pennsylvania
DEPARTMENT OF TRANSPORTATION

MEMO

DATE: December 28, 2020

SUBJECT: Publication 191 – 2020 Edition

TO: District Executives

FROM: T Jay Cunningham, P.E., Acting Director
Bureau of Maintenance and Operations *for* Michael Martin

The PA Department of Transportation's (PennDOT) Bureau of Maintenance and Operations' (BOMO) has renamed and re-issued Publication 191: *Traffic Signal Maintenance Manual* (12-20), to be used for the maintenance and operation of traffic signals within the Commonwealth.

The 2020 Edition of Publication 191 represents a complete publication and supersedes the 2010 Edition under the title Publication 191, *Guidelines for the Maintenance of Traffic Signal Systems*. The following forms are also cancelled as a result of the issuance of the 2020 Edition:

- Form TE-699, "Traffic Signal Descriptions" (4-09)
- Form TE-971, "Master Intersection Record" (8-10)
- Form TE-972, "Response Maintenance Record" (7-10)
- Form TE-973, "Preventative Maintenance Record" (8-10)

This publication is effective immediately and provides the latest industry standards and guidelines.

New policies include:

- Process and content revisions regarding Municipal Traffic Signal Maintenance Agreements which will be required prior to issuance of new or revised traffic signal permits (see Section 2.1);
- Preventative, response, and operational maintenance requirements (see Chapters 4 and 5); and
- The PennDOT Engineering Districts' and Municipal Traffic Signal Permittees' roles and responsibilities for the retention of traffic signal asset data within PennDOT's Traffic Signal Asset Management System (see Section 7.1.2).

This publication is available for download at:
http://www.dot.state.pa.us/public/PubsForms/Publications/PUB%20191.pdf

Should you have any questions or require additional information, please contact Stephen Gault, P.E., PTOE, Chief, TSMO Arterials and Planning Section, at 717.787.6988.

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Traffic Signal Maintenance Manual

Bureau of Maintenance and Operations

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PUB 191 (12-20)

There are hyperlinks throughout this document that should provide network connections to other publications, regulations, Vehicle Code, etc. There are also hyperlinks that reference other sections, exhibits, or appendices within this manual, and these should assist you in navigating.

Internet links often change without notice and may change more frequently than updates to this publication. Updated links will be maintained on the PennDOT Traffic Signal Portal. Please use the signal portal if the links in this publication are broken.

Although not obvious by their color, the Table of Contents and the List of Exhibits also work as hyperlinks. Simply, left click on the section or exhibit number, title, or page number and your computer should take you to the proper page.

You may also find the bookmarks on the left side of the screen helpful.

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1. INTRODUCTION

1.1 Publication Purpose

This publication provides Department policies, procedures, and guidance relative to the maintenance of all types of traffic signals. This publication is intended for traffic signal owners and those maintaining traffic signals on behalf of traffic signal owners.

The term "traffic signal" describes all power-operated traffic control devices by which traffic is warned or directed to take some specific action, which includes the following:

- ✓ Traffic control signals, also known as "red-yellow-green" traffic signals, which alternate assignment of right-of-way at an intersection
- ✓ Flashing beacons (also known as flashing warning devices), including warning beacons, stop beacons, intersection control beacons, school zone speed limit beacons, and rectangular rapid flashing beacons
- ✓ Emergency vehicle access signals
- ✓ Lane-use control signals
- ✓ Ramp metering signals
- ✓ In-roadway lights

Power-operated signs, steadily-illuminated pavement markers, warning lights, and steady burning electric lamps are not traffic signals.

1.1.1 PennDOT Traffic Signal Publications

Although this publication is dedicated to the maintenance aspects of traffic signals, it is important to understand all applicable activities and authority regarding traffic signals, in the following categories:

- ✓ **Laws and Regulations –** federal and state laws & regulations dictate various authorities, requirements and role responsibilities regarding traffic signals
- ✓ **Planning -** traffic signals must be planned, funded, and approved with engineering studies including warrant analysis prior to installation and activation
- ✓ **Design –** traffic signals must be designed in accordance with federal and state standards and policies
- ✓ **Construction –** traffic signals must be installed, modified, and reconstructed in accordance with approved plans and specifications
- ✓ **Maintenance –** operating traffic signals must be supported with response & preventative maintenance to sustain intended performance and longevity of the signal locations

Exhibit 1-1 shows the applicable laws, regulations and primary publications for the design, construction and maintenance of traffic control signals. While **Exhibit 1-1** lists various Department publications under Planning & Programming, Design, Construction and Maintenance bins, the maintenance of traffic signals will involve some of these publications, regardless of the area they are assigned. In fact, there are references throughout this publication to Publications 35, 46, 149, 408, etc.

Proper maintenance of traffic signals will not only keep the signals working for many years but will ensure that the integrity of the initial design and installation standards & specifications are upheld during maintenance practices. Therefore, persons or organizations that maintain traffic signals must understand the comprehensive nature of these traffic signal policies so that proper materials are used and maintenance practices performed.

Exhibit 1-1 Applicable Laws, Regulations, and Publications and References

Laws		Title 75 Pa.C.S. Vehicle Code Chapter 61	Title 75 Pa.C.S. Transportation Chapter 92	
Regulations		United States Code (USC) 23 CFR, Part 655	Manual on Uniform Traffic Control Devices (MUTCD)	Title 67 Pa. Code Chapters 205, 212, and 441
PennDOT Publications	**Planning & Programming**	Pub 10 Design Manual Part 1	Pub 851 TSMO Guidebook: Part I, Planning	
	Design	Pub 13M Design Manual Part 2	Pub 14M Design Manual Part 3	Pub 46 Traffic Engineering Manual
		Pub 149 Traffic Signal Design Handbook	Pub 212 Official Traffic Control Devices	Pub 236 Handbook of Approved Signs
	Construction	Pub 35 (Bulletin 15) Approved Products	Pub 72M Roadway Construction Standards	Pub 111 Traffic Control – Pavement Markings & Signing Standards (TC-8700 Series)
		Pub 148 Traffic Signal Standards (TC-8800 Series)	Pub 213 Temporary Traffic Control Guidelines	Pub 408 Highway Construction Standards
		Pub 647 ITS Standard Drawings (ITS-1200 Series)	Pub 669 Traffic Signal Inspection Pocket Guide	
	Maintenance	Pub 23 Maintenance Manual	Pub 191 Traffic Signal Maintenance Manual	

Publications are available electronically from PennDOT's Traffic Signal Portal. The Traffic Signal Portal also contains policy issued by Strike-off Letter which has not yet been incorporated into publications.

1.2 Traffic Signal Responsibilities in Pennsylvania

1.2.1 Installation, Modification, and Removal of Traffic Signals

Authority to install, modify or remove traffic signals is summarized in **Exhibit 1-2**.

Before installing a new traffic signal or undertaking a major modification to an existing traffic signal, an Intersection Control Evaluation shall be completed to determine the appropriate traffic control at the location. A traffic signal is only one alternative to be considered. Refer to Publication 10X, *Design Manual Part 1*, Part 1X, Appendix AI and the Traffic Signal Portal ICE page for more information.

Exhibit 1-2 Summary of Agency Roles and Responsibilities

Action	Responsibility	
	Department	Local Authorities
Approve erecting traffic signals on state highways	■ ①	②④⑥
Approve erecting traffic signals on local highways	■ ①	②③
Approve the revision of a traffic signal or the complete removal of a traffic signal on state highways	■ ⑤	②④⑥
Approve the revision of a traffic signal or the complete removal of a traffic signal on local highways	■ ⑤	②③
Pay for the traffic signal installation	⑦⑩	■ ⑧
Pay for traffic signal maintenance and operation, including signs, pavement markings, and other items on the approved traffic signal permit	⑩	■ ⑧⑨
Implement design modifications	⑩	■ ⑧

■ Agency with primary responsibility (○ refer to notes for legal authority, conditions, and exceptions)

① The Pennsylvania Vehicle Code, 75 Pa. C.S. §6122(a)(2), requires local authorities to obtain approval from the Department prior to erecting any traffic signal within their boundaries except where Department regulations provide otherwise.

② The Pennsylvania Vehicle Code, 75 Pa. C.S. §6122(c), allows the Department to enter into agreements with local authorities transferring to them the authority to install official traffic-control devices without specific State approval provided they conduct traffic and engineering studies and conform with Department standards. Local authorities with a Transfer of Authority Agreement may approve traffic signals on state owned roadways without specific Department approval. See Publication 46, Chapter 4 for more information about Transfer of Authority Agreements.

③ Title 67 Pa. Code §212.5(c)(1) eliminates Department approval to install, revise, or remove traffic signals **on local highways** in any municipality with current municipal traffic engineering certification in accordance with Title 67 Pa. Code Chapter 205, *Municipal Traffic Engineering Certification*. See Publication 46, Chapter 4 for more information about Municipal Traffic Engineering Certification.

④ Title 67 Pa. Code §212.5(b)(1)(ii)(B) eliminates Department approval to install, revise, or remove traffic signals **on state highways** in cities of the first and second class (Philadelphia and Pittsburgh, respectively) unless the city does not have municipal traffic engineering certification in accordance with Chapter 205.

⑤ Title 67 Pa. Code §212.5(b)(1)(iii) requires Department approval to install, revise, or remove traffic signals **on state highways** by local authorities other than cities of the first and second class.

⑥ Title 67 Pa. Code §212.5(b)(1)(v)(A) requires Department approval to install, maintain, and operate traffic signals on state highways, including changes to the traffic restriction.

⑦ The Department may help underwrite the costs of traffic signals within Department construction projects or through funding programs.

⑧ Local authorities are responsible for the installation, maintenance, and operation of traffic signals with written Department approval **on state highways** per Title 67 Pa. Code §212.5(b)(1)(v)(A) and **on local highways** per Title 67 Pa. Code §212.5(c).

Title 67 Pa. Code §212.5(b)(v)(A) assigns the installation, maintenance and operational responsibilities of traffic signals to the municipalities. Therefore, municipalities own the traffic signals in their jurisdiction, and assume the maintenance and operational responsibilities.

⑨ Local authorities are responsible for all signs and markings included on the Department-approved traffic signal plan per Title 67 Pa. Code §212.5(b)(1)(v)(A), unless indicated otherwise on the traffic signal plan.

⑩ Title 74 Pa. C.S. §9202(i), added by Act 101 of 2016, allows the Department to own, install, replace, synchronize, time, operate or maintain a traffic signal and all associated signs and markings if the Department publishes the location of the signal or the critical corridor as a notice in the Pennsylvania Bulletin. This authority may exist in any municipality.

Department approvals in accordance with **Exhibit 1-2** are carried out through a permitting process described in **Section 1.3**. Publication 46 indicates permittees must agree to maintain and operate the traffic signal prior to the Department reviewing the warrants for installation of a new traffic signal. This commitment includes

maintaining all of the appurtenances, hardware, software, timing plan(s), and any other traffic control devices that are included on the traffic signal permit.

1.2.2 Manufacture and Sale of Traffic Signal Equipment

PennDOT is required to approve all traffic-control devices available for manufacture and sale in Pennsylvania in accordance with 75 Pa. C.S. §6127 and Title 67 Pa. Code §212.8(b)(4), which includes the following traffic signal equipment:

- ✓ Controller units
- ✓ Signal heads—lane-use traffic control, pedestrian, and vehicle
- ✓ Detectors—pedestrian and vehicle
- ✓ Load switches
- ✓ Flasher units
- ✓ Time clocks
- ✓ Relays
- ✓ Preemption and priority control equipment
- ✓ Electrically-powered signs—variable speed limit signs, blank-out signs and internally illuminated signs, including School Speed Limit Signs
- ✓ Portable traffic-control signals
- ✓ Local intersection coordinating units
- ✓ Dimming devices
- ✓ In-roadway warning lights
- ✓ Auxiliary devices and systems

Traffic control devices approved by PennDOT for sale in Pennsylvania are contained in Publication 35 (Bulletin 15). Traffic signal owners shall only use approved equipment when installing, modifying, or repairing traffic signals.

In addition to the regulations for sale of traffic control devices described above, PennDOT also approves construction materials related to traffic signals, including structural steel and aluminum. These construction materials are also listed in Bulletin 15 and should be used for all traffic signal work, including maintenance.

1.2.3 Maintenance of Traffic Signals During Construction

Construction contracts may modify the permittee's maintenance responsibilities for the duration of the construction project, as indicated in the contract specifications.

For signals modified as part of PennDOT construction projects, the maintenance responsibilities during construction are provided in Publication 408, Section 950.3(g), unless otherwise modified by project special provisions. The standard provisions for PennDOT construction contracts indicate:

- For new traffic signal installations, the construction contractor is responsible for all traffic signal equipment and components through completion of the 180-day operational support period.
- For retrofits of existing permanent traffic signals, the construction contractor is responsible for all newly installed traffic signal equipment and components through the 180-day operational support period. The construction contractor shall assume responsibility for the traffic signal cabinet and contents if new equipment or components are installed within the cabinet. The permittee is responsible for all other traffic signal equipment and components.

1.2.4 Publication 191 Overview

Exhibit 1-3 lists some key points for the Permittee from each of the chapters in this publication.

Exhibit 1-3 Key Permittee Points from Publication 191 Chapters

Chapter		Key Points Regarding Permittee Requirements
1	Introduction	✓ Authority to install, modify or remove traffic signals is established by PA Laws & Regulations, see **Section 1.2** ✓ The traffic signal permit is the official document issued by the Department to Permittees for each traffic signal, and it identifies the approved design and operation of the traffic signal, see **Section 1.3** ✓ Prior to making any changes in the operation of a traffic signal, the Permittee shall always contact the appropriate Department Engineering District to request approval, see **Exhibit 1-4**
2	Agreements/Contracts	✓ The Traffic Signal Maintenance Agreement is between the Department and the Permittee. It addresses the required maintenance & operation of the traffic signal installation, including recordkeeping requirements, see **Section 2.1** ✓ Even if a permittee uses a maintenance contractor, the permittee is still ultimately responsible for traffic signal ownership, maintenance, and operations, see **Section 2.3**
3	Maintenance & Operations Program	✓ Permittees should establish a programmatic approach to traffic signal management and operations, see **Chapter 3.** Including, ▪ Budgeting, life cycle analysis, insurance coverage ▪ Qualified maintenance personnel, equipment & inventory resources ▪ Performance measures
4	Maintenance Classifications	✓ Three traffic signal maintenance classifications, see **Section 4.1**: ▪ Preventative maintenance ▪ Response maintenance ▪ Operational maintenance ✓ Traffic signal modifications are sometimes necessary to accommodate traffic changes, improve safety, or for other reasons ✓ Proposed design modifications must first be approved by the Department and the Traffic Signal Permit updated to reflect this modification, see **Section 4.5**
5	Preventative Maintenance	✓ Traffic signal preventative maintenance and operation is the responsibility of the Permittee and shall be accomplished according to the activities & scheduling intervals identified in **Chapter 5** ✓ Preventative maintenance can also trigger response maintenance activities
6	Response Maintenance	✓ Traffic signal response maintenance and operation is the responsibility of the Permittee and shall be accomplished according to the activities & response/repair intervals identified in **Chapter 6** ✓ Maintenance staff should carry sufficient supplies to address common problems quickly and maintain a reasonable inventory of spare parts ✓ PennDOT provides two customer service platforms that the traveling public can utilize to share their concerns regarding traffic signal maintenance and/or operations. PennDOT will coordinate with Permittees on concerns related to traffic signals to ensure a timely notifications and response.
7	Asset Management	✓ PennDOT's Traffic Signal Asset Management System (TSAMS) is an internet-based database to capture and maintain traffic signal asset related data for all traffic signals in Pennsylvania, see **Section 7.1** ✓ Permittees should keep all traffic signal records within TSAMS, either through direct entry of data into electronic forms in TSAMS or via attachment of paper forms in TSAMS, see **Section 7.2** ✓ Permittees considering the attachment of other equipment on traffic signal structures must contact the appropriate PennDOT District Traffic Engineer to discuss the request so that the procedure in **Section 7.3** is followed

Chapter		Key Points Regarding Permittee Requirements
8	Training	✓ Ensure that maintenance personnel and/or the permittee's maintenance contractor are properly trained to repair all of the traffic signal components to comply with the approved traffic signal permit, see **Chapter 8** ✓ The International Municipal Signal Association (IMSA) offers various training and certification courses, see **Exhibit 8-1**

IMPORTANT

- ✓ Prior to making any changes in the operation of a traffic signal, the permittee shall always contact the appropriate Department Engineering District to request approval, see **Exhibit 1-4**.
- ✓ PennDOT generally will not approve a traffic signal permit revision if the traffic signal is not in compliance with the currently approved permit. Therefore, the Permittee must ensure compliance with the traffic signal permit.

1.3 Traffic Signal Permit

PennDOT approval of traffic signals in accordance with the Vehicle Code and Chapter 212 is through a permitting process, as defined in Publication 46, Chapter 4. The term "permittee" is used throughout this publication to refer to the owner of a traffic signal who has been issued a permit by PennDOT to install or modify the signal. The term includes municipalities, local authorities, counties, and PennDOT, as may be defined in statute or regulation.

Permittee is used in this publication to refer to the owner of a traffic signal which has been issued a permit by PennDOT to install or modify the signal. The term includes municipalities, counties, local authorities, and PennDOT, as may be defined in statute or regulation.

The traffic signal permit is an official document issued by the Department for each traffic signal, and it identifies the approved design and operation of the traffic signal. An original traffic signal permit (including all revisions) should be kept up-to-date and be properly stored at the permittee's office, and a signed copy should be kept inside the appropriate traffic signal cabinet. PennDOT will upload approved permits to PennDOT's online Traffic Signal Asset Management System (TSAMS), where they can be obtained electronically.

The traffic signal permit contains information regarding the operation of the traffic signal and the placement of signal equipment, signing, and markings. The traffic signal permit includes the following:

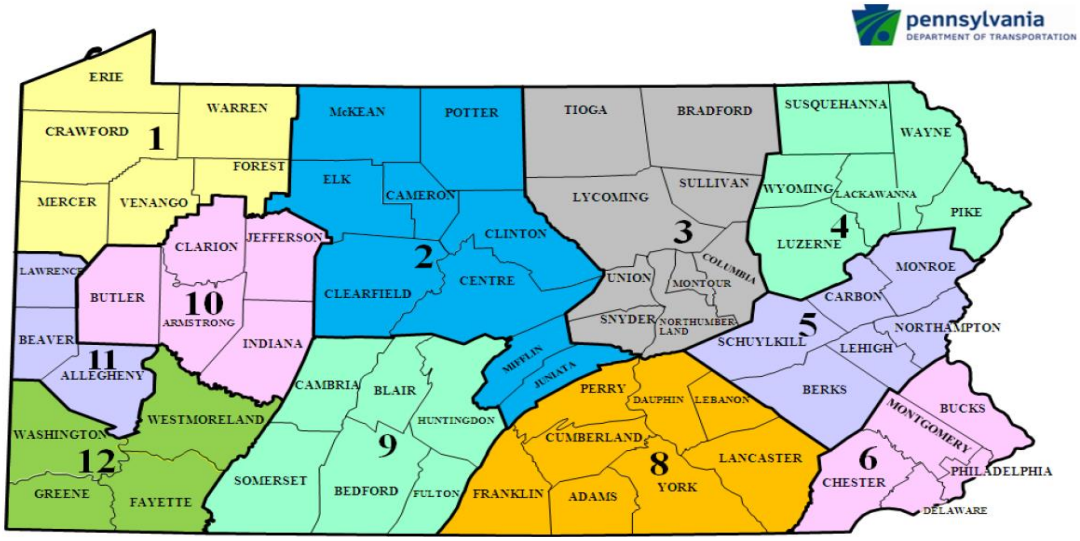
- ✓ Form TE-964, Traffic Signal Permit (Sheet 1)
- ✓ Condition Diagram (1 or more sheets)
- ✓ Coordination/System Timings, if applicable (may be included on condition diagram, a separate sheet, or reference a separate System Permit)

Additional information regarding traffic signal permits is contained in Publication 149.

1.4 PennDOT Traffic Signal Contacts

Questions relative to the design, construction, maintenance, and operation of a traffic signal should be directed to the appropriate PennDOT Engineering District Traffic Unit (see **Exhibit 1-4**). District and Central Office contact information is maintained on the Traffic Signal Portal. These individuals will be able to either answer questions directly or provide additional guidance as to the proper contact person.

Exhibit 1-4 PennDOT Engineering Districts



1.5 Definitions

Appendix A is a glossary that includes definitions of many words and terminology. Therefore, when these words, terminology and publications are referenced in these chapters, they have the meanings indicated.

1.6 Miscellaneous Reference Documents

A list of miscellaneous reference documents with links to the original source material is contained on the Traffic Signal Portal.

2. TRAFFIC SIGNAL AGREEMENTS & CONTRACTS

Traffic Signal Permits issued by PennDOT indicate that it is the permittee's responsibility to maintain the traffic signal in a safe condition at all times. This chapter discusses the Traffic Signal Maintenance Agreement form used to establish maintenance requirements for all signals owned by a permittee as well as additional Highway Occupancy Permit requirements.

Traffic signal owners must understand the maintenance responsibilities for a traffic signal before applying for a permit. Although it may seem very simple and practical, effectively managing safety and operations at a traffic signal may become a difficult task. PennDOT reaffirms the maintenance responsibilities with a traffic signal owner before approving new traffic signals or any revision to existing traffic signals as specified in Title 67 Pa. Code Chapter 212.

If the District determines that a traffic signal is not being properly maintained and safety is being compromised, the Department will immediately notify the municipal traffic signal owner to take appropriate corrective action.

The Department further maintains the right to take corrective action on the municipality's behalf if proper maintenance is not performed and charge the permittee for costs incurred.

2.1 Municipal Traffic Signal Maintenance Agreements

2.1.1 General Provisions

The "Commonwealth and Municipal Traffic Signal Maintenance Agreement" (Traffic Signal Maintenance Agreement) addresses the required maintenance and operation of all traffic signal installations owned by a municipality, and it implements requirements in Title 74 Pa. C.S. Chapter 92. Effective upon issuance of this publication, a Traffic Signal Maintenance Agreement must be in place prior to issuance of a new or revised traffic signal permit to a permittee. The standard Traffic Signal Maintenance Agreement applies to all traffic signals owned by the permittee in perpetuity. Only one Traffic Signal Maintenance Agreement is required for a permittee, regardless of the number of traffic signals owned.

The Traffic Signal Maintenance Agreement is a standard agreement using approved language from the Department's Office of Chief Counsel (OCC); therefore, the language should not be altered. The official template agreement is available from PennDOT OCC's SharePoint site, with a public version available for municipalities on the PennDOT Traffic Signal Portal.

The Traffic Signal Maintenance Agreement requires the municipality to indicate if maintenance will be done with in-house personnel or via contract, and if by contract, it requires a municipality to provide the name(s) of the contractor(s) and a copy of the agreement(s)/contract(s) between the municipality and the contractor(s).

The execution of a municipality-wide Traffic Signal Maintenance Agreement using the current template from OCC supersedes the maintenance requirements which may have previously been adopted for traffic signals, including maintenance agreements for a federal or state funded project using Preapproved Form 18-K-392, and maintenance provisions contained in PennDOT Form TE-160 for individual signals.

In accordance with Commonwealth policy for agreements, a resolution of the governing body is typically required to establish the authority of the individual who signs the agreement on behalf of the municipality.

2.1.2 Initial Agreement

A Traffic Signal Maintenance Agreement shall be prepared using the form from PennDOT OCC's SharePoint site and shall be fully executed prior to the following, regardless of the funding source:

- ✓ Installation of the first traffic signal in a municipality
- ✓ First time traffic signal modification within a municipality, if the permittee has not already executed an agreement

Municipalities are encouraged to execute a Traffic Signal Maintenance Agreement covering all signals in the municipality as soon as possible to ensure timely permit issuance.

2.1.3 Preventative and Response Maintenance

The level of preventative maintenance and response maintenance that is required by the traffic signal permittee is discussed in **Chapter 4** of this publication.

2.1.4 Recordkeeping

Because accurate maintenance records are essential to document the preventative maintenance schedule and to be better able to estimate the need for spare hardware, each permittee is required to maintain a master signal maintenance log, and records of all response and preventative maintenance activities.

Since permittees sometimes contract with different maintenance contractors, the importance of maintaining good records cannot be overemphasized. It is important that responsible parties follow the documentation procedures indicated in **Section 7.2** for preventative and response maintenance activities.

2.1.5 Maintenance Organization

Permittees are required to provide the minimum personnel classifications identified in **Chapter 3** to properly maintain the traffic signal equipment and must secure training for staff.

2.1.6 Permittee Contact Information

The permittee shall provide contact information for both non-emergency and emergency periods, including information for a contracted maintenance provider, if applicable. The contact information shall be maintained in TSAMS, including prompt updates whenever personnel changes or a contracted provider changes.

2.1.7 Authority to Apply for Traffic Signal Approval

A signed Traffic Signal Application, Form TE-160, shall be submitted by the municipality to install or revise a traffic signal, subject to the terms of the Traffic Signal Maintenance Agreement.

The individual signing Form TE-160 must have been granted signature authority, typically by resolution of the governing body. The permittee may establish signature authority for both execution of the Traffic Signal Maintenance Agreement and future submissions of Form TE-160 by the same resolution. This is recommended to expedite subsequent signal change requests, since submissions would not be delayed waiting for a monthly meeting of the elected officials. A sample resolution providing joint signature authority is provided in **Appendix B**.

A permittee may alter the signature authority by adopting a new resolution of the governing body at any time.

2.2 Multi-Municipal Agreements

In the two following situations, it is necessary to have an agreement between the involved municipalities so that each municipality is aware of their fiscal and maintenance responsibilities:

- A traffic signal installed at an intersection that is in two or more municipalities
- An interconnected traffic signal system that involves more than one municipality

In both situations, all municipalities must work together to ensure proper system maintenance and operation in accordance with applicable permits. Also, there are certain maintenance elements that are shared in both of the above situations and without a pre-established cost basis, local authorities could end up thinking that they paid too high for their portion of the bill.

To ensure proper coordination in the above situations, each municipality should enter into a "Cooperative Memorandum of Understanding" for the multi-jurisdictional signal or signal system.

To ensure system uniformity, one agency should be assigned an oversight responsibility, and identified as Party #1 in the multi municipal agreement. For a single intersection, the oversight agency should typically be the municipality with the controller. However, for interconnected signal systems, the municipality with the oversight responsibility could be determined by any of the following considerations:

- The municipality with the master controller or backhaul communications drop
- Either the largest municipality or the one with the highest number of traffic signals in the system
- The municipality that houses the traffic signal system controller or central server

Additionally, the multi-municipal agreement should identify the following:

- The costs shared between the respective municipalities or the components of local traffic signals that each municipality is responsible for, and those components that are borne by an oversight organization.
- If costs are shared between the municipalities, define the method for cost sharing (such as percentages or the prorated number of the intersections within each municipality)
- The location of the system computer and any adaptive signal system equipment
- A willingness to support future additions to the system
- How to resolve conflicts

2.3 Service-Purchase Contracts

When permittees do not have the in-house expertise, staffing, equipment, or inventory of parts necessary to service and maintain traffic signal equipment, the prevailing method of maintaining traffic signals is by a traffic signal contractor. If a permittee is not prepared to maintain their own traffic signals, it is very important that they have a legal document in place to ensure that they can obtain maintenance repairs on a timely basis. Without a contract or agreement, it is very likely that repairs will not be completed in a timely manner, which in turn increases:

- ✓ Costs for temporary traffic control during outages
- ✓ Liability in the event of a crash due to improper operation

Even if a permittee uses a maintenance contractor, the permittee is still ultimately responsible for traffic signal ownership, maintenance, and operations. For this reason, the Department will only officially communicate with the permittee if they observe any deficiencies, and not with the contractor.

PennDOT's Center for Program Development and Management and the Auditor General issued guidance in October 2018 concerning liquid fuels expenditures by municipalities for traffic signal services, indicating:

- Traffic signals represent an element of highway maintenance; and procurement of highway maintenance services requires advertising and bidding, in accordance with a long-standing series of decisions by the appellate courts of the Commonwealth.
- To the extent that a political subdivision requires traffic signal repair services on an emergency basis, a competitively bid maintenance contract can and should include emergency call-out requirements, in accordance with PennDOT guidance on the subject.
- Traffic signals are not "public works" of the political subdivision. "Public works" as the term is used in the various municipal codes is limited to public utilities.
- Traffic signal maintenance, being part of highway maintenance, is not a professional service.

A number of options are available to select a traffic signal contractor, and all of the following are considered competitive bidding under the Pennsylvania Procurement Code:

- Low bid
- Qualifications-based selection
- Two-step process (first low bid, then request qualifications from say the two lowest bidders)

Using a low bid may be fairly simple for preventative maintenance elements, but a permittee generally needs to estimate a certain number of hours and replacement parts to consider the response maintenance side of the equation. Similarly, basing everything on qualifications (e.g., experience, expertise, personnel, project management, and the distance between the contractor's home base and the traffic signals) is subjective. Therefore, perhaps the best criteria are to make it a two-step process – request qualifications from the two or three lowest bidders and then make the final selection based on perceived qualifications. It is also a good idea to request references.

If the permittee uses a contractor to perform the maintenance of the signals, Section 3(b)iv of the Traffic Signal Maintenance Agreement requires that the permittee provides the Department with a copy of the document they use to obtain these services. Unlike the above Traffic Signal Maintenance Agreement between the Department and the permittee, there is no standard format for the document, which allows permittee and a maintenance contractor some creativity and flexibility. For example, permittees can call it a contract or an agreement; they can establish hourly labor and equipment charges; very detailed unit prices for almost countless types of equipment; etc.

A copy of one type of document is included in **Appendix C** as a "Municipal Service Agreement for Maintenance of Traffic Signals."

In general, a permittee is responsible for the maintenance of everything on the traffic signal permit plan, regardless of road ownership, including the traffic signal and all appurtenances (non-longitudinal pavement markings, signs, and any advance warning signs).

Traffic signal maintenance is critical to effectively ensure the safety and mobility of the traveling public through the intersection controlled by a traffic signal. Qualified personnel, maintenance equipment, and a current inventory of traffic signal equipment allow a municipality to obtain a better understanding of their current practices.

2.3.1 Typical Provisions

Permittees are encouraged to ensure that contracts or agreements between the permittee and the contractor address, as a minimum, the following issues to minimize potential legal battles:

- Establish duration of the contract or agreement (e.g., a 3-year contract with an option for renewal)
- Determine materials to be stockpiled by the contractor
- Define the schedule for annual preventative maintenance and the on-call response time
- Establish any charges and the periods of time they apply. For example, specify hourly charges for service personnel, flaggers, crane trucks, auger trucks, backhoes, etc., for both regular business hours and non-business hours (emergency call outs).
- Identify payment timeframes
- Define inventory and maintenance record-keeping responsibilities, including TSAMS updates
- Incorporate references to applicable publications listed in **Exhibit 1-1** of Publication 191

2.3.2 Accreditation – Department/IMSA

As noted in **Chapter 3**, the contractor and the permittee's personnel should be provided with the appropriate training to assure that they have a thorough understanding of current traffic signal technologies and proper maintenance procedures. The Department also encourages permittees to require their traffic signal maintenance contractor satisfactorily completes a certification program sponsored by a nationally recognized organization such as the International Municipal Signal Association (IMSA).

At a minimum, the Department recommends IMSA Work Zone Traffic Control Safety Certification (or LTAP's Temporary Traffic Control Training) and the IMSA Traffic Signal Level 1 Training to effectively understand traffic signal maintenance activities. IMSA Traffic Signal Level 2, IMSA Traffic Signal Level 3,

IMSA Traffic Signal Inspection, and other traffic signal courses may be desirable to obtain a full understanding of traffic signal maintenance and operations. (See IMSA for additional training details.)

2.4 Estimating Prices

Exhibit 3-2 includes some of the most common unit prices related to traffic signals. However, permittees are encouraged to use the unit prices from recent Department-administered projects to get a sense of current costs. Item Price History is provided in the Construction Projects Resources section of PennDOT's Engineering and Construction Management System (ECMS). Although these costs include typical labor costs, maintenance costs tend to be higher than new construction costs because old components frequently need to be removed before new components can be installed. In addition, maintenance normally involves smaller quantities than construction projects.

The primary benefit of understanding future costs is to avoid sticker shock and to help a permittee plan and budget for future upgrades.

2.5 Specifications

Permittees should use Publication 408 for all replacement components for the following reasons:

- ✓ The original construction used PennDOT's standards, and all replacement items should follow the same criteria so that the traffic signal continues to conform to the traffic signal permit
- ✓ Uniform, standardized specifications simplify installation and maintenance for contractors and makes it less likely that compatibility issues will evolve
- ✓ Sole source items tend to be significantly higher in cost

In the event that PennDOT does not have a specification, permittees are encouraged to keep their special provisions as generic as possible to avoid proprietary items. Only items critical to the interconnection of traffic signals should be considered as proprietary. However, permittees are encouraged to use similar equipment from one intersection to the next because this simplifies the formation of some traffic signal systems and reduces the necessary number of spare parts.

2.6 Highway Occupancy Permit Agreements

Title 67 Pa. Code §441.3 stipulates that a Highway Occupancy Permit (HOP) is required from the Department prior to:

- ✓ The construction or alteration of any driveway, local road, drainage facility, or structure within state highway right-of-way
- ✓ Connection to or alteration of a Department drainage facility

A HOP application should be submitted by the traffic signal owner (typically the municipality) if any of the following activities occur as part of traffic signal work within any state highway right-of-way:

- ✓ Embankment removal
- ✓ Curbing and/or sidewalk installation, including ADA ramps
- ✓ Drainage structures
- ✓ Changes in highway geometry
- ✓ Pavement widening
- ✓ Installation of additional lanes

Additional requirements for submission of HOP applications is included in Publication 282, *Highway Occupancy Permit Operations Manual.*

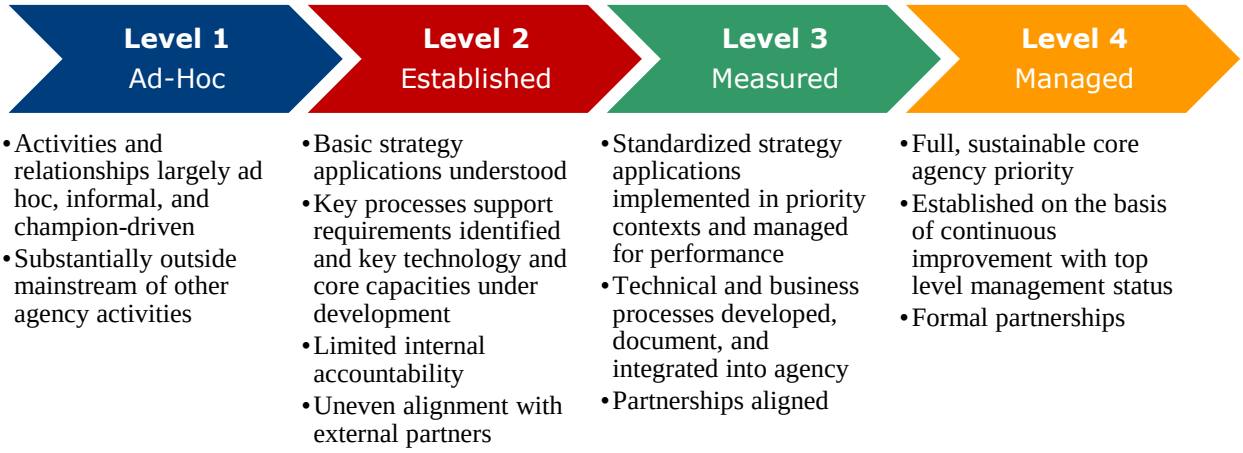
3. ESTABLISHING A TRAFFIC SIGNAL MAINTENANCE AND OPERATION PROGRAM

Traffic signal maintenance and operation shall be provided by the traffic signal owner, unless the signal owner has an agreement with another entity indicating otherwise. Maintenance shall be done in accordance with this publication. Operation includes continuously energizing the traffic signal to provide the operation identified within the traffic signal permit.

3.1 Traffic Signal Program Benchmarking

Traffic signal owners should establish a programmatic approach to traffic signal management and operations. This approach should link transportation goals to organizational capability to clarify how limited resources can be used to focus on doing what is most important, generally defined as providing good basic service. The capability maturity assessment technique can be used with the traffic signal program model. Additional information on this approach is contained in *Traffic Signal Benchmarking and State of the Practice Report*. The capability maturity model framework is illustrated in **Exhibit 3-1**.

Exhibit 3-1 Capability Maturity Model Levels



Source: *Traffic Signal Benchmarking and State of the Practice Report,* 2019

Traffic signal owners should periodically complete a self-assessment to gauge how well the agency is able to fulfill its traffic signal maintenance and operation requirements. It is recommended to complete a self-assessment at least once every five years, and when there are staff changes with oversight responsibility for traffic signals. Additional information is contained in **Appendix D**.

3.2 Budgeting

The cost for installing traffic signals at an intersection frequently exceeds $200,000 (in 2020 dollars). After a traffic signal is installed and tested, the permittee becomes responsible for the cost of maintenance and operation of the traffic signal. Since the permittee assumes liability, it is important that appropriate budgeting for insurance, preventative maintenance, and response maintenance associated with crashes and equipment failure be provided. Permittees are encouraged to track traffic signal maintenance costs using a dedicated account code within the 433 series recommended in the *Chart of Accounts* published through the Governor's Center of Local Government Services. Consistent cost tracking will help monitor trends for budgeting.

Preventative maintenance costs will escalate over time as equipment wears out and requires being replaced. More costly emergency repair costs will increase if proper preventative maintenance care is not provided.

Typical annual maintenance costs per intersection may range from $1,500 to $6,000 and depend on several factors such as the age and complexity of the traffic signal. Periodic operational maintenance, including retiming, should also be factored into the traffic signal budget.

3.2.1 Replacement Component Prices

Traffic signal unit prices for new/replacement products or operational improvements are included in **Exhibit 3-2**. The cost for work zone traffic control should be budgeted in addition to the unit costs in **Exhibit 3-2**. If the replacement includes modification to the traffic signal impacting the traffic signal permit, additional engineering costs will be required to revise the traffic signal permit.

Exhibit 3-2 Installed Unit Prices, in 2020 Dollars

Element	Installed Unit Prices*
Mast arms	$10,000 to $20,000/each
New controller unit (timer) in existing cabinet	$4,000/each
New controller assembly	$12,000/each
3-section, 12-inch LED signal head	$840/each
5-section, 12-inch LED signal head	$1,400/each
LED pedestrian signal head with countdown timer	$800/each
LED replacement bulb	$130/each
Pedestrian pushbutton	$400/each
Accessible pedestrian signals	$1,250/each
Loop detector	$1,200 to $1,800/each
Video detector	$5,500/approach $22,000/intersection
Radar detector	$8,000/approach $30,000/intersection
Junction box	$1,100/each
Emergency vehicle preemption (EVP)	$7,000/intersection
Signs, post-mounted	$55/square foot
Uninterruptible power supply (UPS)	$3,000 to $5,200/intersection
External generator panel (hook-up to accommodate a small generator)	$1,200
Stop bar (thermoplastic)	$125/lane
Lane use arrow pavement marking (thermoplastic)	$200 to $300/each
Traffic Signal Retiming & Analysis (recommended every 3 to 5 years for every traffic signal)	$1,000 to $8,000/intersection

*Unit prices derived from recent Department construction projects (bid prices) with traffic signal industry input.

3.2.2 Life Cycle Analysis

For budgeting purposes, it is also helpful to be aware of the typical service life of various traffic signal assets. Although unscientific, **Exhibit 3-3** shows the average estimated life expectancy, as interpreted by *Estimating Life Expectancies of Highway Assets, Volume1: Guidebook* (2012), NCHRP Report 713. However, the actual life of these traffic signal assets should be based on routine inspections and may vary as a function of the

manufacturer, location, loading, environmental conditions (temperature and wind speed), etc. The life expectancy for equipment can often be extended through proper preventative maintenance.

Traffic Signals are an important part of the Long-Range Transportation Plan Asset Management effort. Municipalities should request their planning partners place a traffic signal improvement line onto the transportation improvement program (TIP). As long as it is on a regional TIP (even if locally funded for minimal amount), the funding stream can be adjusted. The purpose for a TIP line item like, "traffic signal improvements region-wide: traffic signal infrastructure, timing, and operational modifications at: Location #1, Location #2, and at other locations to be determined" allows the possibility of federal funding for maintenance and operations to occur.

Maintaining installation dates and maintenance history in TSAMS (see **Chapter 7**) provides documentation from which life cycle analysis plans can be developed.

Exhibit 3-3 Estimated Service Life

Component or Material	Average Life (years)*
Tubular steel mast arms	20
Steel pole and span wire	20
Loop detector	7.5**
Non-invasive detector	10
Traffic controller	15
Controller cabinet	15
Twisted copper interconnect cable	20
Fiber optic cable	20
Incandescent lamps	1
LED lamps	6.5
Signal heads	20
Signs	12
Thermoplastic pavement markings	4

* Values from Tables 4-11, 4-12, 4-17 of *Estimating Life Expectancies of Highway Assets, Volume1: Guidebook (2012), NCHRP 713*, Transportation Research board of the National Academies, Washington, DC, 2012
** Average life for loop detectors is highly dependent upon pavement condition

3.3 Insurance

Permittees should maintain adequate insurance policies to cover property damage and liability issues related to traffic signals. For example, property insurance should cover traffic signal knockdowns and other damage from hit-and-run crashes, and at least temporarily cover costs to repair traffic signals until vehicle insurance claims are settled. In addition, liability insurance should cover any third-party actions alleging bodily injury, property damage or personal injury resulting from the operations of the permittee such as traffic signal design errors or signal malfunctions.

Traffic signals are susceptible to damage from a lightning strike, especially when located in open areas where the traffic signal is higher than the surroundings. For example, if lightning were to strike the traffic signals and destroy the controller or the wiring, and during the outage a serious crash occurred, a permittee could be legally challenged concerning the timeliness of the traffic signal repair. In this situation, a settlement could be large.

Similarly, if the permittee receives a safety complaint about the traffic signals and they do not address the concern, or at least not in a timely manner in the eyes of the court, a subsequent crash related to the concern could pose a large liability problem.

Therefore, a permittee needs to ensure that they are adequately covered to reduce exposure to tort claims.

3.4 Personnel/Resources

A permittee needs to determine the number of technically proficient staff members that can maintain their traffic signals to meet the guidelines established within this document. When sufficient permittee resources are not available, consider having a traffic signal contractor perform permittee's maintenance functions.

3.4.1 Maintenance Personnel

The qualifications of maintenance personnel are included in **Exhibit 3-4**. If the permittee does not employ staff in these positions, the permittee shall retain contracted services to fulfill these duties.

Exhibit 3-4 Recommended Qualifications for Maintenance Personnel

Personnel	General Tasks	Minimum Requirements
Signal Technician	Responsible for the operation and maintenance of traffic signals and all associated equipment.	▪ Ability to perform response maintenance on solid state equipment up to the device exchange level. ▪ Capability to diagnose a vehicle loop failure and initiate corrective action. ▪ Ability to tune detector amplifiers. ▪ Ability to follow wiring schematics, check and set timings from plan sheet and check all field conditions. ▪ Ability to perform preventative maintenance on all equipment and to maintain accurate records of all work performed.
Signal Specialist	Responsible for the diagnostics and repair of all traffic signal equipment including solid state equipment.	▪ Extensive training and troubleshooting skills in electronics and software. ▪ Ability to repair modules in the shop and to design test equipment needed to diagnose and repair a problem. ▪ Ability to make design modifications to implement or omit special functions. ▪ Ability to implement a recordkeeping system to include maintenance activities, inventory control and identification of recurring problems. ▪ Ability to perform all tasks required of a Signal Technician.
Traffic Engineer	Administrative position with prime responsibility for proper operation of traffic signal equipment. Supervises and plans activities of Signal Technicians and Signal Specialists to ensure adequate preventative and response maintenance programs.	▪ A thorough understanding of traffic signal design, installation, and maintenance. ▪ A working knowledge of the interaction between the following traffic characteristics: intersection geometry, traffic flow theory, control type (fixed time, actuated, etc.), signal phasing and timing, and interconnection. ▪ An ability to supervise subordinate personnel effectively in the assignment of their work. ▪ Possession of a college degree in engineering which includes course work in traffic engineering. ▪ Either four years' experience in the field of traffic engineering or its equivalent in graduate college work.

In order to adequately maintain traffic signals, a general rule-of-thumb is that a permittee should have one qualified technician for every 40 signalized intersections. However, additional technicians are required if the

permittee has a variety of different types of traffic signal equipment, larger intersections, or older traffic signal equipment.

3.4.2 Equipment and Inventory

If a permittee elects to perform their own traffic signal maintenance they should either have the following equipment and supplies, or at a minimum have ready access to them via a rental agency or contractor:

- Vehicles, including bucket trucks
- Test equipment and tools
- Digital multimeter
- Controller and conflict monitor test equipment
- Detector sensor test equipment
- Small tools
- Vacuum cleaner
- Small generator for backup power for signals at major intersections during power outages
- A field laptop with appropriate traffic signal controller and detection software (if applicable)
- A small video monitor when using video detection systems (if applicable)
- Replacement parts: controllers, CMU or MMU units, cabinets, cabinet fans and bulbs, signal heads, mast arms and poles, pushbuttons, detectors, bulbs or LED modules, filters, emergency vehicle preemption equipment, conduit, signal cables, detector cables, communication cables, signs, etc.
- Work zone traffic control devices (including work zone attire and equipment as defined in PennDOT Publication 46 and Publication 213).

3.5 Underground Utilities

3.5.1 Marking of Traffic Signal Assets

Permittees (typically municipalities) fall under the definition of a facility owner in the Underground Utility Line Protection law, Act 287 of 1974, as amended by Act 50 of 2017. This law requires facility owners to:

- ✓ Be a member of the Pennsylvania One Call System, Inc.
- ✓ Respond to all notices through the One Call System within two business days
- ✓ Respond to designer requests for information within ten business days
- ✓ Mark, stake, locate or otherwise provide the position of lines at least one business day prior to the lawful start date of excavation
- ✓ Communicate directly to the excavator within two hours of renotification, and, if necessary and possible, go to the proposed work site to mark, stake or locate its underground lines or to verify the owner's lines are not within the area of the proposed work site
- ✓ Respond to emergency notifications as soon as possible following receipt
- ✓ Report alleged excavation violations resulting in damage to facility owner's traffic signal assets within 30 days after receipt of notice of damage

Traffic signal owners who fail to register for the One Call System cannot recover costs for damaged lines.

Traffic signal components which are considered "lines" and must be marked under the act are identified in **Exhibit 3-5**.

Exhibit 3-5 PA One Call Traffic Signal Terminology

Act 247 term	Traffic signal component
Underground conductor used in providing electric service	All traffic signal wiring
Underground conductor used in providing communication service	All traffic signal communications cable, including interconnect cable and fiber optic cable
Traffic loops	In-pavement inductive loop detectors and lead-in wire

3.5.2 Responsibilities Prior to Performing Maintenance Activities

Before performing any maintenance activities that involve excavations, perform required actions according to the provisions of Underground Utility Line Protection Law:

- ✓ The law contains provisions for design notifications, excavation notifications, and emergency notifications. Notification can occur online or by calling 8-1-1.
- ✓ Excavation work shall not begin until after the lawful start date indicated in the act.
- ✓ Locate and mark existing underground utilities in the field.
- ✓ After completing location and marking of the known utilities, field review the proposed work to ensure that no utility conflicts exist.
- ✓ Traffic signal equipment locations may need to be adjusted due to utility conflicts, which should be documented on final as-built plans.

3.6 Performance Measurement

Meaningful performance measures are central to implementing performance-based planning and management processes by linking objectives, strategies, and tactics.

Example traffic signal program objectives are shown in **Exhibit 3-6**.

Exhibit 3-6 Traffic Signal Objectives

<table>
<tr><td>Safety</td><td colspan="3">Assign right-of-way safely</td></tr>
<tr><td rowspan="4">Operations</td><td>Flow</td><td>Intersection</td><td>Network</td></tr>
<tr><td>Light</td><td>Minimize phase failures</td><td rowspan="2">Smooth flow</td></tr>
<tr><td>Uncongested</td><td>Equitable service</td></tr>
<tr><td>Congested</td><td>Maximize throughput</td><td>Manage queues</td></tr>
<tr><td rowspan="2">Organizational</td><td colspan="3">Responsive to stakeholder needs</td></tr>
<tr><td colspan="3">Comply with agency policies and standards</td></tr>
<tr><td rowspan="3">Maintenance</td><td colspan="3">Minimize life cycle costs</td></tr>
<tr><td colspan="3">Sustain infrastructure state of good repair</td></tr>
<tr><td colspan="3">Sustain system and technology reliability/state of good repair</td></tr>
</table>

Objectives can be further associated with strategic and implementation tactics as shown in **Exhibit 3-7**.

Exhibit 3-7 Traffic Signal Strategies, Tactics, and Measurement Targets

Objective	Strategy	Tactics	Measurement Targets
Assign right-of-way safely	Design intersection and signal operation to serve all users safely	▪ Physical: Heads, Poles, Pushbuttons, Detectors, Cabinets, Signing, Markings ▪ Timings: Clearances ▪ Phasing: Protected, Unprotected, Simultaneous	▪ Good visibility ▪ Abundant clarity ▪ MUTCD compliance ▪ Low crash history
Minimize phase failures	Serve all waiting vehicles	Actuation: ▪ Detectors ▪ Generation extension/gap timing ▪ Generous max times	▪ Green time is adequate most of the time ▪ Delay is within an acceptable range ▪ No phase failures (or no max outs)
Smooth network flow	Progression	Coordination (Pipeline): ▪ Controllers ▪ Communications ▪ System Software ▪ Timings: Cycle, Offset, Split, Sequence	▪ Maximize bandwidth ▪ Minimize arterial stops (number and duration) ▪ Side street delay at acceptable level
Maximize throughput	Fully utilize green time	▪ Disciplined Timings: Cycle, Split, Maximum Green, Reservice ▪ Detection: Residual Queuing	▪ High phase utilization ▪ Low unused green ▪ Low growth of residual queue ▪ High flow
Manage queues	Metering flow	▪ Disciplined Timings: Splits, Maximum Green, Reservice ▪ Detection: Queue Overflow	▪ Queue length at intended locations ▪ High throughput (at bottleneck)
Responsive to stakeholder needs	Response Maintenance	▪ Maintain enough spare equipment to restore full operation in timely manner ▪ Provide on-call staffing or contractors to respond to emergencies 24/7/365	▪ Average response time ▪ Average time to complete repair ▪ Percent of response calls fixed with parts from inventory
Comply with agency policies and standards	Design Modifications	▪ Physical: Heads, Poles, Pushbuttons, Detectors, Cabinets, Signing, Markings ▪ Timings: Clearances	▪ Minimize non-compliance elements
Minimize life cycle costs	Preventative Maintenance	▪ Assign expected lifespan to each traffic signal element, beyond which failure rate or performance is likely to be unacceptable, and plan for timely replacement	▪ Minimize operating equipment beyond expected lifespan ▪ Minimize emergency calls per intersection
Sustain infrastructure state of good repair	Preventative & Response Maintenance	▪ Schedule repair/replacement of components when potential failure is identified through preventative maintenance activities ▪ Provide on-call staffing or contractors to complete emergency repairs in a timely manner	▪ Minimize component failures ▪ Minimize down time for permitted traffic signal operation
Sustain system and technology reliability/state of good repair	Preventative & Response Maintenance	▪ Schedule repair/replacement of components when potential failure is identified through preventative maintenance activities ▪ Provide on-call staffing or contractors to complete emergency repairs in a timely manner	▪ Minimize down time for communication systems ▪ Minimize down time for detectors

3.7 Training

All traffic signal staff should receive training and certification whether they are permittee employees or contractor employees. Training opportunities are described in **Chapter 8**.

3.8 Coordination of Maintenance Activities

Coordination of maintenance and repair activities are important for any permittee, especially as the number of traffic signals a permittee maintains increases. Proactive and timely coordination with both internal and external parties will help ensure that traffic signal maintenance and repair work is planned and completed in a knowledgeable and efficient manner.

- ✓ Internal coordination with signal maintenance staff (in-house or contractor) to ensure the timely and cost-effective performance of required maintenance activities.
- ✓ Internal coordination with permittee staff regarding planned or proposed projects which may impact the current or planned traffic signal maintenance & operations.
- ✓ External coordination with other agencies regarding their planned or proposed projects which may impact the current or planned traffic signal maintenance & operations. This may include utility work, road work, or land developer work.
- ✓ External coordination with other permittees when a traffic signal or a coordinated traffic signal system is located in more than one municipality.

4. TRAFFIC SIGNAL MAINTENANCE CLASSIFICATIONS

4.1 Traffic Signal Maintenance Activity Classifications

The Department recognizes the following three different traffic signal maintenance classifications:

- Preventative maintenance
- Response maintenance
- Operational maintenance

4.1.1 Preventative Maintenance

Preventative maintenance, also known as routine maintenance, is the type of maintenance required to minimize the probability of one or more components of a traffic signal or system from malfunctioning. It also includes the repair or replacement of components, as needed, to maintain the traffic signal or system as it is intended to operate per the approved traffic signal permit. For additional information on preventative maintenance activities, please refer to **Chapter 5**.

Preventative maintenance is typically scheduled utilizing a program of inspection, service, and replacement at pre-determined intervals. A preventative maintenance inspection may identify the need for response maintenance or design modifications.

4.1.2 Response Maintenance

Response maintenance is required when:

- ✓ One or more components of a traffic signal or system fails, causing the traffic signal to malfunction and/or not operate as specified on the approved traffic signal permit
- ✓ Crashes or inclement weather events cause equipment failure
- ✓ Repairs are necessary to address issues identified during preventative maintenance checks

The typical process and key activities related to response maintenance are:

- **Receive notification** – Contractor/permittee notified there is a maintenance issue requiring attention
- **Site arrival** – Technician/contractor mobilizes and travels to the location of the issue
- **Issue diagnosis** – Technician/contractor diagnoses the issue and identifies remedial measures
- **Perform repairs** – Technician/contractor completes the repairs or identifies and initiates repair actions to be completed
- **Log activity** – Technician/contractor logs the response maintenance activities completed or planned

For additional information on response maintenance activities, please refer to **Chapter 6**.

4.1.3 Operational Maintenance

Operational maintenance is the type of maintenance required to identify and undertake operational changes or equipment upgrades needed at an intersection or within a system to respond to changes in traffic patterns over time. Operational maintenance is a subset of preventative maintenance, and an operational review should be regularly scheduled at 2 to 3 year intervals. Operational maintenance focuses on the functionality of traffic signals to meet mobility needs as opposed to the upkeep of the existing signal components. Probe data may be used to evaluate whether performance has degraded since the previous review to reduce data collection costs. For additional information on operational maintenance, please refer to the *Traffic Signal Timing Manual*, 1st Edition (FHWA, 2008) and the *Signal Timing Manual*, 2nd Edition (NCHRP, 2018).

Operational maintenance is typically a scheduled evaluation of an intersection or corridor but may be undertaken in response to a complaint or notification of an operational issue.

4.2 Traffic Signal Maintenance Responsibilities

Traffic signal maintenance and operation is the responsibility of the traffic signal owner and shall be accomplished according to the time frames identified in **Section 4.3**. Traffic signal owners and operators need to determine whether maintenance and operations responsibilities will be provided by either their own personnel and/or by outsourcing (contracted services). The following questions should be considered for a maintenance and operations program:

- What level of staffing is required?
- Does the agency wish to purchase and operate the equipment required for maintenance?
- What skill level is available from in-house staff, and what level can the agency afford to employ?
- If outsourced, does the agency have the right people to manage a contractor?
- How many similar maintenance contracts has the agency done?
- How many years has the agency done similar maintenance contracts?

If considering outsourcing the maintenance of traffic signals, various options are available. This may range from a contractor providing all labor and materials, to other combinations where a contractor would provide specific labor and/or materials with the remaining functions provided by the traffic signal owner. Outsourcing could also include contracting with another municipality. Failure to maintain traffic signals may result in:

- The traffic signal not operating in accordance with the Department-issued Traffic Signal Permit
- More liability for the traffic signal owner
- More capital costs for the signal owner
- Reduced life expectancy for traffic signal equipment
- Increased likelihood of malfunctions requiring response (emergency) maintenance

It is important to ensure that traffic signal owner staff and/or contractors have the appropriate training so that they are up to date with current traffic signal technologies and maintenance and operation procedures. In addition to being appropriately trained as agreed to in the Traffic Signal Maintenance Agreement (see **Section 2.1**), traffic signal maintenance personnel (traffic signal owner staff and/or their contractor) should satisfactorily complete a certification program sponsored by a nationally recognized organization such as the International Municipal Signal Association (IMSA), as described in **Chapter 8**.

Before any maintenance or operation activities are performed, appropriate work zone traffic control shall be in place according to Publication 213. Special consideration should be given to the application of traffic control measures and work zone activities within or adjacent to signalized intersections. Publication 213 specifies actions that should be taken prior to and during the performance of work related to or affecting the operation of traffic signals. Temporary traffic control adjacent to a traffic signal must not conflict with signal operations while the signal is functioning in steady (stop and go) mode.

4.3 Traffic Signal Maintenance Scheduling

Each traffic signal is comprised of many components which, when taken collectively, allow the intersection or signal system to operate efficiently and effectively. Some components are more critical to the continued operations of an intersection than others. As a result, signal components are classified into two categories, primary and secondary, as defined below:

- **Primary component** – A material, device, or activity that is paramount to the structural integrity, functionality, and/or performance of a traffic signal or system.
- **Secondary component** – A material, device, or activity that when malfunctioning and/or deficient may compromise the functionality and/or performance of a traffic signal or system.

Both primary and secondary components must be maintained; however, because of their critical nature, primary components are given scheduling and response time precedence.

- See **Chapter 5** for further details on preventative maintenance activities and scheduling intervals.
- See **Chapter 6** for details on response maintenance activities and response/repair intervals.

Exhibit 4-1 lists the primary and secondary components for each traffic signal functional area.

Exhibit 4-1 Primary and Secondary Components

	Primary Components	Secondary Components
Supports	▪ Mast Arm Support ▪ Strain Pole Support ▪ Pedestal or Wood Support ▪ Span Wire ▪ Foundation ▪ Anchor Bolts ▪ Guy Wire ▪ Grounding	▪ Pedestrian Stub Pole ▪ Mounting Hardware ▪ Tether Wire ▪ Hand Hole Covers
Controller Assembly	▪ Local Controller ▪ Conflict Monitor ▪ Flasher Unit ▪ Load Switches ▪ Power Supply ▪ Relays ▪ Radio Frequency Interference (RFI) ▪ Surge Protection ▪ Grounding	▪ Cabinet ▪ Time Clock ▪ Traffic Optimization Processor (i.e. adaptive, etc.)
Systems & Communications	▪ N/A	▪ Master Controller ▪ Time-Based Coordinator Unit ▪ Communications System ▪ Modem ▪ Router ▪ Server ▪ Systems Software
Electrical Distribution	▪ Wire and Cable ▪ Electrical Service ▪ Wire Connectors ▪ Ground Bushings and Lugs ▪ Ground Rods ▪ Generator Adaptor Kit ▪ Battery Back-up/Uninterrupted Power Supply (UPS)	▪ Conduit ▪ Junction Boxes ▪ Service Receptacle
Signal Heads	▪ Signal Housings ▪ Vehicle and Pedestrian Indications ▪ Optically Programmed Signal Heads ▪ Lane Use Control Signal Heads	▪ Backplates ▪ Mounting Hardware
Detectors	▪ Loop Amplifier ▪ Vehicle Detection System (Loop, Video, etc.)	▪ Pedestrian Push Buttons ▪ Accessible Pedestrian Signals (APS) ▪ Pre-emption Systems ▪ Transit Priority Systems
Signs & Pavement Markings	▪ Internally Illuminated and Blank Out Signs ▪ Signal Permit Signs	▪ Pavement Markings & Legends ▪ Delineation ▪ Other Traffic Control Signs
Services	▪ Indication Alignment ▪ Time, Phasing, and Sequencing Traffic Controller Settings ▪ LED Upgrade ▪ Operational Retiming	▪ Hand Hole ▪ Clear Obstructions for Signal Indications ▪ Clean Signal Lenses ▪ Paint of Structures ▪ Infestation Prevention ▪ Cabinet Air Filter

4.4 Maintenance Reporting and Documentation

Maintenance reporting and documentation shall follow the guidelines outlined in this publication as referenced in the permittee's Traffic Signal Maintenance Agreement.

4.5 Design Modifications

The design and operation of each signalized intersection and system should be reviewed on a regular schedule (e.g., every 2 to 3 years). The review should include preventative/response maintenance personnel and the permittee's traffic engineer. The permittee may also invite department traffic signal unit personnel to participate in the review. Ad hoc discussions leading to design modifications may occur more frequently.

Use Form TE-974 to capture the following information:

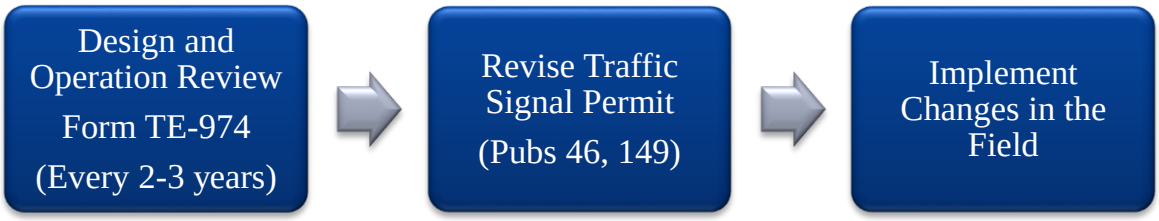
- ✓ Recurring maintenance problems
- ✓ Conformance with the approved plan
- ✓ Conformance with federal/state standards and state-of-the-art design features
- ✓ Compatibility with prevailing traffic demands and physical conditions of the approved traffic signal permit

The following reviews should also be conducted concurrently as part of a thorough design & operation review:

- ✓ Safety review
- ✓ Traffic demand review, when major changes in land use or roadway systems have occurred at nearby locations

Documentation of the Design and Operation Review on Form TE-974 should be uploaded to the intersection file in TSAMS. The design modification process is illustrated in **Exhibit 4-2**.

Exhibit 4-2 Design Modification Process



Maintenance personnel are in the best position to detect recurring problems or design deficiencies as part of their response and preventative maintenance responsibilities. Some recurring but correctable problems include:

- ✓ Traffic signal head visor damage
- ✓ Traffic signal head visibility issues
- ✓ Obstructions to pedestrian push buttons (i.e. snow)
- ✓ Traffic signal hardware knockdowns
- ✓ Detector alignment
- ✓ CCTV alignment

In addition, it is important that maintenance personnel and traffic engineers keep current with technology, standards, and practices so that necessary design modifications can be identified and proposed accordingly to improve signalized intersection performance. Examples include:

- ✓ Pedestrian countdown timers
- ✓ Advance pedestrian walk intervals
- ✓ Video detection
- ✓ Radar/Dilemma Zone detection
- ✓ Eliminating "blind clearance" left turn phasing (no yellow arrow)
- ✓ Modifying left turn phasing and incorporation of Flashing Yellow Arrow (FYA)
- ✓ 12-inch traffic signals instead of 8-inch
- ✓ Backplates and/or the addition of retroreflective borders
- ✓ Install louvers or optically programmed signal heads
- ✓ Adding overhead street name signs
- ✓ ADA curb ramps and/or accessible pedestrian signals
- ✓ Adding positive offset between opposing left-turn lanes to improve sight distance

Flashing Yellow Arrow left turn phasing and retroreflective border on backplates

"Blind clearance" left turn phasing

All of this feedback by maintenance personnel assists designers in reviewing and making suggested improvements to the safety and operation of the traffic signals.

Location-specific constraints such as structural loading and roadway clearance should be reviewed to determine the feasibility of potential design modifications.

Note, except during emergency traffic control, or when otherwise authorized by the Department, proposed design modifications must first be approved by the Department by issuance of a revised traffic signal permit to reflect the modification(s).

Upgrading 8" to 12" signal heads

5. PREVENTATIVE MAINTENANCE ACTIVITIES

Various components all work together to provide a fully functional traffic signal. Neglecting any one of these components can be detrimental to the safe and efficient operation of the entire traffic signal; therefore, it is important to maintain each and every one of these components.

By following the preventative maintenance activities and scheduling intervals for these components as identified in this chapter, the Permittee will help ensure the safe, efficient and proper operation of traffic signals that they own. A natural outcome of these regular preventative maintenance checks is the pro-active triggering of needed response maintenance repairs/replacements to address the identified issues. Issues noted during preventative maintenance which may result in immediate danger to the public shall be addressed through response (emergency) maintenance. Examples include structural degradation, failure of the signal to properly alternate right-of-way, and absence of a conflict monitor or MMU.

When performing preventative maintenance activities, applicable guidelines, specifications, and standards that are housed in the various publications identified in **Exhibit 1-1** will also need to be reviewed and applied by maintenance staff so that the integrity of the initially designed & installed traffic signal components are maintained. Each sub-section in this chapter identifies specific references for that particular signal component (supports, controller assembly, etc.), and should be reviewed and applied accordingly. Consult component manufacturers for specific maintenance recommendations (vendor contact information is contained in Publication 35 (Bulletin 15).

As a general matter, when traffic signal components are replaced, the material and construction specifications in Publication 408 should be followed, and materials and equipment from Publication 35 (Bulletin 15) shall be used. Refer to **Section 1.2.2** for additional information regarding approved traffic control devices.

As identified in **Section 1.3,** the traffic signal permit is the official document issued by the Department for each traffic signal, and it identifies the approved design and operation of the traffic signal. It goes without saying that the signal permit is a key document to be referenced and assessed for compliance when performing preventative maintenance activities.

5.1 Traffic Signal Supports

Vehicular traffic signals are mounted to mast arms or suspended from span wire between strain poles. Vehicular traffic signals and all pedestrian signals are mounted to the mast arm pole, strain pole, or pedestal poles. Pedestrian stub poles can be used for mounting pedestrian push buttons.

While the main component of a traffic signal support is the pole structure itself, there are also other necessary components that make a complete support installation (including the foundation, pole/base connections, welded/bolted support connections, span/tether wire, bolts/washers/nuts, and support paint/coating). When performing preventative maintenance activities, it is important that all of these components are reviewed. Where bolted connections require remedial corrective action, new bolts, washers, and nuts must be used.

In addition to preventative maintenance activities, the various inspections related to welded and bolted connections also apply to the following situations:

- ✓ When inspecting new traffic signal installations
- ✓ When inspecting traffic signal installations in conjunction with the initial signal turn-on and the 30-day testing period

For addition information related to Supports, see the following references:

- ✓ Traffic Signal Portal – Manufacture Structure Drawings
- ✓ Publication 46 (Chapter 4)
- ✓ Publication 148 (TC-8801, TC-8803)
- ✓ Publication 149 (Chapters 5, 12 & 20)
- ✓ Publication 408 (Section 951)
- ✓ Form TE-974

The preventative maintenance activities/scheduling intervals for traffic signal supports (including mast arms, strain poles, pedestal poles, and pedestrian stub poles) are summarized in **Exhibit 5-1**.

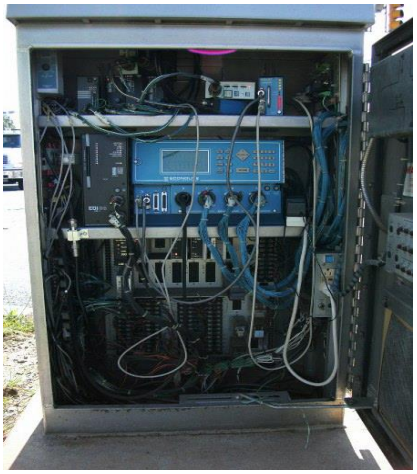
Exhibit 5-1 Preventative Maintenance - Supports

Traffic Signal Supports (Mast Arms, Strain Poles, Pedestal Poles, Pedestrian Stub Poles)	Maintenance Intervals		
	6 Months	12 Months	As Required
General			
Check paint condition and/or corrosion		X	
Paint repairs as needed			X
Check for obstructions in drain at pole base (clear drainage holes in pole bases if present)		X	
Inspect foundations for damage		X	
Inspect the foundation and base plate connection		X	
Verify that leveling nuts are in a snug-tight condition with the bottom of the base plate. Snug-tight is defined as the full force of a person on a 12-inch wrench		X	
Verify that a washer is present under each top nut to provide full bearing and to seal bolt hole gaps		X	
Visually verify that the top nuts are tight and free of corrosion		X	
Check condition of grout or rodent screen at pole bases; replace the grout or rodent screen if it has been removed		X	
Remove the grout or rodent screening under the base plate if there is evidence of anchor bolt weathering. Remove any debris, and examine the anchor bolts under the base plate, for signs of bending, cracking, etc.		X	
Adequately secure handhole covers (replace any missing covers)	X		
Inspect poles, transformer bases, and arms for damage caused by vehicle impacts, weather, or wear and tear (note any deficiencies)		X	
Check pole for plumbness, shim or adjust as necessary		X	
Check for rust and tightness of mounting hardware		X	
Check for missing pole caps and mast arm end caps; replace as required		X	
Check signal cable for wear at entrance of poles, brackets, signal heads and where it's lashed to the span wire. Install or replace rubber grommets as required.	X		
Check for wires/cables that may rub, or touch mast arm supports	X		
Check Guy Wires (inspect guy anchors for proper attachment and/or damage)	X		
Check galvanized nuts, bolts, and washers for any significant signs of corrosion		X	
Inspect for rust and cracks especially at seams, joints, and base plate		X	
Inspect 100 percent of all welds for visual evidence of cracking		X	
Document any evidence of weld metal or base metal cracking	X		
Document any adverse bolted connection findings	X		
Verify luminaire(s) are operational during dusk to dawn time periods		X	
Mast Arm Supports			
Inspect horizontal and vertical angles of arms and poles (check pole and/or arms for warping or other damage: note deficiencies)		X	
Visually inspect connections. The connection should be tight with no visible gap between the connection or flange plates, bolts, nuts, or washers.		X	
Verify that a washer is used between the connection or flange plate and each nut		X	

Traffic Signal Supports (Mast Arms, Strain Poles, Pedestal Poles, Pedestrian Stub Poles)	Maintenance Intervals		
	6 Months	12 Months	As Required
Visually inspect arm to column connections. The connection should be tight with no visible gap between the connection or flange plates, bolts, nuts, or washers.		X	
Check for cracks in the vertical column to base plate connection; any cracks generally initiate opposite the arm to shaft connection (about 180° from the centerline of the arm for single-arm structures)		X	
Check for cracks in the welded connection between the arm or column connection plates; any cracks generally initiate at the uppermost (12 o'clock) or lowermost (6 o'clock) positions of the connections due to the dead load and oscillation (galloping) caused by wind loads		X	
Strain Pole Supports			
Check for cracks in the shaft or column to base plate connection; any cracks generally initiate opposite the span wire connections		X	
Check condition of strain vises, if applicable		X	
Check bonding of span wire and tether wire to strain pole		X	
Visually inspect each tether wire for excess sag; adjust as necessary		X	
Inspect all connecting span wire hardware (anchors, guards, cable lashing, supporting brackets); tight or replace as necessary		X	

5.2 Controller Assembly

The controller assembly is the cabinet and all of the complete electrical and electronic components mounted inside the cabinet for controlling signal operation.



- ✓ Cabinet
- ✓ Controller Unit
- ✓ Conflict Monitor
- ✓ Flasher Units
- ✓ Load Switches and other

The controller unit is the heart of the controller assembly which selects and times signal displays. Several types of traffic signal controller units are used in Pennsylvania:

- ✓ **NEMA TS1**
  Use function-based standards that allow for interchangeability between manufacturers.
- ✓ **NEMA TS2**
  - Type 1 units allow for high-speed communication between equipment and for future expandability
  - Type 2 units retain the TS1 type connectors allowing for a degree of downward capability
- ✓ **Type 170**
  Older hardware-based controllers that were most often used in the City of Pittsburgh and Philadelphia. While no new installations are permitted by current specifications, many existing installations exist and must be maintained.
- ✓ **Type 2070**
  Advanced type of controller, modular in design, and use an open architecture allowing compatibility with off-the-shelf products. They allow for communications and are configurable for

use with traffic management applications. Most often used in the City of Pittsburgh and Philadelphia.

- ✓ **Advanced Transportation Controller (ATC)**
  Provide an open architecture hardware and software platform that can support a wide variety of Intelligent Transportation Systems (ITS) applications including traffic management, safety, security and other applications.

For addition information related to Controller Assemblies, see the following references:

- ✓ Publication 46 (Chapter 4)
- ✓ Publication 148 (TC-8802)
- ✓ Publication 149 (Chapter 3)
- ✓ Publication 408 (Section 952)
- ✓ Form TE-974

The preventative maintenance activities/scheduling intervals for controller assemblies are summarized in **Exhibit 5-2**.

Clean and replace air filters

Exhibit 5-2 Preventative Maintenance - Controller Assembly

Controller Assembly	Maintenance Intervals		
	6 Months	12 Months	As Required
General			
Paint steel cabinet to prevent rusting			X
Check anchor bolts and banding for rust or tightness		X	
Check controller cabinet condition. If necessary, relocate so the controller is not damaged by vehicle impacts		X	
Lubricate door hinges and locks		X	
Clean/vacuum inside cabinet		X	
Verify conduit entering the cabinet is sealed. If necessary, re-seal conduit (use approved duct seal)		X	
Seal around cabinet base with silicone caulking		X	
Check gasket around cabinet door		X	
Check drain plug (if equipped); Check for obstructions in drainage if evidence of water accumulating in cabinet		X	
Check for infestation, address as needed		X	
Replace air filter	X		
Check operation of cabinet light and switch - replace if necessary		X	
Check fan operation (thermostat set to operate at 85 - 90 degrees Fahrenheit)		X	
Visually check wiring and connectors	X		
Check and tighten all terminal connections		X	
Verify that all spare conductors are landed on spare terminal blocks or taped off		X	
Verify all cables are tagged or otherwise identified		X	
Place latest permit plan and cabinet wiring diagram(s) in cabinet, if missing		X	
Check Power Supply module	X		
Check Load Switches and verify operation of each switch position	X		
Check conditioning of incoming line voltage		X	
Test Circuit Breakers (cabinet and main)		X	
Check police functions		X	
Verify operation of vehicle detectors (including timing of delayed or extended output)	X		
Verify vehicle and pedestrian calls		X	
Verify operation of detector panel relays		X	

Controller Assembly	Maintenance Intervals		
	6 Months	12 Months	As Required
Check flasher unit for proper operation	X		
Check Radio Frequency Interface	X		
Check Traffic Optimization Processor	X		
Verify correct date, time and DST (Daylight Saving Time) function for controller		X	
Verify communication with master controller, if applicable		X	
Place user and/or programming manuals in cabinet, if missing		X	
Note and record make, model, firmware version and serial number for controllers, conflict monitors and other major components		X	
Conduct Operational Review (see Section 4.1.3)			3-5 Years
Conflict Monitor Unit (or Malfunction Monitor Unit)			
Scan conflict monitor for logged events, note any entries		X	
During intersection operation, observe the conflict monitor indicators and/or display screen to verify sensing of all indications and proper monitor settings	X		
Verify operation of conflict monitor – remove load switch to create red fail and observe response of monitor	X		
Test conflict monitor by a computerized conflict monitor tester; replace monitor if it fails test		X	
Test the cabinet wiring and harnesses by using a jumper wire and pulling the load switch, if cabinets are frequented by rodents that chew on electrical wires/cables		X	
Controller Unit (Electromechanical)			
Check time, phasing and sequencing settings	X		
Check dial assembly for wear, burned contacts, key positions	X		
Check cam assembly for wear, cracks, burned contacts, tension on contacts	X		
Clean and lubricate cam assembly		X	
Controller Unit (NEMA, Type 170, Type 2070, ATC)			
Check time, phasing and sequencing settings (verify input time versus approved timing, including coordination and time-of-day parameters; yellow & red clearance intervals)	X		
Run internal diagnostic routine on the controller		X	
Upload controller timing and parameters via laptop; place copy in controller		X	
Check response to detector input	X		
Check indicator lamp and replace if burned out	X		
Check real time on clock	X		
Upgrade controller firmware to most current version, and also as appropriate to address items affecting operational efficiency and safety			X
If a master controller, check that is it operating appropriately, and signals are coordinated	X		
Disconnect controller from master (if applicable) and check that the signal goes into backup or free operation		X	
Verify that the permittee is on the manufacturers' mailing or email list so that they are notified of software or firmware upgrades		X	
Check the time provided for the pedestrian crossing. Any noticeably short timing for safe pedestrian crossing of the street should be reported and addressed.		X	

5.3 Systems and Communications

Coordinated signal timing is typically applied on corridors with closely spaced intersections (1/4 mile or less). The objective of coordinated traffic signals is to synchronize multiple intersections, reduce the number of stops along a corridor, and provide for a continuous flow of traffic at the target speed.

Maintaining communications between local controllers along a coordinated corridor and with the central system or master controller is critical to ensure the system operates as intended for smooth traffic flow. Communications infrastructure ownership should be verified before performing maintenance. PennDOT may own communications systems to facilitate signal operation across jurisdictional boundaries. Various systems and communication methods are used to coordinate traffic signals along a corridor:

Newer Technologies:

- ✓ Spread Spectrum Radio (Broadband)
- ✓ Cellular
- ✓ Fiber Optic
- ✓ Wireless Broadband
- ✓ Unified Command and Control

Older Technologies Still in Operation:

- ✓ Hardwire
- ✓ Telephone-Dialup
- ✓ Closed-Loop
- ✓ Spread Spectrum Radio (Serial)
- ✓ Time-Based Coordination
- ✓ GPS Time Clocks for Coordination

For addition information related to Systems and Communications, see the following references:

- ✓ Publication 46 (Chapter 4)
- ✓ Publication 149 (Chapters 11 & 12)
- ✓ Publication 408 (Section 953)
- ✓ Form TE-974

The preventative maintenance activities/scheduling intervals for systems and communication are summarized in **Exhibit 5-3**.

Exhibit 5-3 Preventative Maintenance - Systems and Communications

Systems and Communication	Maintenance Intervals		
	6 Months	12 Months	As Required
Perform preventative maintenance in accordance with the manufacturer's recommendations		X	
Check operation of the communication system ▪ Verify that communications between all system components is functioning ▪ Verify function of system components, including modems, ethernet/ethernet bridges, managed network switches, transmitter/receivers, antennas, servers, and system software	X		
Check master controller		X	
Check time-based coordinator unit; verify time clock is accurate and that it is adjusted for daylight savings time		X	
Check communication cables and connections	X		
Check mounting hardware		X	
Verify integration with Department's Unified Command & Control (UCC) where applicable	X		
Verify consistency between system database and controller databases, and ensure all databases match the approved permit	X		
Check overhead communications cables; verify that trees or vegetation are not encroaching on aerial lines. Address as necessary.		X	
Check fiber optic cable ▪ If aerial, check from where it is connected at the trunk line, check that all coils are secure and at the proper bend radius ▪ If attached to a wood pole, check that the drop and u-guard are secure ▪ In the controller cabinet, open the patch panel and check all tip connections		X	
Check wireless signal strength ▪ Test wireless signals at each intersection to verify they are operating within limits ▪ Adjustments shall be made to correct any deficiencies found in the communications system; including trimming of trees/vegetation that may be interfering with signal reception	X		

5.4 Electrical Distribution

Electrical distribution consists of all the electrical components that power and operate a traffic signal. Without a properly maintained and functioning electrical distribution the most state-of-the-art traffic signal would operate ineffectively.

- ✓ Electrical Service
- ✓ Junction Boxes
- ✓ Conduit
- ✓ Wire / Wire Connectors
- ✓ Grounding
- ✓ Surge Protection
- ✓ Generator Adapter Kit
- ✓ Uninterruptible Power Supply (UPS), and others

For addition information related to Electrical Distribution, see the following references:

- ✓ Publication 46 (Chapter 4)
- ✓ Publication 148 (TC-8804)
- ✓ Publication 149 (Chapter 8)
- ✓ Publication 408 (Section 954)
- ✓ Form TE-974

The preventative maintenance activities/scheduling intervals for electrical distribution are summarized in **Exhibit 5-4**.

Exhibit 5-4 Preventative Maintenance - Electrical Distribution

Electrical Distribution	Maintenance Intervals		
	6 Months	12 Months	As Required
General			
Measure service voltage	X		
Check physical condition of meter and power service disconnect box. Disconnect box should be properly locked and free of rust.	X		
Check Service Receptacle (check GFCI receptacle on power distribution panel: replace if necessary)		X	
Check wire and cable	X		
Check wire connectors		X	
Inspect all splices in each traffic signal pole base and handhole to verify they are all solidly connected and not degraded. If deterioration is identified, re-splice using splices consistent with National Electric Code (NEC) for wet environments.		X	
Visually check the condition of the traffic signal cable for dry rot, nicks, cuts or other damage to the outer jacket insulation; perform resistance and continuity tests, if required)		X	
Check all overhead cables and connections		X	
Check that signal cable is not rubbing against cable outlet (free-swinging, end-mounted signals only)		X	
Test for grounding, corrosion, and loose connections. Verify fuses or power breakers are functioning.		X	
Check relays and lightening arrestor for burned or pitted contacts	X		
Check the integrity of lightning arrestor	X		
Check all surge protectors for critical applications of controls or signals that exit or enter the cabinet, and the power supply. Includes: detectors, pedestrian pushbutton loops, service loops, communication systems, etc.	X		

Electrical Distribution	Maintenance Intervals		
	6 Months	12 Months	As Required
Grounding and Bonding			
Check ground rod, clamp, and ground wire connections	X		
Check that each pole, metal conduit, metal junction box, and other required metal components are properly electrically bonded	X		
Check controller cabinet neutral and grounding bus		X	
Check the ground rod, clamp connection, and bonding of conduits (secure all straps and rod connections)		X	
Check ground bushings and lugs (check grounding bushings on rigid metallic conduit; replace as necessary)	X		
Handhole - check ground rod, clamp and ground wire connections	X		
Junction Boxes and Conduit			
Check that junction boxes are sealed from water with securely seated covers		X	
Clear lip of junction box cover to ensure proper seating of cover; tighten cover bolts if present		X	
Inspect inside the junction box for abnormal amounts of water or water damage. If water is present, take measures to drain by installing weep holes.		X	
Any junction boxes visibly cracked should be sealed or replaced			X
Replace any covers that are cracked or don't fit & seal properly			X
Check junction boxes for proper grade and any surrounding ground erosion that could draw water; note any deficiencies		X	
Clear debris and/or overgrowth around junction box		X	
Check visible conduit (check above ground conduit for damage; replace damaged and/or missing conduit straps)		X	
Check for any exposed ground conduit. ▪ If conduit is undamaged, bury it ▪ If conduit is crushed or cracked, it needs replaced and buried		X	
Fix any repairable penetrations of conduit which are damaged by equipment as follows: ▪ Sealed with electrical putty or an approved sealant as recommended by the cable or conduit manufacturer and in a manner that does not damage the cable ▪ Insert grade 3 or 4 stainless steel wool in the conduit before the sealant to prevent rodent infestation			X
Check the wiring insulation for damage which could cause electrical shorts		X	
Emergency Generator Connection			
Inspect the disconnect enclosure, transfer switch, surge protection, and connector cable assembly.		X	
Check that the connector cable is ▪ Sufficient length to allow the attachment of an external power source in accordance with the latest NEC ▪ Compatible with the municipal generator and has neoprene all weather flexible protective boots on each end		X	
Check operation of the traffic signal for a minimum of five minutes using a municipal generator and provided cord		X	
Test the electrical automatic relay switch over		X	
Uninterruptible Power Supply (Battery Back-up)			
Test the UPS in accordance with the manufacturer's specifications to verify that it is working properly		X	
Test battery(s) for loss of charge – **replace every 3 years**	X		
Check Uninterruptible Power Supply	X		
Verify automatic transfer switch operation		X	
Verify incoming line voltage		X	
Verify DC output to batteries		X	
Verify AC output on inverter		X	
Check electrical connections		X	
Test system via simulated power outage at cabinet		X	
Record events and run time either saved on UPS unit manually or uploaded to laptop		X	

5.5 Signal Heads

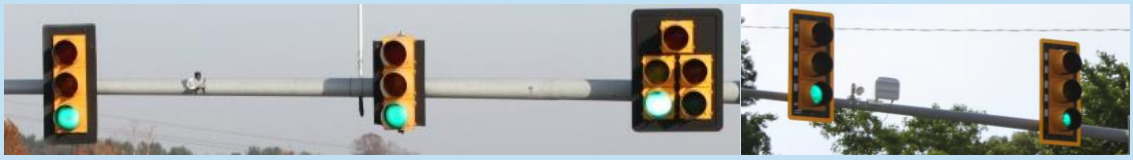
Traffic signal indications provide the driver or pedestrian with a visual sign as to when they can proceed through an intersection. It is essential that drivers and pedestrians have a clear view of the traffic signal indications. Therefore, the traffic signal indications should be routinely inspected to ensure that advance signs, foliage, or snow does not impair driver and/or pedestrian visibility.

Vehicular indications include red, yellow, green circular or arrow indications. Pedestrian indications typically include a Portland orange "hand" symbol and a white "person" symbol as well as a numeric countdown. This section explains not only these indications but the traffic signal housing in which the indications are installed.

A complete signal head assembly includes the following components:

- ✓ Housing / Reflectors / Backplates / Visors / Louvers
- ✓ LED Signal Modules (older signals may still use incandescent bulbs), or Optically Programmed Signal Heads for special-use situations
- ✓ Mounting Assembly Hardware

Damaged backplates should be replaced with aluminum, louvered backplates



Another type of signal head is the LED Lane-Use Traffic Control Signal. These lane-use signals are special overhead signals that permit or prohibit the use of specific lanes on a highway. Lane-use signals are typically used for reversible-lane control (see *MUTCD* Section 4M).

For addition information related to Signal Heads, see the following references:

- ✓ Publication 46 (Chapter 4)
- ✓ Publication 148 (TC-8805)
- ✓ Publication 149 (Chapter 6)
- ✓ Publication 408 (Section 955)
- ✓ Form TE-974

The preventative maintenance activities/scheduling intervals for signal heads are summarized in **Exhibit 5-5**.

Exhibit 5-5 Preventative Maintenance - Signal Heads

Signal Heads	Maintenance Intervals		
	6 Months	12 Months	As Required
General			
Check vehicle and pedestrian indications	X		
Check optically programmed signal heads	X		
Check lane use control signal heads	X		
Check alignment of vehicular signal heads (aim toward center of approach at a point approximately 150 feet in advance of stop bar)	X		
Check alignment and visibility restrictions of optically programmed heads and heads w/ louvers to verify they are operating properly with desired viewing intent	X		

Signal Heads	Maintenance Intervals		
	6 Months	12 Months	As Required
Check alignment of pedestrian signal heads relative to the crossing they serve	X		
Check visibility of traffic signal indications to verify that advance signs, foliage, overhead utilities, etc. do not impair visibility. Schedule one of these semi-annual checks when leaves are present. Overhanging trees which block signal indications shall be trimmed in order to meet the visibility requirements in *MUTCD* Section 4D.12.	X		
Check horizontal lane-positioning of vehicular signal heads/signs to verify they are mounted according to Traffic Signal Permit		X	
Check the clearance between the roadway and the bottom of signals and/or signs located over the roadway; adjust height as necessary		X	
Check terminal block connections		X	
Housing Assembly (including: Backplates, Visors, Louvers, Lenses & Reflectors)			
Inspect signal housings for cracks, damage, and secure assembly of all attachments (backplates, visors, louvers, etc.). Tighten up as necessary.		X	
Clean and inspect backplates for cracks, damage and secure attachment. Tighten up as necessary. Backplates (dull black in color), including a 2 inch (minimum) fluorescent yellow retroreflective border, are required on all new traffic signals, including replacement of existing signal heads.		X	
Clean and inspect visors for cracks, damage and secure attachment. Tighten up as necessary. Visors must be dull black in color on the side toward the indication.		X	
Clean and inspect louvers for cracks, damage and secure attachment		X	
Check that when louvers are used, they are installed with tunnel or full-circle visors		X	
Clean and inspect lenses and reflectors, as necessary; replace those that are damaged		X	
For existing metal signal heads, check paint condition and repaint as necessary			X
Mounting			
Check for cracked and/or damaged mounting brackets		X	
Check gaskets and mounting hardware, retighten as necessary		X	
Check for wear on span wire and signal mounting hardware		X	
Check bushings on cable outlet and universal hangers, replace as necessary		X	
Check that signal heads on mast arms are mounted using fixed mounts unless approved otherwise on the Traffic Signal Permit		X	
Indications (LED Modules / Incandescent Lamps)			
Re-lamp all existing incandescent signal indications		X	
Replace incandescent indications with LED indications ▪ Proactively, as part of Permittee's signal planning & budgeting process ▪ When incandescent indications have reached the end of their useful life ▪ No change required on the traffic signal permit, but suggest notifying the District Traffic Engineer ▪ Update TSAMS as an inventory change			X
Check LED indications for brightness level to ensure replacement prior to complete failure. Note serial numbers and/or date of manufacture for LED modules		X	
Replace LED signal modules			5-7 years
Re-lamp all sealed beams for programmed signal heads		X	
Remove white strobe light indications within the red lens and replace with approved red indications; these type indications are prohibited (Section 4D.06 of the *MUTCD*)	X		

5.6 Detectors

Any traffic-responsive control system depends on its ability to sense traffic for local intersection control and/or system-wide adjustment of timing plans. Malfunctioning detection will typically result in a constant call, causing wasted time, increased delay, wasted fuel, and increased emissions as phases are served unnecessarily for the maximum time. Therefore, properly functioning detection is critical to an intersection's safe and efficient operation. To ensure maximum effectiveness of each device, it is recommended that manufacturer's recommendations are followed.

A traffic signal system accomplishes this by using one or more of the following detector types:

Vehicle Detectors (Pavement Invasive):

- ✓ Inductive Loops
- ✓ Magnetic
- ✓ Magnetometer (wireless transmit)

In-pavement sensors can fail for a number of reasons, including, but not limited to:

- Sensor sensitivity is set too low and in need of adjustment
- Pavement cracking and shifting
- Breakdown of wire insulation
- Poor sealants or inadequate sealant application
- Inadequate splices or electrical connections due to installation methods, moisture, or corrosion
- Damage caused by construction activities, including resurfacing and sidewalk/ADA ramp work
- Lightning/electrical surges
- "Stuck" sensor in which case the sensor detector can be reset

Vehicle Detectors (Pavement Non-Invasive):

- ✓ Radar
- ✓ Infrared
- ✓ Video (various technologies including thermal, omni-view, etc.)

Overhead sensors can fail for a number of reasons, including, but not limited to:

- Poor positioning and alignment of sensor devices, including post-installation movement of sensor
- Improper setup of vehicle detection zones
- Camera lens viewing impediments (dirt, moisture, sun, etc.)
- Sensor damage
- Software issues

Pedestrian Detectors:

- ✓ Pedestrian Pushbutton
- ✓ Accessible Pedestrian Systems

Preemption Detectors (Emergency Vehicles):

- ✓ Optical
- ✓ Acoustic
- ✓ GPS
- ✓ Pushbutton: located in an emergency services building (this is typically for signals immediately adjacent to the dispatch location)

Specialized Preemption Detectors

- ✓ Railroad Preemption (highway-rail grade crossings)
- ✓ Queue / Ramp Preemption
- ✓ Transit Signal Priority

Intersection/System Observation:

- ✓ CCTV

For addition information related to Detectors, see the following references:

- ✓ Publication 46 (Chapter 4)
- ✓ Publication 148 (TC-8803; TC-8806)
- ✓ Publication 149 (Chapters 7 & 10)
- ✓ Publication 408 (Section 956)
- ✓ Form TE-974

The preventative maintenance activities/scheduling intervals for detectors are summarized in **Exhibit 5-6**.

Exhibit 5-6 Preventative Maintenance - Detectors

Detection	Maintenance Intervals		
	6 Months	12 Months	As Required
General			
Perform preventative maintenance in accordance with the manufacturer's recommendations	X		
Verify that detectors are performing and operating as designed for the intersection per the Traffic Signal Permit	X		
Verify that the CCTV system is performing and operating as designed.	X		
Vehicle Detectors- Pavement Invasive (Inductive Loops, Magnetic, Magnetometer)			
Visually inspect the sensor in the roadway	X		
Check sensor/lead-in splices	X		
Measure each loop sensor for resistance (R), inductance change DL%, and loop quality (Q)		X	
Check that all sensor leads are properly tagged		X	
Check sensor amplifiers for false actuations by vehicles in adjacent lanes	X		
Check sensor amplifier for fail light indicator	X		
Tune the detector if necessary (re-tune sensor detector amplifier at the cabinet if necessary)	X		
Check that the connectors are tight and secure	X		
Check that necessary delays are functioning properly	X		
Check wireless Magnetometer battery life and replace as necessary			X
Vehicle Detectors - Pavement Non-Invasive (Video, Radar, Infrared)			
Check alignment of detectors and verify detection zones are in proper location relative to lane(s) being detected with the proper traffic direction configured, as appropriate	X		
Check that detector device positioning is proper for the type of system used	X		
Check detector device mounting hardware for proper and secure connections		X	
Check that detector device cable connections are properly secured		X	
Inspect detector device for damage		X	
Verify operation of detector processor at cabinet		X	
Verify that detection system is using the latest software version and upgrade (update card firmware, if applicable)	X		
Verify detector cables are labeled for identification		X	
For video detection, assess impact of changes in sun's seasonal position on detection accuracy	X		
For video detection, check camera lens for moisture or dirt buildup; clean camera lens. (More frequent maintenance may be required during the winter months due to road salt spray)	X		
For radar detection, verify that gaps are being properly identified by the system and that vehicles are being detected in only one direction	X		
Pedestrian Detectors			
Verify the operation of each push button and visually verify pedestrian signal operation ▪ Check for button tightness ▪ Check housing for damage or signs of vandalism, replace as necessary		X	
Check push button signs for location, legibility, damage; clean as necessary ▪ If two buttons for crossing in different directions are located on the same support, the appropriate signing should be in place to ensure that it is clear and easily understood which button applies to which crossing ▪ Signs should be securely mounted and aligned with the appropriate crosswalk		X	

Detection	Maintenance Intervals		
	6 Months	12 Months	As Required
Verify accessible pedestrian system (APS) features are operating in accordance with the permit. Maintenance of APS includes ensuring none of the following has occurred or is occurring: ▪ No response to ambient sound ▪ Weak or no vibration ▪ Malfunction of audible message or tone, and direction ▪ Delay between onset of walk interval and start of speech message ▪ Failure due to wire short going to the vibrator cover/pushbutton ▪ Mechanical failure of pushbutton magnetic switch ▪ Failure of control board		X	
Vehicle Preemption Systems (Emergency and Specialized)			
Check/test emergency vehicle preemption (EVP) systems for proper timing and operation: ▪ Check that operation complies with traffic signal permit and current standards ▪ After the preempting vehicle has cleared the intersection and/or a preset time period, verify that the signal returns to normal operation. Pay special attention to the transitioning into and out of a preemption sequence; the interval timings for both vehicle and pedestrians should be verified. Any available logs should be checked for abnormal activity/inactivity. ▪ For Optical EVP systems, test for pick up, range, and that unwanted light refraction does not actuate other phases; adjust detectors as needed to optimize performance ▪ For Acoustic EVP systems, test the emergency vehicle sirens for compliance with Class A siren specifications ▪ For GPS EVP systems, there is little preventative maintenance required as problems with communication links are identified during normal use		X	
Optical & Acoustic EVP systems use fail safe, or confirmation lights, to provide indication to the driver that the approach is being preempted. When EVP is in operation, the confirmation light flashes for the preempted approach and is dark for the conflicting approaches. Maintenance responsibilities include: ▪ Verifying the lights are properly aligned with each corresponding approach and testing for confirmation light off/dark operation using the appropriate transmission signal for the particular area (acoustical, optical) ▪ Re-lamp confirmation lights, as needed		X	
Button-activated EVP operates typically from within a building such as a fire company/emergency building. Verify button operation and repair, replace, or clean as necessary.		X	
Check railroad preemption system. Verify that the system is working properly, refer to traffic signal permit, Publication 149 (Appendix D) and Publication 408, Section 953.		X	
Complete comprehensive joint inspections of preemption system for railroad interconnect in accordance with Federal Railroad Administration guidelines		X	
Check queue & ramp preemption system. Verify that the detection system is functioning properly, in accordance with the traffic signal permit		X	
Check transit priority system. Verify that the system is working properly. Transit signal priority software is used to manage the system, collect data, and generate reports. It is recommended that maintenance be performed by an experienced technician.		X	

5.7 Advanced Traffic Signal Technology

Adaptive signal systems provide responsive, real-time signal timings to match current traffic conditions along a corridor. Vehicle sensing is continually processed to generate new customized timing sequencing to best handle the present traffic flow conditions.

Adaptive signal systems utilize the following:

- ✓ Specialized adaptive system hardware
- ✓ Specialized adaptive system software
- ✓ Vehicle detection systems

For addition information related to Advanced Traffic Signal Technology, see the following references:

- ✓ Publication 46 (Chapter 4)
- ✓ Publication 149 (Chapter 11)
- ✓ Publication 408 (Section 957)

- ✓ Form TE-153
- ✓ Form TE-974

The preventative maintenance activities/scheduling intervals for advanced traffic signal technology systems are summarized in **Exhibit 5-7**.

Exhibit 5-7 Preventative Maintenance - Advanced Traffic Signal Technology

Advanced Traffic Signal Technology	Maintenance Intervals		
	6 Months	12 Months	As Required
Verify that adaptive signal system (system) is providing real-time corridor optimization, including handling of incidents and traffic shifts	X		
Verify that system can function in an actuated-coordinated mode or adaptive mode selectable by time of day and day of week, or as specified on the approved plans		X	
Verify that system allows preemption phases to override the system and operate per the approved preemption sequencing, if applicable		X	
Verify that system accommodates queue preemption, if applicable		X	
Verify that system fallback state is configured for loss of adaptive processor and/or server communication, including controller operation and alarms as applicable	X		
Verify adaptive operation is using and receiving proper detection data to generate signal timings	X		
Review system logs and resolve any unexpected errors which have been recorded	X		
Verify remote communications connectivity to all field devices	X		
Verify that system is connected to the Commonwealth Network to allow PennDOT access	X		
Login to commonwealth network to maintain password credentials			60 days
Verify that system is collecting and storing local, real-time traffic data for a minimum of 4 weeks, or as specified on the approved plans	X		
Verify that system can be operated and monitored from a TMC, if applicable	X		
Verify that system's detection system provides the necessary functional requirements to allow the system to function as designed	X		

5.8 Signs and Pavement Markings

Signing

At traffic signals, signing is used to regulate traffic flows, designate the use of approach lanes, restrict certain movements, and guide motorists. It is important that all signs pertaining to operation of the traffic signal be included on the permit and verified in the field during inspections. Missing signs could confuse motorists or cause a conflict that may otherwise not occur if the appropriate regulatory signs were in place. The following types of signs may be included on a traffic signal permit plan:

- ✓ **Overhead Signs**

  Generally, consists of signs mounted on mast arms or span wire. Most often these signs are mounted adjacent to the traffic signals. Examples include LEFT TURN YIELD ON GREEN, NO TURN ON RED, or Street Name signing. Signing is also mounted overhead in advance of a multilane intersection approach. This type of signing is referred to as lane use control signing and is important to direct motorists into the appropriate lanes to minimize the potential for sideswipe crashes.

Appropriate overhead lane use control

- ✓ **Ground Mounted Signs**
  Consist of turn restrictions, lane use control, and other regulatory signing
- ✓ **Pedestal Support Signs**
  Signs on traffic signal supports may include NO PEDESTRIAN CROSSING, push button signing, and sometimes RIGHT TURN SIGNAL signs
- ✓ **Internally Illuminated Signs**
  Unlike retroreflective signs that gradually deteriorate, when an internally illuminated sign stops working the message is not legible. In the past, this has been a specific problem with Signal Ahead (W3-3) signs, but it could also be an issue with signs used in conjunction with railroad preemption.

Replace signs with current version of sign from Pub 236

Pavement Markings & Legend Markings

Pavement markings provide the motorist with guidance so that they remain in the appropriate lane as they approach and travel through an intersection. Typical markings at intersections include lane lines, word and arrow markings, stop and yield lines, and crosswalks.

- ✓ **Longitudinal Markings**
  These include markings that run in the direction of travel. Currently on State highways, the Department maintains longitudinal pavement markings.
- ✓ **Transverse Markings**
  Transverse markings are those which run perpendicular to direction of travel. They include stop and yield lines, and crosswalks. Dotted extension lines connecting lanes through the intersection are also considered transverse markings since they are crossed by vehicles. Maintenance of these markings is the responsibility of the permittee even if the pavement markings are on a State road at a traffic signal, unless indicated otherwise on the traffic signal permit.
- ✓ **Legend Markings**
  Legend markings are used to designate the use of a lane. At signalized intersections, they frequently include "Arrows" and "ONLY" legends. Maintenance of these markings is the responsibility of the permittee, even if on a State road at a traffic signal, unless indicated otherwise on the traffic signal permit.

Traverse & legend markings need replaced frequently since they are driven over more often. Therefore, permittees are encouraged to use preformed thermoplastic material.

Example of pavement markings in good condition


Poorly maintained pavement markings

For addition information related to Signs & Pavement Markings, see the following references:

- ✓ *MUTCD* (Sections 2A.08 signs & Section 3A.03 pavement markings)
- ✓ Publication 46 (Chapters 2 & 3)
- ✓ Publication 111 (TC-8600, TC-8604, TC-8700C & TC-8702B)
- ✓ Publication 148 (TC-8801 & TC-8803)
- ✓ Publication 149 (Chapter 13)
- ✓ Publication 236
- ✓ Publication 408 (Sections 935, 936, 975, 976, & 1103)
- ✓ Form TE-974

The preventative maintenance activities/scheduling intervals for signs and pavement markings are summarized in **Exhibit 5-8**.

Exhibit 5-8 Preventative Maintenance - Signs and Pavement Markings

Signs and Pavement Markings	Maintenance Intervals		
	6 Months	12 Months	As Required
General Signing			
Check signing for conformance with traffic signal permit, looking for: ▪ Missing signs ▪ Incorrect signs ▪ Improper sign locations ▪ Existing field signal operation-related signs that need added to the permit	X		
Visibly check for damaged or older deficient signs	X		
Clean all signal permit signs (overhead, ground mounted, pedestal)		X	
Check that signs conform to the minimum sign retroreflectivity values in Section 2A.08 of the *MUTCD;* replace signs which do not meet minimum requirements		X	
Check structure mounting hardware to verify signs are properly angled/aimed & are securely fastened; tighten or replace banding as necessary		X	
Check that overhead mounting locations/spacings follow the recommendations provided in Publication 148	X		
Prior to adding additional overhead signs or replacing existing signs with larger sizes: ▪ Verify that the sign structure is capable of accommodating the additional loading (see Publication 149, Chapter 20) ▪ Obtain a required revision of the traffic signal permit			X
Check that ground mounted signs are securely fastened, tighten or replace fastening as necessary		X	
Check ground mounted signs for plumbness, damage to installation, and proper ground anchoring/breakaway connection	X		
Check other intersection & approach traffic control signs to verify that they don't impede or conflict with the operation of the traffic signal under the permit	X		
Internally Illuminated Signing			
Check internally illuminated signs & blank out signs for conformance with traffic signal permit	X		
Verify the transparent reflective sheeting is capable of being internally illuminated and is retroreflective when not energized	X		
For internally illuminated Street Name Signs show approved street name on both faces (double-sided), unless otherwise approved by the Department on the signal permit	X		
Verify that mast arm bracket connections are secure, and that any swing brackets allow the sign to swing freely		X	
Verify drain holes in the bottom of the sign are unobstructed and that no corrosion is present		X	
Inspect wiring from Internally Illuminated Sign to service disconnect box		X	
Inspect entrance junction box to verify a weather-tight seal is still provided to the sign assembly		X	
Inspect photocell and LEDs and replace as necessary		X	
Pavement Markings & Legend Markings			
Check pavement markings and legends for conformance with traffic signal permit, looking for: ▪ Missing markings ▪ Incorrect markings ▪ Improper marking locations ▪ Existing field signal operation-related markings that need added to the permit		X	

Signs and Pavement Markings	Maintenance Intervals		
	6 Months	12 Months	As Required
Restore pavement markings and legends as required.			X
Check that all pavement markings meet minimum marking retroreflectivity values in the Section 3A.03 of the *MUTCD*; replace pavement markings which do not meet minimum requirements			
Check delineation		X	

5.9 Time Clock Flashing Warning Devices

Flashing warning devices that are to be activated during certain time periods shall include a controller with time clock. It is important that these devices operate only when intended. For example, school zone speed limit sign flashers are activated only when school is in session. This enhances the meaning of the school zone speed limit. If the devices flash during non-school hours the device may generate motorist disrespect which in turn could affect the usefulness of other flasher installations.

Basic maintenance responsibilities include, setting clocks, programming a calendar (school, holidays, and specific dates) and disabling the device. When school is not in session (unexpected school closure for reason such as winter weather) school zone flashers shall be disabled.

For addition information related to Time Clock Flashing Warning Devices, see the following references:

- ✓ Publication 148 (TC-8801)
- ✓ Publication 149 (Chapter 15)
- ✓ Publication 236
- ✓ Publication 408 (Section 1103)
- ✓ Form TE-974

The preventative maintenance activities/scheduling intervals for time clock flashing warning devices are summarized in **Exhibit 5-9.**

Exhibit 5-9 Preventative Maintenance – Time Clock Flashing Warning Devices

Time Clock Flashing Warning Devices	Maintenance Intervals		
	6 Months	12 Months	As Required
Verify clock is set to the proper time of day and day of week		X	
Verify flasher is scheduled to operate at the proper times in accordance with the permit		X	
Verify static hours plates are consistent with electronic flashers and the permit, where applicable		X	
Check the total warning device assembly for soundness: ▪ Structural support (pole, anchoring foundation) ▪ Sign mounting hardware ▪ Flasher wiring		X	
If solar powered, check that the solar power system (panel dimensions and battery capacity) is properly sized to provide 24/7 operation: ▪ Check that batteries are in a lockable enclosure. ▪ Check that the design of the enclosure allows batteries to be easily removed and replaced.		X	
If solar powered, replace batteries			Every 3-5 years
Check that all power inputs are protected by fuses or other current limiting devices. If hardwired, check that wiring from sign is connected to a circuit breaker in the electrical service disconnect box.		X	
Verify that both solar powered and hardwired systems shall be able to recover from power loss and return to their operation state independent from user intervention		X	

6. RESPONSE MAINTENANCE

Various components all work together to provide a fully functional traffic signal. Neglecting any one of these components can be detrimental to the safe and efficient operation of the entire traffic signal; therefore, it is important to maintain each and every one of these components.

By following the response maintenance activities and corresponding response & repair intervals for these components as identified in this chapter, the Permittee will help ensure the safe, efficient and proper operation of traffic signals that they own. **Section 6.1** also identifies the difference between a temporary repair versus a final repair. A natural progression of response maintenance, especially if it is repetitive for similar issues, is to forward this information through proper channels as planned improvements or upgrades that may be necessary.

Maintenance staff should carry sufficient inventory supplies (spare parts such as LEDs, controllers, loop amplifiers, conflict monitors, emergency generators, etc.) to address common problems quickly.

While it may not be feasible to maintain an inventory of larger and more expensive equipment, such as mast arms and strain poles, it is prudent to keep necessary supplies that enable the temporary hanging of signal heads if a pole is knocked down. For example, keeping a few signal heads and span & tether wire that could be strung between remaining poles or having access to wooden poles.

When performing the response maintenance activities in this chapter, various publications identified in **Exhibit 1-1** should be consulted and applied by maintenance staff to ensure the integrity of the initially designed and installed traffic signal components are maintained. Each **Chapter 5** sub-section identifies specific references for that particular signal component (supports, controller assembly, etc.); these references also apply to the various components listed in **Section 6.1** as well.

As a general matter, when traffic signal components are replaced, the material and construction specifications in Publication 408 should be followed, and materials and equipment from Publication 35 (Bulletin 15) shall be used. Refer to **Section 1.2.2** for additional information regarding approved traffic control devices.

As identified in **Section 1.3,** the traffic signal permit is the official document issued by the Department for each traffic signal, and it identifies the approved design and operation of the traffic signal. When performing response maintenance activities, reference the signal permit to ensure for compliance.

6.1 Response Maintenance Components

The response maintenance activities and their corresponding response and repair intervals for the various traffic signal components are summarized in the following seven exhibits:

- **Exhibit 6-1** Supports
- **Exhibit 6-2** Controller Assembly
- **Exhibit 6-3** Systems & Communications
- **Exhibit 6-4** Electrical Distribution
- **Exhibit 6-5** Signal Heads
- **Exhibit 6-6** Detectors
- **Exhibit 6-7** Advanced Traffic Signal Technology
- **Exhibit 6-8** Signs & Pavement Markings
- **Exhibit 6-9** Time Clock Flashing Warning Devices

Terminology associated with these seven exhibits is as follows:

- Business Hours: Monday through Friday, 7:00 AM to 5:00 PM, excluding state holidays, or as defined within a Traffic Signal Maintenance Agreement, Exhibit D (see **Section 2.1**)
- Non-Business Hours: Any time not during Business Hours as defined above

- Response Maintenance: see **Section 4.1.2**
- Response Interval: The duration of time between when either the signal owner or its contractor receives notification of a traffic signal malfunction(s) and the time in which the appropriate response staff arrives on-site to address the malfunction(s). For those components with a 2-hour response time, a longer response time may be justified due to extenuating circumstances such as a regional emergency, or exceptions previously agreed upon with the local PennDOT Engineering District.
- Repair Interval: The period of time in addition to the Response Interval for which to implement Temporary and/or Final Repairs depending on the type of malfunction experienced.
  - Temporary Repair: Use of temporary means or modes to temporarily restore the traffic signal to safe operations until Final Repairs can be completed. As a minimum, traffic signals should be set to operate in flashing mode, and not be left in an unlighted condition. For long term signal outages where sustained flashing mode is not possible, alternative traffic control methods need to be coordinated with the appropriate Engineering District.
  - Final Repair: The completed repair or replacement of failed components to restore the traffic signal to proper and safe operation in accordance with the approved traffic signal permit. Final repairs shall be completed as soon as possible within the time specified, unless a formal request for a time extension is agreed upon by the local Department Engineering District for reasons such as inability to complete repairs due to weather conditions, component fabrication constraints, or equipment availability.

Exhibit 6-1 Response Maintenance - Supports

Component	Response Intervals			Repair Intervals			
	Business Hours	Non-Business Hours		Temporary Repair		Final Repair	
Support Structures (Mast Arm, Strain Poles, Pedestals, or Wood Poles)	2	4	hours	24	hours	30	days
Span Wire	2	4	hours	-	-	24	hours
Foundation	2	4	hours	24	hours	30	days
Anchor Bolts	2	4	hours	24	hours	30	days
Guy Wire	2	4	hours	24	hours	30	days
Grounding/Bonding	2	4	hours	24	hours	30	days
Pedestrian Stub Pole	24	72	hours	24	hours	30	days
Mounting Hardware	24	72	hours	24	hours	30	days
Tether Wire	24	72	hours	24	hours	30	days
Hand Hole Covers	24	72	hours	24	hours	30	days

Exhibit 6-2 Response Maintenance – Controller Assembly

Component	Response Intervals			Repair Intervals			
	Business Hours	Non-Business Hours		Temporary Repair		Final Repair	
Local Controller	2	4	hours	24	hours	30	days
Conflict Monitor	2	4	hours	-	-	24	hours
Flasher Unit	2	4	hours	24	hours	30	days
Load Switches	2	4	hours	24	hours	30	days
Power Supply	2	4	hours	24	hours	30	days
Relays	2	4	hours	24	hours	30	days
Radio Frequency Interference (RFI)	2	4	hours	24	hours	30	days
Surge Protection	2	4	hours	24	hours	30	days
Grounding	2	4	hours	24	hours	30	days
Traffic Optimization Processor (adaptive)	2	4	hours	24	hours	30	days
Cabinet	48	72	hours	24	hours	30	days
Time Clock	48	72	hours	24	hours	30	days

Exhibit 6-3 Response Maintenance – Systems & Communications

Component	Response Intervals			Repair Intervals			
	Business Hours	Non-Business Hours		Temporary Repair		Final Repair	
Master Controller	24	72	hours	24	hours	30	days
Time-Based Coordinator Unit	24	72	hours	24	hours	30	days
Modem	24	72	hours	24	hours	30	days
Ethernet/Ethernet Bridge	24	72	hours	24	hours	30	days
Managed Network Switch	24	72	hours	24	hours	30	days
Transmitter/Receiver	24	72	hours	24	hours	30	days
Antennas	24	72	hours	24	hours	30	days
Cables/Connections	24	72	hours	24	hours	30	days
Mounting Hardware	24	72	hours	24	hours	30	days
Server	24	72	hours	24	hours	30	days
Systems Software	24	72	hours	24	hours	30	days
Communications System	24	72	hours	24	hours	30	days

Exhibit 6-4 Response Maintenance – Electrical Distribution

Component	Response Intervals			Repair Intervals			
	Business Hours	Non-Business Hours		Temporary Repair		Final Repair	
Wire and Cable	2	4	hours	-	-	24	hours
Electrical Service	2	4	hours	24	hours	30	days
Wire Connectors	2	4	hours	-	-	24	hours
Ground Bushings and Lugs	2	4	hours	24	hours	30	days
Ground Rods	2	4	hours	-	-	24	hours
Generator Adaptor Kit	2	4	hours	24	hours	30	days
Battery Back-up/Uninterrupted Power Supply (UPS)	2	4	hours	24	hours	30	days
Conduit	48	72	hours	24	hours	30	days
Junction Boxes	48	72	hours	24	hours	30	days
Service Receptacle	72	72	hours	24	hours	30	days

Exhibit 6-5 Response Maintenance – Signal Heads

Component	Response Intervals			Repair Intervals			
	Business Hours	Non-Business Hours		Temporary Repair		Final Repair	
Signal Housings	2	4	hours	-	-	24	hours
Vehicle and Pedestrian Indications	2	4	hours	-	-	24	hours
LED Indication Visibility – caused by snow buildup in housing	2	4	hours	-	-	24	hours
Optically Programmed Signal Heads	2	4	hours	-	-	24	hours
Lane Use Control Signal Heads	2	4	hours	-	-	24	hours
Backplates	48	72	hours	24	hours	30	days
Mounting Hardware	24	72	hours	24	hours	30	days

Exhibit 6-6 Response Maintenance - Detectors

Component	Response Intervals			Repair Intervals			
	Business Hours	Non-Business Hours		Temporary Repair		Final Repair	
Sensor Amplifier	2	4	hours	24	hours	30	days
Vehicle Detection System (Loop, Video, etc.)	2	4	hours	24	hours	30	days
Pedestrian Push Buttons	48	72	hours	24	hours	30	days
Accessible Pedestrian Signals (APS)	48	72	hours	24	hours	30	days
Emergency Vehicle Preemption Systems	48	72	hours	24	hours	30	days
Railroad Preemption System	2	4	hours	24	hours	30	days
Ramp and Queue Preemption System	2	4	hours	24	hours	30	days
Transit Priority Systems	48	72	hours	24	hours	30	days

Exhibit 6-7 Response Maintenance – Advanced Traffic Signal Technology

Component	Response Intervals			Repair Intervals			
	Business Hours	Non-Business Hours		Temporary Repair		Final Repair	
Adaptive System – response to automated trigger alarm (for failure of an adaptive system component: detectors, communications, hardware, or software)	2	4	hours	24	hours	30	days

Exhibit 6-8 Response Maintenance - Signs & Pavement Markings

Component	Response Intervals			Repair Intervals			
	Business Hours	Non-Business Hours		Temporary Repair		Final Repair	
Internally Illuminated and Blank Out Signs	2	4	hours	24	hours	30	days
Signal Permit Signs	2	4	hours	24	hours	30	days
Pavement Markings & Legends	48	72	hours	24	hours	30	days
Delineation	72	72	hours	24	hours	30	days
Other Traffic Control Signs	48	72	hours	24	hours	30	days

Exhibit 6-9 Response Maintenance – Time Clock Flashing Warning Devices

Component	Response Intervals			Repair Intervals			
	Business Hours	Non-Business Hours		Temporary Repair		Final Repair	
Time Clock	24	72	hours	24	hours	30	days
FWD Schedule/Programming	24	72	hours	24	hours	30	days
FWD Operation	24	72	hours	24	hours	30	days
FWD Assembly (support, hardware, etc.)	24	72	hours	24	hours	30	days
FWD Networking (school zone flashers)	24	72	hours	24	hours	30	days

6.2 Customer Service

6.2.1 PennDOT/Municipal Partnership

Traffic signal permittees (typically municipalities) are responsible for the maintenance and operations of their traffic signals per the conditions of their traffic signal agreements and permits with the Department. It is a common misconception by the general public that PennDOT owns, maintains, and ultimately operates traffic signals. Even though this misconception exists, it is PennDOT's intent to partner with signal owners to

provide timely and through customer service when addressing public concerns/issues of maintenance and operations.

6.2.2 Customer Service Tools

PennDOT provides two customer service platforms that the traveling public can utilize to share their concerns regarding traffic signal maintenance and/or operations:

1. 1-800-FIX-ROAD: Toll free hotline that connects callers directly to their local PennDOT County Maintenance Office to report maintenance concerns on state roads such as potholes, signage issues, signal concerns, etc. It is not used to report traffic accidents, disabled vehicles, or other emergencies as those calls are addressed with the 911 system.
2. Customer Care Center (CCC): Online resource to identify and describe maintenance concerns. There is a "Traffic, Signs, or Signals" concern type that may be chosen to record signal related concerns. From there, the customer can specifically identify that their concern is related to signals and is then able to record the location of the concern on an interactive map and add explanatory details.

Permittees are encouraged to publicize contact information for complaints and keep records of those received.

6.2.3 PennDOT Customer Service Process

The CCC is PennDOT's clearinghouse to receive, process and follow-up on all maintenance concerns regardless of source or method used, such as telephone (including 1-800-FIX-ROAD), letter, and police condition report. All concerns called into 1-800-FIX-ROAD shall be entered into the CCC as they are received. Reference PennDOT's Publication 23 (Chapter 24 – Highway Maintenance Customer Service Handling) for additional details regarding the process and roles for highway maintenance customer service handling.

For concerns identified as being related to traffic signals, a member of the District Traffic Unit shall be assigned the Responsible Person who will take action to address the concern regardless of who owns and maintains the traffic signal(s). It is recommended that each District provide their District CCC Coordinator with the name of at least one individual in their Traffic Unit who can be directly assigned as the Responsible Person for traffic signal concerns. The Responsible Person should make the initial customer contact within two working days of the "Received Date" listed for the concern record, as per Chapter 24 of Publication 23.

To ensure resolution and to provide the customer with quality feedback, the following steps are recommended to complete the review process for concerns related to a traffic signal:

- ✓ If additional information on the concern is needed, then contact the customer to discuss the concern in detail.
- ✓ Check if any current or future Department projects are planned for the intersection of concern.
- ✓ Contact the traffic signal permittee to discuss the concern and obtain information on the intersection as needed. If appropriate, inform the permittee that there is a traffic signal concern that they need to address and establish a timeframe for resolution. This established timeframe may require the "Estimated Completion Date" to be revised; see Section 24.7 of Publication 23, Chapter 24. The Responsible Person should use the "History" field (in a concern's "Problem Assignment/Work Progress" area) to document their correspondence.
- ✓ Once a concern is resolved and considered closed, the Responsible Person can close the concern by following the process outlined in Section 24.11 of Publication 23, Chapter 24. The Responsible Person is encouraged to attach applicable written correspondence or documentation within the CCC system.

7. ASSET MANAGEMENT

7.1 Traffic Signal Asset Management System (TSAMS)

PennDOT's Traffic Signal Asset Management System (TSAMS) is an internet-based database to capture and maintain traffic signal asset related data for all traffic signals in Pennsylvania.

There are two TSAMS modules for each asset, an Inventory Module and a Maintenance Module:

- ✓ **TSAMS Inventory Module** – a repository of assets, with details of major components and subcomponents. The Inventory Module provides a snapshot of current components and subcomponents and retains a history of removed components.
- ✓ **TSAMS Maintenance Module** – a history of asset-related activities providing information on the maintenance that has been performed, including what changes were made, who made the changes, how it was done, and why it was done

7.1.1 Background and Purpose

Historically, District offices and permittees collected and maintained various types of isolated data related to traffic signal assets. The data was locally managed using various databases, workbooks, and/or hard copy files. The purpose of TSAMS is to facilitate a centralized, user friendly, universal system that will benefit various stakeholders.

TSAMS stakeholders are:

- ✓ Traffic Signal Permittees (Municipalities and other Local Authorities)
- ✓ PennDOT Central Office & District personnel
- ✓ Planning Partners
- ✓ Signal Maintenance Contractors
- ✓ Signal Construction Contractors
- ✓ Traffic Signal Design Consultants
- ✓ Traffic Signal Operations Consultants

Benefits

Standardized asset management can facilitate the following traffic signal stakeholder activities:

- ✓ Municipal budgeting for maintenance and capital upgrades
- ✓ Municipal management of operations for traffic signal and traffic signal systems
- ✓ Municipal, county, and planning partner collective long-range planning efforts
- ✓ PennDOT administration of the Green Light-Go (GLG) and Automated Red Light Enforcement (ARLE) funding programs
- ✓ PennDOT reporting of statewide traffic signal asset needs and trends
- ✓ PennDOT evaluation of product performance and reliability to maintain the Approved Products List in Bulletin 15
- ✓ And more…

Equal access to standardized traffic signal data will provide stakeholders with the ability to holistically monitor and analyze the current state of traffic signal assets in Pennsylvania.

By working together to better understand the current state of the statewide traffic signal assets, stakeholders can help to make Pennsylvania traffic systems safer, more reliable, and less costly by ensuring that traffic signal assets receive regular preventative maintenance and that regional resources are effectively allocated towards the most pressing needs.

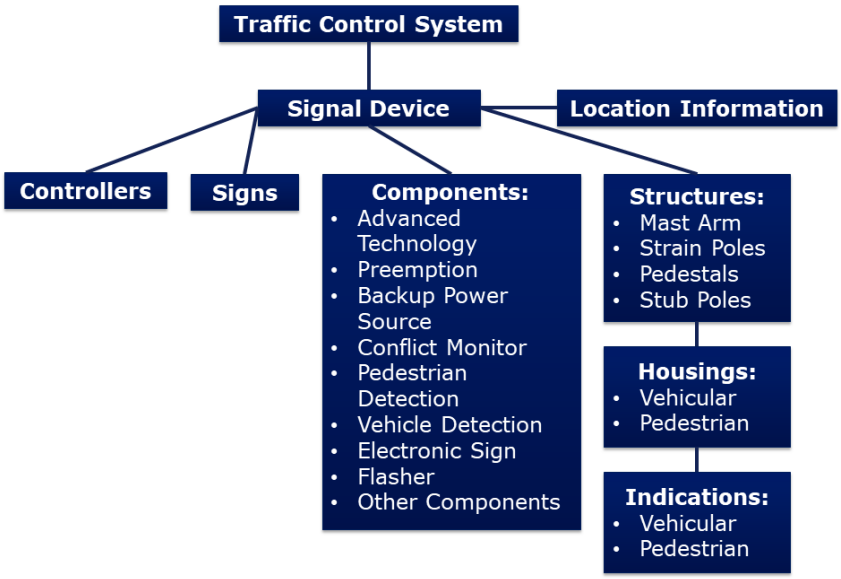
An important additional benefit of the TSAMS centralized system is the ready access to relevant data for user groups such as Central Office, Engineering Districts, Municipalities, Planning Partners, and Practitioners. For example, instead of having Districts and Municipalities handling the regular stream of traffic signal permit and information requests, planning partners and practitioners are able to directly view and download the relevant data from TSAMS (such as permits, current signal cabinet photos, equipment information, and more) entirely on their own.

TSAMS Asset Inventory Data Module

The TSAMS Inventory Module of the database includes existing traffic signal inventory data and related traffic signal documents. The system provides the ability to create new signal records or edit existing signal records. It also provides the ability to attach documents to each signal record.

The database provides traffic signal stakeholders the ability to identify the components of each signal and its attributes. **Exhibit 7-1** is a flowchart depicting the entry hierarchy for traffic signal components detailed in the database.

Exhibit 7-1 TSAMS Data Hierarchy



When selecting components for a signal record, the values (components and attributes, including cost information) available for selection come from an approved product database. Preapproved items in the database can be added, modified or deleted by request to the PennDOT TSAMS administrator.

Additionally, records for other signaling devices are similarly inventoried in TSAMS. These are referred to in TSAMS as "Non-Signals" and include:

- ✓ Intersection Control Beacon
- ✓ Electronic Sign
- ✓ Rectangular Rapid Flashing Beacon (RRFB)
- ✓ Flashing Warning Device
- ✓ Pedestrian Crossing Flashing Warning Device
- ✓ Roundabouts
- ✓ Ramp Meter
- ✓ In-Roadway Warning Lights
- ✓ School Area Flashing Warning Device
- ✓ School Zone Speed Limit Sign

The attachments which accompany the TSAMS database signal records fall into ten major categories and may include (as applicable):

- ✓ **Agreements**
  - Traffic Signal Maintenance Agreements
  - Memorandum of Understanding
  - Form TE-160 (Application for Traffic Signal Approval)
  - Form TE-952P (Application for Permit to Operate Temporary Traffic Control Signals)
- ✓ **Permits**
  - Form TE-964 (Traffic Signal Permit, Sheet 1)
  - Traffic Signal Permit Plans
  - Coordination Plans
  - System Permit Plan
  - Form TE-670 (Flashing Warning Device Permit)
  - Flashing Warning Device Permit Plans
- ✓ **Correspondence**
  - Correspondence related to permit issuance and revision
  - Complaints from the citizens and supporting documents
- ✓ **Design Documents & Drawings**
  - Construction Plans
  - CADD/MicroStation files
  - Americans with Disabilities Act (ADA) documents
  - Emergency preemption supporting documents
  - Product approval detailed design specifications
  - Product approval independent test reports
  - Shop drawings
  - Form TE-152 (Traffic Signal Proprietary Item Analysis Engineering and Traffic Study)
  - Form TE-153 (Pennsylvania Adaptive Signal Control System Evaluation)
  - Traffic Counts
  - Traffic Signal Design Report
- ✓ **Studies**
  - Clearance time calculations
  - Left turn phasing calculations
  - Turn lane evaluations
  - Form TE-110 (Turn Restrictions Engineering and Traffic Study)
  - Form TE-118 (No Turn on Red Restriction Study)
  - Form TE-150 (Traffic Signal Warrant Analysis)
  - Form TE-672 (Pedestrian Needs Accommodation at Intersection Checklist)
- ✓ **Traffic Analysis**
  - Capacity Analysis results output/worksheets
  - Capacity analysis models (Synchro, SimTraffic, HCS)
  - Timing Evaluations
- ✓ **Financials** (not currently in TSAMS but may be included in the future)
  - Schedule and budget documentation
- ✓ **Photographs**
  - Photographs of the intersection
  - Photographs of the equipment

TSAMS Asset Maintenance Data Module

The TSAMS Maintenance Module of the database includes the following Maintenance Functional Areas: maintenance operations, component maintenance, and custom maintenance components.

Maintenance records for each component will include:

- ✓ Date
- ✓ Start Time/End Time
- ✓ Repair Technician
- ✓ Maintenance Type
- ✓ Maintenance Task
- ✓ Equipment Used
- ✓ Adding New Components
- ✓ Removing Components
- ✓ Updating Existing Components Data
- ✓ Associated Costs

The attachments which may accompany the TSAMS signal maintenance records include (as applicable):

- ✓ Activities (not currently in TSAMS but may be included in the future)
  - Master intersection record
  - Preventative maintenance documentation
  - Response maintenance documentation
  - Form TE-974 (Design Modification Checklist)
  - Maintenance supporting documents and records
  - Inspection punch lists
- ✓ Photographs
  - Photographs of the intersection
  - Photographs of the equipment

7.1.2 TSAMS Stakeholder Roles

To accurately manage the over $1 Billion (in 2020 dollars) in traffic signal assets statewide and to make informed decisions regarding the operation, maintenance, and budgeting for those assets requires decisions based on quality data. Ensuring the quality and sustainability of data and information included in the TSAMS database depends on having a systematic approach to collecting, analyzing, and using this information. Signals, systems, and the corresponding traffic signal asset data are a shared responsibility requiring multi-jurisdictional cooperation and input of local municipalities, PennDOT, planning organizations, and other stakeholders.

Data Quality Control: Stakeholder Access Controls

To ensure the quality of the traffic signal asset data in the TSAMS database, PennDOT has established database security using Role-Based Access Controls (RBAC) through ECMS. The roles define which system functionality each TSAMS user can access, what data each TSAMS user can view, and what data each TSAMS user can enter or modify. Entries and changes to the database made by stakeholders with ECMS privileges will be routed through a quality assurance "protocol" depending on the nature of the entry and the RBAC clearance of the stakeholder.

Access to TSAMS is controlled by user IDs, passwords, and roles:

- ✓ Every TSAMS user (other than "guest users") will have a User ID from the PennDOT Engineering Construction Management System (ECMS), which currently provides security for many PennDOT systems
- ✓ Passwords are maintained by TSAMS users in ECMS, and logging into TSAMS requires a correct User ID and password combination
- ✓ Each User ID will be assigned at least one user role in the TSAMS system

As stated above, traffic signal stakeholders gain access to the TSAMS database through their ECMS account. Users who already have ECMS access to other PennDOT programs, but not TSAMS, will need to submit a request to their organization's ECMS Security Administrator for an adjustment to their ECMS privileges. Generally, users who do not currently have ECMS access must fill out the appropriate ECMS application forms.

For certain situations, a contractor may need temporary/short-term access to TSAMS to create or modify TSAMS records as part of a construction project. These users do *not* need to gain access to TSAMS through ECMS. They should instead register as a "guest user". Guest users can only make proposed edits to TSAMS records. These proposed edits must be approved by District Personnel to become permanent.

Additional information about accessing TSAMS as a registered ECMS user or as a guest user can be found in the TSAMS Access Guide in the key links section of the TSAMS log-in webpage.

Data Sustainability: Stakeholder Responsibilities for Entering & Maintaining Data

With the introduction of TSAMS, the recordkeeping associated with traffic signal assets has been centralized, thus facilitating the timely sharing of recordkeeping with the Department.

- ✓ The Traffic Signal Maintenance Agreement and Form TE-160 (Application for Traffic Signal Approval) require accurate and up-to-date recordkeeping as an essential component of traffic signal maintenance
- ✓ Act 89 (Title 74 Chapter 92) requires that traffic signal owners maintain traffic signals and update signal timings in accordance with these agreements
- ✓ Title 74 Chapter 92 requires that all traffic and intersection data for critical corridors be provided to the Department in a timely manner

To ensure the database remains current, and thus useful for decision making, stakeholders must make timely updates and entries into TSAMS. While the long-term goals of the Department include the data entry and data maintenance for all applicable TSAMS data fields and attachments in both the Inventory Module and Maintenance Module, the Department understands that, at this point in time, not all stakeholders have systems and processes designed to maintain all of the TSAMS data fields.

As such, the Department will provide a phased expansion of data entry and maintenance requirements for stakeholders, starting with the following initial TSAMS data responsibilities:

- ✓ **PennDOT District Personnel are responsible for ensuring that all signals within their respective District Boundaries have a record in TSAMS** and that the associated status, traffic signal permits, maintenance agreements, and TE-160's are current.
    - **Traffic Signal Status -** PennDOT District Personnel are responsible for updating the traffic signal status of the record in TSAMS (planned, testing, operational, etc.).
    - **Traffic Signal Permits -** PennDOT District Personnel are responsible for uploading current, approved traffic signal permit document into TSAMS at the time the permit is issued.
        - Signal Owners are still responsible for creating, updating, and securing PennDOT approval of the traffic signal permit documents (outside of the TSAMS context).
    - **TE-160's & Maintenance Agreements -** PennDOT District Personnel are responsible for uploading current, approved TE-160's and maintenance agreements into TSAMS at the time the TE-160's and agreements are executed.
        - Signal Owners are still responsible for creating, updating, and securing PennDOT execution of the TE-160's and maintenance agreements (outside of the TSAMS context) as described in **Chapter 2**.

- ✓ **PennDOT District Personnel are also responsible for reviewing and approving the proposed edits to TSAMS records (made by guest users) for the signals within their respective District Boundaries.**
- ✓ **Signal Owners (or their designated representatives) are responsible for uploading current traffic signal cabinet photos** (i.e. photos displaying the equipment inside the cabinet) for the signals under their ownership, within one week of any cabinet updates.

Specific funding programs may require the maintenance of additional TSAMS data. Stakeholders are strongly encouraged to enter and maintain more TSAMS data fields than what is currently required under these initial TSAMS data responsibilities.

Examples of the Data Responsibilities in Practice

The processes summarized on the following pages provide some examples of how and when the TSAMS data responsibilities should be effectively carried-out by the appropriate stakeholders.

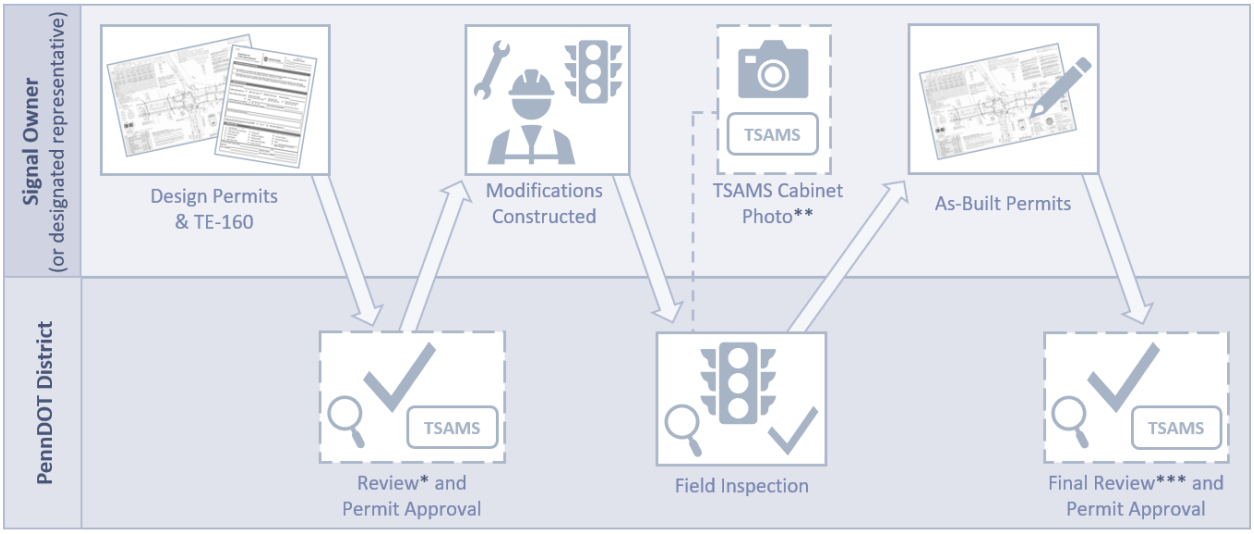
Did you know?

Because TSAMS is a web application, it is available anywhere there is access to the internet. Data can be entered using desktop, laptop, tablet, and cellular devices. This allows data to be updated when technicians are in the field making modifications to signals.

Traffic Signal Permit Modification Process

Exhibit 7-2 shows a summary of TSAMS data responsibilities when a Signal Owner (or their designated representative) wants to modify a traffic signal such that the current, approved traffic signal permit is no longer consistent with field conditions.

Exhibit 7-2 TSAMS Data Responsibilities during the Traffic Signal Permit Modification Process Flowchart

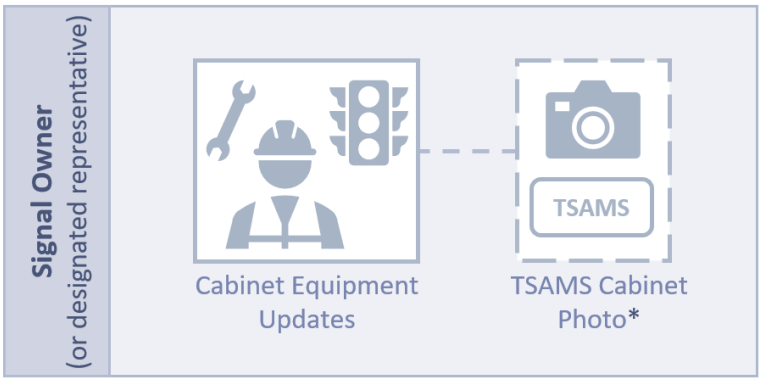


*The District uploads planned permits & TE-160 to TSAMS upon approval.
**The Permittee (or their designated representative) uploads a traffic signal cabinet photo to TSAMS during the District Field Inspection.
***The District uploads as-built permits to TSAMS upon approval.

Traffic Signal Cabinet Equipment Update

Exhibit 7-3 shows a summary of TSAMS data responsibilities when any preventative or response maintenance performed by the Signal Owner (or their designated representative) results in visual modifications to the inside of the traffic signal cabinet.

Exhibit 7-3 TSAMS Data Responsibilities during the Traffic Signal Cabinet Equipment Update Process Flowchart



*The Permittee (or their designated representative) uploads a traffic signal cabinet photo to TSAMS within one week of the update.

7.2 Documentation

Documentation is important for several reasons:

- Maintenance records are critical to ensure that traffic signal maintenance is performed at regular intervals
- Documentation of a traffic signal's equipment and operation may make future upgrades to the signal much easier and allows for sharing of information. Other public agencies may occasionally request this documentation, especially for nearby projects involving traffic signal installations or upgrades to ensure compatibility between traffic signals and having up-to-date plans with signal equipment/timing information helps ensure accuracy and allows for ease of information exchange.
- Historical measures of effectiveness (MOEs) can help justify appropriate changes in the traffic signal budget

7.2.1 Documentation Types

Regardless of the appropriate traffic signal maintenance and operations classification and/or how it's performed, one important but often neglected requirement of traffic signal maintenance is keeping relevant and up-to-date documentation. The records necessary for effective traffic signal maintenance fall into four basic categories: Maintenance Service Records, Signal Timing Charts, Traffic Signal Permit, and Maintenance Manuals/As-Built Plans. Some examples of traffic signal documentation include but are not limited to wiring schematics, controller time settings, software, conflict monitor programming sheet, manuals, technical publications, maintenance records, etc.

Maintaining up-to-date traffic signal maintenance records can help provide efficient service, detect and correct recurring problems, develop future maintenance schedules and strategies, and may protect a permittee from a tort liability claim. The following are types of traffic signal records that should be kept when managing maintenance activities:

- **Master Intersection Record** – list of all maintenance functions performed at the intersection, which should be updated within one day of the activity but no more than one week later
- **Preventative Maintenance Record** – a log for each preventative maintenance service that includes the date, tasks performed, and signatures of personnel performing the work
- **Response Maintenance Record** – a log recording the location, date, time, caller, receiver and complaint received, maintenance personnel, time dispatched, trouble found, and time cleared

- **Design and Operation Review Record** – a record of recurring maintenance problems, conformance with the approved plan, conformance with federal/state standards and state-of-the-art features, and compatibility with prevailing traffic demands and physical conditions of the approved traffic signal permit

7.2.2 Documentation Methods

A copy of all traffic signal records should be kept within TSAMS, either through direct entry of data into electronic forms in TSAMS or via attachment of paper documentation in TSAMS.

In the past, it was recommended to maintain paper records in the traffic signal cabinet. However, paper records should be digitized and imported to TSAMS to eliminate paper records, which has the following benefits:

- ✓ Paper records in field cabinets can be destroyed by insects and critters
- ✓ Paper records may be destroyed by disasters including severe weather and vehicle crashes
- ✓ Cabinet-based records only reflect work done while onsite and do not reflect remote changes, and field technicians may be missing relevant information when diagnosing problems
- ✓ Paper records may not be accessible during emergency situations when travel to the site is restricted

7.3 Attaching Other Equipment on Traffic Signal Structures

Traffic signal permittees may receive requests to install other equipment to traffic signal structures which is not directly associated to the function of operation of the traffic signal, including, but not limited to, security cameras, cellular antennas, and automated license plate readers. This policy is established to ensure the following:

- ✓ Additional equipment does not exceed the structural capacity of the traffic signal structures
- ✓ Additional equipment does not interfere with the traffic signal operation or create a distraction for drivers

7.3.1 Request Procedure

The following procedure shall be followed to request placement of other equipment on traffic signal structures.

Step 1: Notify the Department

The Department requires that the permittee considering other equipment on traffic signal structures contact the appropriate PennDOT District Traffic Engineer to discuss the request. The PennDOT District Traffic Engineer shall ensure the permittee is aware of the process described herein. Potential concerns should be discussed at this stage prior to developing and submitting a formal request.

Step 2: Submit a Request to the Department

The permittee shall submit the following to the appropriate PennDOT District Traffic Engineer:

- ✓ Contact information for the owner of the equipment to be installed on the traffic signal structure
- ✓ A letter from the permittee specifying the purpose and justification of the request, approval by the permittee of the request, and a statement indicating the equipment will not interfere with the operation identified on the traffic signal permit.
- ✓ Documentation that the other equipment on traffic signal structures will not cause confusion or distraction to any motorist. If it is determined after placement the other equipment creates confusion or is a driver distraction, it shall be removed immediately.

- ✓ An engineering study of the equipment placement, structural adequacy of the existing traffic signal structure, ADA accessibility, operational verification with relation to the traffic signal permit, and other appropriate evaluations needed to ensure the appropriate placement of the other equipment on the traffic signal structure. *Note: if structural adequacy cannot be verified then a new traffic signal support will need to be provided along with supporting calculations.* All engineering studies must be performed by a professional engineer licensed in the Commonwealth of Pennsylvania.
- ✓ Construction plans that provide location, connections, and other key information needed to connect to the traffic signal structure.
- ✓ A Highway Occupancy Permit if any additional adjustments such as placement of other equipment within the state highway right-of-way are required other than attaching to a traffic signal structure.
- ✓ If the permittee is requesting third party equipment that it would not own, then the following additional information would need to be provided:
    - A pole attachment agreement between the traffic signal permittee and the third party, which addresses the following:
        - Term of the agreement
        - Placement length
        - Construction
        - Third party contact information
        - Maintenance and operations plan
        - Access to the other traffic signal equipment
        - Relocation/replacement responsibility if the traffic signal structure is relocated or replaced by the traffic signal permittee or the Department
    - A letter from the third party verifying the other equipment will not affect the operation of the traffic signal
    - Equipment details, deployment purpose, placement information, design details, design notes, construction details, equipment grounding, and other information needed to successfully deploy the other equipment on the traffic signal structure

No devices shall be installed on the traffic signal structure unless approved by the appropriate PennDOT District Traffic Engineer.

Step 3: Department Review

The Department will review the request and provide the permittee with a written response from the District Traffic Engineer indicating one of the following:

- Approval of the request
- Rejection of the request with justification
- Request for additional information to be provided for further review

If additional information is requested, the permittee and the Department will continue to work together through the comments or additional information requests like any other traffic signal permit update request.

7.3.2 Permanent Documentation of Other Equipment

The engineering study for the other equipment shall be uploaded to TSAMS so it is included in future structural calculations related to equipment on the same traffic signal structure. Upon completion of construction of other equipment within an intersection, the owner shall upload updated photographs of the intersection that includes the other equipment.

Districts may require the traffic signal permit plan to be updated to include other equipment to ensure the permit can be used enforce requirements related to the location and operation of the other equipment.

8. TRAINING RECOMMENDATIONS

8.1 General

Training provides technical skills needed to effectively use and maintain and operate traffic signals. Training should reflect the actual need of the agency and its personnel. As traffic signals and their systems become more sophisticated, additional training may be warranted. If untrained personnel are used to maintain traffic signals there could be problems that are not identified, which could cost the permittee more in the long run.

Training also provides exposure to new hardware, software and concepts to help agencies stay on the leading technological edge.

Training is also available from traffic signal equipment suppliers. It is desirable to require equipment suppliers to commit an appropriate number of hours to train Department, permittees and maintenance contractors on the proper adjustments and operation of the new equipment. The session should include theory of operation, field adjustment/calibration to accommodate day-to-day operation, preventative maintenance, diagnostic software, and repair. This is a good way to incrementally expand personal knowledge.

8.2 PennDOT Traffic Signal Training Courses

PennDOT offers a variety of traffic signal training courses. Information on these are listed below and can be found on the Traffic Signal Portal.

8.2.1 Introduction to Traffic Signals Course

The Introduction to Traffic Signals self-study provides an overview of traffic signal procedures to Department personnel, municipal officials, planning partners, contractors, developers, consultant engineers, and other traffic signal stakeholders. This course is intended to be a high-level overview of various traffic signal items. The main emphasis is to provide an overview of the lifecycle of a traffic signal from initiation, warrants, design, operation and maintenance.

Participants will understand the various laws, regulations, standards, policy, and guidance information provided by the Department along with understanding the various components of a traffic signal. The course also serves as a refresher for experienced staff or as an introduction to additional subjects related to traffic signals outside of their current job duties.

At the end of this course, you will be able to:

- ✓ Locate and navigate the various publications related to traffic signals in Pennsylvania
- ✓ List the steps within a traffic signal agreement between the Department and other agencies
- ✓ Perform a partial traffic signal warrant analysis
- ✓ Identify various traffic signal components used in the field
- ✓ List the items in a typical traffic signal plan set
- ✓ Define common traffic signal timing and phasing terminology
- ✓ Define asset management and list the different types of traffic signal maintenance

8.2.2 Traffic Signal Design Course

The Traffic Signal Design self-study is designed to enable the participants to obtain an understanding of the fundamental concepts and PennDOT standard practices related to the design of traffic signal systems within the Commonwealth of Pennsylvania. This course is structured to parallel the progression of decisions, activities and functions related to the design of traffic signal systems.

Participants will understand the various laws, regulations, standards, policy, and guidance information provided by the Department along with understanding the various components of a traffic signal. The course

also serves as a refresher for experienced staff or as an introduction to additional subjects related to traffic signals outside of their current job duties.

At the end of the course, participants will be able to:

- ✓ List the steps required to plan, design, and implement a signalized intersection
- ✓ Devise an appropriate data collection plan for planning, designing, and operating a signalized intersection
- ✓ Perform a warrant analysis using the MUTCD warrants, including PennDOT warrants
- ✓ Design basic phasing of the intersection – which movements will get a separate phase, and how they are numbered
- ✓ Determine location of signal supports, displays and detection
- ✓ Design the electrical distribution system for an intersection
- ✓ Select signal-related signs and pavement markings, including turning-movement signs, stop bars and crosswalks
- ✓ Create a traffic signal design report

8.2.3 Construction and Inspection Course

The Traffic Signal Construction and Inspection self-study addresses compliance with the applicable traffic signal construction documents (specifications, plans, standard drawings, etc.). Inferior work on signals or inadequate traffic management during project construction can create potentially dangerous conditions with liability impacts for local agencies. The purpose of this course is to introduce traffic signal construction and inspection issues.

Upon completion of the course, participants will be able to:

- ✓ Locate applicable Traffic Signal Catalog Cuts
- ✓ Describe the applicable Traffic Signal Proprietary Approvals
- ✓ List the Traffic Signal Product Approvals process
- ✓ List the important specification sections of Publication 408 and its requirements
- ✓ Understand and navigate Publication 669
- ✓ Traffic Signal Testing procedures
- ✓ Develop and modify a Traffic Signal Inspection Form

8.2.4 Maintenance and Operations Course

This PennDOT Traffic Signal Maintenance and Operations self-study was created from a need to understand that the congestion and delays that exist on our streets and roadways can be better managed with a thorough understanding of effective traffic signal operations and maintenance. Well maintained and operated traffic signal control projects are essential to this process. This course will focus on the proper elements of a well maintained and operated traffic signal system. The course is divided into two primary parts: Traffic Signal Operations and Traffic Signal Maintenance.

At the end of this Traffic Signal Operations and Traffic Signal Maintenance course, you are able to:

- ✓ List the types of traffic signal maintenance classifications
- ✓ Create the types of documents required for maintenance
- ✓ Describe typical maintenance activities
- ✓ Develop a traffic signal maintenance agreement
- ✓ Design basic phasing of the intersection
- ✓ Devise an appropriate data collection plan operating a signalized intersection
- ✓ Calculate signal timing for both actuated and coordinated operational strategies, including pedestrian clearance intervals
- ✓ Implement traffic signal timing and phasing plans

8.3 Local Technical Assistance Program (LTAP) Opportunities

The Pennsylvania Local Technical Assistance Program (LTAP) was created to share transportation knowledge, improve road maintenance and safety skills, and put research and new technology into practice at the municipal level.

The PennDOT Local Technical Assistance Program (LTAP) is one of 58 LTAP centers across the nation (one in each state, Puerto Rico and seven regional centers serving American Indian tribal governments.) These centers are dedicated to transferring transportation technology through training, technical assistance, and other customer services to municipal elected officials and their staff. The LTAP program is designed to help Pennsylvania's municipalities, which maintain over 77,000 miles of roadways, make the best use of their roadway maintenance dollars. PennDOT LTAP provides technical information and proven technologies dealing with roadway maintenance and safety methods to meet the growing demands on municipal governments. PennDOT LTAP has provided technology transfer services to Pennsylvania's 2,560 municipal governments since 1983.

8.4 IMSA Training

The International Municipal Signal Association (IMSA) offers various training and certification courses (see **Exhibit 8-1**). At a minimum, IMSA Work Zone Traffic Control Safety Certification (or LTAP's Temporary Traffic Control Training) and IMSA Traffic Signal Level 1 Training should be completed to effectively understand the traffic signal maintenance activities. IMSA Traffic Signal Level 2, IMSA Traffic Signal Level 3, IMSA Traffic Signal Inspection, and other traffic signal courses may be desirable for the municipalities and the maintenance contractors to obtain a full understanding of traffic signal maintenance and operations. Interested municipalities and municipal maintenance contractors can refer to IMSA for additional training details.

Exhibit 8-1 Available IMSA Training

Training	Description
IMSA Work Zone Traffic Control Safety Certification	▪ Training on Part 6 Temporary Traffic Control from the *MUTCD* ▪ Teaches principles to be observed in the design, installation, and the maintenance of traffic control to enhance motorist and worker safety in work zones
IMSA Traffic Signal Level 1 Training	▪ Designed for the entry-level technician that has had some prior training or experience in electrical technology ▪ Principals of operation and the primary electrical details of cabinet wiring and components ▪ Equipment, methods, and materials of signal system construction ▪ Basics of traffic signal design, maintenance, and legal issues
IMSA Traffic Signal Level 2 Training (Field Technician)	▪ Areas of training include worksite safety, maintenance of traffic, traffic signal system equipment standards and operation, installation inspection, troubleshooting, equipment repair, replacement and programming, test equipment, signal phasing and timing, detection, system communications, preventative maintenance, and documentation
IMSA Traffic Signal Level 3 Training	▪ An exam for which other training prerequisites are required along with a minimum level of experience
IMSA Traffic Signal Inspection	▪ Introduction to Traffic Signal Inspection ▪ Inspection of Underground Facilities ▪ Inspection of Traffic Signal Supports ▪ Inspection of Overhead Equipment ▪ Inspection of the Vehicular and Pedestrian Detection Systems ▪ Inspection of the Controller Assembly ▪ Safety Requirements ▪ Final Acceptance and Turn-On
Other Training	▪ May include training by vendors of a municipality's equipment to train personnel on unique operational characteristics and maintenance of that specific equipment

Traffic Signal Maintenance Manual

APPENDICES

Bureau of Maintenance and Operations

pennsylvania
DEPARTMENT OF TRANSPORTATION

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PUB 191 (12-20)

APPENDIX A. GLOSSARY

When used in this publication, the following definitions, terminology and titles have the meanings included herein:

AASHTO – The American Association of State Highway and Transportation Officials.

Actuated operation – A type of traffic control signal operation in which some or all signal phases are operated on the basis of actuation (vehicle detection, pushbutton, etc.).

ADA – Americans with Disabilities Act (1990).

Adaptive signal system – A technology using detection data and algorithms to adjust signal timing parameters for current conditions. Adaptive signal systems still rely on local controllers for many timing parameters and share many features of traditional systems, but they have more flexibility in how they adjust timing parameters.

As-built plans – A modified traffic signal plan showing the roadway geometrics and the traffic signals after completion of the construction project, showing any field adjustments due to structural shifts of signal supports, unanticipated corner radius changes, etc.

Conflict monitor -- A device housed in the controller cabinet which continuously checks for the presence of conflicting signal indications such as simultaneous green signal indications on both the mainline and side road approaches. If a conflict is detected, the monitor places the signals into a flashing operation.

Controller – The electronic device that controls the sequence and duration of traffic signal indications.

Department – Term used to reference the Pennsylvania Department of Transportation.

Detector – A device for indicating the presence of a vehicle or pedestrian.

Design modifications – A proposed change to the approved design and operation of an existing traffic signal or signal system to accommodate changes in prevailing traffic or physical conditions or update the installation to current state-of-the-art design. Typical modifications include addition or removal of signal phases or special functions; changes in signal displays, configurations, or locations; detector modifications; upgrading of equipment and communication systems; and revisions to related signs and pavement markings. These changes can be initiated by any involved party but cannot be physically implemented until the signal permit is updated.

Documentation – The information for the traffic signal or signal system, including the traffic signal permit, equipment manuals and warrantees, summary and detailed listing of all signal maintenance, and design modifications, etc.

Infrared detection – An overhead mounted device that illuminates a select area with low-power infrared energy supplied by light-emitting diodes (LEDs) or laser diodes, and then converts the reflected energy into an electrical signal to indicate the presence of a vehicle or person. Infrared detectors may have special applications for detecting pedestrians and bicyclists.

Incandescent indications – Vehicular or pedestrian signals, or a blank-out sign, that are illuminated with a traditional light bulb having a thin tungsten filament.

Intersection – The area embraced between the prolongation and connection of the lateral curb lines, or if none, the lateral boundary lines of the roadways (i.e., the traveled portion) of two or more streets or highways.

Isolated intersection – A signalized intersection that is located far enough from other signalized intersections so that the signal timing at the other intersections does not influence the traffic flow at this intersection.

Local controller – The controller located at an intersection and which operates the traffic signals only at that intersection and does not control or directly influence any other intersection.

Local authorities –

i. County, municipal and other local boards or bodies having authority to enact regulations relating to traffic.

ii. The term also includes airport authorities except where those authorities are within counties of the first class or counties of the second class.

iii. The term also includes State agencies, boards and commissions other than the Department, and governing bodies of colleges, universities, public and private schools, public and historical parks.

LTAP – PennDOT's Local Technical Assistance Program which is dedicated to transferring transportation technology through training, technical assistance, and other customer services to municipal officials and their staff (see https://gis.penndot.gov/LTAP).

Loop detectors – The most commonly used device to monitor traffic on the approach to a traffic control signal, consisting of multiple circles of wire in a basic square or rectangular shape that is buried within the roadway and which detects changes in their magnetic field caused by the metal in passing vehicles.

Maintenance service manuals – The document provided by the manufacturer of a piece of equipment that specifies how to adjust, clean, lubricate, calibrate, and otherwise maintain the equipment to ensure its proper operation and its longevity.

Maintenance service records – An accumulation of paperwork that captures all service performed to the traffic signals at a specific intersection. This paperwork identifies all inspections, cleaning, tightening, calibrations, adjustments, replacements, lubrications, etc., that were performed from either a preventative viewpoint, or repairs due to crashes or equipment failure.

MUTCD – The current edition of the *Manual on Uniform Traffic Control Devices*, as adopted by the Federal Highway Administration (FHWA), and available at http://mutcd.fhwa.dot.gov/.

Master controller – The controller that supervises and directs the timing patterns for all local controllers within a traffic control signal system for the purpose of coordinating the operation of the signal system to improve traffic flow and safety.

Microwave detection – Equipment that transmits an electromagnetic signal and compares the reflected signal from all objects in the protected area by use of the Doppler Effect, and based on a selected sensitivity level it determines if the detection criteria are met and if so advises the controller of the presence of traffic.

Operations – As it relates to traffic, this is the day-to-day control of traffic systems, including the analysis of the systems, detection of problems and deficiencies, setting of priorities, assignment of resources and development of improvements through geometric design, traffic control, or other means. Frequently referred to as "traffic operations."

Pedestrian detection – Hardware used to notify the traffic controller of the presence of a pedestrian, typically via a pushbutton.

Pretimed operation – A non-actuated traffic control signal where right-of-way at the intersection is assigned according to one or more predetermined schedules and is therefore not influenced by the presence or absence of traffic. Pretimed operation may also be referred to as fixed-time operation.

Preventative (routine) maintenance. Maintenance scheduled on a regular basis to minimize future maintenance and to maximize the life of the equipment. It includes inspection, calibration, cleaning, testing, sealing, painting, etc., in accordance with a predefined schedule. This maintenance is similar to the maintenance schedule for a vehicle.

Push button detection – A mechanical switch that when pushed or activate, it tells the controller of the presence of a pedestrian.

Radar detection – A detector that uses radar waves to track vehicles as they approach and leave an intersection.

Response maintenance – Emergency repair performed on an as-needed basis due to either equipment failure or a crash. Upon notification, the maintenance service team is dispatched to secure the site, diagnose the problem, perform the repairs, and record its activities as quickly as possible.

Signal timing charts – The table that captures the traffic signal timing analysis.

Surge Protection Devices (SPDs) – Any of a number of devices designed to protect electronic systems against damages caused by lightning or other electrical disturbances. When used on traffic signal equipment, these devices should conform to the National Fire Protection Association's NFPA 780 (installation of Lightning Protection Systems) standard. In accordance with the new guidelines, critical applications include inductive loops, video cameras, pedestrian pushbutton loops, service loops for controls or signals that exit or enter the cabinet, and the AC that supplies the power.

Traffic control signal -- The specific type of traffic signal that provides alternating stop and go traffic control with red-yellow-green (R-Y-G) signal indications.

Traffic signal – The broad category of highway lights including traffic control signals (provide alternating stop and go), pedestrian signals, flashing beacons, lane-use control signals, ramp metering, and in-roadway lights.

Traffic signal housing – The outer part of a traffic signal section that protects a light and other required components from the elements.

Traffic signal permit – The document approved by the Department to authorize the installation and operation of the traffic signal. The traffic signal permit is for a traffic signal at a specific intersection, and it includes the Traffic Engineering Form TE-964, and traffic signal plans showing the intersection plan sheets with the locations of the traffic signals, traffic signal supports, controller cabinet, junction boxes, detectors, stop lines, street names, approach grades, distance to nearest signals, etc., plus the traffic signal phasing diagram.

Traffic signal support – The physical means whereby signal heads, signs, and luminaires are supported in a particular location. Structural supports are to be designed to carry the loads induced by attached signal heads, signs, luminaires, and related appurtenances.

Traffic signal system – Two or more traffic control signals operating in coordination with each other.

Traffic signal timing – The analysis of intersection geometrics, speeds, and historical traffic volumes used to identify the specific duration in seconds for the green, yellow, red, Walk, and Don't Walk intervals of each phase. For traffic actuated signals, the traffic signal timing also includes information on the incremental extensions of the green intervals due to the continued presence of approaching vehicles.

Uninterrupted power supply (UPS) – A battery backup system designed to instantly provide electrical power for the operation of the controller and traffic signals during a power outage. UPS essentially became viable with the conversion to LED signals.

Video detection – The process of using a video imaging system to analyze the feed from a video camera mounted above the roadway to determine the presence or passage of vehicles in one or more specific travel lanes on an approach to the intersection.

Wireless detection – The use of equipment coupled with a radio transmitter that informs a receiver in the controller cabinet of the presence or passage of vehicles in one or more specific travel lanes. The type of detection may vary, but the radio transmission is used in lieu of wire or coaxial cable.

APPENDIX B. TSMA RESOLUTION

RESOLUTION

BE IT RESOLVED, by authority of the _____
(Name of governing body)

of the _____ , _____
County, and it
(Name of MUNICIPALITY)

is hereby resolved by authority of the same, that the _____
(designate official title)

of said MUNICIPALITY be authorized and directed to submit the attached Traffic Signal Maintenance

Agreement and to submit future modifications to the attached Traffic Signal Maintenance Agreement, either in writing or via electronic signature, to DEPARTMENT and to sign this Agreement on behalf of MUNICIPALITY.

ATTEST: _____
(Name of Municipality)

_____ By: _____
(Signature and designation of official title) (Signature and designation of official title)

I, _____, _____
(Signature and designation of official title) (Signature and designation of official title)

of the _____ , do hereby certify that the foregoing

is a true and correct copy of the Resolution adopted at a regular meeting of the

_____, held the _____ day of _____ , _____ 20 .

DATE: _____ _____
(Signature and designation of official title)

APPENDIX C. MUNICIPAL SERVICE AGREEMENT

MUNICIPAL SERVICE AGREEMENT
FOR MAINTENANCE OF TRAFFIC CONTROL SIGNALS

Agreement is signed, this _____ day of _____, 20___, with an effective date of _____, 20___ by and between **_____,** **INC.,** a _____ Corporation, with its principal place of business at _____, hereinafter known as "**XXXXXXXXXX**"

AND

(municipality) _____

(address) _____

(address) _____

(telephone) _____

hereinafter known as "**MUNICIPALITY**";

SAMPLE FORMAT

WITNESSETH:

WHEREAS, MUNICIPALITY and **XXXXXXXXXX** hereto desire to enter into a contract for the maintenance, service and repair of traffic control signals, situate and located in _____, _____ County; and

WHEREAS, MUNICIPALITY has by official and duly authorized action approved this municipal services agreement following a competitive bidding process or through other statute, law or regulation authorizing the services, maintenance and repairs contemplated by this Agreement for the benefit of **MUNICIPALITY,** and **XXXXXXXXXX** hereby relies upon said

representation for the purposes of providing maintenance, service and repair of traffic control signals and devices for the benefit of **MUNICIPALITY.**

NOW, THEREFORE, it is mutually agreed and represented as follows:

1. EXCLUSIVE CONTRACTOR. XXXXXXXXXX shall be the exclusive contractor for the maintenance, service and repair of all traffic control signals within **MUNICIPALITY** for the benefit of **MUNICIPALITY** during the term of this Agreement in accordance with the RFP submitted on _____, 20___.

2. SCOPE OF SERVICES. XXXXXXXXXX shall, subject to the general control of **MUNICIPALITY,** render and perform the following services:

(a) Afford **MUNICIPALITY** the full benefit of the experience, judgment, advice and assistance of its officers, employees and other members of its organization, in respect to all matters pertaining to the maintenance, service and repair of said traffic control signals; and

(b) Perform any maintenance, service, or repair of said traffic control signals; necessary to keep said traffic control signals in good working condition including, but not limited to the maintenance set forth in "Commonwealth of Pennsylvania, Department of Transportation's *Traffic Signal Maintenance Manual*" (Pub. 191) and updates associated therewith; and

(c) Twenty-four (24) hours on-call emergency service or repair; and

(d) Keep and maintain at all times records pertaining to the maintenance, service, or repair performed by **XXXXXXXXXX,** all of which shall be furnished to **MUNICIPALITY** upon reasonable request and uploaded to PennDOT's Traffic Signal Asset Management System (TSAMS); and

(e) Make purchases, and maintain an inventory of, necessary parts and supplies for maintenance, service, or repair of said traffic control signals, including, but not limited to, parts and supplies purchased at the request of **MUNICIPALITY**, which are unique to the traffic control signals in **MUNICIPALITY**; and

(f) **XXXXXXXXXX** shall maintain, and require all contractors and subcontractors working at **XXXXXXXXXX** direction to maintain, public liability and workmen's compensation insurance and shall submit certificates therefore to **MUNICIPALITY** upon reasonable request.

3. HOURLY RATES. MUNICIPALITY and **XXXXXXXXXX** agree that **MUNICIPALITY** shall pay **XXXXXXXXXX** in accordance with the following hourly rate schedule:

(a) Service Personnel. Request for service be paid at a rate of _____ dollars and _____ cents ($____.___) per hour, or prorated, for maintenance, service or repair of said traffic control signal(s) during regular business hours during the term of this agreement, and at the rate of _____ dollars and _____ cents ($____.___) per hour or prorated, for emergency requests for service not made during regular business hours.

(b) Flagger/Safety personnel. Flagger/Safety personnel shall be paid at a rate of _____ dollars and _____ cents ($____.___) per hour, or prorated, for maintenance, service or repair of said traffic control signal(s) during regular business hours during the term of this agreement, and at the rate of _____ dollars and _____ cents ($____.___) per hour or prorated, for emergency requests for service not made during regular business hours.

(c) Crane Trucks. Crane Trucks shall be paid at a rate of _____

dollars and _____ cents ($____.___) per hour during the term of this agreement

(d) Auger Trucks. Auger Trucks shall be paid at a rate of _____ dollars and _____ cents ($____.___) per hour during the term of this agreement

(e) Backhoe. Backhoe shall be paid at a rate of _____ dollars and _____ cents ($____.___) per hour during the term of this agreement.

(f) Digger Derrick. Digger Derrick shall be paid at a rate of _____ dollars and _____ cents ($____.___) per hour during the term of this agreement

(g) Regular Business Hours. For the purpose of this Agreement "regular business hours" shall be from _____ a.m. to _____ p.m. prevailing time, except Saturday, Sundays and legal holidays. Request for service made outside of Regular Business hours as defined herein, including calls made on Saturday, Sundays and legal holidays, shall be classified as emergency requests for service,

(h) Payment for services. **MUNICIPALITY** agrees to pay **XXXXXXXXXX** within a period of thirty (30) days after submission of an invoice by **XXXXXXXXXX** to **MUNICIPALITY**. Payments made by **MUNICIPALITY** after a period of thirty (30) days shall include a late fee of *one and one-half* percent (*1.5%*) of the total invoice submitted to **MUNICIPALITY** by **XXXXXXXXXX**. Failure of **MUNICIPALITY** to pay **XXXXXXXXXX** in accordance with the subparagraph shall constitute reasonable grounds and basis for **XXXXXXXXXX** to terminate the municipal services agreement without any further liability, claim or demand for traffic control maintenance, service and repair by **MNNICIPALITY**.

4. SERVICE AUTHORIZATION REQUESTS. **MUNICIPALITY** and **XXXXXXXXXX** agree that **XXXXXXXXXX** shall be authorized to respond to any request for regular or emergency services upon telephone or other form of request, verbal or written, by any

municipal agent, municipal police officer, State police officer, local or county emergency service manager or other duly authorized agent of **MUNICIPALITY** for necessary emergency service or repair of said traffic control signals within the timeframes indicated in PennDOT Publication 191, *Traffic Signal Maintenance Manual*, for response maintenance activites.

5. TRAFFIC CONTROL SIGNALS. For purposes of this Agreement, "Traffic Control Signals" shall be defined as any device, whether manually, electrically, or mechanically operated, by which vehicular and/or pedestrian traffic is alternately directed to stop and permitted to proceed.

6. TERM OF AGREEMENT/RENEWAL OF AGREEMENT. This Agreement shall be in force and effect for a term beginning with the dates hereof and shall continue for a period of one (1) year thereafter. Upon expiration of this Agreement, an option to renew all terms of this agreement can be executed in writing once agreed upon by both parties. Either party may terminate this agreement for any reason by providing the other party with sixty (60) days written notice.

7. MODIFICATIONS/INTERRETATIONS. This agreement represents the entire agreement between the parties. All modifications to the Agreement shall be in writing and signed by the authorized representative of the parties, and no verbal modification shall be binding or enforceable in any event. For purposes of contract interpretation, this Agreement shall be construed as if prepared for the benefit of both **MUNICIPALITY** and **XXXXXXXXXX.**

8. TERMINATION. If at any time the **MUNICIPALTY** shall be of the opinion and so certify in writing that **XXXXXXXXXX** is violating any of the conditions or covenants of this Agreement, or the specifications thereof, or is executing the same in bad faith or not in accordance with the terms thereof, the **MUNICIPALITY** may cancel and terminate this

Agreement by a written notice to be served upon **XXXXXXXXXX** at its office address set forth in this Agreement.

9. BINDING EFFECT. This Agreement shall be binding upon all parties hereto and their respective heirs, executors, administrators, successors and assigns.

10. NOTICES. All notices, demands and requests under this Service Agreement shall be in writing and shall be deemed given when sent by United States registered and/or certified mail, postage prepaid, return receipt requested, and addressed as follows:

TO **XXXXXXXXXX**: _____
_____
_____

TO **MUNICIPALITY**: _____
_____
_____

Notices, demands and requests which shall be served upon **XXXXXXXXXX** and/or **MUNICIPALITY** in the manner aforesaid shall be deemed to have been served and/or given for all purposes hereunder at the time such notice, demand or request shall be mailed by United States registered and/or certified mail as aforesaid, in any post office and/or branch post office regularly maintained by the United States Government. Either party may, by notice given to the other party, designate a new address to which notices, demands and requests shall be sent and, thereafter, any of the foregoing shall be sent to the address most recently designated by such party.

11. PENNSYLVANIA LAW. This Agreement shall be construed in accordance with the laws of the Commonwealth of Pennsylvania.

IN WITNESS WHEREOF, the parties hereto have executed, or caused to be executed by their duly authorized officials, this Agreement in duplicate, each of which shall be deemed an

original on the date first above written.

MUNICIPALITY	(S P E L L O U T XXXXXXXXXX's N A M E)
By: _____	By: _____
Title: _____	xxxxxxxxxxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxxxxxxxxxx
Address: _____	xxxxxxxxxxxxxxxxxxxxxxxxxxxx xxxxxxxxxxxxxxxxxxxxxxxxxxxx
Address: _____	

APPENDIX D. TRAFFIC SIGNAL PROGRAM BENCHMARKING

Traffic signal owners should establish a programmatic approach to traffic signal management and operations providing a framework to intentionally link transportation goals such as safety, mobility, reliability, and state-of-good-repair to organizational capability to clarify how limited resources can be used to focus on doing what is most important, generally defined as providing good basic service. The capability maturity assessment technique can be used with the traffic signal program model. Additional information on this approach is contained in *Traffic Signal Benchmarking and State of the Practice Report*. The capability maturity model framework is illustrated below.

Capability Maturity Model Levels

- Activities and relationships largely ad hoc, informal, and champion-driven
- Substantially outside mainstream of other agency activities

- Basic strategy applications understood
- Key processes support requirements identified and key technology and core capacities under development
- Limited internal accountability
- Uneven alignment with external partners

- Standardized strategy applications implemented in priority contexts and managed for performance
- Technical and business processes developed, document, and integrated into agency
- Partnerships aligned

- Full, sustainable core agency priority
- Established on the basis of continuous improvement with top level management status
- Formal partnerships

Source: *Traffic Signal Benchmarking and State of the Practice Report,* 2019

Capability maturity can be measured across various dimensions, as described in the following sections. Traffic signal owners should periodically complete a self-assessment to gauge how well the agency is able to fulfill its traffic signal maintenance and operation requirements. In addition to the dimensions described herein, additional dimensions are described in the *Traffic Signal Benchmarking and State of the Practice Report*.

Systems and Technology

Systems and technology include local control, central control, detection, and communication systems.

Systems and Technology Capabilities

Grade	Level	Capability
A	**Level 4**	In addition to Level 3: ▪ Systems and technology performance measures are continuously evaluated to identify deficiencies and opportunities for improvement. ▪ Performance measures inform budget and resource allocation decisions. Asset management and system and technology investments are informed by performance measures.
B	**Level 3**	In addition to Level 2: ▪ Performance measures are established to validate that systems and technology provide the require functionality to execute needed operations and maintenance strategies and attain objectives.

		▪ Processes are established to periodically review systems performance measures. ▪ Traffic signal equipment is replaced/updated through regular upgrades that consider life cycle and functionality gaps.
C	**Level 2**	▪ Systematic processes (systems engineering, architecture standards, etc.) linking operations and maintenance objectives and needs to requirements are used for systems procurement. ▪ System performance is defined based on operations and maintenance objectives and strategies. ▪ System components are replaced based on life cycle and/or when improvements in functionality are needed.
D	**Level 1**	▪ Ad hoc selection of systems and technology is typically based on the preferences of key individuals. ▪ The appropriate function and performance of systems and technology is not well-defined and the capability to evaluate performance is limited and typically dependent on complaints. ▪ Systems and technology are not able to verify whether the signal operates in accordance with the PennDOT-issued permit. ▪ Visual observations and citizen complaints are used to determine the effectiveness of signal operation and maintenance. ▪ System components are typically replaced when there is equipment failure.

Adapted from *Traffic Signal Benchmarking and State of the Practice Report,* 2019

Signal Infrastructure

Signal infrastructure includes poles, mast arms, span wire, wiring, signal heads. Signs and pavement markings associated with the traffic signal operation and identified on the traffic signal permit are also considered part of the signal infrastructure.

Infrastructure Capabilities

Grade	Level	Capability
A	**Level 4**	In addition to Level 3: ▪ Infrastructure measures are regularly evaluated to ensure consistency with required condition and functionality. Gaps in functionality and opportunities for enhancement are monitored to identify needed investments.
B	**Level 3**	In addition to Level 2: ▪ Infrastructure condition is regularly monitored and recorded in an asset management system. ▪ Signal infrastructure is periodically reviewed for compliance with current PennDOT and national standards. ▪ Traffic signal equipment is replaced/upgraded considering life cycle and equipment condition.
C	**Level 2**	▪ Established specifications are used for procurement to ensure components meet operations and maintenance needs. ▪ Traffic signal permit condition diagrams are consistent with field conditions. ▪ As-built conditions are reflected with updated traffic signal permits and signal inventory in TSAMS.

		▪ Copies of the current traffic signal permit are readily accessible to support ongoing design, maintenance, and operations activities.
D	**Level 1**	▪ Ad hoc selection of components is made based on preferences of key individuals. ▪ Infrastructure condition is not regularly monitored or documented. ▪ Signal components which are replaced due to equipment failure or knockdowns is not updated on the traffic signal permit condition diagram. ▪ Field views are necessary each time design and operations activities are initiated since traffic signal infrastructure is unlikely to match the traffic signal permit and/or signal inventory in TSAMS.

Adapted from *Traffic Signal Benchmarking and State of the Practice Report,* 2019

Maintenance Business Processes

The maintenance business processes dimension goes beyond day-to-day activities and require broader institutional support and involvement to address. This dimension includes procurement processes, sustainable funding, internal awareness, and support.

Maintenance Business Process Capabilities

Grade	Level	Capability
A	**Level 4**	In addition to Level 3: ▪ Maintenance objectives, strategies, and performance measures are fully integrated across the program. ▪ The relationship between activities, processes, systems, and performance is acknowledged by efforts to predict, detect, and proactively make improvements. ▪ Processes are continuously improved validating the effectiveness of day-to-day activities, systems, and technology and workforce capabilities with performance measures. ▪ Design modifications are regularly implemented to address recurring maintenance and safety issues.
B	**Level 3**	In addition to Level 2: ▪ Measures (output and/or outcome) are defined for maintenance-related activities. ▪ Measures (output and/or outcome) are established to validate the attainment of maintenance objectives and the effectiveness of strategies. ▪ Reporting of maintenance output and outcomes is a core business practice.
C	**Level 2**	▪ Established maintenance strategies, activities, processes are practices to guide preventative, routine/scheduled, and emergency maintenance. ▪ Guidelines, checklists, or other documentation is available or under development to support traffic signal maintenance to ensure the reliability of infrastructure, systems, and technology. ▪ Efforts to make improvements to maintenance processes are limited, tend to be reactive, and have limited accountability.
D	**Level 1**	▪ Maintenance activities are not well-defined, ad hoc, and are driven by individuals who are equipped with or developing the skills and expertise to implement maintenance strategies. ▪ Little or no documentation exists to guide maintenance processes. ▪ Processes to evaluate infrastructure condition are ad hoc and not well-defined. The systems, technology, and infrastructure components may be dated

		(potentially obsolete), with gaps in functionality and typically replaced upon failure.

Adapted from *Traffic Signal Benchmarking and State of the Practice Report,* 2019

Management Processes

Management activities involve the budgeting and programming of general operating and capital improvement program budgets, staffing considerations and supervision for traffic signals, customer service to the public and elected leaders, and engagement with the media and stakeholders.

Maintenance Business Process Capabilities

Grade	Level	Capability
A	**Level 4**	In addition to Level 3: ▪ Program business processes are continuously improved by validating the effectiveness of the day-to-day activities, systems and technology, and workforce capabilities with measures. ▪ Asset management, funding processes, training, implementation of technology and innovation, and investments in innovation and technology are informed by evaluation measures. ▪ Priorities and investments are reference in the agency's strategic plan.
B	**Level 3**	In addition to Level 2: ▪ A set of measures (output and/or outcome) are defined for management-related activities as well as the overall program. ▪ The capability and processes to validate and routinely report on the attainment of program objectives and strategies is developed or under development. ▪ Asset management inventory is available.
C	**Level 2**	▪ The potential loss of continuity from attrition of key staff is mitigated by documenting program goals and objectives in the form of a Traffic Signal Management Plan (TSMP). ▪ Workforce competencies, asset inventories, procurement processes (e.g. systems engineering) are documented. ▪ An asset management system is available to track life cycle of equipment.
D	**Level 1**	▪ The traffic signal program goals and objectives are only articulated by one or more program champions, and documentation has not been fully-developed. ▪ The loss of key staff due to attrition or retirement presents a risk to continuity of administration activities. ▪ Little or no documentation exists to provide direction, vision, and goals to guide traffic signal program processes. ▪ Updates to existing guidelines are rare and not tracked.

Adapted from *Traffic Signal Benchmarking and State of the Practice Report,* 2019

Workforce

This dimension characterizes the people within the organization, who each carry beliefs, attitudes, and behaviors that are influenced by their education and training to produce knowledge. This dimension concentrates on the development, training, and competency of qualified staff across all levels in the program including technical, engineering, and management positions.

Workforce Capabilities

Grade	Level	Capability
A	**Level 4**	In addition to Level 3: ▪ Workforce competencies are evaluated to ensure consistency with industry standards and program needs, and routinely updated to improve competencies. ▪ Appropriate program performance measures are evaluated to identify and address potential gaps between staff capability and program needs. Training and certifications are prescribed to address gaps.
B	**Level 3**	In addition to Level 2: ▪ Workforce competencies are linked to current and planned program needs and monitored for consistency. ▪ Training and certifications are tracked to ensure that staff capability is consistent with program needs.
C	**Level 2**	▪ Workforce competencies are established and job descriptions are documented to support alignment of staff capability with design, operations, and maintenance strategies. ▪ Workforce development is supported fiscally with structured internal and/or external training and certification as appropriate to maintain competency.
D	**Level 1**	▪ The workforce maintains minimum levels of capability to complete required tasks. Workforce competencies/position descriptions are not well defined. ▪ Training is ad hoc and lacks formal structure. Funding to support training, development of core skills and certification is limited.

Adapted from *Traffic Signal Benchmarking and State of the Practice Report,* 2019