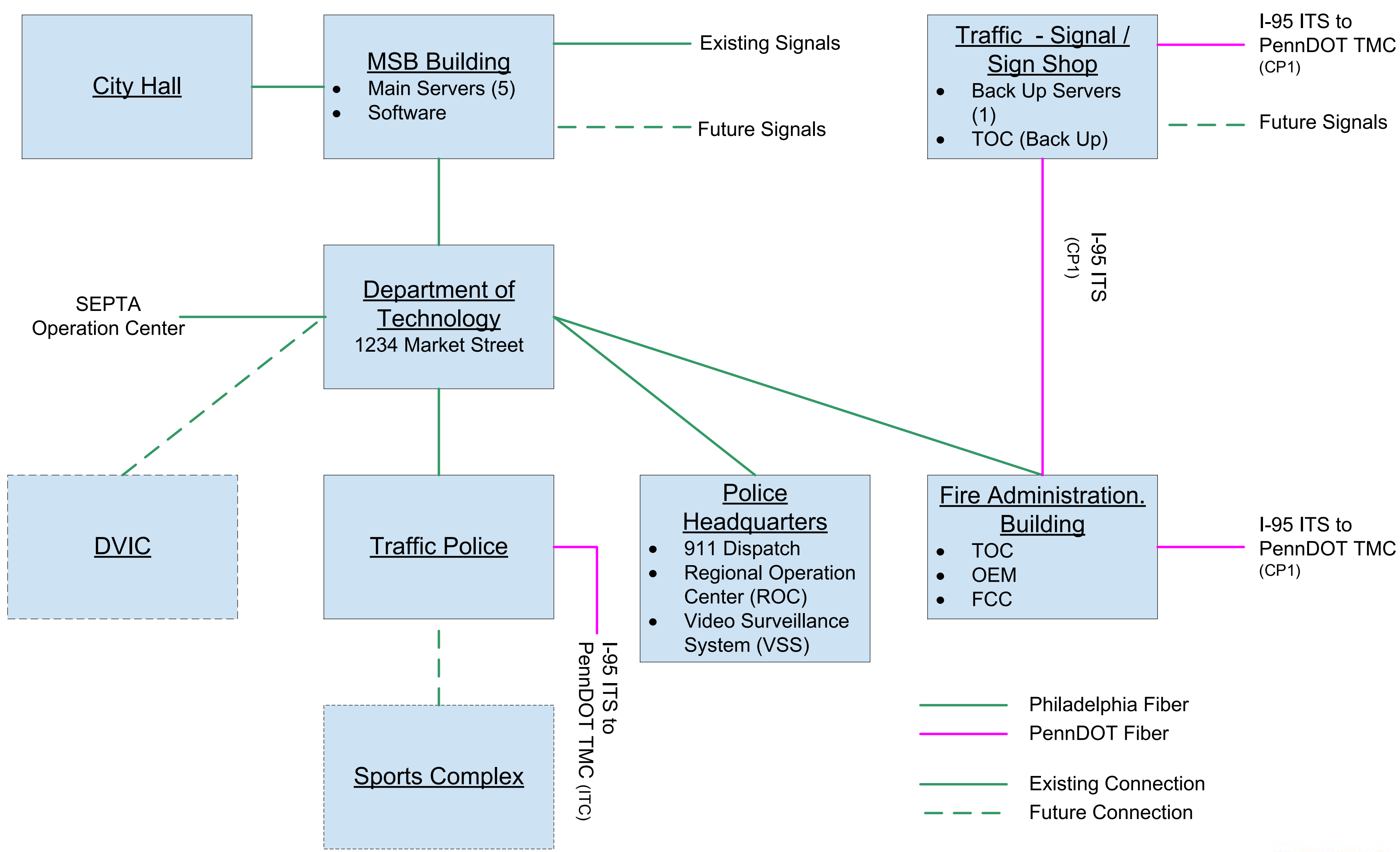


Figure 8: Communications Network



Over time, the type of information the TOC shares with others will gradually evolve. For example, the TOC will initially focus on road closures or major incidents. At some point in the future, the TOC will begin disseminating maintenance and construction activity.

Implementation timeframes shown in **Table 12** reflects Steering Committee priorities, technical feasibility, and phasing in functionalities so as not to overwhelm TOC staff.

5.5.1 Agencies Interfacing with Philadelphia TOC

- **PennDOT District 6-0 TMC —** PennDOT is responsible for managing traffic on the expressway system and roadway maintenance on all state-owned roads, including many of Philadelphia's major arterials. PennDOT TMC operational capabilities include use of CCTV cameras, traffic detectors, travel time detectors, VMS signs, Emergency Service Patrols (ESP) and posting traveler information into 511PA. The TMC is starting to manage traffic signals on key regional arterials during emergency situations. Specifically with respect to Philadelphia TOC, PennDOT will be responsible for after-hours operation of Philadelphia traffic signals and ITS assets, and will co-manage arterials in the I-95 corridor.
- **Philadelphia Traffic Police —** Philadelphia Traffic Police, along with PennDOT District 6-0 TMC, are the entities anticipated to work most closely with the Philadelphia TOC. PPD is responsible for planning and implementing pre-planned street closures, traffic control at special events, and backing up PSP on expressways in Philadelphia. They are headquartered at the Philadelphia Naval Business Center in South Philadelphia. T-Band serves as a dedicated communications channel for the Traffic Police. They are interested in situational information including traffic conditions and CCTV video feeds; traffic signal operations, particularly the need to implement alternative timing plans for special events, road closures, and other incidents; and emergency routing.
- **Philadelphia Fire FCC —** FCC is responsible for handling 911 calls associated with fire and medical emergencies and dispatching first responder units. FCC is interested in traffic situational information to route responders to their destination, especially if there is a road blockage due to the incident itself or other emergency vehicles obstructing traffic. Emergency pre-emption signal treatment is another FCC priority. In some situations, CCTV video feeds can assist dispatchers in determining the number and types of assets to dispatch to the incident scene.
- **Philadelphia OEM —** OEM is responsible for planning, coordinating, and supporting a response to a wide variety of hazardous situations. As such, one of their primary concerns is emergency evacuation, whether it involves a small geographic area due to a HAZMAT situation, or a major evacuation of Center City from a large-scale terrorist attack. OEM is interested in situational information, traffic conditions, and CCTV video feeds; implementation of alternative signal timing plans to evacuate residents or speed access of emergency vehicles; and dissemination of information to the public, such as street closures or the need to avoid specific areas.
- **PSP Consolidated Dispatch Center (CDC) —** PSP is responsible for law enforcement and incident management on all expressways in Philadelphia, including I-76, I-95, I-676, and PA 63. They also have the sole legal authority to close an expressway. Norristown CDC dispatches PSP personnel in Delaware, Philadelphia, and Montgomery counties. PSP

interest is limited to traffic conditions in the vicinity of expressway ramps, and how those conditions may impact the expressway.

- **DRPA TMC —** DRPA owns four Delaware River bridges, three of which terminate in Philadelphia. Traffic signals at 6th and 7th Streets routinely impact traffic entering and exiting the Ben Franklin Bridge. Traffic signals on Front Street, in South Philadelphia, have a similar impact on the Walt Whitman Bridge. A proposed TMC will consolidate operation of DRPA's CCTV cameras and VMS signs at a single location. DRPA is primarily interested in traffic signal operations and situational information on streets in the vicinity of its bridges.

- **SEPTA Operations Center —** SEPTA's Operations Center is the command and control center for all SEPTA operations including buses, subway-elevated lines, regional rail, trolleys, and paratransit services. SEPTA police dispatch is also located there. SEPTA desires situational information on the street system to help operate its buses. SETPA coordination will also focus on transit vehicle priority treatment. The SEPTA Operations Center is co-located in the same building as the city's fiber communications hub.

- **RIMIS —** RIMIS is a web-based regional information exchange network linking TOCs, transit operations centers, county 911s, and state police. As previously described, RIMIS will provide situational information on incidents, maintenance and construction activity, and special events. By inputting data into RIMIS, situational information can be pushed to a wide number of users. RIMIS become operational July 2010.

- **Media/Traffic Reporting Services —** News media and traffic reporting services are interested in road network conditions, incident information, scheduled maintenance and construction activity, and video feeds. The news media want a point of contact to obtain traffic information about a particular incident.

- **Philadelphia International Airport —** This entity represents the operations staff of the airport responsible for its day-to-day operations. They are primarily interested in road network conditions and construction activity that may affect travelers arriving and departing the airport. They may eventually be interested in disseminating travel information to airport passengers and workers. Parking at the airport is managed by PPA. Posting parking information on VMS signs is a long-term need.

- **Municipal Radio Room —** The Municipal Radio Room dispatches Streets Department resources by means of Street-Band radio.

- **BCBC —** BCBC operates two Delaware River crossings, one of which, the Tacony Palmyra Bridge, terminates in Philadelphia. Traffic signals on Tacony Street/State Road are located at the terminus of its bridge ramps. BCBC is interested in traffic conditions and traffic signal operations. BCBC does not have a TOC; BCBC police at each river crossing are responsible for bridge operations.

- **PPA —** PPA manages on-street parking, off-street garages, parking lots at Philadelphia International Airport, and tow trucks to remove illegally parked vehicles. PPA is interested in road network conditions and incident information, and may eventually want the TOC to post parking availability information on VMS signs. The Philadelphia TOC will be interested in parking lot utilization in the vicinity of special events venues, and use of PPA tow trucks to remove vehicles that illegally obstruct traffic flow.

Table 12: Information Sharing Matrix — Information to/from Philadelphia TOC by Timeframe

Philadelphia Traffic Operations Center To/From	PennDOT District 6-0 TMC	Philadelphia Traffic Police	Philadelphia Fire FCC	Philadelphia OEM	PA State Police CDC	DRPA TMC	SEPTA Operations Center	RIMIS	Media/Traffic Reporting Services	Philadelphia International Airport	Municipal Radio Room	BCBC	Philadelphia Parking Authority	Municipal Police/Fire	Philadelphia Sports Complex	Special Events Promoters	NJDOT STMC	County 911 Centers	Sports Complex Parking	NJ Transit Bus Ops South	Adjoining Municipalities
General																					
Video conferencing	◉	◉	◉	◉		◉	◉			◉					○						
Traffic Information																					
Road network conditions	●	●	●	●	◉	◉	◉	◉	●	◉		◉	○	○	○		◉	◉		◉	○
Traffic images	●	●	●	●	◉	◉	◉	◉	◉	◉		○		○	○		◉	◉		○	○
Remote surveillance control	●	●	●	●											○						
Traffic info coordination	●					◉						○									○
Traffic control coord.	●																				
Field equipment status	●										●										
Equipment maint. status	●										●										
Traffic probe data	○	○	○	○	○	◉	○	○	○	○					○			○			
Emergency Information																					
Incident information	●	●	●	●	◉	◉	◉	●	●			○	◉	○							
Incident response status	●	●	●	●	◉	◉	◉	●				○	◉	○							
Emg. traffic control request	●	●	●	●	◉	◉				○		◉		○	○						
Emergency traffic control info	●	●	●	●	◉	◉				○		◉		○	○						
Emergency routes		◉	◉	◉	◉																
Evacuation information		●		●																	
Maint. and Const. Info																					
Maint. and const. work plans	◉	◉	◉	◉	◉	◉	◉	◉	◉	◉		○			○		◉				
Work plan feedback	◉	◉	◉	◉		◉	◉			○		○			○						
Work zone information	○	○	○	○	○	○	○	○	○	○		○			○		○				
Transit Information																					
Transit system data							◉														
Traffic control priority							○														
Special Events																					
Event plans	●	●	●	●	●	●	●	●							●	●					
Parking Information																					
Parking lot input										○			○						○		
Parking lot information										○			○						○		

Timeframe: ● Opening day ◉ 0-5 years after opening day ○ 5+ years after opening day

Source: DVRPC, 2009

- **Municipal Police/Fire —** When an incident occurs at or near the Philadelphia municipal boundary, emergency responders may request emergency traffic control actions to change signal timings or warn motorists to avoid the scene. This request can come either directly through individual municipalities or through the County 911 dispatch center.

- **Philadelphia Sports Complex —** Sports Complex is an amorphous conglomeration representing the teams, venue owners, and SCSSD. There has been periodic discussion about constructing a Sports Complex Operations Center to manage traffic and security issues related to events at the complex. Traffic Police are assigned to manage traffic at all major events. The Philadelphia TOC will assist them in implementing pre-planned traffic control plans and responding to requests for assistance, such as changing signal timings and/or posting VMS messages.

- **Special Events Promoters —** The Philadelphia TOC will interact with event promoters, gathering event information. Major event venues include the Pennsylvania Convention Center, Penns Landing, Philadelphia Zoo, Independence Mall, and the Ben Franklin Parkway. OEM compiles event information and distributes it to other city agencies.
- **NJDOT STMC —** NJDOT's STMC is co-located with the New Jersey Turnpike Authority and the New Jersey State Police in Woodbridge. STMC is interested in situational traffic information: traffic conditions and construction activity in Philadelphia that may impact vehicles entering or leaving New Jersey
- **County 911 Centers —** Suburban county 911s function as the centralized public safety call taker and dispatcher for police, fire, and emergency medical services. When an incident occurs at or near the Philadelphia municipal boundary, the 911 center is a centralized point of contact to disseminate traffic condition, detour route, and construction activity information to adjoining municipalities.
- **Philadelphia Sports Complex Parking —** Parking lots in the vicinity of the Philadelphia Sports Complex are operated by a combination of the PPA and private operators. The Philadelphia TOC will work with parking lot operators and PPD to direct motorists to lots with available parking.
- **New Jersey Transit Bus Operations South —** New Jersey Transit buses loop through Center City using the Ben Franklin Bridge, 6th Street, Broad Street, Vine Street, and the Ben Franklin Bridge back to New Jersey. New Jersey Transit bus dispatchers are interested in traffic conditions or incidents that impact bus schedules.
- **Adjoining Municipalities —** Adjoining municipalities are responsible for managing signals on arterials entering or leaving the city. Of particular concern is City Avenue and Cheltenham Avenue, which lie along Philadelphia's border with Lower Merion and Cheltenham townships, respectively. Philadelphia operates the signals on both roads. Municipalities generally do not actively manage their traffic signals, nor are they interested in real-time traffic signal coordination. While periodic signal coordination is sufficient, they primarily desire real-time traffic condition and detour information, in particular when it affects their municipality.

5.5.2 Information Flows between Philadelphia TOC and Other Entities

The Philadelphia TOC will share a wide range of traffic and emergency information with other agencies. The information flows listed below are based on descriptions contained in the National ITS Architecture, customized to reflect Philadelphia TOC needs. The type of information, and agencies receiving it, will evolve over time as the TOC expands its capabilities.

- **Video Conferencing —** During major incidents regional agencies will periodically need to meet to formulate and implement joint actions. Video conferencing and use of Smart Board technology will enable agencies to hold meetings without physically sending vital staff resources off to other locations to participate in them.

- **Road Network Conditions —** Incident information, delays, travel times, traffic speeds, traffic volumes, road closures, detour routes, and special traffic restriction information. Initially, the only information available for distribution will be incidents, delays, road closures, and traffic restrictions. Travel times and traffic speeds will be phased in as traffic detection devices are deployed.

- **Traffic Images —** Real-time full-motion video suitable for traffic monitoring by other entities. The objective is to push out all video, and let others decide what to watch based on events or proximity to their facilities. The Philadelphia TOC will rely upon PennDOT District 6-0 TMC to distribute video to the media and other information service providers.

- **Remote Surveillance Control —** Select entities will be granted full PTZ control to remotely operate the TOC's CCTV cameras.

- **Traffic Information Coordination —** Traffic information exchanged between TOCs. It contains more operational data than contained under road network condition information, including signal timing plans, real-time signal control information, VMS information, and raw traffic data.

- **Traffic Control Coordination —** Enables remote monitoring and control of traffic field devices including traffic signals, VMS signs, and traffic detectors. It is intended to allow cooperative control of field equipment during day-to-day operations and incidents; it will allow PennDOT District 6-0 TMC to monitor and control Philadelphia TOC assets during off hours. A secondary benefit is that it builds system redundancies if something happens to the TOC.

- **Field Equipment Status —** Current status of traffic signals and other ITS equipment, including identification of field equipment requiring repair and known equipment malfunctions. Typically this information is shared with maintenance crews. Due to joint operation of traffic signals and ITS devices with PennDOT, this information will also be shared with District 6-0.

- **Equipment Maintenance Status —** Repair status of traffic signals and other ITS field equipment reported by maintenance crews.

- **Traffic Probe Data —** Vehicle data that is used to determine traffic conditions. It includes speeds and travel times.

- **Incident Information —** Notification of the existence of an incident. Information includes location, severity, type of incident, and impact on traffic. Incident information is applicable to all types of incidents that affect the transportation system, not just traffic crashes.

- **Incident Response Status —** A summary of the incident status and its impact on the transportation system; traffic management strategies implemented at the site, including road closures, diversions, traffic signal control overrides; and current and planned response activities. This information is an integral component of incident command management.

- **Emergency Traffic Control Request —** A special request from PPD, FCC, OEM, PennDOT, and others to pre-empt current traffic timing plans and implement an alternative traffic control strategy in response to an incident or special event. Its genesis could be a change in signal timing for a detour, emergency evacuation, traffic control pre-emption along an emergency vehicle route; or a request for placement of a public safety or emergency-related message on a dynamic message sign.

- **Emergency Traffic Control Information —** Status of a special traffic control strategy or system activation implemented in response to a request for emergency traffic control, emergency access routes, an evacuation, or a request to employ VMS signs to support public safety objectives. Identifies the selected traffic control strategy and system control status.

- **Emergency Routes —** PPD, FCC, or OEM requests that the Philadelphia TOC implement emergency signal timings to give priority signal treatment to emergency vehicles. Request specifies street(s) and limits; also notifies the TOC when to terminate the timing plan.

- **Evacuation Information —** Evacuation instructions and information received from OEM and PPD, including information on evacuation zones, evacuation times, evacuation routes, emergency vehicle routes, and re-entry times. Evacuation information also includes which pre-arranged signal timing plans to implement, and what messages to post on VMS signs.

- **Maintenance and Construction Work Plans —** Scheduled maintenance and construction activity including location, duration, hours, impact on traffic, and proposed detour routes.

- **Work Plan Feedback —** Comments and suggestions by agencies to minimize the traffic impact of scheduled maintenance and construction activity.

- **Work Zone Information —** Work zone status including whether construction is actually taking place, duration, the nature of activity, and impact on traffic. If traffic monitoring equipment are deployed as part of the construction job, travel speed and CCTV images may be available.

- **Transit System Data —** Status of current transit operations including service disruptions and major schedule deviations.

- **Traffic Control Priority —** A request for the TOC to initiate transit priority for a bus route that is systematically behind schedule.

- **Event Plans —** Event operators provide information about special events, including date, time, duration, and anticipated attendance. Event information is also anticipated to be shared among operations centers.

- **Parking Lot Input —** Instructions to parking operators to open or close specific entrances to support a traffic control plan. Also involves coordination to post parking information on VMS signs. Parking lot input is applicable to SEPTA stations and special events venues.

- **Parking Lot Information —** General information from parking operators on number of parking spaces, current parking availability, and parking lot entrances open or closed.

5.6 Support Environment

This section outlines TOC physical attributes and support systems.

5.6.1 TOC Design Elements

A review of various FHWA and ITS studies, and a survey conducted by the Mayor's Office of Transportation and Utilities, identified a number of design elements that should be considered during TOC design.

- **TOC Square Footage —** There appears to be a correlation between the number of signals and the square footage of a TOC. As shown in **Table 13**, larger TOCs (those that manage over 2,000 traffic signals) generally exceed 5,000 square feet. For most TOCs, the actual control room represents less that 25 percent of the TOC footage. Offices, conference rooms, and a back room for servers and communications devices tend to constitute 75 percent of the TOC area.

Table 13: TOC Square Footage

TOC Size	Number of Traffic Signals	Square Footage
Small TOC	0-400	700-1,400 SF
Medium TOC	600-750	1,400-2,500 SF
Large TOC	2,000-3,000	5,000-5,500 SF

Source: DVRPC based on various national studies, 2010

- **Workstation Furniture —** Many vendors provide specialized workstation furniture for operations centers. They permit the operator to electronically adjust the workstation height, allowing the operator to either sit or stand, to reduce operator stress. They typically come with provision for multiple monitors and telephones, articulated monitor arms, built-in power strips, Central Processing Unit (CPU) storage, cable management, and task lighting.

- **Staff Amenities —** When TOC staff are expected to work overnight or have extended shifts during emergencies, a minimum level of amenities is usually provided. They typically include lockers for personal items, sleeping area/showers, kitchen area, and secure off-street parking for staff. Amenities provided for Fire Department and OEM personnel should satisfy TOC requirements.

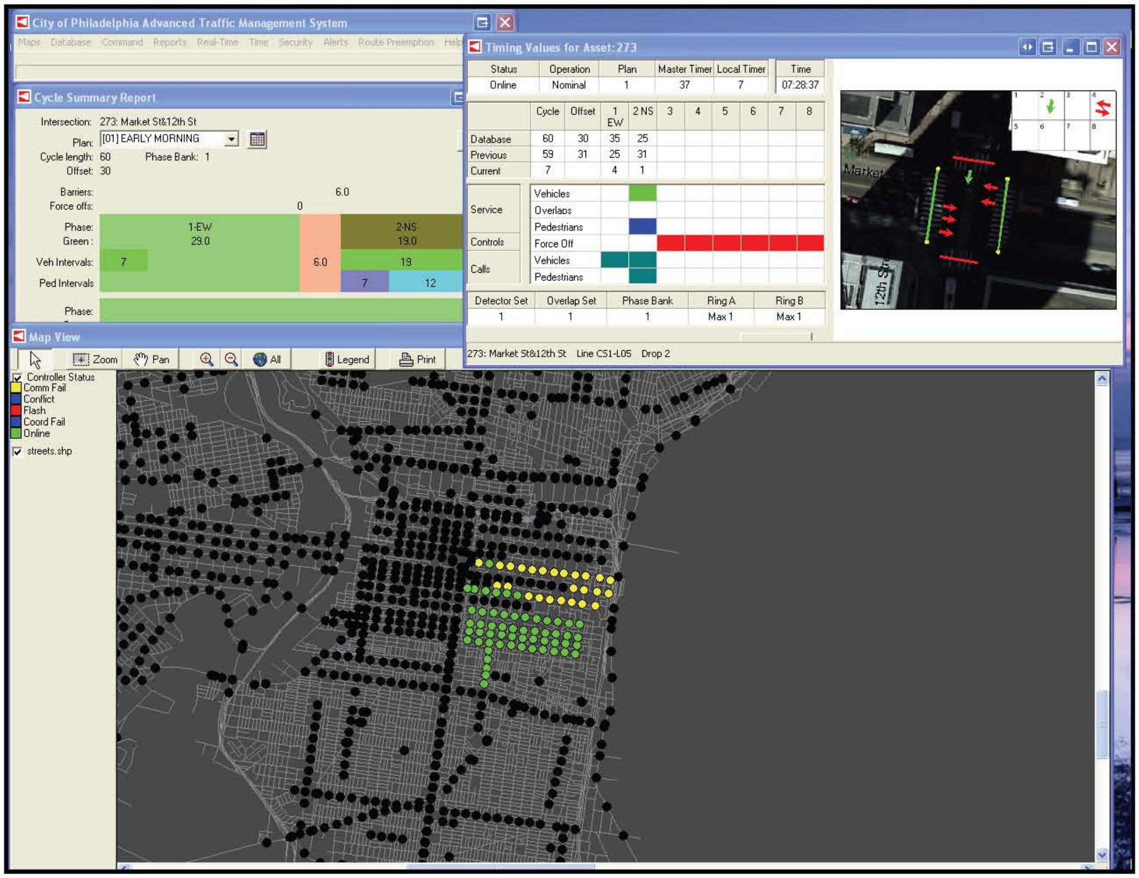
- **Video Wall —** A video wall will enable operators, supervisors, and other TOC personnel to share a common view of situational information. OEM has offered to share its video wall with the TOC.

- **Conference Room —** Many TOCs have a large conference room that doubles as a war room in emergencies. The room is typically equipped with TV monitor(s) with access to the TOC video feeds, PZT controls, and conference call and video conferencing capabilities. It is unclear whether the TOC will have its own office and conference rooms, or whether they will share facilities with OEM.

- **Video Conferencing and Smart Board Technology —** PennDOT plans to implement video conferencing capability, enabling its staff to participate in emergency meetings without physically leaving the TMC. OEM currently has limited video conferencing capability in its operations center. Video conferencing facilities should be upgraded to match PennDOT's functionality.

■ **Security —** Security pertains not only to entry into the TOC but also protection of backup generators and communications lines into the TOC. Locating the Philadelphia TOC in FAB should satisfy security requirements.

Figure 9: KITS Software Sample Screen Shot



Source: Philadelphia Streets Department, 2010

5.6.2 Traffic Signal Maintenance and Retiming

■ **Traffic Signal Maintenance —** FHWA/ITE guidelines recommend that agencies should ideally respond to signal and controller failures within one hour after receiving notification during normal business days and within two hours outside the business day. The same report showed that most agencies actually respond within two hours and four hours, respectively.

■ **Traffic Signal Retiming —** FHWA/ITE guidelines recommend that traffic signals should be retimed every three years. Many cities find a five-year cycle more practicable.

5.6.3 Backup Systems

Most TOCs have multiple backup systems in case they lose power or communications.

- **Power —** A survey of other TOCs revealed that they universally had Uninterruptible Power Supply (UPS) devices to power their equipment during power interruptions. More than half of the TOCs have backup diesel generators to supply longer-term temporary power.

- **System Servers —** Primary system servers will be located in MSB; a backup server will be located at the Traffic Signal/Sign Shop. This will provide ATMS software redundancy.

- **Communications —** Using city-owned fiber and PennDOT fiber as the backbone communications network offers both security and risks. In theory, any disruptions to public communications should not impact these private communications networks. Also, using a combination of DOT, traffic, and PennDOT fiber provides multiple self-healing options in case a cable is cut. Redundancy can be increased by tapping into SEPTA's backbone fiber network.

- **Backup TOC —** It is generally recommended that a backup TOC be available if the TOC is forced to close. Either PennDOT District 6-0 TMC or the Traffic Signal/Sign Shop can function as a backup TOC.

6 TOC Funding Requirements

This section presents the expenditures associated with constructing a TOC and the ongoing annual operation and maintenance costs to support it. The two most significant cost components are TOC staffing levels and buildout of the signal system.

6.1 TOC Capital Start-Up Costs

By using existing traffic signal system software and co-locating with OEM, Philadelphia dramatically reduced the cost of constructing a TOC as compared to other cities. As part of the reconstruction of I-95, PennDOT recently purchased the KITS traffic signal system module and integrated it with existing signals. PennDOT also constructed a fiber link between FAB and the Traffic Signal/Sign Shop.

As TOC capabilities expand to include CCTV cameras, VMS signs, or transit priority treatment, additional KITS software modules will have to be purchased. Philadelphia may be able to utilize PennDOT TMC ATMS software for some functions. However, from an operational perspective, it is desirable to use a single unified ATMS package rather than having to switch software to manage different devices. Based upon the cost of the KITS traffic signal module, it was estimated $200,000 would be needed for KITS software enhancements.

OEM is utilizing Department of Homeland Security (DHS) monies to renovate its operations center. Since the TOC will become a component of the operations center, DHS will pay for the construction of TOC offices, furniture for three workstations, and purchase of ancillary TOC equipment as part of the overall renovation. However, DHS will not pay furniture and equipment installation costs. OEM and the Streets Department agreed that the TOC will cover the installation costs. Estimated installation costs are $150,000, based on cost information obtained from similar TOCs.

The resultant cost to construct a TOC, exclusive of personnel costs and engineering services, will be $350,000 (see **Table 14)**.

Table 14: TOC Capital Cost

Item	Cost ($)
Additional ATMS Software Modules	200,000
Equipment Installation and Software Integration	150,000
OEM Renovation and Workstation Furniture	0
Total Cost	**350,000**

Sources: Philadelphia Streets Department and DVRPC, 2010

6.2 Annual Operation and Maintenance Costs

Annual operation and maintenance costs fall into three categories: traffic signal software and IT equipment maintenance, TOC personnel costs, and traffic signal technician costs.

KITS software comes with a five-year warranty, including free software upgrades. Therefore, in the short-term there are no software maintenance cost to the city. Based upon other TOCs, service contracts and miscellaneous maintenance for traffic signal servers and ITS devices are estimated to cost in the range of $200,000-$300,000 per year.

As depicted in the discussion of staffing levels in the proceeding chapter, at opening day nine employees are required to perform signal timings, manage the communication system and CCTV/VMS sign devices, and to actually staff the TOC. Assuming they are all new employees, their collective salary will be $560,000 per year, exclusive of fringe benefits (see **Table 15)**. Reassigning existing staff to new duties can reduce these costs. Annual salaries are based upon current salary levels at the Streets Department and DVRPC for similar positions. Traffic signal engineers would be equivalent to CE II positions, and the ITS engineers equivalent to district traffic engineers.

Table 15: TOC Personnel Costs

Position	Number of New Staff	Annual Salary ($)	Salary Total ($)
Traffic Signal Engineers	2	60,000	120,000
ITS Engineers	2	75,000	150,000
TOC Supervisor	1	70,000	70,000
TOC Operators	4	55,000	220,000
Sub Total			**560,000**
Signal Technicians	14	45,000	630,000
Total Personnel Cost			**1,190,000**

Sources: Philadelphia Personnel Department and DVRPC, 2010

Traffic signal technicians, the third component of annual operation and maintenance costs, are the most problematic. Unlike TOC operators or ITS engineers who are required to manage the TOC and IT/ITS equipment, hiring additional traffic signal technicians to maintain signal equipment is largely discretionary. Based upon the number of signals per technician, the city falls substantially below minimal staffing levels. However, given current financial constraints faced by the city, it is unlikely that it will hire the additional 14 technicians called for in this document, at a total salary of $630,000. However, the city should make some effort toward increasing the number of technicians.

6.3 Traffic Signal System Buildout Cost Implications

By the end of 2010 or early 2011, approximately 800 traffic signals will be on the signal system, leaving another 2,100 offline. At $175,000 per signal, it would cost approximately $367 million to fully buildout the system. Placing a signal on the system involves:

- incorporating signal information and timing plans into the traffic signal system database;
- replacement of old electro mechanical signal controller with Type 170 controllers and an Ethernet connection;
- installation of new signal poles, mast arms, signal heads, and fiber optic communications; and
- incidental costs such as new Americans with Disabilities Act (ADA) pedestrian ramps and restriping cross walk markings.

In lieu of funding several massive signal system projects, a more incremental approach is proposed. Large-scale signal projects, such as the Center City signal system, are not easy to implement due to difficulty in obtaining federal funding, complexity in managing the project, and the excessive timeframe to bring to conclusion. With a modest $4 million investment per year, the city can place another 20-22 traffic signals on the system. Benefits of an incremental approach include targeting signal improvements to corridors throughout the city, increased likelihood in obtaining federal funds, and improved oversight over consultants and contractors.

Traffic signal upgrades are typically funded through Congestion Mitigation Air Quality (CMAQ) funding. Regionally, $40 million in CMAQ funds are available each year. A $4 million investment represents 10 percent of the program. Since Philadelphia owns 21 percent of the traffic signals in Pennsylvania, dedicating $4 million a year to city signals appears to be very reasonable. CMAQ may require a local match; this requirement varies on a year-by-year basis.

A more ambitious program of adding 50 intersections per year would cost $9 million. At that rate it would take 20 years to add another 1,000 signals to the system.

7 Traffic Operations Center Best Practices

This section will summarize how other major cities operate their signal systems and manage their TOCs. Information was derived from FHWA's ITS Deployment Statistics Database.

The ITS Deployment Statistics Database compiles responses from an annual U.S. Department of Transportation (USDOT) Deployment Tracking Survey that measures how much ITS technology has been deployed throughout the country. The survey is conducted at the metropolitan level and on a statewide basis. The metropolitan survey targets transportation professionals at state and local government level in 108 of the largest metropolitan areas. In the survey, a series of arterial management questions focus on signal systems and the role of TOCs in arterial management. Deployment tracking surveys were conducted in 2004, 2005, 2006 and 2007. Information on signal system statistics, incident management capabilities, and traveler information were obtained from the 2007 survey. All other information was obtained from the 2006 survey.

7.1 Traffic Signal Statistics

Traffic signal characteristics for the largest municipal signal systems in the country are shown in **Table 16**. Even though Boston does not fall within this category, it is included in the table because it is representative of a large northeast city like Philadelphia.

- With 2,924 signals, Philadelphia operates the third largest municipal signal system in the country, after New York and Los Angeles.
- Most of these larger cities have over 50 percent of their signals operating either as a closed loop signal system or as part of a centralized signal system. By comparison, Philadelphia only has 8 percent of its signals on the signal system.
- Only three cities significantly use emergency vehicle pre-emption. The others typically have less than 100 signals enabled for emergency vehicle pre-emption.
- Only Los Angles and Houston have significant transit vehicle priority treatment. The other cities typically have less than 30 intersections with transit vehicle priority treatment. Philadelphia with 45 intersections fares well in this category.
- Because the data is from 2007, the number of intersections with red light running enforcement may be higher now.
- Only one of the cities uses adaptive traffic signal control. Again, this could be an undercount due to old data.
- Over 70 percent of the cities capture signal operations data electronically from their signal systems.

7.2 TOC Capabilities and Functions

Table 17 highlights the range of TOC responsibilities.

- Every TOC that responded to the survey is involved in corridor management/traffic signal coordination and control, and special events traffic management.
- Roadway network surveillance is another almost universal responsibility of municipal TOCs.
- Incident management, evacuation management, information dissemination to other agencies, and en-route driver information are typical functions in most TOCs.
- Emergency services traffic control coordination, lane management, network performance monitoring, and road weather management appear to be more minor functions, available in only a limited number of cities.
- No TOC performs ramp management or environmental monitoring.

Table 18 documents how TOCs are integrated with other operations centers in their region.

Almost all of the TOCs said they coordinate their traffic signals with outside agencies. With only one exception, they all coordinate changes to traffic signal timing plans in real-time with other agencies. A majority of the TOCs also share timing plan information in real-time. However, TOCs are reluctant to permit external control of their traffic signals. Only Houston Transtar indicated they turn over control of their signals to another TOC.

In terms of sharing CCTV cameras, only three cities — New York, Baltimore, and Denver — turn over control or share control of their CCTV with other entities. Denver is the only TOC that also shares control of its VMS and Highway Advisory Radio (HAR) devices. New York indicated that there are regional guidelines regulating video sharing, and Denver has a non-binding MOU regulating external control of its devices.

Table 19 documents TOC involvement in incident management.

- Among those that responded, the TOCs almost universally used CCTV to detect incidents. Traffic detectors and motorist calls to 911 operators were only sporadically used by municipal TOCs to detect incidents.
- TOCs were unanimously involved in special events planning and operations.
- Over a majority of the TOCs were responsible for deploying temporary traffic control devices at the scene of an incident.

Table 20 documents how TOCs disseminate traveler information to the public.

- All the agencies that responded to the question utilize the internet to disseminate traveler information.
- A few agencies use e-mail, pagers or PDAs, or dedicated TV or radio to disseminate traveler information. In reviewing previous survey results, the use of e-mail and pagers as a means of communications appears to be diminishing.

- Based on the age of the data, from 2006 and 2007, the use of 511 appears to be lower than what would exist today.
- The most common information disseminated is incident information. Only three cities provided arterial travel times or speeds to the public.
- Even though almost all the cities monitor their arterials with CCTV cameras, only three cities share their video with the public.
- Two cities provide parking availability information.

Table 21 documents the types of information posted on VMS signs.

- Most cities are very selective in deploying VMS signs. New York operates 40 signs, the highest number in operation. Los Angeles uses only 12 signs, the second highest total among municipal TOCs.
- All agencies that responded post special events information, the event's impact on traffic, and information about the event.
- The next two most common types of information posted are incident information and AMBER Alerts.
- Traffic congestion, maintenance and construction activity, traffic diversion routes, and parking activity are only sporadically posted.

7.3 TOC Start-Up and Ongoing Operations

The ITS Deployment Statistics Database asked a series of questions that can offer guidance to Philadelphia on how to sell the concept of a TOC to policy decision makers, the types of issues encountered during development, and how TOCs are managed once in operation.

Table 22 lists the primary reasons why other cities decided to construct a TOC. The primary reasons are incident management and improving customer satisfaction. Improved safety and emergency evacuation are secondary reasons. In terms of persuading the public to support construction of a TOC, obtaining positive media stories about the TOC and scanning tours for elected officials appear to be the most effective approaches. It is interesting to note that cities cited using an emergency situation as a selling point.

Liability appears to be the most significant legal issue, see **Table 23**. Privacy issues were also identified as a major concern. Rules and regulations and intellectual property issues were ranked as moderate concerns. The two most frequent means to achieve interoperability with other TOCs was through the use of ITS standards and development of regional standards. Positive benefits of ITS standards may be somewhat overstated because respondents were responding to a USDOT survey, and USDOT is pushing the use of these standards. Other techniques are the purchase of common hardware and utilization of APIs to bridge different systems. Purchase of the same software was the least used approach.

In terms of ongoing operations (**Table 24)** almost all the respondents reply upon local monies to fund ongoing TOC operations. Only New York City was able to receive federal funding. The most effective methods employed by other cities to recruit TOC staff is outreach to local colleges and advertising in local media. Recruiting services and advertising in trade publications do not appear to be as effective. It is interesting to note that even though it was not listed in the survey as a potential response, two cities stated that in-house recruiting/training was their most effective means to obtain TOC staff.

Figure 10: Lake County Traffic Management Center

Source: Lake County IL, 2010

Table 16: Traffic Signal Statistics

Traffic Signal Characteristics	Phila.	New York	Los Angeles*	Chicago	Miami-Dade	Houston	San Diego	District of Columbia*	Baltimore	Denver	Boston
Total Number of Signals	**2,924**	12,109	4,290	2,897	2,670	2,486	1,585	1,540	1,309	1,262	814
Number on Closed Loop or Signal System	**235**	6,400	3,200	476	2,169	119	910	1,540	953	771	560
Number of Emergency Vehicle Pre-emption	**0**	38	NA	0	500	1,700	1,095	20	58	360	35
Number That Allow Transit Vehicle Priority	**45**	14	1,000	0	0	1,700	20	20	16	32	20
Number of Red Light Running Enforcement	**15**	180	10	69	0	50	8	NA	47	0	0
Number Under Real-time Adaptive Signal Control	**0**	0	756	0	0	0	0	0	0	0	NA
Number with Electronic Data Collection Capability	**0**	1,400	3,200	229	0	1,300	22	500	953	771	400

* 2006 survey data

Source: FHWA 2007 *ITS Deployment Statistics Database*

Table 17: TOC Role and Responsibilities

TOC Role and Responsibilities	New York	Los Angeles	Chicago*	Miami-Dade	Houston*	San Diego	District of Columbia	Baltimore	Denver	Boston
Network or Roadway Surveillance and Data Collection	■	■				■		■	■	■
Incident Management (detection, verification, and monitoring incident status)	■	■						■	■	■
Information Dissemination to Other Agencies	■	■							■	■
En-Route Driver Information (VMS, HAR)	■	■				■			■	
Environmental Monitoring (weather, air quality)										
Special Events Traffic Management	■	■		■		■		■	■	■
Evacuation Management and Traffic Coordination	■	■		■					■	■
Emergency Services Traffic Control Coordination	■							■	■	
Ramp Management and Control										
Lane Management and Control (HOV, reversible lanes)	■								■	
Corridor Management/Traffic Signal Coordination or Control	■	■		■		■		■	■	■
Network Performance Monitoring, Evaluation, and Reporting		■							■	
Road Weather Management								■		

* Did not respond to this question

Source: FHWA 2006 *ITS Deployment Statistics Database*

Table 18: Integration with Other Agencies

Information Sharing	New York	Los Angeles	Chicago*	Miami-Dade	Houston	San Diego	District of Columbia	Baltimore	Denver	Boston
Share Arterial Travel Times, Speeds Traffic Condition Information with:										
■ Agencies Highway Incident Management	■	■	■				■			
■ Freeway Management Agencies	■	■	■				■			■
■ Arterial Management Agencies	■	■	■				■			■
■ Public Transit Agencies	■	■	■				■			
Share, in Real-Time, Signal Timing Plans with Another Agency:										
■ Share Timing Plans Information	■	■			■		■		■	■
■ Coordinate Changes to Timing Plans	■	■			■	■	■	■	■	■
■ Turn Over Control of Signals					■					
Field Devices Turn Over or Share Control with Other Agencies:										
■ CCTV	■							■	■	
■ VMS									■	
■ HAR									■	
■ Dynamic Lane Assignment										

* Did not respond to signal timing plan question

Source: FHWA 2006 and 2007 *ITS Deployment Statistics Database*

Table 19: TOC Incident Management Functions and Capabilities

Incident Management	New York	Los Angeles*	Chicago	Miami-Dade**	Houston**	San Diego	District of Columbia*	Baltimore	Denver	Boston**
Arterial Miles Patrolled by ESP (mi)	418	0	4,450	10	0	0	20	0	200	0
Incident Detection:										
■ CCTV	■	■	■			■	■	■		
■ Detector Technology	■	■	■							
■ Traveler Reported Information	■		■					■		
Deploy Variable Speed Systems										
Deploy Speed Enforcement on Technology Arterials	■		■						■	
Deploy Special Events Systems	■	■	■	■	■	■	■	■	■	
Video Imaging to Assist with Data Collection at Incidents to Speed Lane Reopening	■		■					■		
Deploy Temporary Traffic Control Devices at Arterial Incident Scene	■		■		■	■	■	■		

* 2006 survey data ** Did not respond to all questions

Source: FHWA 2007 *ITS Deployment Statistics Database*

Table 20: TOC Traveler Information Functions and Capabilities

Traveler Information	New York	Los Angeles*	Chicago	Miami-Dade **	Houston*	San Diego*	District of Columbia*	Baltimore	Denver	Boston**
Arterial Travel Times	■						■			
Arterial Travel Speeds		■					■			
Incident Information	■	■	■				■	■	■	
Parking Availability			■						■	
Internet	■	■	■		■	■	■	■	■	
Pager or PDA	■									
E-mail			■				■	■		
511										
Phone (non-511)			■							
TV/Radio			■			■				
CCTV Images Made Available to the Public	■						■		■	

* 2006 survey data ** Did not respond to all questions

Source: FHWA 2007 *ITS Deployment Statistics Database*

Table 21: Information Displayed on VMS Signs

VMS and HAR Statistics	New York	Los Angeles	Chicago	Miami-Dade	Houston	San Diego	District of Columbia	Baltimore	Denver	Boston
Total Permanent VMS Signs	40	12	17	0	0	9	6	9	8	
Operates HAR	■	■				■	■		■	
Type of VMS Message										
Travel Time										
Average Speed										
Congestion	■					■			■	
Diversions						■			■	
Incident Information	■	■				■			■	
Maintenance and Construction Work Site Information	■	■							■	
Advisory Speed Limits										
Weather Alerts										
Information from Other States							■			
Transit Operations						■				
Roadway Status						■				
Special Events Impacting Traffic	■	■				■	■	■	■	
Local Special Events Announcements	■	■				■	■	■	■	
AMBER Alerts	■						■		■	
Public Service Announcements									■	
Driver Safety Campaigns							■			
Parking Availability						■			■	

Source: FHWA 2006 and 2007 *ITS Deployment Statistics Database*

Table 22: TOC Start-Up

	New York	Los Angeles	Chicago	Miami-Dade	Houston	San Diego	District of Columbia	Baltimore	Denver	Boston
Reason to Invest in TOC										
■ Agency Cost Savings										
■ Incident Management	1					1		3		
■ Voter or Customer Satisfaction		2				2			3	
■ Improved Environment		1		2						
■ Improved Travel Reliability				3		3		2	2	
■ Improved Safety	3	3		1				1		
■ Evacuation Management	2									
■ Other									1	
Three Most Effective Methods to Persuade Public to Support Deployment of TOC										
■ Open Meetings with the Public				3						
■ Contractor Provided Briefings								3		
■ Emergency Situation	1	3				2			3	
■ Public Involvement	3					3				
■ Newspaper Articles/Local Media		2		1		1		1	1	
■ Scanning Tour for Elected Officials	2	1		2				2	2	
■ On-line Message Boards										

Response is the three most important factors, with 1 ranked as the most important.

Source: FHWA 2006 *ITS Deployment Statistics Database*

Table 23: TOC Start-Up Issues

	New York	Los Angeles	Chicago	Miami-Dade	Houston	San Diego	District of Columbia	Baltimore	Denver	Boston
Three Most Important Legal Issues Involved in Making a Decision to Deploy a TOC										
■ Rules and Regulations	1			3						
■ Contract Disputes and Claims										
■ Intellectual Property		3		2		3				
■ Liability	2	1		1		2				
■ Privacy	3	2				1				
What Technology was Employed to Facilitate Interoperability with Other Agencies										
■ Use ITS Standards	■	■				■			■	■
■ Purchase of Same Hardware	■					■			■	■
■ Purchase of Same Software	■					■			■	
■ Contractor Developed Interface	■			■		■			■	
■ Development of Regional Standards	■	■				■			■	■

Response is the three most important factors, with 1 ranked as the most important.

Source: FHWA 2006 *ITS Deployment Statistics Database*

Table 24: TOC Continuing Operations

	New York	Los Angeles	Chicago	Miami-Dade	Houston	San Diego	District of Columbia	Baltimore	Denver	Boston
Approximate Percentage to Finance Ongoing TOC Operations										
■ Local	20	100		100		100			99	
■ State										
■ Federal	80								1	
■ Private										
Three Most Effective Methods to Recruit TOC Personnel										
■ College Outreach	2	2		3					1	1
■ Advertising in Local Media	3			2		1			2	3
■ Recruiting Services		3				2				
■ Notices in Trade Publications	1					3				2
■ Existing Staff		1								
■ In-House Training				1						

Response is the three most important factors with 1 ranked as the most important

Source: FHWA 2006 *ITS Deployment Statistics Database*

8 Glossary

ADA	Americans with Disabilities Act
API	Application Program Interface
ATMS	Advanced Traffic Management System
BCBC	Burlington County Bridge Commission
CCTV	Closed Circuit Television
CDC	Consolidated Dispatch Center
CE	Civil Engineer
CMAQ	Congestion Mitigation Air Quality
ConOps	Concept of Operations
CP	Cottman Princeton Interchange
CPU	Central Processing Unit
DHS	Department of Homeland Security
DOT	Division of Technology
DRPA	Delaware River Port Authority
DVIC	Delaware Valley Intelligence Center
DVRPC	Delaware Valley Regional Planning Commission
ESP	Emergency Service Patrol
FAB	Fire Administration Building
FCC	Fire Communications Center
FHWA	Federal Highway Administration
GIS	Geographic Information System
GR	Girard Interchange
HAR	Highway Advisory Radio

HAZMAT	Hazardous Material
HOV	High Occupancy Vehicle
IEEE	Institute of Electrical and Electronic Engineers
IMSA	International Municipal Signal Association
IP	Internet Protocol
IT	Information Technology
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation System
IVR	Interactive Voice Response
KITS	Kimley-Horn Integrated Transportation System
MOU	Memo of Understanding
MSB	Municipal Services Building
NJDOT	New Jersey Department of Transportation
NTCIP	National Transportation Communications for ITS Protocol
OEM	Office of Emergency Management
PEMA	Pennsylvania Emergency Management Agency
PennDOT	Pennsylvania Department of Transportation
PPA	Philadelphia Parking Authority
PPD	Philadelphia Police Department
PSP	Pennsylvania State Police
PTZ	Pan, Tilt, and Zoom
PVN	Private Virtual Network
RCRS	Road Condition Reporting System
RIMIS	Regional Integrated Multi-modal Information Sharing
ROC	Regional Operations Center

RSAN	Roam Secure Alert Network
RTMC	Regional Traffic Management Center
RTMS	Remote Traffic Microwave Sensor
SCSSD	Sports Complex Special Services District
SEPTA	Southeastern Pennsylvania Transportation Authority
STMC	Statewide Traffic Management Center
TMC	Traffic Management Center
TMDD	Traffic Management Data Dictionary
TOC	Traffic Operations Center
UPS	Uninterruptible Power Supply
USDOT	U.S. Department of Transportation
VOIP	Voice Over Internet Protocol
VMS	Variable Message Sign
VSS	Video Surveillance System

APPENDIX A

PennDOT Regional TMC and District TMC Forms

List of PennDOT Forms

- RCRS Blank Form
- Form TMC–100: Incident Reporting Form
- Form TMC–110: ITS Activation Form
- Form TMC–111: ITS Device Activation for Planned Events
- Form TMC-150: Sample Incident Response Plan
- Shift Passdown Report
- Broadcast Partner Camera Requests
- Form TMC–120: Device Malfunctioning Reporting Form
- PennDOT Daily Sign Report
- DMS Software Control by Device ID

RCRS

County:	Route:	Direction:

Cause:	Crash	Debris	Weather	Special Event	Roadwork
Other: ____________________					

Status:	Closed	Lane Restriction	Police Jurisdiction:	PSP	Local PD

Beginning Location		
Beginning County:		
Municipality:		
Street:		
OR	Mile: (NOT AVAILABLE FOR MOST ROADS)	
OR	Intersecting State Route	
OR	Segment:	Offset:

Ending Location		
Beginning County:		
Municipality:		
Street:		
OR	Mile: (NOT AVAILABLE FOR MOST ROADS)	
OR	Intersecting State Route	
OR	Segment:	Offset:

Date and Time Closed:	Estimated Reopen Date and Time:	
Description:		
Incident involves:	Fatality	School Bus	HAZMAT Material
HAZMAT Placard ID#	Material Name:	

Reported by:	Phone #	Date and Time Reported:

PennDOT – Eastern RTMC
FORM TMC-100: Incident Reporting Form

RCRS Closure ID Number:
(If this incident has been entered into RCRS stop here, save in appropriate P:\ drive folder. Otherwise complete the remainder of the form and save in appropriate P:\ drive folder)

1. SR: ______________________________
2. Direction: __________________________
3. Cause (Choose one):

☐ Crash ☐ Winter Weather ☐ Flooding ☐ Road Work ☐ Bridge Outage
☐ Down Utility ☐ Down Tree ☐ Debris/Obstruction ☐ Special Event
☐ Other

4. Status: __________ Closed __________ Lane Restriction
5. Police Jurisdiction: __________ PSP __________ Local
6. Beginning County: _____________________
7. Beginning Location: ____________________
8. Ending County: ________________________
9. Ending Location: _______________________
10. Fatality? ☐ Yes ☐ No
11. School bus? ☐ Yes ☐ No
12. Hazardous Material? ☐ Yes ☐ No
    Placard ID Number: _____________ Name of Material: _______________
13. Description of Incident

    ____
    ____
    ____

14. Date and Time Closed: ____
15. Estimated Date and Time to Reopen: ________________________________
16. Actual Date and Time Reopened: ___________________________________
17. Information reported by: ____
18. Phone Number: ____
19. Date and Time Reported: ____

PennDOT – Eastern RTMC
FORM TMC-110: ITS Activation Form

RCRS Closure ID Number: _____

District 4-0 DMS Devices Used: (check)

☐DMS-04-001 ☐DMS-04-002 ☐ DMS-04-003 ☐DMS-04-004 ☐DMS-04-005 ☐DMS-04-006

☐DMS-04-007 ☐DMS-04-008 ☐DMS-04-009 ☐DMS-04-010 ☐DMS-04-011 ☐DMS-04-012

☐DMS-04-013 ☐DMS-04-014 ☐DMS-04-015 ☐DMS-04-016 ☐DMS-04-017 ☐DMS-04-018

☐DMS-04-019 ☐DMS-04-020 ☐DMS-04-021 ☐DMS-04-022 ☐DMS-04-023 ☐DMS-04-024

☐DMS-04-025 ☐DMS-04-026 ☐DMS-04-027 ☐DMS-04-028 ☐DMS-04-029 ☐DMS-04-030

☐DMS-04-031 ☐DMS-04-032 ☐ DMS-04-033 ☐DMS-04-034 ☐DMS-04-035 ☐DMS-04-036

☐DMS-04-037 ☐ DMS-04-038 ☐DMS-04-039 ☐DMS-04-040 ☐DMS-04-041 ☐DMS-04-042

☐DMS-04-043 ☐DMS-04-044 ☐DMS-04-045 ☐DMS-04-046 ☐DMS-04-047 ☐DMS-04-048

District 4-0 HAR Devices Used: (check)

☐HAR-04-001 ☐HAR-04-002 ☐HAR-04-003 ☐HAR-04-004 ☐HAR-04-005 ☐HAR-04-006

☐HAR-04-007 ☐HAR-04-008 ☐HAR-04-009

District 5-0 DMS Devices Used: (check)

☐DMS-05-001 ☐DMS-05-002 ☐DMS-05-003 ☐DMS-05-004 ☐DMS-05-005 ☐DMS-05-006

☐DMS-05-007 ☐DMS-05-008 ☐DMS-05-009 ☐DMS-05-010 ☐DMS-05-011 ☐DMS-05-012

☐DMS-05-013 ☐DMS-05-014 ☐DMS-05-015 ☐DMS-05-016 ☐DMS-05-017 ☐DMS-05-018

☐DMS-05-019 ☐DMS-05-020 ☐DMS-05-021 ☐DMS-05-022 ☐DMS-05-023 ☐DMS-05-024

☐DMS-05-025 ☐DMS-05-026 ☐DMS-05-027 ☐DMS-05-028 ☐DMS-05-029 ☐DMS-05-030

☐DMS-05-031

District 5-0 HAR Devices Used: (check)

☐HAR-05-001 ☐HAR-05-002 ☐HAR-05-003 ☐HAR-05-004 ☐HAR-05-005 ☐HAR-05-006

☐HAR-05-007 ☐HAR-05-008 ☐HAR-05-009 ☐HAR-05-010 ☐HAR-05-011 ☐HAR-05-012

FORM TMC-111: ITS DEVICE ACTIVATION FOR PLANNED EVENTS

Eastern RTMC: District - 0

DMS									
DATE	PLANNED EVENT	DEVICE I.D	COUNTY	LOCATION: ROADWAY/DIRECTION	MESSAGE TO BE DEPLOYED		START TIME	END TIME	RECORDED BY:
					PHASE #1	PHASE #2			
00-00-00	Construction	000-00-0000		I-78 Eastbound	Caution Work Area Ahead	Left Lane Closed ½ Mile	0:00 XM	0:00 XM	

HAR								
DATE	PLANNED EVENT	DEVICE I.D.	COUNTY	LOCATION: ROADWAY/DIRECTION	MESSAGE TO BE DEPLOYED	START TIME	END TIME	RECORDED BY:
00-00-00	Construction	000-00-000			*Message Codes: XX-XX-XX-XX-XX*	0:00 XM	0:00 XM	

CLOSURE	Contact #1:		Contact #2:		Contact #3:	
INCIDENT SCENARIO:	I-81 Closure SB	LOCATION:	Between Exit 168 and Exit 165		COUNTY:	Luzerne

Important Note: DMS should be activated in the following prioritized order. For instructions on the operation of specific manufacturer softwares please see Appendix D: DMS Software Operation Manuals

STATE DMS ID #	DISTRICT DMS ID #	SOFTWARE	DMS SIGN MANUFACTURER	PHASE #1	PHASE #2	PHASE #3	Operator Comments
DMS-04-022	22	PSC SMC 1000-2000 BASESTATION	Precision Solar Controls	I-81 SB CLOSED	EXIT 168-165	ALL TRAF MUST EXIT	
DMS-04-012	10	PSC SMC 1000-2000 BASESTATION	Precision Solar Controls	I-81 SB CLOSED	EXIT 168-165	USE ALT ROUTE	
DMS-04-047	69	PSC SMC 1000-2000 BASESTATION	Precision Solar Controls	I-81 SB CLOSED	EXIT 168-165	USE ALT ROUTE	
DMS-04-011	9	AMSIG EasyHost	American Signal Company	I-81 SB CLOSED EX 168-165	USE ALT ROUTE		
DMS-04-008	5	PSC SMC 1000-2000 BASESTATION	Precision Solar Controls	I-81 SB CLOSED	EXIT 168-165	USE ALT ROUTE	
DMS-04-021	20	PSC SMC 1000-2000 BASESTATION	Precision Solar Controls	I-81 SB CLOSED	EXIT 168-165	USE ALT ROUTE	
DMS-04-090	29		Precision Solar Controls	I-81 SB CLOSED EX 168-165	USE ALT ROUTE		
DMS-04-048	70	PSC SMC 1000-2000 BASESTATION	Precision Solar Controls	I-81 SB CLOSED	EXIT 168-165	USE ALT ROUTE	
DMS-04-036	44	AMSIG EasyHost	American Signal Company	I-81 SB CLOSED EX 168-165	USE ALT ROUTE		
DMS-04-027	30	PSC SMC 1000-2000 BASESTATION	Precision Solar Controls	I-81 SB CLOSED	EXIT 168-165	USE ALT ROUTE	
DMS-04-035	43	AMSIG EasyHost	American Signal Company	I-81 SB CLOSED EX 168-165	USE ALT ROUTE		
DMS-04-065	OH 107	AMSIG NET	American Signal Company	I-81 SB CLOSED EXIT 168 TO 165 USE ALT ROUTE			
DMS-04-086	OH 101	AMSIG NET	American Signal Company	I-81 SB CLOSED EXIT 168 TO 165 USE ALT ROUTE			
DMS-04-063	OH 105	AMSIG NET	American Signal Company	I-81 SB CLOSED EXIT 168 TO 165 USE ALT ROUTE			
DMS-04-032	37	AMSIG EasyHost	American Signal Company	I-81 SB CLOSED EX 168-165	USE ALT ROUTE		
DMS-04-017	16	PSC SMC 1000-2000 BASESTATION	Precision Solar Controls	I-81 SB CLOSED	EXIT 168-165	USE ALT ROUTE	

HAR ID #	BEACON	CODE #	COMMENTS
HAR-04-005	I-81 SB	ON - 2102000 OFF - 3102000	Pager - 315-0320
HAR-04-006	I-81 SB	ON - 2101000 OFF - 3101000	Pager - 978-1114
	I-84 WB	ON - 2102000 OFF - 3102000	
	Rt 6 WB	ON - 2104000 OFF - 3104000	
HAR-04-009	I-81 SB	ON - 912 OFF - 902	Pager - 315-0308
HAR-04-008	I-84 WB	ON - 2101000 OFF - 2101000	Pager - 315-0385

CCTV ID #		COMMENTS
CAM-04-004		http://164.156.16.43/public/Districts/District4/WebCams/D4Cam004.jpg

pennsylvania
DEPARTMENT OF TRANSPORTATION

DISTRICT 6 TRAFFIC MANAGEMENT CENTER

SHIFT PASSDOWN REPORT

Date______________________________ **Next Shift Start**_______________________

Outgoing Operators__________________________ **Incoming Operators**___________________________

District 6

Incidents / Roadwork	RCRS (Enter ID)	Equipment Issues

District 5

Incidents / Roadwork	RCRS (Enter ID)	Equipment Issues

District 4

Incidents / Roadwork	RCRS (Enter ID)	Equipment Issues

Comments____

____

____

Broadcast Partner Camera Requests

Date: ____________________

Time	KYW / CBS 3	WPVI / ABC 6	NBC 10	WXTF / FOX 29	UPN 57

FORM TMC-120: ITS Device Malfunctioning Reporting Form
Eastern RTMC

DISTRICT -0

Date	Time	Device Type	Device I.D.	County	Location: Roadway/Direction	Description of Problem	Reported By
00-00-00	0:00 XM	HAR	000-00-000				

PennDOT
Daily Sign Report

Date: ____________________

Sign #	Location	Status	Time
DMS-001	I-95N north/PA 420		
DMS-002	I-95N north/Exit 10		
DMS-003	I-95S north/Allegheny Ave		
DMS-004	I-95S south/Betsy Ross Br		
DMS-007	I-95N north/Girard Ave		
DMS-008	I-95N north/Bridge St		
DMS-009	I-476N @ MM 13.95		
DMS-010	I-95N @ Ashburner St		
DMS-011	I-95S south/Ashburner St		
DMS-012	I-476S Ridge Pike		
DMS-013	I-95S south/Tennis Ave		
DMS-014	I-95S south/Woodbine Ave		
DMS-015	I-95N @ Cornwells Ave		
DMS-12	I-95N south/Grant Ave		
DMS-201	US 202N south/PA 252		
DMS-202	US 202N north/North Valley Rd		
DMS-203	US 202N north/PA 401		
DMS-204	US 30E west/PA 100		
DMS-401	US 422E west/PA 363		
DMS-402	US 422E west/Troutman Rd		
DMS-630	PA 63E @ Tyrone Rd		
DMS-701	I-76W east/Croton Rd		
DMS-702	I-76W @ Conshohocken Curve		
DMS-705	I-76W east/University Ave		
DMS-706	I-76E west/Montgomery Ave		
DMS-707	I-76E east/Croton Ave		
DMS-9	I-95S @ Levick St		
P-001	I-95S south/PA 332		
P-002	I-95S south/US 1		
P-003	Bus US 1 @ I-95N		
P-004	Bus US 1 @ I-95S		
P-005	PA 413N south/I-95		
P-006	PA 413S north/I-95		
P-007	I-95N ramp to I-476		
P-008	US 13S @ PA 63W		

Sign #	Location	Status	Time
P-009	US 13S @ PA 63E		
P-010	I-95S north/Street Rd		
P-011	I-95S @ Island Ave		
P-012	I-95S north/HAR sign		
P-013	I-95N north/Washington Ave		
SP-001	US 1 N south/PA 52		
SP-370	US 30W @ United Artists		
SP-378	Bus US 30E west/Moscow Rd		
SP-403	US 422E east/River Bridge Rd		
SP-901	I-95 N south/Blueball Ave		
V-181	On ramp from Boot Rd to PA 100N		
V-183	PA 100N south/Ship Rd		
V-184	PA 100N north/Kirkland Ave		
V-185	PA 100S south/PA 113		
V-208	US 202S south/North Valley Rd		
V-209	US 202N north/PA 401		
V-210	US 202S north/Church Rd		
V-211	US 202N south/King Rd		
V-212	US 202 south/PA 100		
V-213	US 202S north/PA 322		
V-214	US 202N north/Matlack St		
V-215	US 202S south/Plesant Grove Rd		
V-216	US 202N north/PA 491		
V-371	US 30E Valley Creek Corp Center		
V-372	US 30E east/Ship Rd		
V-373	US 30W west/Ship Rd		
V-374	US 30W west/Whitford Rd		
V-376	US 30E east/PA 113		
P-301	PA 309S s/North Wales Rd		
P-302	PA Turnpike exit @ Ft Washington		
P-303	PA 309N @ Cheltenham Ave		
P-403	PA 422E w/PA 29		
P-206	US 202S @ Brandywine		
1A9BS333	I-476N @ MM 10.6		

For status, use OK, Comm Failure, In Use, Not Deployed, or Offline. Use Notes for additional info.

UPDATED 3/18/08

NOTES: ____________________

____

DMS Software Control by Device ID
District 4-0

Statewide_ID	District_ID	Manufacturer	Model	Vendor Software for Activation	Version
District 4-0					
DMS-04-001	1	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-002	3	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-007	4	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-008	5	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-082	6	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-009	7	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-010	8	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-011	9	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-012	10	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-013	12	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-014	13	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-015	14	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-016	15	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-017	16	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-018	17	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-019	18	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-020	19	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-021	20	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-022	22	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-023	23	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-024	24	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-025	26	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-026	27	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-027	30	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-028	31	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-029	32	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-030	33	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-031	36	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-032	37	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-033	38	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-034	40	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-035	43	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-036	44	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-037	51	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-038	53	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-039	54	Precision Solar Controls	SMC 1000-2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-040	58	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-041	63	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-042	64	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-083	65	American Signal Co.	T-333	AMSIG EasyHost	2.2.10
DMS-04-044	66	Precision Solar Controls	SMC 2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-045	67	Precision Solar Controls	SMC 2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-046	68	Precision Solar Controls	SMC 2000	PSC STDFULL BASESTATION	Basestation 1.0 (Standard Full 1.2)
DMS-04-047	69	Precision Solar Controls	SMC 2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-048	70	Precision Solar Controls	SMC 2000	PSC SMC 1000-2000 BASESTATION	Basestation 1.15 (1000/2000 1.4)
DMS-04-049	71	Precision Solar Controls	SMC 2000	PSC STDFULL BASESTATION	Basestation 1.0 (Standard Full 1.2)
DMS-04-050	72	Precision Solar Controls	SMC 2000	PSC STDFULL BASESTATION	Basestation 1.0 (Standard Full 1.2)
DMS-04-051	73	Precision Solar Controls	SMC 2000	PSC STDFULL BASESTATION	Basestation 1.0 (Standard Full 1.2)

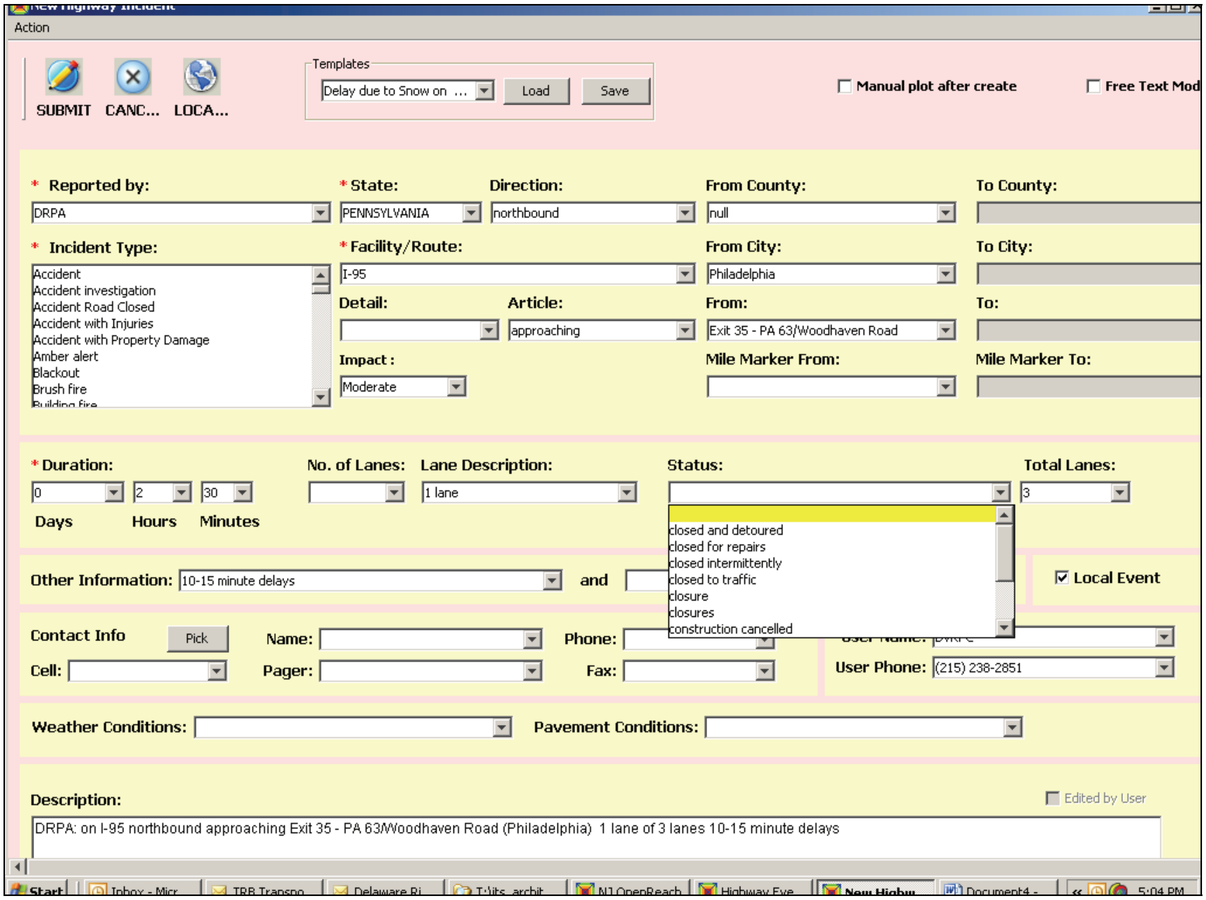
APPENDIX B

RIMIS Screenshots

List of RIMIS Screenshots

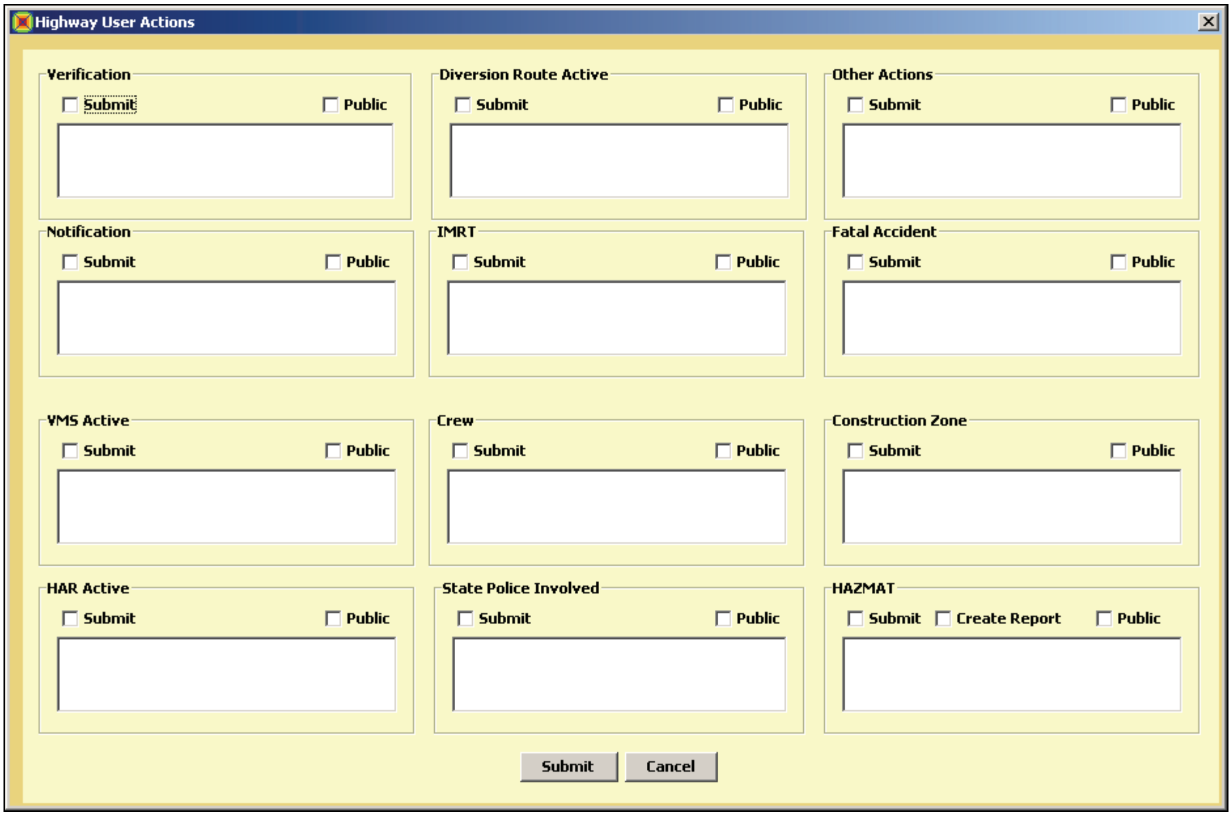
- Incident Report Screen
- Highway User Actions
- Highway Events List
- Highway Construction List
- Situational Map

Figure B-1: Incident Report Screen



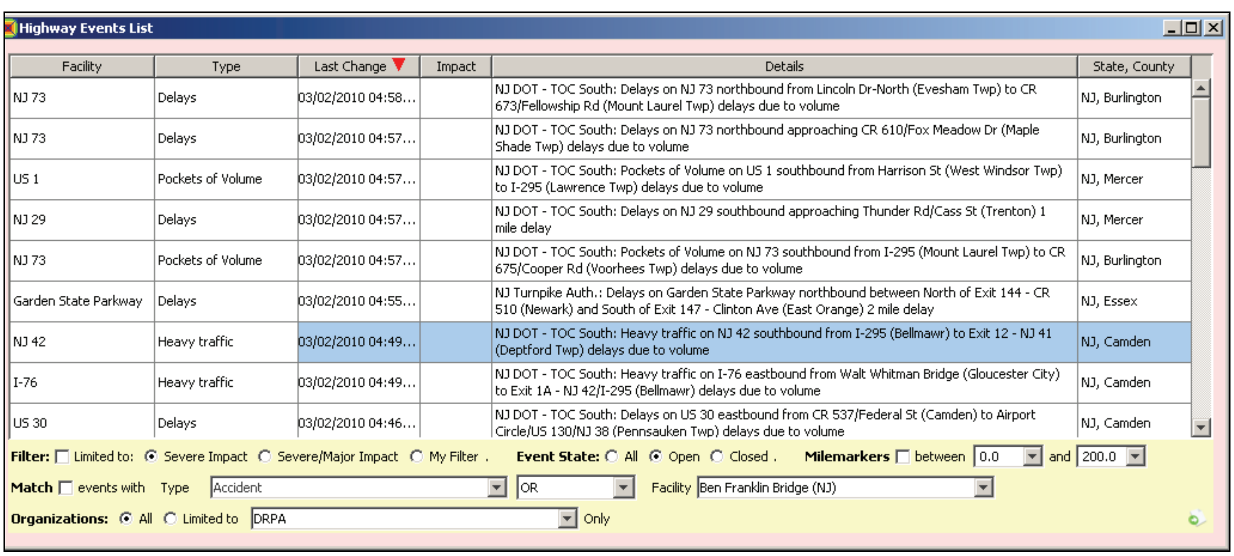
Source: RIMIS, 2010

Figure B-2: Highway User Actions



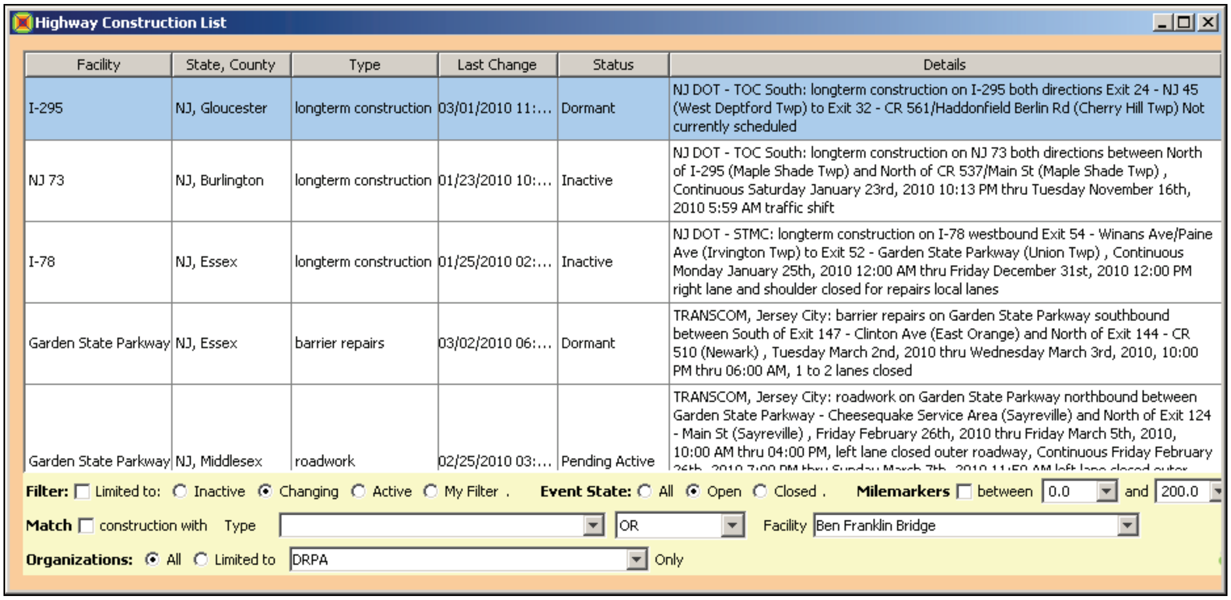
Source: RIMIS, 2010

Figure B-3: Highway Events List



Source: RIMIS, 2010

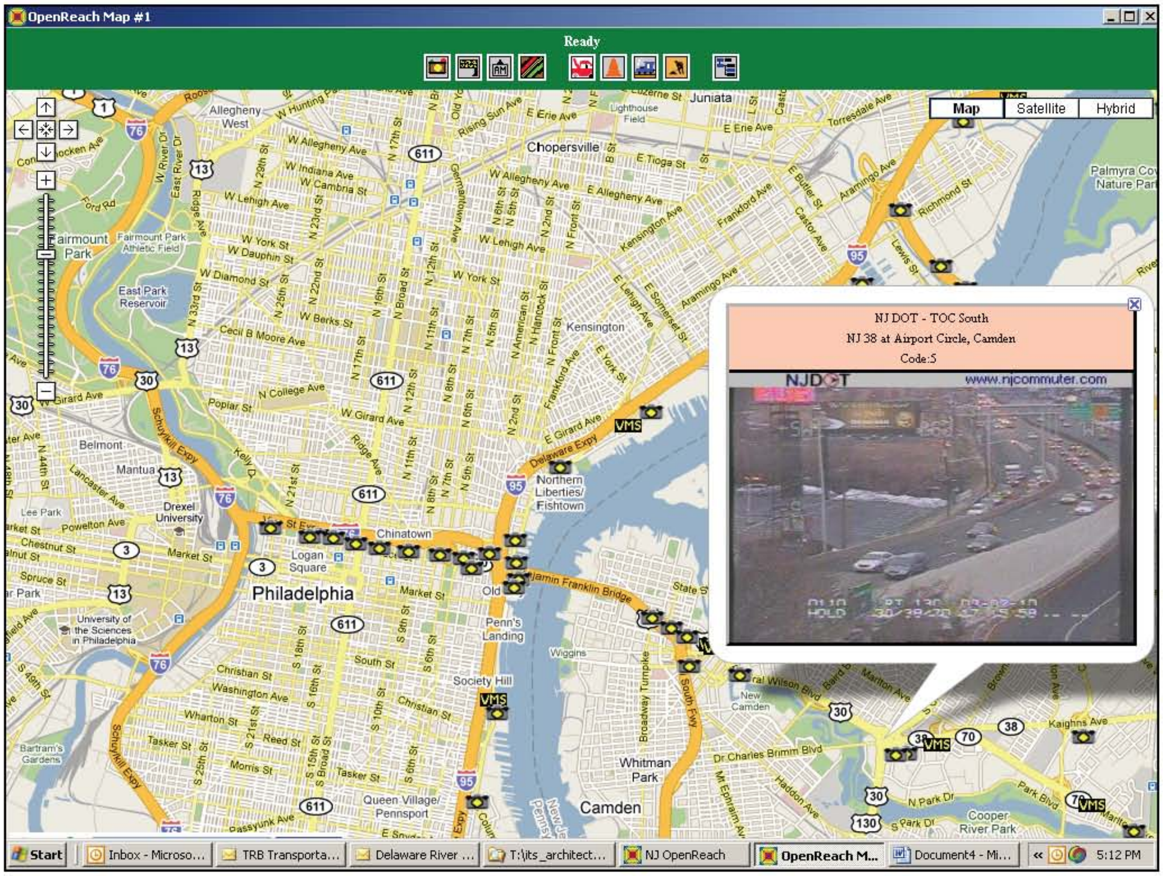
Figure B-4: Highway Construction List



Facility	State, County	Type	Last Change	Status	Details
I-295	NJ, Gloucester	longterm construction	03/01/2010 11:...	Dormant	NJ DOT - TOC South: longterm construction on I-295 both directions Exit 24 - NJ 45 (West Deptford Twp) to Exit 32 - CR 561/Haddonfield Berlin Rd (Cherry Hill Twp) Not currently scheduled
NJ 73	NJ, Burlington	longterm construction	01/23/2010 10:...	Inactive	NJ DOT - TOC South: longterm construction on NJ 73 both directions between North of I-295 (Maple Shade Twp) and North of CR 537/Main St (Maple Shade Twp) , Continuous Saturday January 23rd, 2010 10:13 PM thru Tuesday November 16th, 2010 5:59 AM traffic shift
I-78	NJ, Essex	longterm construction	01/25/2010 02:...	Inactive	NJ DOT - STMC: longterm construction on I-78 westbound Exit 54 - Winans Ave/Paine Ave (Irvington Twp) to Exit 52 - Garden State Parkway (Union Twp) , Continuous Monday January 25th, 2010 12:00 AM thru Friday December 31st, 2010 12:00 PM right lane and shoulder closed for repairs local lanes
Garden State Parkway	NJ, Essex	barrier repairs	03/02/2010 06:...	Dormant	TRANSCOM, Jersey City: barrier repairs on Garden State Parkway southbound between South of Exit 147 - Clinton Ave (East Orange) and North of Exit 144 - CR 510 (Newark) , Tuesday March 2nd, 2010 thru Wednesday March 3rd, 2010, 10:00 PM thru 06:00 AM, 1 to 2 lanes closed
Garden State Parkway	NJ, Middlesex	roadwork	02/25/2010 03:...	Pending Active	TRANSCOM, Jersey City: roadwork on Garden State Parkway northbound between Garden State Parkway - Cheesequake Service Area (Sayreville) and North of Exit 124 - Main St (Sayreville) , Friday February 26th, 2010 thru Friday March 5th, 2010, 10:00 AM thru 04:00 PM, left lane closed outer roadway, Continuous Friday February

Source: RIMIS, 2010

Figure B-5: Situational Map



Source: RIMIS, 2010

Publication Title: Philadelphia Traffic Operations Center: Concept of Operations

Publication Number: 10044

Date Published: December 2010

Geographic Area Covered: Philadelphia, Pennsylvania

Key Words: traffic operations center, traffic operations center capabilities, traffic signals, ITS plan, concept of operations, traffic operations

Abstract: This document defines the concept of operations for the proposed Philadelphia Traffic Operations Center. It defines the center's goals, capabilities, and features to be phased in over the next five-plus years. Operational policies, support environment, and traffic management center practices are also recommended.

Staff Contact:
Stanley Platt
Manager, Office of Transportation Operations Management
☏ (215) 238-2851
splatt@dvrpc.org

Delaware Valley Regional Planning Commission
190 N. Independence Mall West, 8th Floor
Philadelphia PA 19106
Phone: (215) 592-1800
Fax: (215) 592-9125
Internet: www.dvrpc.org