pennsylvania
DEPARTMENT OF TRANSPORTATION

470-10-09

DATE: October 28, 2010

SUBJECT: PennDOT Publication 191
Guidelines for the Maintenance and Operation of Traffic Signals

TO: District Executives
All Engineering Districts

FROM: Daryl St. Clair, P.E., Acting Director /s/
Bureau of Highway Safety and Traffic Engineering

This letter informs District staff that Publication 191 "Guidelines for the Maintenance and Operation of Traffic Signals," has been completely rewritten through the use of a two step clearance transmittal process to incorporate the latest industry standards and guidelines from the American Association of State Highway and Transportation Officials (AASHTO) standard specifications, the Manual on Uniform Traffic Control Devices (MUTCD), the Institute of Transportation Engineers (ITE) and International Municipal Signal Association (IMSA) Traffic Signal Maintenance Handbook, and the National Electric Code.

This update is effective immediately and is anticipated to be time and resource neutral for all Engineering Districts.

If you have any questions or concerns regarding the attached publication please contact Glenn C. Rowe, P.E., Chief, Transportation Operations Division, Bureau of Highway Safety and Traffic Engineering at (717) 783-6479.

Attachment

4700/DPF(3-0333)/deh(7-6853)

CC: FHWA Pennsylvania Division Office
Kingsley Azubike, PE, PTOE, FHWA Pennsylvania Division Office
Pennsylvania State Association of Township Supervisors
Pennsylvania State Association of Boroughs
Pennsylvania State Association of Township Commissioners
Pennsylvania League of Cities and Municipalities
American Council of Engineering Companies of Pennsylvania
Associated Pennsylvania Constructors
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Assistant District Executive - Services
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District Bridge Engineers
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Matthew Depaoli, Transportation Operations Division, BHSTE
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OS-299 (7-08)	TRANSMITTAL LETTER	PUBLICATION: 191
pennsylvania DEPARTMENT OF TRANSPORTATION		DATE: 10/28/2010

SUBJECT:

Guidelines for the Maintenance and Operation of Traffic Signals

INFORMATION AND SPECIAL INSTRUCTIONS:

PennDOT has issued Publication 191, Guidelines for the Maintenance and Operation of Traffic Signals, to be used for the maintenance and operation of traffic signals within the Commonwealth.

This publication is effective immediately and provides the latest industry standards and guidelines in conformance with the most recent release of the American Association of State Highway and Transportation Officials (AASHTO) standard specifications, the Manual on Uniform Traffic Control Devices (MUTCD), the Institute of Transportation Engineers (ITE) and International Municipal Signal Association (IMSA) Traffic Signal Maintenance Handbook, and the National Electric Code.

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

Hard copies are also available for purchase through the PennDOT Sales Store.

CANCEL AND DESTROY THE FOLLOWING:

This will replace the 1989 edition of PennDOT Publication 191 "Guidelines for the Maintenance of Traffic Signal Systems."

ADDITIONAL COPIES ARE AVAILABLE FROM:

☒ PennDOT SALES STORE
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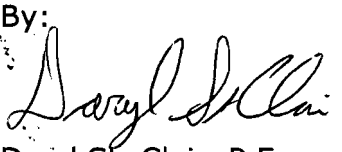
APPROVED FOR ISSUANCE BY:

Allen D. Biehler, P.E.
Secretary of Transportation
By:



Daryl St. Clair, P.E.
Acting Director, Bureau of Highway Safety and Traffic Engineering

pennsylvania
DEPARTMENT OF TRANSPORTATION

Guidelines for the Maintenance and Operation of Traffic Signals

Publication 191

October 2010

Revision #	Date	Approved By:	Revision Description

Bureau of Highway Safety and Traffic Engineering

Publication 191

Guidelines for the Maintenance and Operation of Traffic Signals

TABLE OF CONTENTS

Table of Contents
(Continued)

EXHIBITS

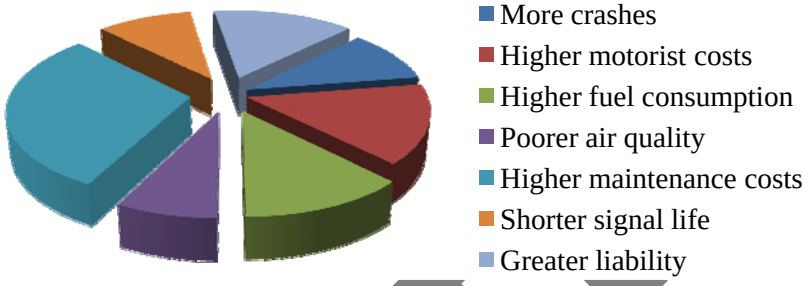
APPENDICES

EXECUTIVE SUMMARY

Purpose

The purpose of this publication is to provide guidance and assistance on the maintenance and operation of traffic signals. In accordance with Section 212.5 of Title 67 of the Pennsylvania Code (67 Pa. Code §212.5), municipalities are responsible for the installation, maintenance and operation of traffic signals on both State and local highways. The consequences of inadequate maintenance are illustrated below.

Consequences of Poor Maintenance



Benefits of Maintenance

Inadequate maintenance can lead to improper operation and/or deficiencies of traffic signals. These potential problems may lead to safety issues. Ensuring that proper maintenance responsibilities are administered also allows the municipalities to have the necessary documentation if a crash occurs at an intersection. A public benefit of proper maintenance and operation of traffic signals is a reduction in fuel consumption, greenhouse gas emissions and driver delay. For the municipality another benefit is a reduction in costs as a result of less frequent response maintenance activities, a potential reduction in liability, and a longer service life of the traffic signals.

A public benefit of proper maintenance and operation of traffic control signals is a reduction in fuel consumption, greenhouse gas emissions and driver delay.

Maintenance activities are not only important to maintain the traffic signals, but are also an opportunity to improve current operations. This publication provides guidance as to proper traffic signal maintenance and improvement opportunities. Recent national guidance provided by the Federal Highway Administration (FHWA) in the Traffic Signal Timing Manual indicates the continued emphasis on sustainability and improvement of existing traffic control signals through retiming and of regionalization. A key regional focus should be made when evaluating maintenance and operations on traffic signal systems and corridors that benefit of the general public, rather than municipal boundaries.

Traffic Signal Ownership in PA

Based on the Pennsylvania Transportation Advisory Committee (TAC) January 27, 2005 report (Pennsylvania Traffic Signal Systems; A Review of Policies and Practices), only about 46 percent of the municipalities within the Commonwealth have traffic signals, and of those almost two-thirds have five or fewer traffic signals as illustrated.

Municipal Traffic Signal Ownership Breakdown

Number of Signals	Number of Municipalities
0	1373
1	335
2-5	433
6-10	190
11-25	141
26-50	65
51 to 150	24
151 or more	4
TOTAL	**2665**

National Transportation Operations Coalition (NTOC)
Traffic Control Signal Self Assessments

In 2004 and again in 2006, the NTOC sent questionnaires to municipalities throughout the United States to obtain a self assessment of traffic signal operations. Based on information received from these questionnaires, the NTOC developed a report entitled the "National Traffic Signal Report Card," which was published in 2007 (available at http://www.ite.org/REPORTCARD/technical_report%20final.pdf.

Although all of the information was anonymous, the Department was able to obtain a summary of the results of responses received by participating municipalities in Pennsylvania. The national and Pennsylvania results are included in the following table, both of which indicate significant room for improvement. In all six evaluation categories Pennsylvania's rating was either at or below the national average.

Self Assessment Grades for Traffic Signal Operation

Assessment Area	National Score	Pennsylvania Score
1. Management	D-	F
2. Signal Operation at Individual Intersections	C	D
3. Signal Operation in Coordinated Systems	D	F
4. Signal Timing Practices	C-	F
5. Traffic Monitoring and Data Collection	F	F
6. Maintenance	C-	C-
Overall Grades	**D**	**F**

Since most municipalities do not have the personnel, technical expertise, or equipment inventory of spare parts to perform the necessary maintenance, many municipalities obtain the services of a traffic signal contractor to maintain their traffic signals. This publication provides municipal guidance on items that should be considered when selecting a contractor, such as issues to address to avoid legal battles and recommended minimum certifications. A sample maintenance contract is also provided in Appendix I.

The following is an overview of information contained within each section of this publication.

Section Name	Description
1. Introduction	▪ Traffic signals definitions and descriptions as they appear in the PA Vehicle Code Title 75 (75 Pa. C.S. §101) relative to installation, modification, or removal ▪ Agency roles and responsibilities ▪ Municipal responsibilities and duties for basic traffic signal operation ▪ Description of the Traffic Signal Permit and each of its components ▪ Importance of adequate insurance; timely response to minimize liability ▪ District/Central Office Traffic Signal Contacts ▪ Definitions and Terminology ▪ Beneficial Reference Documents
2. Establishing A Traffic Signal Maintenance And Operation Program	▪ NTOC Traffic Signal Report Card findings and its recommendations to improve traffic signal maintenance and operations ▪ Budgeting – Equipment service life, ballpark costs for new signals, and unit costs for common traffic signal equipment ▪ Scheduling ▪ Recommended qualifications for maintenance personnel; equipment and supplies necessary for municipalities to perform their own maintenance ▪ Explanation of Measures of Effectiveness and how they are used to evaluate quality of traffic signal operation within a municipality
3. Traffic Signal Maintenance Classifications	▪ Guidance on deciding whether or not municipal forces or a private contractor performs maintenance ▪ Options identified if a private contractor is used ▪ Response Maintenance description, checklist, and schedule ▪ Preventative Maintenance description ▪ Operational Maintenance overview ▪ Design Modifications overview
4. Documentation	▪ Importance of documentation/maintenance records in justifying budget changes and allowing for ease of future maintenance/upgrades ▪ Documentation types and records

Section Name	Description
5. Maintenance Activities	▪ Traffic signal support selection; post-installation procedures; maintenance for welded and bolted connections ▪ Traffic signal indications and the use of visors, backplates, and louvers ▪ Types of signal indications ▪ Types of traffic signal detection ▪ Controller function and maintenance ▪ Conflict monitor testing ▪ Communication systems ▪ Vehicle preemption systems ▪ Electrical distribution components ▪ Signing and pavement markings ▪ Sidewalks and ADA
6. Traffic Signal Retiming and Equipment Upgrade Activities	▪ Providing guidance on the importance of retiming ▪ Regionalization by disregarding municipal boundaries and focusing on regional corridors where traffic signal systems are present across borders ▪ Guidance on when and how to retime traffic signals ▪ Incorporating various types of upgrades as part of maintenance activities ▪ Retiming benefits such as delay, fuel, and emissions reduction ▪ Safety benefits of traffic control signal improvements ▪ Description of various traffic signal improvement programs
7. Traffic Signal Maintenance Agreements	Template agreements for: ▪ General Provisions ▪ Preventive and Response Maintenance ▪ Recordkeeping ▪ Signal Maintenance Organization ▪ Contractor Integrity Provisions ▪ The Americans With Disabilities Act ▪ Contract Provisions – Right to Know Law 8-K-1532
8. Municipal Service Purchase Contracts	▪ Guidance on how to select a contractor ▪ Description of issues and how to address them ▪ Department recommendations for minimum certification (IMSA WZTC and IMSA Level I) ▪ Estimating prices ▪ Emphasis on use of replacement components approved in Pub 408 ▪ Importance of legal documentation to ensure maintenance can be performed on a timely basis

Section Name	Description
9. Design Modifications	▪ Typical modifications and requirements for a traffic signal permit revision ▪ Procedures for future modifications ▪ Guidance on the importance of effective feedback from field personnel to identify problems that may require modification ▪ Checklist for design modification review ▪ Department assistance and approval
10. Maintenance Contracts/Agreements	▪ Overview and template of basic maintenance agreement ▪ Guidance on when a HOP Agreement is required with the Department
11. Multi-Municipal Agreements	▪ Traffic signal installed at an intersection that is in two or more municipalities ▪ An interconnected traffic signal system that involves more than one municipality
12. Training Recommendations	▪ Importance of certification/training to effectively use and maintain a traffic signal's features and components ▪ Emphasizes the need for additional training as systems become more sophisticated ▪ Describes the benefits and training as exposure to new hardware, software, and concepts to help agencies stay on leading edge of technology ▪ Summary of the various types of IMSA training and certifications
Appendices	▪ Useful forms, templates, and checklists are provided for a successful traffic signal maintenance program

1. INTRODUCTION

1.1 PUBLICATION PURPOSE

The purpose of this publication is to provide guidance to those responsible for the maintenance and operations of traffic control signals, that is, the "red-yellow-green" (R-Y-G) type of traffic signal that provides for alternating traffic flows, along with any associated pedestrian signals.

To provide continued high quality service to the traveling public, a well-timed traffic control signal requires continuous and effective maintenance.

Although "traffic control signal" is the proper term for the R-Y-G traffic signals, the broader category of "traffic signal" is frequently used within this publication, due to the fact that: (1) the referenced laws or regulations are addressing the whole family of traffic signals, (2) many Department forms have always used the shorter term (e.g., "traffic signal permit"), and (3) the shorter term may be used to simplify and shorten the text and to reduce redundancy. In any event, traffic control signals are the most common type of traffic signals, but other types include:

- ✓ Pedestrian signals
- ✓ Flashing beacons
- ✓ Emergency vehicle access signals
- ✓ Lane-use control signals
- ✓ Ramp metering signals
- ✓ In-roadway lights

Section 6122 of The Pennsylvania Vehicle Code (75 Pa. C.S. §6122) requires local authorities to obtain approval from the Department prior to erecting any traffic signal within their boundaries except where Department regulations provide otherwise. The Department's regulation on this issue is titled "Municipal Traffic Engineering Certification", Chapter 205 of Title 67 of the Pennsylvania Code (67 Pa. Code Chapter 205), and this regulation only allows the following local authorities to install, modify or remove traffic signals without specific Department approval:

1. In cities of the first and second class (i.e., Philadelphia and Pittsburgh, respectively) providing they have a qualified traffic engineer possessing a current professional engineer's license issued by the Pennsylvania State Registration Board for Professional Engineers.

2. In any other municipality with **current** "Municipal Traffic Engineering Certification" as provided in Chapter 205.

3. When otherwise provided in an agreement with the Department.

Additionally, Section 212.5(b)(v)(A) of Title 67 of the PA Code (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. These roles and responsibilities are summarized in Exhibit 1.1

Inadequate maintenance can lead to inaccurate operation and/or deficiencies of traffic signals. These potential problems lead to safety issues, which is why it is essential that both preventative and emergency

response maintenance be provided. Ensuring that proper maintenance responsibilities are administered allows municipalities to have the necessary documentation if a crash occurs at the intersection. Public benefits of proper maintenance and operation of traffic signals are the reduction in fuel consumption, greenhouse gas emissions and driver delay. For the municipality another benefit potential cost savings can result from less frequent response maintenance activities, a potential reduction in tort claims, and a longer service life of the traffic signals.

Exhibit 1.1: Summary of Agency Roles and Responsibilities

Action	Responsibility
Approve all signals, except those municipalities with "Municipal Traffic Engineering Certification."	Department
Pay for the construction to install traffic signals.	Local authorities; except the Department does sometimes help underwrite the costs of traffic signals within Department construction projects.
Pay for maintenance and operation of the traffic signals, including the signs pavement markings, and other items on the approved traffic signal permit.	Local authorities, except as indicated on the traffic signal permit.
Approve the revision of a traffic signal permit or the complete removal of a traffic signal.	Department
Implement design modifications.	Local authorities

Important!

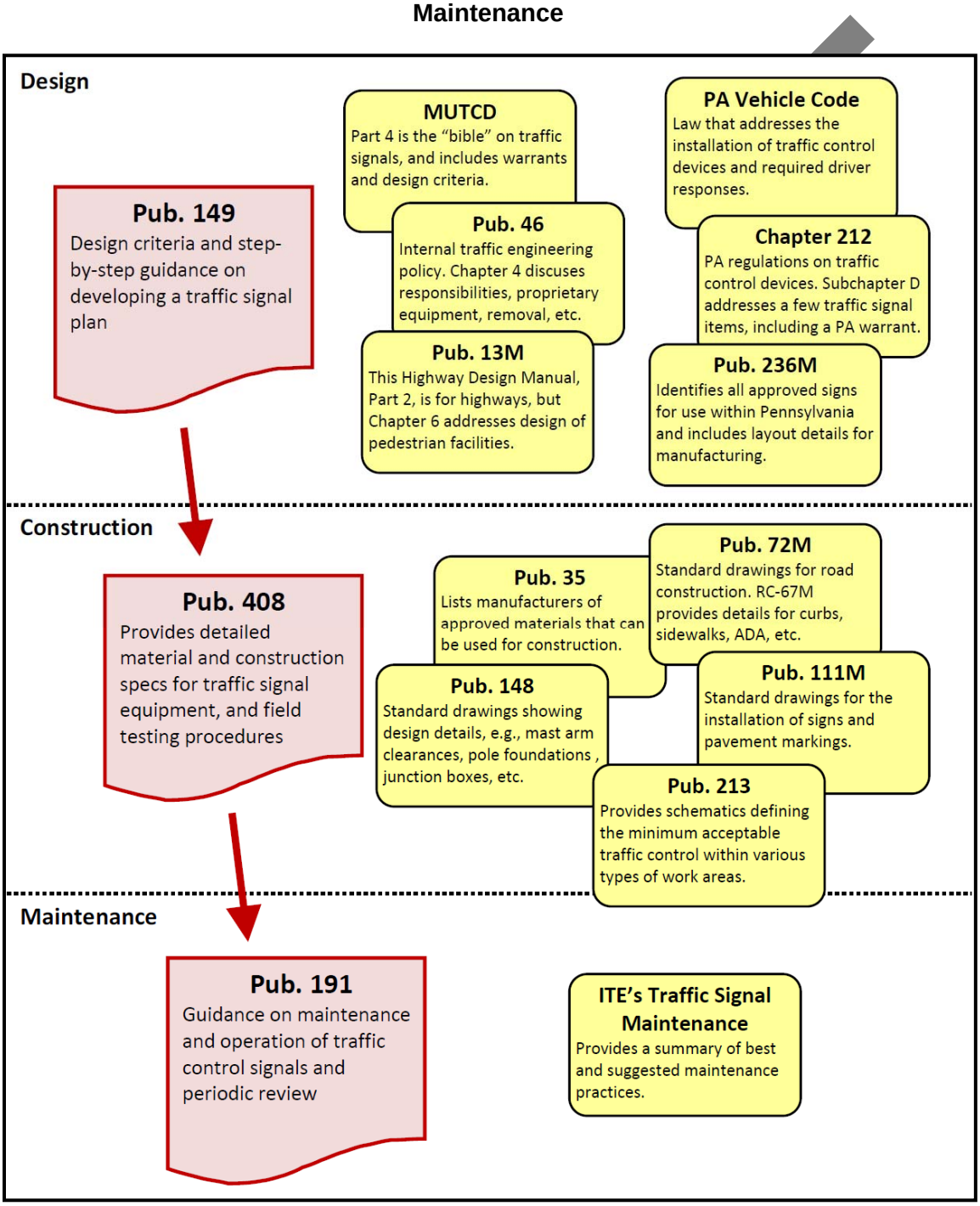
It is important to note that prior to making any changes in the operation of a traffic signal, the municipality should always contact the appropriate Department Engineering District (see Exhibit 1.5) to request approval.

It is also important to note that the Department generally will not revise a traffic signal permit at the request of municipality if it is determined that the traffic signal was never in compliance with the previously-approved permit. Therefore, it is very important for the municipality to ensure compliance with the traffic signal permit.

1.2 PENNDOT TRAFFIC SIGNAL PUBLICATIONS

Exhibit 1.2 shows the primary Department publications for the design, construction and maintenance of traffic control signals, and other related reference documents.

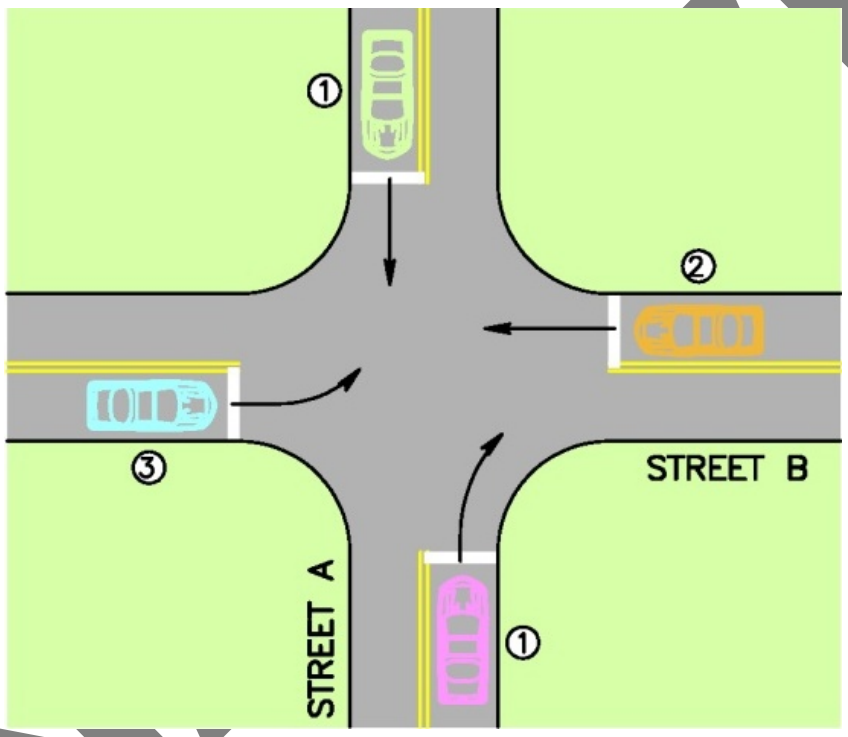
Exhibit 1.2: Primary and Secondary Publications for Design, Construction and Maintenance



1.3 BASIC OPERATION

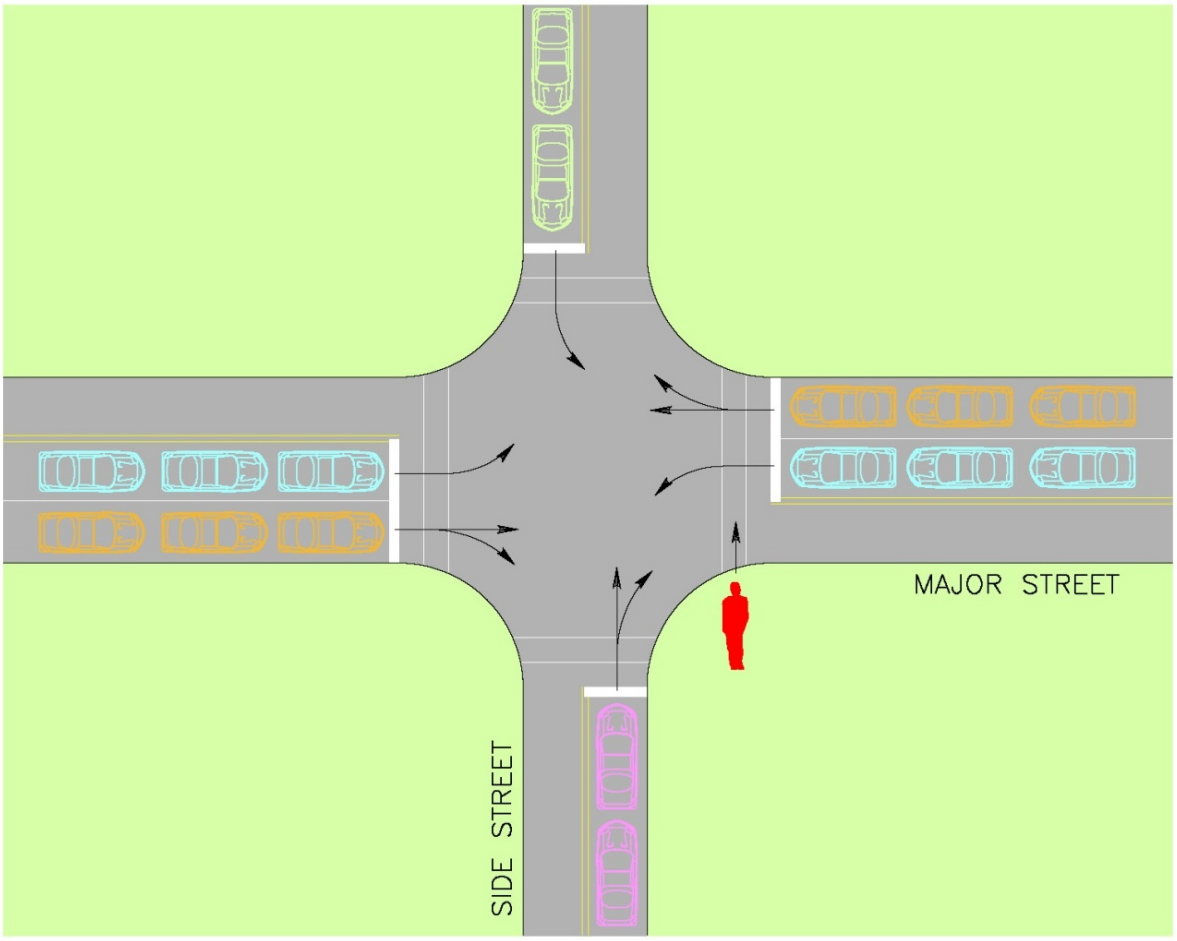
Basic signal operation is the efficient cycling of the signal phases from green-yellow-red based on traffic demand. The traffic signal should assign right-of-way to vehicles within the intersection in a way that minimizes conflict while maximizing traffic flow. At a multi-way STOP-controlled intersection this right-of-way alternates randomly, based on time of arrival, often resulting in an inefficient operation. To aid in understanding the assignment of basic right of way, Exhibit 1.3A and 1.3B are provided. These graphically depict right-of-way for a multi-way STOP and a typical signalized intersection.

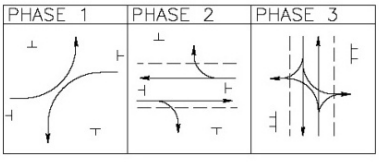
Exhibit 1.3A Right-of-Way Example at a Multi-Way STOP



Assuming Street A vehicles arrive simultaneously with Street B vehicles arriving a moment later at the same instant, ROW is as follows: Street A vehicles (1) arrive simultaneously and do not conflict so can proceed at the same time. With Street B vehicles arriving simultaneously, vehicle (2) has ROW left-turn vehicle (3) must yield to opposing through traffic.

Exhibit 1.3B Right-of-Way Example at Typical Traffic Signal





Right of Way Sequence

These vehicles have ROW in phase 1.

These vehicles have ROW in phase 2.

This pedestrian has ROW during phase 3.

These vehicles have ROW in phase 3 after pedestrian.

This left–turn vehicle must yield to pedestrian and opposing right–thru traffic during phase 3.

Although it would be possible to eliminate all vehicular and pedestrian conflicts within a signalized intersection, it would be extremely inefficient and impractical, thereby creating huge delays. Therefore, in addition to signal indications, Section 3112 of the Vehicle Code (relating to traffic control signals) also establishes rules-of-the-road that supplement the signal indications and require drivers to yield right-of-way to:

- Other vehicles and pedestrians lawfully within the intersection when the green indication is first exhibited.
- Oncoming traffic before making a left turn.
- Any pedestrian lawfully within a crosswalk before making a left or right turn.
- Pedestrians lawfully within a crosswalk and other vehicles lawfully using the intersection before making a turn-on red.

Section 4.2 of Publication 46 clearly indicates that prior to approving any traffic signal, the Department requires municipalities to agree to maintain and operate the 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.

Federal Law (23 CFR 655.603) establishes the Federal Highway Administration's (FHWA's) *Manual on Uniform Traffic Control Devices (MUTCD)* as the national standard for traffic control devices. And, in accordance with that standard and the information contained herein, municipalities should:

- Develop an appropriate budget to effectively maintain and manage the municipal traffic signals. (see Section 2.2)
- Provide spare equipment or have a means to obtain spare equipment quickly to minimize the interruption of traffic signal operation as a result of equipment failures. (see Section 2.4)
- Ensure that the traffic signal controller is operating in accordance with the approved traffic signal permit and maintain a record of all maintenance activities in accordance with the approved traffic signal permit. (see Sections 3.1, 3.2, and 5.4)
- Clean and service equipment and other appurtenances as indicated by the manufacturer's recommendations or as frequent as your preventative maintenance schedule indicates if no manufacturer recommendations are provided. (see Section 3.2)
- Clean the traffic signal indications and replace the light sources as indicated by the manufacturer's recommendations or in accordance with your preventative maintenance schedule if no manufacturer recommendations are provided. (see Sections 3.2 and 5.2)
- Provide for alternate operation of the traffic signal during a period of failure, using flashing mode or manual control, or manual traffic direction by proper authorities, or by erecting other traffic control devices with the Department's approval. (see Sections 1.4, 2.4, 2.6, 5.7.5, 6.4, and 8.5)
- Ensure that maintenance personnel and/or the municipal maintenance contractor are properly trained to repair all of the traffic signal components to comply with the approved traffic signal permit. (see Chapter 12)
- Ensure that the traffic signal displays and associated equipment is clearly visible to traffic. (see Section 5.2)

- If part of a coordinated signal system, ensure that interconnection between traffic signals is functioning in order to maintain the progressive flow of traffic. (see Sections 2.8, 6.2, and 6.3)

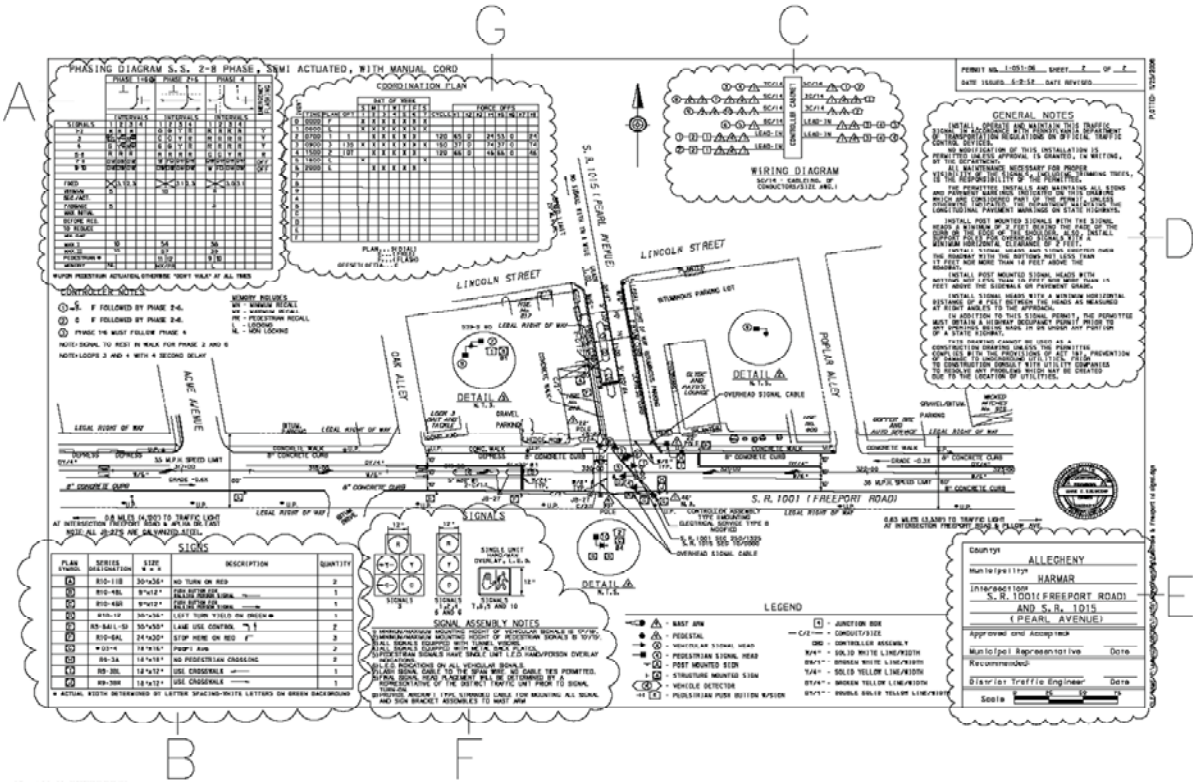
1.4 TRAFFIC SIGNAL PERMIT

The traffic signal permit is an important document for evaluating whether a traffic signal is operating and being properly maintained. This official document is typically issued by the Department to the municipalities 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 municipal building, and a copy should be kept inside the appropriate traffic signal cabinet.

The traffic signal permit is explained in Chapters 21.0, 22.0 and 23.0 of Publication 149 (i.e., the "Traffic Signal Design Handbook".)

The traffic signal permit contains information regarding the operation of the traffic signal and the placement of signal equipment, signing, and markings. Sheet 2 of the traffic signal permit is typically a signal plan sheet showing a scaled drawing of the intersection with the approved traffic control signal and other associated traffic control devices (e.g., signal structures, vehicular and pedestrian signal heads, controller, traffic detectors, traffic signs and any sign structures, pavement markings, pedestrian curb ramps, etc.). The scale of a full-size plan sheet is typically 1 inch equals 25 feet.

In addition to the scaled intersection drawing, other components shown on the traffic signal permit are as follows:



A. Movement, Sequence, and Timing Chart (Phasing Diagram) – This diagram indicates the traffic signal phasing and timing settings. (An explanation of the meaning of the symbols is contained in Section 22.1.2 of Publication 149.)

PHASING DIAGRAM S.S. 2-8 PHASE, SEMI ACTUATED, WITH MANUAL CORD

	PHASE 1+6				PHASE 2+6				PHASE 4				EMERGENCY FLASHING
	INTERVALS				INTERVALS				INTERVALS				
SIGNALS	1	2	3	4	1	2	3	4	1	2	3	4	
1-2	R	R	R		G	G	Y	R	R	R	R		Y
3	G	Y	R		G	G	Y	R	R	R	R		Y
4	G	Y	R		G	G	Y	R	R	R	R		Y
5-6	R	R	R		R	R	R	R	G	G	Y	R	R
7-8	DW	DW	DW		W	FD	DW	DW	DW	DW	DW	DW	OFF
9-10	DW	DW	DW		DW	DW	DW	DW	W	FD	DW	DW	OFF
FIXED		3.1	2.3			3.1	2.3			3.0	3.1		
MINIMUM	5				10				5				
SEC./ACT.													
PASSAGE	5								5				
MAX. INITIAL													
BEFORE RED.													
TO REDUCE													
MIN. GAP													
MAX. I	10				54				38				
MAX. II	10				57				35				
PEDESTRIAN *					11	12			9	10			
MEMORY	NL				MX/PR				L				

*UPON PEDESTRIAN ACTUATION, OTHERWISE "DON'T WALK" AT ALL TIMES

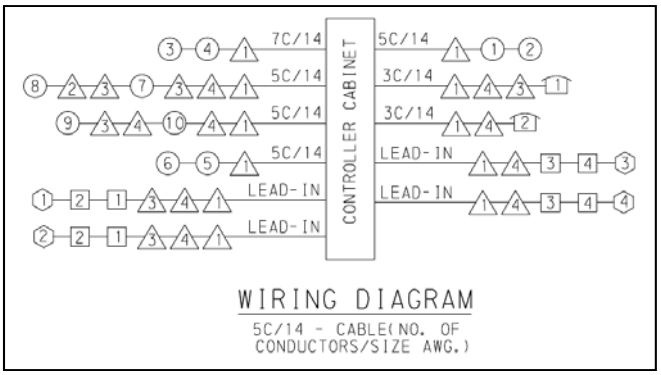
B. Signing Table – This table indicates the signing required on the permit that is associated with the traffic signal operation.

SIGNS

PLAN SYMBOL	SERIES DESIGNATION	SIZE W x H	DESCRIPTION	QUANTITY
A	R10-11B	30"x36"	NO TURN ON RED	2
B	R10-4BL	9"x12"	PUSH BUTTON FOR WALKING PERSON SIGNAL ←	1
C	R10-4BR	9"x12"	PUSH BUTTON FOR WALKING PERSON SIGNAL →	1
D	R10-12	30"x36"	LEFT TURN YIELD ON GREEN ●	1
E	R3-8A(L-S)	30"x30"	LANE USE CONTROL	2
F	R10-6AL	24"x30"	STOP HERE ON RED	3
G	* D3-4	78"x16"	Pearl Ave	2
H	R9-3A	18"x18"	NO PEDESTRIAN CROSSING	2
I	R9-3BL	18"x12"	USE CROSSWALK ←	1
J	R9-3BR	18"x12"	USE CROSSWALK →	1

* ACTUAL WIDTH DETERMINED BY LETTER SPACING-WHITE LETTERS ON GREEN BACKGROUND

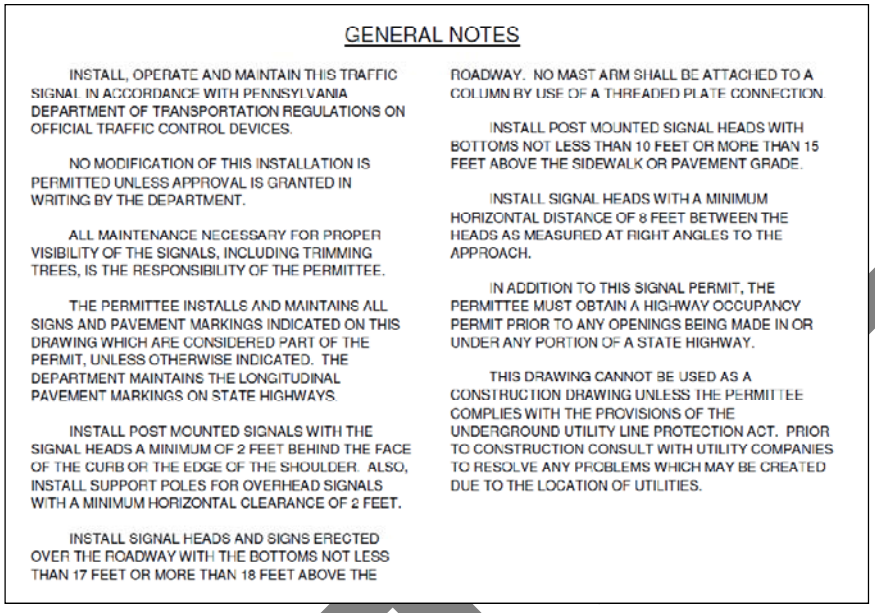
C. Wiring Diagram – This diagram indicates how the traffic signal is wired between junction boxes, poles, signals, and controller. Although Section 22.1.8 of the current Publication 149 does not require this diagram, some Engineering Districts request this information on the Traffic Signal Permit since it is useful information in the future should this information be needed for an improvement. (The various symbols used in this chart are defined in the "legend" on the plan sheet.)



WIRING DIAGRAM

5C/14 - CABLE(NO. OF CONDUCTORS/SIZE AWG.)

D. General Notes – As illustrated below, these are generic remarks that define and clarify some of the installation requirements and the permittee's responsibilities. Although these notes are general, the location and verbiage can vary from one permit to another; therefore, they should not be overlooked.



GENERAL NOTES

INSTALL, OPERATE AND MAINTAIN THIS TRAFFIC SIGNAL IN ACCORDANCE WITH PENNSYLVANIA DEPARTMENT OF TRANSPORTATION REGULATIONS ON OFFICIAL TRAFFIC CONTROL DEVICES.

NO MODIFICATION OF THIS INSTALLATION IS PERMITTED UNLESS APPROVAL IS GRANTED IN WRITING BY THE DEPARTMENT.

ALL MAINTENANCE NECESSARY FOR PROPER VISIBILITY OF THE SIGNALS, INCLUDING TRIMMING TREES, IS THE RESPONSIBILITY OF THE PERMITTEE.

THE PERMITTEE INSTALLS AND MAINTAINS ALL SIGNS AND PAVEMENT MARKINGS INDICATED ON THIS DRAWING WHICH ARE CONSIDERED PART OF THE PERMIT, UNLESS OTHERWISE INDICATED. THE DEPARTMENT MAINTAINS THE LONGITUDINAL PAVEMENT MARKINGS ON STATE HIGHWAYS.

INSTALL POST MOUNTED SIGNALS WITH THE SIGNAL HEADS A MINIMUM OF 2 FEET BEHIND THE FACE OF THE CURB OR THE EDGE OF THE SHOULDER. ALSO, INSTALL SUPPORT POLES FOR OVERHEAD SIGNALS WITH A MINIMUM HORIZONTAL CLEARANCE OF 2 FEET.

INSTALL SIGNAL HEADS AND SIGNS ERECTED OVER THE ROADWAY WITH THE BOTTOMS NOT LESS THAN 17 FEET OR MORE THAN 18 FEET ABOVE THE ROADWAY. NO MAST ARM SHALL BE ATTACHED TO A COLUMN BY USE OF A THREADED PLATE CONNECTION.

INSTALL POST MOUNTED SIGNAL HEADS WITH BOTTOMS NOT LESS THAN 10 FEET OR MORE THAN 15 FEET ABOVE THE SIDEWALK OR PAVEMENT GRADE.

INSTALL SIGNAL HEADS WITH A MINIMUM HORIZONTAL DISTANCE OF 8 FEET BETWEEN THE HEADS AS MEASURED AT RIGHT ANGLES TO THE APPROACH.

IN ADDITION TO THIS SIGNAL PERMIT, THE PERMITTEE MUST OBTAIN A HIGHWAY OCCUPANCY PERMIT PRIOR TO ANY OPENINGS BEING MADE IN OR UNDER ANY PORTION OF A STATE HIGHWAY.

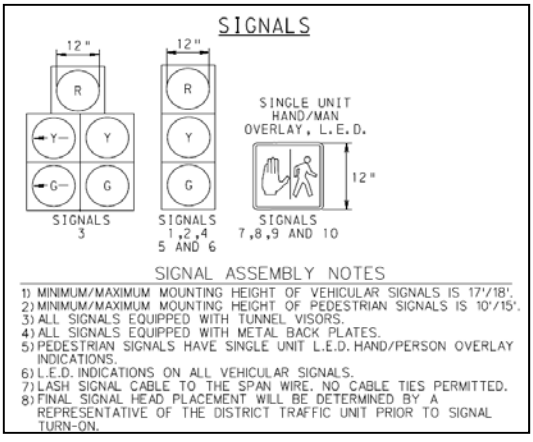
THIS DRAWING CANNOT BE USED AS A CONSTRUCTION DRAWING UNLESS THE PERMITTEE COMPLIES WITH THE PROVISIONS OF THE UNDERGROUND UTILITY LINE PROTECTION ACT. PRIOR TO CONSTRUCTION CONSULT WITH UTILITY COMPANIES TO RESOLVE ANY PROBLEMS WHICH MAY BE CREATED DUE TO THE LOCATION OF UTILITIES.

E. Signature Block – The block in the lower right of the permit which identifies and includes intersection name, location, and approval signatures.

County:
ALLEGHENY
Municipality:
HARMAR
Intersection:
S. R. 1001 (FREEPORT ROAD)
AND S. R. 1015
(PEARL AVENUE)
Approved and Accepted:
Municipal Representative Date
Recommended:
District Traffic Engineer Date
Scale 0 25 50 75

F. Signals Legend – This graphic shows the required arrangement of each traffic signal display, their size, and other pertinent information. The numbers below each graphic correspond to the same number on the plan view.

It is very important that the traffic signal faces always retain the same special relationships with one another. The notes may also specify the presence of visors, backplates and louvers, and the need for specific types of pedestrian signal heads.



SIGNALS

12" 12"

R R

Y— Y Y

G— G G

SINGLE UNIT HAND/MAN OVERLAY, L.E.D.

12"

SIGNALS 3

SIGNALS 1,2,4 5 AND 6

SIGNALS 7,8,9 AND 10

SIGNAL ASSEMBLY NOTES

1) MINIMUM/MAXIMUM MOUNTING HEIGHT OF VEHICULAR SIGNALS IS 17'/18'.
2) MINIMUM/MAXIMUM MOUNTING HEIGHT OF PEDESTRIAN SIGNALS IS 10'/15'.
3) ALL SIGNALS EQUIPPED WITH TUNNEL VISORS.
4) ALL SIGNALS EQUIPPED WITH METAL BACK PLATES.
5) PEDESTRIAN SIGNALS HAVE SINGLE UNIT L.E.D. HAND/PERSON OVERLAY INDICATIONS.
6) L.E.D. INDICATIONS ON ALL VEHICULAR SIGNALS.
7) LASH SIGNAL CABLE TO THE SPAN WIRE. NO CABLE TIES PERMITTED.
8) FINAL SIGNAL HEAD PLACEMENT WILL BE DETERMINED BY A REPRESENTATIVE OF THE DISTRICT TRAFFIC UNIT PRIOR TO SIGNAL TURN-ON.

G. Coordination Plan – This table provides cycle, offset, and phase splits (force offs) by time of day when a traffic signal is part of a coordinated signal system. It is generally described in more detail in the Coordination Program sheet that should be included with the traffic signal permit. The components of this sheet are described in the following two graphics.

COORDINATION PLAN

EVENT	TIME	PLAN	OFT	DAY OF WEEK S 1	M 2	T 3	W 4	T 5	F 6	S 7	CYCLE	FORCE OFFS ϕ1	ϕ2	ϕ3	ϕ4	ϕ5	ϕ6	ϕ7	ϕ8
0	0000	F		X	X	X	X	X	X	X									
1	0600	E		X	X	X	X	X	X	X									
2	0700	1	1		X	X	X	X	X		120	65	0		24	53	0		24
3	0900	3	135	X	X	X	X	X	X	X	150	37	0		74	37	0		74
4	1500	2	107		X	X	X	X	X		120	66	0		46	66	0		46
5	1800	E		X						X									
6	2000	E			X	X	X	X	X										
7																			
8																			
9																			
A																			
B																			
C																			
D																			
E																			
F																			

Coordination Program Sheet

Permit No. _____ Sheet 2 of 3

Date Issued _____ Date Revised _____

In this example, at Time 0:00 or midnight, Plan 1 is in effect for all days of the week.

For Plan 2 (6:00) use:
Cycle1 - see (A)
Offset 1 - see (A)
Split 1 - see (B)

COORDINATION PROGRAM

PLAN NO.	DAY OF WEEK M	T	W	T	F	S	S	TIME	CYCLE	OFFSET	SPLIT	REMARKS
1	X	X	X	X	X	X	X	0:00	-		-	FREE
2	X	X	X	X	X			6:00	1	1	1	95 SEC
3	X	X	X	X	X			14:00	2	1	1	115 SEC
4	X	X	X	X	X			19:00	-	-	-	FREE
5												
6												
7												
8												
9												
10												
11												
12												
13												

Here the signal cycle length is identified. If "FREE" is noted the signal runs during these times with no coordination. In this example it does so 0:00 - 6:00 M-F and 0:00 SAT to 6:00 MON.

In this example each cycle is associated with only one set of offsets. Cycle 1, Offset 1 is 46 seconds meaning this signal's start of main street yellow is 46 sec after the master intersection

OFFSETS (SEC.)

	CYCLE NO.:	1	2			
	LENGTH: (SEC)	95	115			
OFFSET	1	46 (A)	6			

OFFSET REFERENCED TO BEGINNING OF MAIN STREET YELLOW INTERVAL (PHASE 2+6)

SPLITS (SEC.)

		PHASE							
CYCLE	SPLIT	1	2	3	4	5	6	7	8
(B) 1	1	16	58		21	16	58		21
2	1	16	78		21	16	78		21

For Cycle 1 and Split 1 identified above, the splits for each signal phase are identified. Phase numbers would be noted on the signal permit plan. Note that the split includes the green, yellow and red for that phase.

PHASE TIME INCLUDES CHANGE AND CLEARANCE INTERVAL TIMES.

FILE:

COUNTY: _____

MUNICIPALITY: _____

INTERSECTION: _____

_____

In addition to the traffic signal plan, the cover sheet is the Department's TE-964 "Traffic Signal Permit" form (ftp://ftp.dot.state.pa.us/public/PubsForms/Forms/TE-964.pdf) which is the official document that captures the Department's approval of the traffic signal. This form also captures some basic information such as who the permit is issued to, the hours that the signal will be on flash, the type of controller mounting, the permittee's responsibilities, etc.

The TE-964 "Traffic Signal Permit" form and other standard Department forms relating to traffic signals are identified in Exhibit 1.4. Each of these is available for download from the Department's "Traffic Signal Portal Page" (see http://www.dot.state.pa.us/Portal%20Information/Traffic%20Signal%20Portal%20(9-14-2009).htm).

Exhibit 1.4: Standard Department Forms

Form	Title and Importance
TE-699	Traffic Signal Description. This one-page form captures key features of the traffic signal and is the start of an asset management system. Items of interest include type of controller, type and model no. of the detectors, etc. ftp://ftp.dot.state.pa.us/public/PubsForms/Forms/TE-699.pdf
TE-952	Application for Permit to Install and Operate Traffic Signals. This is the application that the municipality submits to the Department when they request authorization to install a traffic signal. It also is a commitment that if the Department approves the application, they will install them. ftp://ftp.dot.state.pa.us/public/PubsForms/Forms/TE-952.pdf
TE-964	Traffic Signal Permit. This is technically Sheet 1 of the traffic signal permit, and contains the department's approval and approval date. The traffic signal plan sheets comprise the balance of the actual "traffic signal permit." ftp://ftp.dot.state.pa.us/public/PubsForms/Forms/TE-964.pdf
TE-971	Master Signal Maintenance Log. A suggested paper format for manually tracking maintenance activities from a macroscopic point of view. Twenty different events can be summarized on each sheet. (See Appendix E.) ftp://ftp.dot.state.pa.us/public/PubsForms/Forms/TE-971.pdf
TE-972	Response Maintenance Record. A suggested paper format for tracking detailed response activities in an organized one-page format. One sheet is used for each maintenance callout. (See Appendix F.) ftp://ftp.dot.state.pa.us/public/PubsForms/Forms/TE-972.pdf
TE-973	Preventative Maintenance Record. A suggested paper format for tracking detailed preventative maintenance activities in an organized one-page format. One sheet is used for the preventative maintenance reviews of each traffic control signal. (See Appendix G.) ftp://ftp.dot.state.pa.us/public/PubsForms/Forms/TE-973.pdf
TE-974	Design Modification Checklist. A two-page checklist designed to encourage a thorough review of recurring maintenance problems, state-of-the-art technologies, etc. (see Appendix H.) ftp://ftp.dot.state.pa.us/public/PubsForms/Forms/TE-974.pdf

1.5 INSURANCE GUIDELINES

Municipalities should ensure that they have adequate insurance to cover property damage and liability issues. 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 municipality such as traffic signal design errors or signal failures.

Also of concern is the potential for damage from a lightning strike. 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 municipality could be legally challenged concerning the timeliness of the traffic signal repair. In this situation, a settlement could be large.

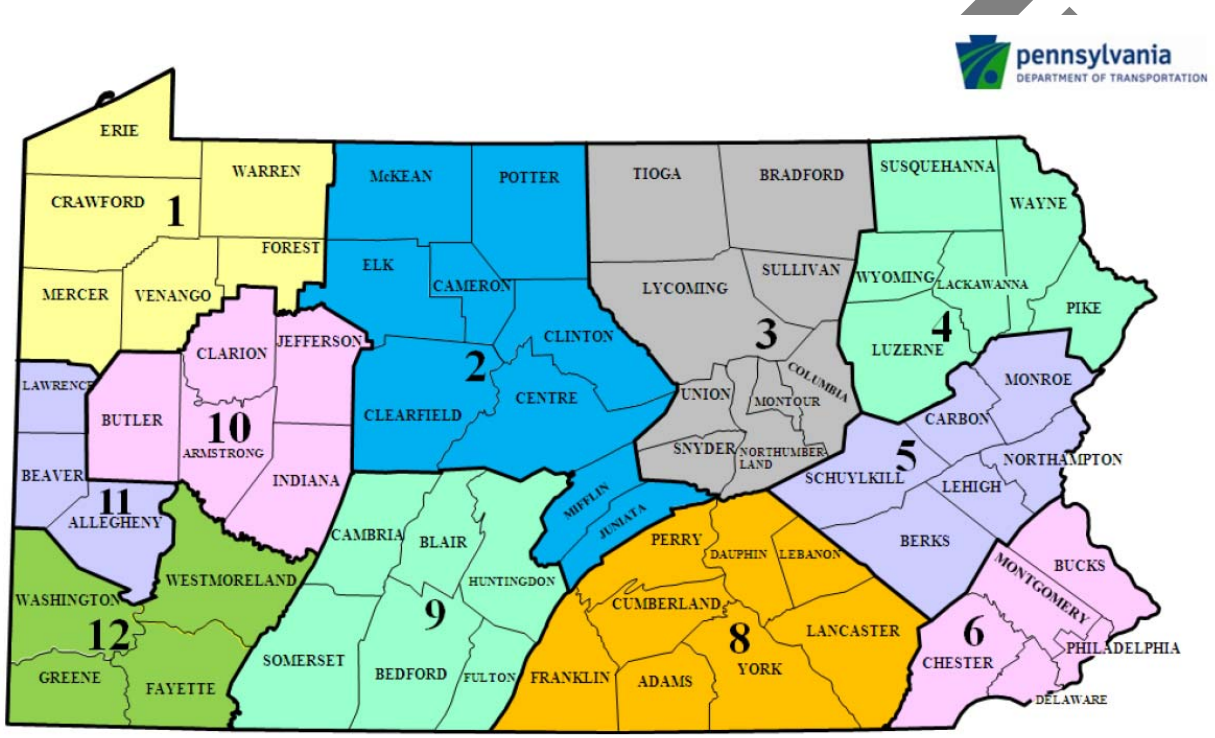
Similarly, if the municipality receives a safety complaint about the traffic signals and they do not address the concern, or at least not in a timely manner in the eyes of the court, a subsequent crash related to the concern could pose a large liability problem. (See Section 5.1.1 if the *Traffic Signal Maintenance Handbook* for some other issues.)

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

1.6 DISTRICT/CENTRAL OFFICE TRAFFIC SIGNAL CONTACTS

Exhibit 1.5 contains telephone numbers for District/Central Office personnel in the event that a municipality or a municipal contractor has any questions relative to the design, construction, maintenance, and operation of a traffic signal. These individuals will be able to either answer questions directly or provide additional guidance as to the proper contact person.

Exhibit 1.5: PennDOT Engineering Districts and Key Personnel



Engineering District	Traffic Signal Supervisor*	Municipal Services Supervisor*
1-0	(814) 678-7177	(814) 678-7142
2-0	(814) 765-0402	(814) 765-0408
3-0	(570) 368-4250	(570) 368-4239
4-0	(570) 963-3187	(570) 963-4117
5-0	(610) 871-4477	(610) 871-4151
6-0	(610) 205-6567	(610) 205-6541
8-0	(717) 787-9237	(717) 787-4839
9-0	(814) 696-7238	(814) 696-7221
10-0	(724) 357-2844	(724) 357-7986
11-0	(412) 429-4970	(412) 429-4809
12-0	(724) 439-7268	(724) 439-7136

* Central Office: Traffic Signal Manager = (717) 783-0333 &
Municipal Services Manager = (717) 783-2446

1.7 DEFINITIONS AND REFERENCES

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

1.8 MISCELLANEOUS REFERENCE DOCUMENTS

The miscellaneous publications in Exhibit 1.6 are published by other agencies and should be used to supplement materials and guidance expressed in this publication. These documents provide additional design, construction, and operational guidance.

Exhibit 1.6: Miscellaneous Reference Documents

Document Name and Information
Guidelines for Accessible Pedestrian Signals, Final Report, FHWA, 2007, http://www.trb.org/Main/Public/Blurbs/159956.aspx.
Manual on Uniform Traffic Control Devices (MUTCD), FHWA, 2009, http://mutcd.fhwa.dot.gov/.
National Traffic Signal Report Card, National Transportation Operations Coalition (NTOC), 2007, http://www.ite.org/REPORTCARD/technical_report%20final.pdf.
Pennsylvania Traffic Signal Systems; A Review of Policies and Practices, Pennsylvania State Transportation Advisory Committee, January 27, 2005, ftp://ftp.dot.state.pa.us/public/Bureaus/Cpdm/TAC/Pennsylvania%20Traffic%20Signal%20Systems%20-%20A%20Review%20of%20Policies%20and%20Practices,%20Final%20Report.pdf.
Pennsylvania Vehicle Code, 75 Pa.C.S. §6122, Authority to Erect Traffic Control Devices, http://www.dot4.state.pa.us/pdotforms/vehicle_code/chapter61.pdf .
Signal Retiming on a Shoestring, FHWA-HOP-07-006, FHWA , March 2005, http://ops.fhwa.dot.gov/publications/signal_timing/signaltimingshstrg.pdf
Traffic Detector Handbook, Report No. FHWA-HRT-06-139, FHWA, October 2006, http://www.tfhrc.gov/its/pubs/06108/index.htm.
Traffic Control System Operations: Installation, Management, and Maintenance, Institute of Transportation Engineers, 2000, http://www.ite.org.
Traffic Signal Design Handbook, Montana DOT, Chapter 12, November 2007, http://www.mdt.mt.gov/other/traffic/external/pdf/chapter_12.pdf.
Traffic Signal Maintenance Handbook, Institute of Transportation Engineers (ITE), 2010, http://www.ite.org.
Traffic Signal Operations and Maintenance Staffing Guidelines, Federal Highway Administration, Report No. FHWA-HOP-09-006, March 2009, http://ops.fhwa.dot.gov/publications/fhwahop09006/fhwahop09006.pdf.
Traffic Signal Timing Manual, Report No. FHWA-HOP-08-024, FHWA, http://ops.fhwa.dot.gov/publications/fhwahop08024/fhwa_hop_08_024.pdf.
Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals – American Association of State Highway and Transportation Officials (AASHTO), 5th edition.
Transportation Funding Study, Pennsylvania Transportation Advisory Committee, May 2010, http://www.dot.state.pa.us/internet/web.nsf/TranAdvCommittee?OpenFrameSet.
Transit Signal Priority (TSP): A Planning and Implementation Handbook, U.S. DOT, March 2005

2. ESTABLISHING A TRAFFIC SIGNAL MAINTENANCE AND OPERATION PROGRAM

Good maintenance is one of the keys to effective traffic signal operations. Poorly operating traffic signals are highly visible and provide an unsafe environment to the traveling public. Malfunctioning detectors and inappropriate traffic signal timing waste time and fuel, increase the release of pollutants from vehicles, and frustrate drivers. It is for these reasons that a municipality should be fully aware of their liabilities and their duty to provide safe and efficient travel to highway users in a way that minimizes the release of pollutants while reducing driver delay and fuel use. Only with a well-run maintenance program can this be achieved.

2.1 OVERVIEW

In their *2007 National Traffic Signal Report Card*, the National Transportation Operations Coalition (NTOC) documented their most recent findings regarding traffic signal operation in the United States, and gave the industry an overall score of "D" and traffic signal maintenance a score of "C-."

Their report documents results provided by traffic signal owners throughout the country and determined that the following five key components make-up an excellent maintenance program:

- Adequate policies and staffing (municipal or contract staffing) to provide for timely response within 1 hour during normal business hours and 2 hours outside of regular business hours after a critical malfunction is reported.
- Regular preventative maintenance and operational reviews, including a comprehensive semi-annual maintenance review, quarterly operational reviews and annual conflict monitor testing.
- An inventory of all traffic signal control equipment and management information (e.g., schematics, interconnection information and software documentation).
- Continuous malfunction monitoring and notification of critical components that provide reports to maintenance personnel within 5 minutes after detection of a failure.
- Having at least 90 percent of all detection devices working properly.

Nationally, agencies with a small number of signals had poorer maintenance scores than those with a larger number of traffic signals. Therefore, considering the high number of municipal subdivisions in Pennsylvania, and the fact that most of the municipal subdivisions that have traffic signals have less than five traffic signals, it is highly probable that traffic signal maintenance in Pennsylvania is worse than in the balance of the nation.

It is important to note that there are three distinct types of traffic signal maintenance that will be frequently referenced throughout this manual, two which are planned activities and the other type which is responsive:

1. Preventative maintenance. This type of maintenance is the periodic scheduled maintenance to minimize future problems. It includes inspection, calibration, cleaning, testing, sealing, painting, etc., in accordance with a predefined schedule to minimize the probability of unexpected failure and to maximize the life of the equipment. This maintenance is similar to the scheduled maintenance for an automobile.
2. Response maintenance. This maintenance is emergency repair because of either equipment failure

or a crash, and the goal is to make the traffic signal fully functional as soon as possible. Since response maintenance is frequently necessary at the most inopportune time, the objective is to minimize this type of maintenance.

3. Operational maintenance. This type of maintenance is the periodic scheduled operational maintenance to minimize existing and future congestion problems. This maintenance includes the analysis of traffic signal timings and other operational activities that can potentially improve safety and mobility at the traffic signal.

2.2 BUDGETING

The cost for installing traffic signals at an intersection frequently exceeds $100,000 (in 2010 dollars). After a traffic signal is installed and tested, the appropriate municipality becomes responsible for the cost of maintenance and operation of the traffic signal. Since the municipality assumes liability, it is important that appropriate budgeting for insurance, preventative maintenance, and response maintenance associated with crashes and equipment failure be provided.

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 depends on several factors such as the age and complexity of the traffic signal. However, most municipalities base their traffic signal operations and maintenance budget on the previous year's budget.

Traffic signal unit prices for new/replacement products or operational improvements are included in Exhibit 2.1. However, in addition to the unit costs in Exhibit 2.1, the cost for work zone traffic control is typically an additional 15 to 20 percent.

For budgeting purposes, it is also helpful to be aware of the typical service life of various traffic signal assets. Although unscientific, Exhibit 2.2 shows the average estimated life expectancy by several state Departments of Transportation based on responses to a 45-page questionnaire for the Transportation Research Board in 2006 (see NCHRP Synthesis 371 online at http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_syn_371.pdf). 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, etc.

Traffic Signals are an important part of the Long Range Transportation Plan Asset Management effort. Municipalities should request to their planning partners that traffic signal improvement line item be placed 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.

Exhibit 2.1: Installed Unit Prices, in 2010 Dollars

Element	Unit Prices*
Mast arms	$6,000 to $9,000/each
New controller	$9,000/each
3-section, 12-inch LED signal head	$800/each
5-section, 12-inch LED signal head	$1,300/each
LED pedestrian signal head	$600/each
LED replacement bulb	$150
Pedestrian pushbutton	$250/each
Loop detector	$1,200 to $1,800/each
Video detector	$4,000/approach $16,000 intersection
Junction box	$1,000/each
Emergency vehicle preemption (EVP)	$3,000/ approach, $10,000/intersection
Signs, misc	$35/square foot
Uninterruptible power supply (UPS), i.e., battery backup for LED signals	$3,000 to $6,000/intersection
External generator panel (hook-up to accommodate a small generator)	$500
Traffic Signal Retiming & Analysis (recommended every 3 to 5 years for every traffic signal)	$1,000 to $8,000/intersection

* Most of the unit prices were derived from recent Department construction projects (Publication 287, i.e., Construction Cost Catalog), inflated to 2010 prices, but a few of the unit prices came from the traffic signal industry.

Exhibit 2.2: Estimated Service Life

Component or Material	Average Life (years)
Tubular steel mast arms	24.6
Steel pole and span wire	22.8
Loop detector	8.6
Non-invasive detector	10.4
Traffic controller	13.5
Controller cabinet	17.5
Twisted copper interconnect cable	17.7
Fiber optic cable	23.6
Incandescent lamps	1.4
LED lamps	7.2
Signal heads	18.8
Signs	11
Thermoplastic pavement markings	4.2

* Values from Tables 6, 13, and 19 of *Managing Selected Transportation Assets: Signals, Lighting, Signs, Pavement Markings, Culverts, and Sidewalks*, NCHRP Synthesis 371, Transportation Research board of the National Academies, Washington, DC, 2007

2.3 SCHEDULING

As will be discussed in Section 3.2, preventative maintenance should be normally scheduled by the municipality every 6 months, and it can be completed at any time during the year. However, response (emergency) maintenance can occur at any time, so the municipality needs to have adequate personnel in place to respond to these situations.

2.4 PERSONNEL/RESOURCES

A municipality needs to determine the number of technically-proficient staff members that can maintain their traffic signals to the guidelines established within this document. When sufficient municipal resources are not available, consider having a traffic signal contractor perform municipal maintenance functions. Other considerations a municipality may consider include making a developer fund a municipal maintenance contract when determining the appropriate traffic signal maintenance budget.

In either case, the municipality should either have a professional engineer on staff or available to assist in overseeing the traffic signal maintenance. This individual should have experience in traffic flow theory and in the operation of traffic signals.

If traffic signals are being maintained by municipal staff, it is recommended that this individual(s) be in a supervisory role and responsible for directing the work activities pertaining to the municipalities traffic engineering and operations, including the installation, monitoring, modification, maintenance and administration of all traffic signals and signal systems. This individual(s) should ensure that traffic signal-related maintenance activities are adequately planned and executed and that there is an adequate inventory of replacement parts. The municipal engineer is responsible for investigating and preparing specific recommendations for all traffic-related inquiries from both the public and governmental agencies and for

providing overall traffic engineering expertise. This person plans, administers and supervises the installation, alteration, maintenance and repair of all types of traffic control devices, including the development and administration of contracts for the installation or modification of traffic signals.

Technicians

In order to adequately maintain traffic signals, a general rule-of-thumb is that a municipality should have one qualified technician for every 40 signalized intersections. However, additional technicians are required if the municipality has more than 150 traffic signals, a variety of different types of traffic signal equipment, larger intersections, or older traffic signal equipment.

The qualifications of technicians are included in Exhibit 2.3, and they should apply to both municipal and contractor employees:

Exhibit 2.3: Recommended Qualifications for Maintenance Personnel[1]

Requirement	Technician 1	Technician 2	Maintenance Supervisor
General Tasks	Replacement and repair of controllers, traffic signals, wiring and other field equipment. Works under direction.	Skills include programming of traffic controllers, troubleshooting controllers and ancillary equipment. Requires minimal direction. Provides direction and training to Technician 1 level.	Full supervisory responsibility. Supervises Technician 1 and Technician 2 levels. Greater technical knowledge than Technician 2 is required. Administrative duties include ordering spares and supplies, contract administration, budgets, provision for training.
Education and Experience	• High school (minimum). • Knowledge of electrical standards, codes, practices and repair techniques. • Certification to IMSA Traffic Signal Level I within one year of employment.	• Certification to IMSA Traffic Signal Level II. • Minimum of 2 years experience as Technician 1.	• Combination of training, education and experience for a total minimum of 5 years. • Certification to IMSA Traffic Signal Level II. • Additional training beyond IMSA Traffic Signal Level II.
Physical Requirements	• Must be able to work for long periods in inclement weather. • May be required to lift heavy objects, work from bucket trucks	Same as Technician 1.	

Using municipal personnel to perform maintenance on traffic signals that are located in two or more municipalities, or that are part of an interconnected traffic signal system can be challenging. At a minimum, a multi-municipal agreement should exist in these cases to minimize potential maintenance issues (see Chapter 11).

[1] Information provided from Table 1.2, *Traffic Signal Operations and Maintenance Staffing Guidelines*, FHWA-HOP-09-006, Federal Highway Administration, March 2009

Exhibit “C” in the Commonwealth and Municipal Traffic Signal Maintenance Agreement (see Appendix C, Page C-10) contains additional detail for the type of work activities required.

In addition, to performing routine maintenance (preventative and emergency response), research indicates that operational maintenance (traffic signal timing) should be reevaluated every 3 to 5 years to determine if the traffic signal retiming is necessary, and even more often if development or traffic volumes change significantly. In FHWA’s report entitled *Traffic Signal Operations and Maintenance Staffing Guidelines* (Report No. FHWA-HOP-09-006, dated March 2009), this additional manpower need for retiming is estimated at 43 hours per intersection, as included in Exhibit 2.4.

If a municipality determines, through evaluation of the current traffic signal operations, that the timing should be modified, an official request with traffic analysis documentation should be submitted to the Department’s appropriate District Traffic Engineer for approval and for revision of the traffic signal permit.

Specialized Equipment and Inventory

If a municipality 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 Publications 46 “Traffic Engineering Manual” and 213 “Temporary Traffic Control Guidelines”).

Exhibit 2.4: Person Hours for Key Signal Timing Activities[2]

Task	Person-Hours per Intersection
Project management	0.8
Weekday turning movement counts	19.8
Saturday turning movement counts	4.6
Field intersection inventory	1.5
Qualitative assessment	1.5
Signal timing analysis	7.5
Fine tuning	6.0
Final delivery	1.3

2.5 MEASURES OF EFFECTIVENESS

Two typical measures of effectiveness (MOEs) used to evaluate the overall quality of the traffic signal operation are: (1) average delay per vehicle per intersection; and (2) average number of stops per day per intersection. These MOEs are good indicators of the quality of the design and/or the signals suitability with respect to current traffic volumes. Although it can be argued that a poorly maintained traffic signal will have negative effects on these MOEs, it is not true that poor MOEs are caused solely by the lack of proper maintenance – they may be in large part due to heavy traffic volumes and inadequate roadway capacity.

A large number of emergency repair calls involving equipment failure is an indication that there is a need for better preventative maintenance. In fact, a good preventative maintenance program will practically eliminate the need for emergency maintenance, with some agencies reporting after hour calls being reduced by as much as 90 percent. For this reason major emphasis should be placed on preventative maintenance, since safety and liability would also be related to the number of emergency repair calls.

Possible MOEs include:

1. Annual number of emergency calls per intersection.
2. Number of burnout/non-functioning lights replaced per year.
3. Average response time for emergency calls.
4. Average time to complete an emergency repair.
5. Percent of response calls that were fixed with all new parts from inventory.
6. Percent of loop detectors online.
7. Maintenance records showing all maintenance performed at each signal, including the technician and the date.
8. Number of traffic signal operational improvements to existing traffic signals.

The importance of using MOEs is to determine if the current maintenance program is working properly,

[2] Reproduced from Table 2.15, *Traffic Signal Operations and Maintenance Staffing Guidelines*, FHWA-HOP-09-006, Federal Highway Administration, March 2009

and if changes are needed. If the MOEs are going in the wrong direction, it may be justification for increasing the traffic signal budget, changing maintenance contractors, etc.

To gauge how well you are doing currently, a municipality should know how well they have performed in the past. To be able to do so, baseline MOEs should be established so that trends can be established.

In 2005 and again in 2007, the National Transportation Operation Coalition (NTOC) prepared a *"National Traffic Signal Report Card,"* to evaluate traffic signals in United States. As part of the evaluation, NTOC judged the quality of maintenance based on agency responses to questions. The nine sets of questions used for their 2007 report card are included in Appendix B. These questions could be used as possible MOEs.

The NTOC report also indicates that key components of an excellent maintenance program included in the five bullet points listed in Section 2.1. These key components should be goals for a successful municipal maintenance program.

2.6 TRAINING

As indicated in Exhibit 2.3, all traffic signal technicians should receive training and certification by the International Municipal Signal Association (IMSA). This is true whether the technicians are municipal employees or contractor employees. Traffic signal technicians should also be familiar with work zone traffic control requirements as defined in Publication 213 (Temporary Traffic Control Guidelines).

2.7 DOCUMENTATION

Whenever preventative maintenance or response maintenance is performed, a record of the work must be documented in accordance with Chapter 4.

2.8 COORDINATION

Coordination of maintenance and repair activities are important for any municipality with traffic signals. It increases in importance as the number of signals a municipality must maintain increases. Maintenance activities must be coordinated among municipal staff and/or with the contractor who conducts the maintenance such that it is performed in a timely and cost-effective manner. Coordination with other agencies and the review of proposed projects is essential since their projects could affect the traffic signal current operations. This includes utility work, road work, or a design by a land developer. For example a municipality may plan to replace traffic signal indications but if that traffic signal is being replaced by a land developer as part of a site plan in the near future, replacement of the signal indications may waste maintenance funds.

Coordination with other municipalities is also necessary when a traffic signal or a coordinated traffic signal system is located in more than one municipality (see Chapter 11).

2.9 CONTRACTS AND MUNICIPAL CONTRACTORS

Municipalities are responsible for the costs associated with the installation and maintenance of all traffic signals within their jurisdiction. Moreover on state and/or federal funded projects, except for the cities of Philadelphia and Pittsburgh, and any municipality with current municipal traffic engineering certification

issued in accordance with Chapter 205 of Title 67 of the PA Code (67 Pa. Code Chap. 205), municipalities are required to also enter into a *Traffic Signal Maintenance Agreement* with the Department as discussed in Chapter 8. This traffic signal maintenance agreement defines the municipality's responsibilities to the maintenance of the traffic signal.

This traffic signal maintenance agreement also requires a municipality to document whether they will use municipal personnel or contract services for maintenance. If a municipality elects to use contract services for either preventative maintenance or response maintenance, a municipality further agrees to submit a copy of the contract or agreement between them and the contractor to the Department. An example of this type of document is referenced in Chapter 8 and is included in Appendix I.

3. TRAFFIC SIGNAL MAINTENANCE CLASSIFICATIONS

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

- Response (emergency) maintenance
- Preventative (routine) maintenance
- Operational maintenance
- Design modifications

A municipality is responsible for evaluating their program requirements and determining the acceptable level of traffic signal maintenance and operation actions to meet the guidelines established in this publication. A municipality will need to determine whether maintenance and operations responsibilities will be provided by either their municipal personnel and/or by a private maintenance contractor. 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 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 a specific segment of labor and/or materials with the remaining functions provided by the municipality. If traffic signals are not properly maintained it will cost the municipality more in capital costs, reduce the life expectancy of the traffic signal, and create additional liability at an intersection. For example, missing signs could result in a crash for which the municipality can be found at fault if no regular maintenance of the traffic signal was performed.

It is important to ensure that the municipal staff and/or municipal contractor 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 adequately trained, traffic signal maintenance personnel (contractor or municipal), should satisfactorily complete a certification program sponsored by a nationally recognized organization such as the International Municipal Signal Association (IMSA), as described in Chapter 12.

Before any “on street” maintenance or operation activities are performed, the applicable traffic control shall be in place as indicated in Publication 213 (i.e., Temporary Traffic Control Guidelines). Traffic control adjacent to the traffic signal could conflict with the signal operation causing a crash to occur.

Maintenance reporting and documentation shall follow the guidelines outlined in Chapter 3. Additional details regarding contractor maintenance are provided in Chapters 7.0 and 8.0.

3.1 RESPONSE (EMERGENCY) MAINTENANCE

Response Maintenance, also as known as Emergency Maintenance, is the immediate repair of operational deficiencies and/or physical malfunctions that may occur. Response Maintenance duration is dependent on the following elements:

- Receive notification – Point in time the contractor or municipality is notified that there is an issue requiring attention.
- Site arrival/problem diagnosis – The time it takes the contractor to diagnose the issue.
- Perform repairs – The time it takes the contractor to perform repairs.
- Log activity - This includes formally logging the activity into the maintenance log.

The goal of providing response maintenance is to restore the traffic signal to normal operation as indicated on the current, approved Traffic Signal Permit. Response Maintenance repairs can be either Final Repair or Temporary Repair as described below.

RESPONSE MAINTENANCE RECORD SHEET

Instructions: Fill in the blanks and/or check appropriate boxes

Location:	Location No.:	Date:
Reported by: When:	Police Notified: ☐ Yes ☐ No If "yes", When:	Officer's Name & Rank:
Reported Trouble:		
Weather Conditions: ☐ Clear ☐ Rain ☐ Snow ☐ Ice ☐ Fog		Ambient Temperature (°F):
Assigned To:	When:	Truck No.:
Time of Arrival:	Condition Found on Arrival:	

Work Performed:

☐ 1. Lamp Out	☐ 12. Power Failure
☐ 2. Detector Failure	☐ 13. Signal Damaged
☐ 3. Detector Amplifier Failure	☐ 14. Pole Knockdown
☐ 4. Load Switch Failure	☐ 15. Controller Knockdown
☐ 5. Conflict Monitor Failure	☐ 16. Guy Wire Down
☐ 6. Timing Incorrect	☐ 17. Span Wire Down
☐ 7. Signal Stuck	☐ 18.
☐ 8. Signal Out	☐ 19.
☐ 9. Lack of Progression	☐ 20.
☐ 10. Interconnection Failure	☐ 21.
☐ 11. Systems Master Failure	☐ 22.

Condition on Departure:	☐ Emergency Repair ☐ Final Repair	Time of Departure:
Parts Replaced or Repaired:		
Signature of Supervisor:	Signature of Repair Person:	

- Final Repair – Restore the traffic signal to operate in accordance with the approved Traffic Signal Permit.
- Temporary Repair – Use alternate means to restore the traffic signal to safe operation until final repair can be made. As a minimum, traffic signals should be set to operate in flashing mode, and not be left in an unlighted condition. For long-term traffic signal outages where even flashing mode is not possible, alternative traffic control methods need to be coordinated with the appropriate Engineering District.
- Examples of typical response maintenance problems are included in Exhibit 3.1 and on the suggested Response Maintenance Record (TE-972) as included in Appendix F.

Exhibit 3.1: Typical Response Maintenance Items

Signal Heads
Restore unlighted traffic signal (includes pedestrian signals)
Correct misaligned traffic signal (includes pedestrian signals)
Repair or replace mounting hardware
Repair or replace damaged signal head or parts thereof (e.g., visor, lens, backplates, and reflector)
Clean any obstructed indications including, but not limited to dirt or snow
Controller Assembly
Restore correct phasing and time setting in controller unit
Replace a malfunctioning controller unit
Replace a malfunctioning conflict monitor
Repair or replace malfunctioning flasher
Repair or replace malfunctioning load switch
Repair or replace malfunctioning time clock
Repair or replace malfunctioning relay
Traffic Signal Supports
Repair or replace defective poles or other supporting hardware
Replacement of any damaged traffic signal supports
Base Plate cracks
Pole cracks
Cracks in any weld metal or base metal
Anchor bolt connection failures, or other nut and bolt failures
Gaps between base plate connection and foundation
Foundation cracks
Restore required clearance between the roadway and bottom of signals and/or signs located over the roadway
Detection (Vehicular)
Repair or replace malfunctioning detector amplifier
Repair or replace malfunctioning detector sensor
Repair or replace malfunctioning video detection equipment
Repair or replace malfunctioning preemption system equipment
Tune or adjust detection amplifier
Redirection or re-establishment of detection equipment
Detection (Pedestrian Push Button)
Repair or replace malfunctioning push buttons
Repair of accessible pedestrian signal messages or indications
Removal of obstructions preventing pedestrian push button accessibility, e.g., piles of snow
Signs (As indicated on the Traffic Signal Permit)
Correct misaligned signs
Repair or replace damaged or missing signs
Pavement Markings
Restore pavement markings that are the responsibility of the permittee as indicated on the Traffic Signal Permit (e.g. stop lines, crosswalks, legends, etc.)

Response to a knockdown or equipment failure may require an emergency repair using temporary measures. Some repairs are not permitted to be performed using emergency (temporary) measures and require final repairs instead, e.g., signal heads or span wire. Exhibit 3.2 identifies the types of repairs permitted and not permitted for various knockdowns and failures.

Exhibit 3.2: Response Maintenance Schedule

Knockdowns	Type of Repair Permitted
Support - Mast Arm	Emergency or Final
Support - Strain pole	Emergency or Final
Span Wire/Tether Wire	Final Only
Pedestal	Emergency or Final
Push Button Support	Emergency or Final
Cabinet	Emergency or Final
Signal Heads	Final Only
Equipment Failure	**Type of Repair Permitted**
Lamp Burnout (Vehicular & Pedestrian)	Final Only
Local Controller	Emergency or Final
Master Controller	Emergency or Final
Detector Sensor—	
Loop	Emergency or Final
Magnetometer	Emergency or Final
Wireless	Emergency or Final
Magnetic	Emergency or Final
Microwave	Emergency or Final
Video	Emergency or Final
Radar	Emergency or Final
Pushbutton	Emergency or Final
Preemption System	Emergency or Final
Detector Amplifier	Emergency or Final
Conflict Monitor	Final Only
Flasher	Final Only
Time Clock	Emergency or Final
Load Switch/Relay	Final Only
Coordination Unit	Emergency or Final
Communication Interface, Modem	Emergency or Final
Signal Cable	Final Only
Blank-Out Sign	Emergency or Final

3.2 PREVENTATIVE (ROUTINE) MAINTENANCE

Preventative Maintenance, also known as Routine Maintenance, is the establishment of a pre-developed program of periodic inspections and procedures to minimize the probability of a failure which would require future response (emergency) maintenance. It also includes the repair or replacement of components, as necessary, to maintain the signal as it is intended to operate on the Traffic Signal Permit.

Preventative maintenance can be completed anytime during the year. It is especially important to perform the reviews after severe weather to ensure that the traffic signal has not been damaged. For example:

- High winds can twist or misalign signal heads and video cameras (misalignment is especially problematic for optically programmed signals).

- High winds can damage signs.
- Rain, snow or water in signal heads could create an electrical short.

Specific preventative (routine) maintenance considerations to be evaluated could include:

Operations
Are intersection phases appropriate for observed conditions?
Are intersection timings appropriate for observed conditions?
Is the intersection on the appropriate "recall" mode?
Is "dual entry" used for the appropriate phases?
Is there suitable progression between intersections?

Maintenance
Are detectors functioning properly?
Are individual signals interconnected and communicating properly?
Are all grounds solidly connected and in working order?
Are battery(s) fully charged and holding the correct voltage?

Other
Could lane reassignment or minor geometric enhancements improve operations?
Could basic, low-cost access management practices improve operations?
Do emergency services need addressed?
Are pedestrians accommodated?
Are timing changes necessary?

3.3 OPERATIONAL MAINTENANCE

For operational maintenance, please refer to Chapter 6.

3.4 DESIGN MODIFICATIONS

For design modifications, please refer to Chapter 9.

4. DOCUMENTATION

Documentation is important for several reasons:

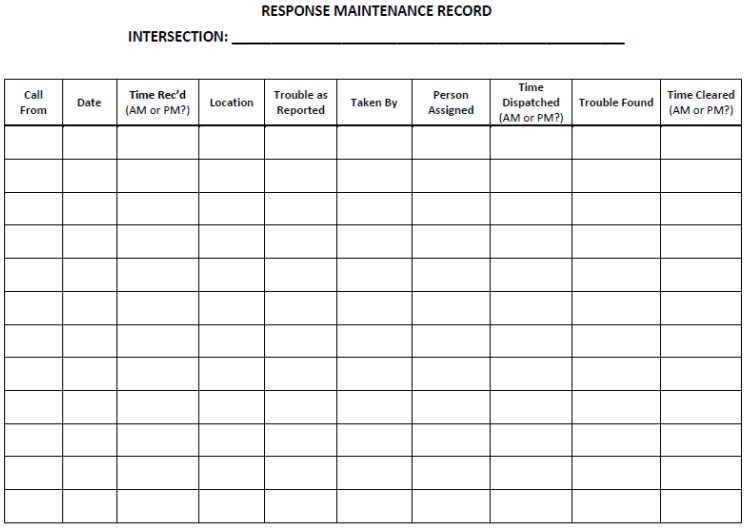
- Maintenance records are critical to ensure that traffic signal maintenance is performed at regular intervals.
- Documentation of a traffic signal's equipment and operation may make future upgrades to the signal much easier and allows for sharing of information. Other public agencies may occasionally 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.

4.1 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 municipality from a tort liability claim. The following are types of traffic signal records that should be kept when managing maintenance activities:

- Master Record – master log of all service calls that includes the date, type of maintenance performed, and signatures of personnel performing the work.
- Preventive Maintenance Record – a log for each preventive maintenance service that includes the date, tasks performed, and signatures of personnel performing the work.
- Preventive Maintenance Problem Record – a record of potential problems identified, corrective action taken, and information about a follow-up inspection.



RESPONSE MAINTENANCE RECORD

INTERSECTION: _____

Call From	Date	Time Rec'd (AM or PM?)	Location	Trouble as Reported	Taken By	Person Assigned	Time Dispatched (AM or PM?)	Trouble Found	Time Cleared (AM or PM?)

- Response Maintenance Record – a log recording the location, date, time, caller, receiver and complaint received, maintenance personnel, time dispatched, trouble found, and time cleared.

4.2 DOCUMENTATION METHODS

Form TE-699 "Traffic Signal Description" includes basic information on a traffic signal's equipment and operation, important when needing to perform repairs where the traffic signal must be restored to the approved traffic signal permit. Some of the information contained in this form includes:

- Type of mounting
- Number and size of signal indications
- Controller, conflict monitor, and detector manufacturer and model number
- Type of controller operation

Form TE-699 "Traffic Signal Description" (copy located in Appendix D) becomes more critical when developing a municipal traffic signal equipment asset management system since information would then be readily available for entry. Up-to-date and accurate information can benefit all parties in making informed decisions.

A further explanation of Form TE-699 is included in Appendix C of Publication 149 (i.e., the "Traffic Signal Design Handbook"). If a municipality has any questions concerning the proper traffic signal documentation, please contact your appropriate Engineering District Traffic Signal Unit.

A copy of all maintenance records should be kept within the appropriate traffic signal cabinet and in a centralized municipal location with easy access. Suggested forms for maintenance records are identified below and included in Appendices E, F, G, and H:

- TE-971 – Master Signal Maintenance Log (see Appendix E)
- TE-972 – Response Maintenance Record (see Appendix F)
- TE-973 – Preventative Maintenance Record (see Appendix G)
- TE-974 – Signal Modification Checklist (see Appendix H)

5. 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. The following traffic signal components are detailed in the following sections:

- Supports
- Indications
- Detection
- Controller
- Communications
- Emergency Preemption
- Electrical Distribution
- Signing and Marking
- Sidewalks and ADA Curb Ramps

5.1 TRAFFIC SIGNAL SUPPORTS

Overhead traffic signals are supported by either mast arms connected to signal support poles or span-wire that is tethered to strain poles. Mast arm installations are typical except where the intersection is too wide and proper signal placement cannot be accomplished with a suitable mast arm length (typically less than 60 feet).

5.1.1 Traffic Signal Support Installation

(a) Post-Installation Procedures

When inspecting or evaluating traffic signal supports, it is essential that Publication 148 (i.e., “Traffic Standards – Signals, TC-8800 Series”) and Publication 149 (i.e., “Traffic Signal Design Handbook”) are reviewed.

Inspections of the welded and bolted connection apply in 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.
- When municipalities conduct the recommended annual preventative traffic signal maintenance and inspection activities.

(b) Welded Connections:

Inspect 100 percent of all welds for visual evidence of any cracking.

Document and **immediately** report any evidence of weld metal or base metal cracking of the traffic signal installation for further investigation. If cracks are observed, schedule response (emergency) maintenance as soon as possible.

(c) Bolted Connections

- Ensure that a washer is used between the connection or flange plate and each nut.
- Visually examine the connection. The connection should be tight with no visible gap between the connection or flange plates, bolts, nuts, or washers.
- Galvanized nuts, bolts, and washers should not show any significant signs of corrosion.
- Document and immediately report any adverse findings to the appropriate official for further investigation. Immediate action shall be taken by the local authorities if adverse findings are observed.
- Where bolted connections require remedial corrective action, new bolts, washers, and nuts must be used.
- Inspect the foundation and base plate connection.
- 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.
- Ensure 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 man on a 12-inch wrench.
- For pole replacement, ensure that the distance between the bottom of each leveling nut and the concrete foundation is less than the bolt diameter, unless indicated otherwise on the approved design drawings for the traffic signal support. Note that, if the distance is not less than the bolt diameter, the American Association of State Highway and Transportation Officials' (AASHTO) "Standard Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals" requires that the bending stresses in the anchor bolts be considered when determining the structural adequacy of the installation.
- Replace the grout or rodent screen if it has be removed.
- Ensure that a washer meeting Section 1104.02 of Publication 408 (i.e., "Highway Specifications") is present under each top nut to provide full bearing and to seal bolt hole gaps.
- Verify that the top nuts are tight. Remove, lubricate, and retighten any loose nuts using the method described for overhead sign structures in Section 948 of Publication 408 or the method described in AASHTO's "Standard Specification for Structural Supports for Highway Signs, Luminaires, and Traffic Signals," Section 5.17.6.2 'Anchor Pretensioning.' Both methods are similar turn-of-the-nut procedures. (Contact the Department for more specific assistance.)
- Where sufficient anchor bolt projection exists, install an additional top nut if a single nut exists.
- Verify that the threads have been burred above the top nut to prevent loosening.

5.1.2 Mast Arms

(a) Maintenance and Inspection

Bolted Connections:
Inspect arm to column connections.

Welded Connections:
Inspect 100 percent of all welds for visual evidence of cracking.

- Cracks on traffic signal supports with mast arms may occur in the vertical column to base plate connection and generally initiate opposite the arm to shaft connection (about 180° from the centerline of the arm for single-arm structures).
- Cracks in the welded connection between the arm or column connection plates usually 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.

Document and **immediately** report any evidence of weld metal or base metal cracking to the proper officials for further investigation. Appropriate response (emergency) maintenance should be scheduled as soon as possible if such cracks are observed.

5.1.3 Strain Poles

(a) Maintenance and Inspection

Bolted Connections:
Inspect connections.

Welded Connections:
Inspect 100 percent of all welds for visual evidence of cracking.

- Cracks in the shaft or column to base plate connection usually initiate opposite the span wire connections.
- Document and **immediately** report any evidence of weld metal or base metal cracking to the appropriate officials for further investigation. Schedule the appropriate response (emergency) maintenance as soon as possible if such cracks are observed.

5.1.4 Pedestal Poles

See Section 5.1.1 for pre- and post-installation procedures. In addition ensure a round top cap is in place to minimize injuries.

5.1.5 Appurtenances Unrelated to Traffic Control

With the use of technology becoming more widespread, appurtenances are sometimes installed on traffic signal supports even though they are not for the purpose of controlling traffic. These installations are discouraged on signal supports; however, if installed, a structural analysis should be performed to ensure the signal support can handle the additional load(s) and a modification of the traffic signal permit.

5.2 TRAFFIC SIGNAL INDICATIONS

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 a 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.

5.2.1 Traffic Signal Housing

As indicated in the *Manual on Uniform Traffic Control Devices (MUTCD)*, a Traffic Signal Housing is the part of the traffic signal section that protects the light source and other required components. There are two primary types of Traffic Signal Housing:

Vehicular Housing

Pedestrian Housing

Traffic signal housings should be inspected routinely using the guidance materials provided in the TE-972 and TE-973 Forms (see Appendices F and G). These documents will provide the necessary details to consider when providing both response and preventative maintenance. Additionally, the Traffic Signal Permit, Publication 408 (i.e., “Highway Specifications”), and Publication 148 (i.e., “Traffic Standards – Signals, TC-8800 Series”) are key materials that should be used to evaluate the pedestrian housing. The importance of the traffic signal housing is critical to ensuring that the indications are protected.

If a traffic signal housing needs to be replaced, please refer to Publication 35 (i.e., "Approved Construction Materials," also referenced as Bulletin 15) to determine what manufacturers and model numbers are approved to the Department's specifications. All installations shall follow Publication 408 (i.e., "Highway Specifications") and Publication 148 (i.e., "Traffic Standards – Signals, TC-8800 Series").

(a) Vehicular Traffic Signal Housing

Vehicular traffic signal housings supplement the indications through the use of appurtenances such as backplates, visors, and louvers.

Backplates are used to provide a dark contrast to the traffic signal housing and indications to improve visibility. FHWA encourages their use on all approaches with a speed limit of 45 mph and above, and where sun glare, bright sky, and/or complex or confusing backgrounds indicate a need for enhanced traffic signal face target value. FHWA also permits the use of a yellow retroreflective strip with a width of 1 to 3 inches placed around the perimeter of the backplates with PennDOT Central Office approval.

Visors attach to the traffic signal housing and shield the indications from sun glare and the elements, also improving visibility. Visors should be flat black in color on the side toward the indication. Visors are typically cut-away where the bottom is open, but tunnel visors and full circle visors may be considered to make it more difficult for drivers in adjacent approaches to view traffic signals not intended for their approach. Louvers may be installed over the indications to further restrict indications' view from directions of travel for which they do not control.

Traffic signal heads on mast arms should be mounted using fixed-mounts as opposed to free-swing mounts unless there is a compelling reason. Hardware assemblies differ depending on whether the heads are mounted mid-span or end-span.

(b) Pedestrian Traffic Signal Housing

The pedestrian traffic signal housing, like vehicular traffic signal housings, use visors to protect and increase visibility of the indications. Screen visors can be used to protect the Light Emitting Diode (LED) indications from the weather.

For both vehicular and pedestrian traffic signal housings, it is essential that drivers and pedestrians have a clear view of the traffic signal indications. Therefore, traffic signal indications should be routinely inspected to ensure that advance signs, foliage, or snow does not impair their visibility.

5.2.2 Light Emitting Diode (LED) Indications

The Energy Policy Act of 2005 (EPACT 2005) effectively eliminates the use of incandescent traffic signal modules on new installations, and also encourages the upgrading of existing incandescent modules to more energy efficient LED technology.

The Department has created the following four categories to place LED products and has developed detailed specifications that take into account national practices, updated testing parameters, materials

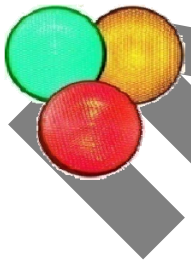
validation, and a 5-year warranty:

- Circular LED Vehicle Traffic Signal Module.
- 12-Inch LED Vehicle Arrow Traffic Signal Module.
- LED Pedestrian Signal Module. (Note, in accordance with Publication No. 149, all new pedestrian signal heads shall be countdown pedestrian signals, except at locations where the crossing is so short that the duration of the pedestrian change interval is 3 seconds or less.)
- LED Countdown Pedestrian Signal Module.

LED traffic signals can benefit a municipality since they use 80 to 90 percent less energy than incandescent bulbs, resulting in significant energy cost reductions. In addition, they typically last about 5 to 7 years so maintenance cost reductions can also be realized with their use. One benefit to LEDs is that the individual module slowly burns out since instead of an incandescent bulb which will fail immediately. LEDs should be periodically monitored for brightness level to ensure replacement prior to complete failure.

One drawback to LEDs is that they do not generate heat (thereby saving energy), which may lead to issues with snow captured in the traffic signal housing. Under unique snow and wind combinations the lens visibility can actually become restricted. This problem has occurred with incandescent bulbs, but not to the extent that it occurs with LEDs due to the lack of heat provided by LED modules. If snow buildup becomes a significant problem, a municipality should contact the appropriate PennDOT Engineering District to determine the proper course of action. Currently, the Department is evaluating and testing industry solutions at known problem locations, but will not allow the widespread use of these solutions until valid testing is performed to ensure that municipalities are receiving credible products. In the interim, if snow buildups restrict the signal indication, the municipality should have the snow removed immediately to ensure public safety.

The below table provides examples of several common LED traffic signal module types.

Circular LED Modules	12-Inch LED Vehicle Arrow Modules	LED Pedestrian Signal	LED Countdown Pedestrian Signal
			
▪ Most commonly used vehicular indication	▪ Arrow modules typically used for an exclusive turn phase ▪ Use of red arrow now permitted in some cases but requires approval from appropriate District.	▪ Hand/person pedestrian crossing signal ▪ Should no longer be used for new installations except where crossing so short only 3 sec change interval used	▪ Enhances safety over conventional pedestrian signal by providing pedestrians a visual on how long they have to cross the street

In accordance with PennDOT Publication 149 "Traffic Signal Design Handbook" countdown pedestrian signals are now preferred and should be used in lieu of hand/person pedestrian traffic signals. It is recommended that a municipality upgrade to these pedestrian traffic signals and adjust the Traffic Signal Permit accordingly.

5.2.3 Optically Programmed Traffic Signals

Optically programmed traffic signals are sometimes used at the downstream signal of two closely-spaced traffic signals. They are designed not to be visible from the first traffic signals so that drivers do not get confused by two conflicting traffic signal indications. They are also used at intersections where roads intersect at acute angles.

Please refer to Chapter 9.0 in Publication 149 (i.e., the "Traffic Signal Design Handbook") for additional guidance to ensure that the optically programmed signals are functioning properly.

5.2.4 Louvers

Louvers are full-circle inserts with one or more built-in fins or vanes that restrict the viewing angle of the signal. When used they should be installed with tunnel or full-circle visors.

Although they serve the same basic purpose as the optically programmed traffic signals, they are not as easily aligned and they also reduce the signal's light output.

5.2.5 Incandescent Indications

When incandescent indications have reached the end of their useful life and need to be replaced, Department approved LED products in Publication 35 (i.e., "Approved Construction Materials," also referenced as Bulletin 15), Section 1104.06 should be used as a replacement. Incandescent replacement indications are to no longer be used. It should be noted that some manufacturers provide incandescent look LED indications that have a similar appearance to a bright incandescent indication, whereas earlier LED indications had many bright LEDs, making it easy to distinguish them from incandescent indications.

5.2.6 Preemption Fail Safe Lights

Emergency Vehicle Preemption (EVP) is used to override a traffic signal's standard phasing such that priority is given to an emergency vehicle. This can work through detecting a siren sound or by a vehicle's transmitter being picked up by a receiver thereby preempting the traffic signal to provide a green indication in the direction the emergency

vehicle is moving. Such a system can improve traffic safety and reduce emergency response time.

Fail Safe, or confirmation lights, provide indication to the emergency vehicle driver whether the approach is being preempted. The lights shall be mounted on traffic signal mast arms or strain wire, facing the direction of approaching traffic. The confirmation light shall remain off/dark when emergency vehicle preemption (EVP) is not active. When EVP is in operation, the confirmation light shall flash for the preempted approach. Maintenance responsibilities include ensuring 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, etc.).

5.2.7 Strobe Lights

Some municipalities have used white strobe lights within red signal indications for the purpose of calling attention to the red indication, especially at locations where this was the first traffic control signal on the highway for a mile or more. However, studies indicate that the strobe lights did not improve safety and FHWA has issued a final rule that prohibits the use of strobe lights (the prohibition is now included in Section 4D.06 of the *MUTCD 2009 Edition*). Therefore, these strobe lights should be removed as part of routine maintenance and replace with other traffic signal red indications approved in Publication 35 (i.e., "Approved Construction Materials," also referenced as Bulletin 15).

5.3 TRAFFIC SIGNAL DETECTION

Many types of detection systems exist, most available as a means of detecting vehicles. The detection of pedestrians typically used by the Department is push button technology only.

Publication 149 (Traffic Signal Design Handbook) provides key guidance when selecting the proper detection system at an intersection. To ensure maximum effectiveness of each device it is recommended where possible, that manufacturer's recommendations are followed.

Detection systems should be inspected routinely using the guidance materials provided in the TE-972 and TE-973 Forms (see Appendices F and G). These documents will provide the necessary details to consider when providing both response and preventative maintenance. The Traffic Signal Permit, Publication 408 (i.e., "Highway Specifications") and Publication 149 (i.e., "Traffic Signal Design Handbook") are key materials that should be used when evaluating detection systems.

5.3.1 Vehicle Detection

Detection is critical to an intersection's safe and efficient operation. When a traffic signal is properly timed with detection fully functional, its operation is generally efficient. If an intersection lacks detection, unnecessary delay will occur resulting in wasted fuel and increased emissions. An example of a common occurrence with malfunctioning detection is a failed loop detector for a left-turn lane. Upon failure the signal controller is sent a signal to call the left-turn phase each cycle. This occurs whether vehicles are present or not, holding opposing traffic at a red indication. This again results in

increased emissions and delays.

(a) Loop Detection

Loop detection uses electrically charged cables to detect traffic that is located in the detection zone. For small intersections loop detection is very cost effective. Drawbacks of loops, however, include disruption to traffic during installation since they are an intrusive type of technology in which saw-cuts are made into the pavement. Loops require regular replacement as a result of pavement failure due to heavy truck traffic and freeze-thaw cycles. Also, future milling and resurfacing generally requires that loops be re-installed. Loops preclude one from modifying the detection zone once installed.

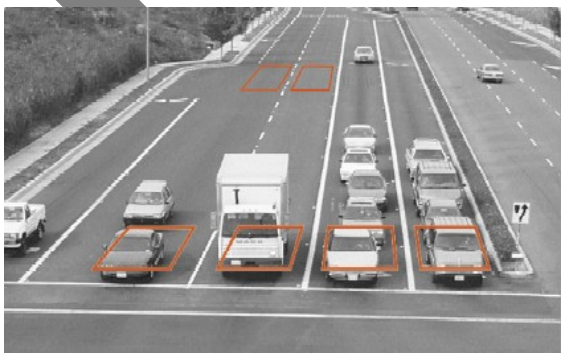
When loops fail it is for a number of reasons. These can include, but are not limited to:

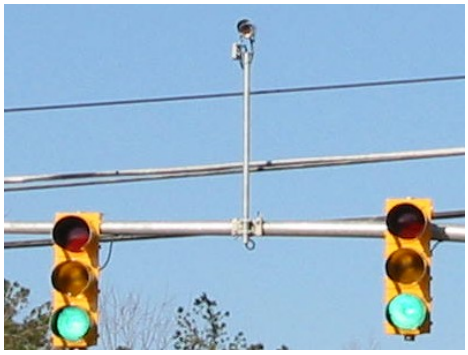
- Loop sensitivity of the detector card is set too low and in need of adjustment.
- Pavement cracking and shifting.
- Breakdown of wire insulation.
- Poor sealants or inadequate sealant application.
- Inadequate splices or electrical connections due to installation methods, moisture, or corrosion.
- Damage caused by construction activities.
- Lightning/electrical surges
- “Stuck” loop in which case the loop detector can be reset by depressing loop detector reset button, or if an older detector, turning a knob to retune and then reset.

Corrective actions can range from simply repairing splices or applying new sealant to full-depth pavement repair and new loop installation.

(b) Video Detection System

Video detection systems are those that use video cameras for the detection of vehicles by sending a video image from the camera to a video processor in the controller cabinet. These systems in unique cases can be part of a closed circuit television (CCTV) system where the video feed is transmitted to monitors at the municipality or to a PennDOT Traffic Operations Center. The detection zones which are created for the camera(s) are typically viewed by plugging a laptop into the traffic signal controller. A benefit to video detection is that detection zones may be removed, replaced, or redrawn at any time. Other benefits include the detection of bicycles and motorcycles as well as a single camera being capable of detecting an entire approach.





A major benefit of video detection is that it is a non-intrusive technology. When used at intersections with multi-lane approaches it can become more cost-effective when compared to using loop detection. Video detection can be installed with little impact to moving traffic and when the pavement deteriorates and/or is resurfaced the camera still functions. Cameras must be mounted at a required height over the roadway in order to effectively detect vehicles. It should be noted that with those traffic signals where volume-density (advanced) detection is used, video cameras mounted on mast arms generally cannot adequately perform volume-density detection. They must be either mounted close to the point of detection or at a much greater height.

Disadvantages of video image detection are the initial capital costs and that they are adversely affected by camera motion from the wind. In addition, light level and sun glare can cause problems. Other weather elements such as fog, rain and snow can affect its operations and result in false calls. Since the introduction of this technology, dramatic improvements have minimized these problems with today's cameras. Even so, preventative maintenance must be performed by qualified personnel.

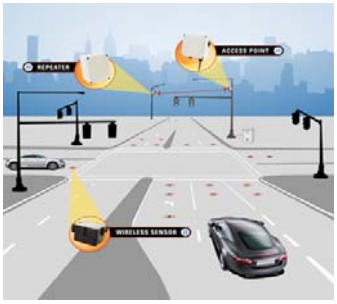
(c) Microwave Detection System

Microwave detection is mounted above the roadway to detect moving vehicles using microwave energy which is analyzed by a microprocessor. Like video detection this technology is non-intrusive. A disadvantage to this system is that it cannot detect stopped vehicles. Once the vehicle is detected, the call to the controller is locked, and if the vehicle moves the call is still in place. This detection would not work well where turn-on-red is permitted or where left turns are permitted and not always need the protected phase called upon. Benefits of microwave detection is that it is relatively unaffected by inclement weather and requires minimal maintenance.

(d) Infrared Detection System

Infrared detection is another nonintrusive type of detection that is highly reliable and allows for detection by lane. It works by detecting thermal radiation of vehicles. Infrared detection is independent of weather and can be used to detect both moving and stationary vehicles. They require very little maintenance.

(e) Wireless Detection System



Wireless detection uses a magnetometer and radio in a hardened casing which is installed within the pavement in the center of a travel lane. Both stationary and moving vehicles can be detected, and sensors transmit data to an access point which then relays the information to the traffic signal controller. The benefit of wireless detection is that it does not require costly trenching and wiring. It is lane intrusive, however, disrupting traffic flow, but installation is relatively quick. Sensors operate on battery power which can last up to 10 years. These sensors are virtually maintenance free.

(f) Digital Wave Radar

Digital Wave Radar is a non-intrusive radar technology used for advance/dilemma zone detection.

Systems are capable of detecting vehicle presence and speed in order to identify vehicles within the dilemma zone, the zone in which a driver would find it difficult to safely stop as the light changes from green to yellow. Gaps within the dilemma zone shall then be identified such that the corresponding phase call will be dropped and the phase safely terminated. Maintenance includes ensuring that gaps are being properly identified by the system, the sensor is mounted securely, vehicles are being detected in only one direction, and that all cables and connections are properly secured.

5.3.2 Pedestrian Detection "Push Button" Detection

Push-button sensors activate a pedestrian signal for crossing a particular leg of an intersection. A circuit closure, created when a pedestrian pushes the button, causes a low-voltage current to flow to the controller, activating the call for the pedestrian phase.

Maintenance includes ensuring the button moves freely and activates the appropriate pedestrian phase. 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 approach. Signs should be securely mounted and aligned with the appropriate crosswalk. In addition, any noticeably short timing for safe pedestrian crossing of the street should be reported and addressed.

Accessible pedestrian signal (APS) use is becoming more widespread in the U.S. after having been used for quite some time in Europe and Japan. This is a device for the visually impaired that communicates information to pedestrians in a non-visual format using audible tones, verbal messages, and/or vibrating surfaces. The speaker that emits the sound is integrated into the push button housing. It emits a tone so that the user can locate the button. In addition, the button has a tactile device in the form of a raised arrow which helps the pedestrian to identify for which direction the button is intended to activate the traffic signal.

Maintenance of APS includes ensuring none of the following has occurred or is occuring:

- No response to ambient sound
- Weak or no vibration
- Malfunction of audible message or tone
- 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
- Faulty pedestrian driver

5.4 TRAFFIC SIGNAL CONTROLLERS

Several types of traffic signal controllers are used in Pennsylvania. The most common are NEMA controllers. These controllers used function-based standards. The first was the NEMA TS1 standard in 1976 which was developed as the first industry-wide signal controller standard allowing for interchangeability between manufacturers. NEMA TS2 replaced the TS1 standard. It allows for high-speed communication between equipment and for future expandability. There is a NEMA TS2 Type 1 which allows for this high speed communications and a Type 2 which retains TS1 type connectors to allow for a degree of downward capability.

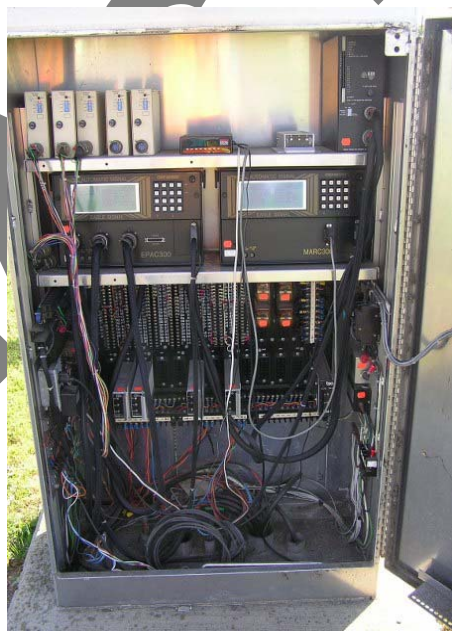
Type 2070 Controllers are an advanced type of controller, modular in design, and use an open architecture allowing compatibility with off-the-shelf products. They allow for communications and are configurable for use with traffic management applications. Type 2070 Controllers are most often used in the City of Pittsburgh and Philadelphia.

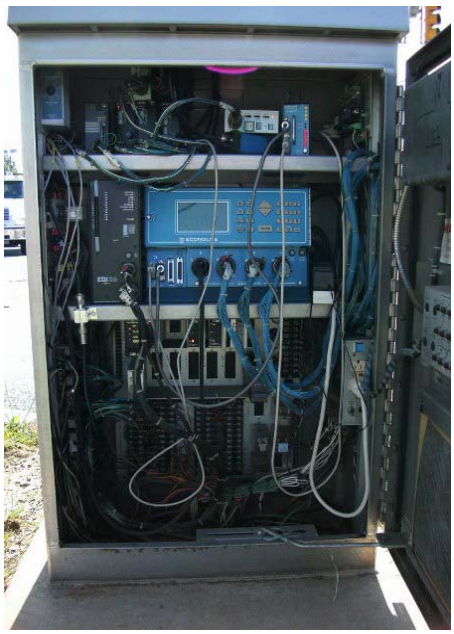
Type 170 Controllers are most often used in the City of Pittsburgh and Philadelphia. Standards for these controllers were developed by New York and California and are hardware-based. The purpose of hardware-based standards is to provide flexibility with interchanging components and to facilitate replacing components when the 170 controllers are in need of repair.

5.4.1 Controller Function

(a) Local Controller

The local controller resides at the intersection in which it controls and its function is to control a single intersection. The exception is when it is operating two closely spaced offset traffic signals and has adequate phase capability.





(b) Master Controller

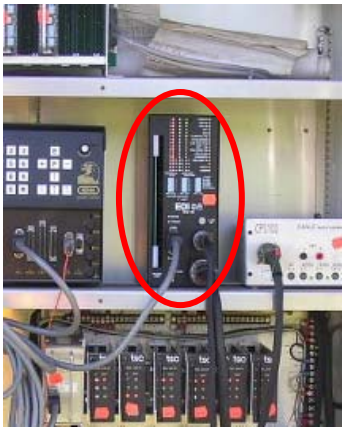
A master controller resides at what is typically referred to as the "master intersection" for a series of signals that are interconnected as part of a coordinated signal system. It is at this intersection where all other intersection phases are referenced, typically referred to as "offset". This is the time before or after the reference phase, for example beginning of the major street green, that another signal's same phase would begin.

5.4.2 Controller Maintenance

Controllers should be evaluated considering the following:

- When were signal timings last revised? Both the Department and FHWA recommend reviewing the timings every 3 to 5 years or if traffic volumes have significantly changed such that operation is inefficient.
- Is phasing appropriate? Are additions, deletions, or modifications of phasing necessary?
- Does controller operation need an updated from pretimed to actuated?
- Are the yellow and red clearance change intervals appropriate?
- If a master controller, is it operating appropriately? Are signals running coordinated?
- Master controllers, where present, shall be disconnected to ensure the signal goes into backup or "free" operation
- Check controller cabinet condition. Is it necessary to relocate so the controller is not damaged by vehicle impacts?
- Check indicator lamps and replace if burned out.
- Check that phases are being appropriately called and extended by loop amplifiers.
- The Department strongly suggests that all electromechanical controllers be replaced with NEMA traffic signal controllers.

5.4.3 Conflict Monitor



A conflict monitor, or the more sophisticated malfunction management unit (MMU), continuously checks for the presence of conflicting signal indications. This monitor is hardwired into the output side of each load switch. If two conflicting phases are called, load switch failure occurs and the conflict monitor will place the signal into flashing operation. This is a significant problem if two green phases are simultaneously displayed on conflicting approaches. All traffic signal controllers require conflict monitors for this reason. Any municipality that determines a signal solid state signal controller is in operation without a conflict monitor should immediately contact their local engineering district for guidance on how to address the issue.

The most common occurrence when a conflict monitor fails is switch to flashing yellow/red operation. Less commonly steady red or yellow could occur, or the worst condition, steady green on conflicting approaches. One of the following test procedures should be conducted to ensure proper conflict monitor operation:

- Test conflict monitor yearly by a computerized conflict monitor tester. To assure the reliability of the computerized monitor tester, a calibration of the unit is to be done annually. The units need to be returned to the appropriate manufacturer in order for this calibration to be done properly.
- Perform conflict monitor test by removing the monitor and running a complete test with the conflict monitor tester unit. A spare monitor should be installed temporarily while the test is being performed

or monitors may be shop-tested by rotating pre-tested monitors to the field. Documentation of the tested monitor should include the following:

1. Date
2. Name of Technician
3. Location - includes intersection name, city and/or county
4. Serial number of conflict monitor
5. Comments regarding fail or pass conditions, i.e. which streets were yellow/red during the test

- Failed monitors should be either repaired so that they pass the above-described monitor test or replaced with a monitor that passes the test.

Although extremely thorough, the computerized testing tests only the unit itself and is not connected to the cabinet. Using a jumper wire and pulling the load switch also tests the cabinet wiring and harnesses (and is a quick test of the unit). This is an important test to perform if cabinets are frequented by rodents that chew on electrical wires/cables.

5.4.4 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 to. 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.

5.5 TRAFFIC SIGNAL COMMUNICATIONS

5.5.1 Hardwire

Hardwire communications options include phone line, fiber optic, or direct wiring. Maintenance includes checking that communications between all components that are part of the system are functioning. It is not possible to inspect underground hardwire; however, where communications are overhead, ensure that any trees or vegetation nearby have been trimmed away from the aerial lines.

5.5.2 Radio Spread Spectrum

Test all radio communications at each intersection to ensure no faults are detected in the radio diagnostics and the received signal strength indicator (RSSI) is within the acceptable fade margin. Adjustments shall be made to correct any deficiencies found in the communications system. If the radio or associated equipment needs to be replaced it shall be done in accordance with Section 957 of Publication 408 (i.e., “Highway Specifications”) and the manufacturer’s recommendations.

5.5.3 Time-Based

Ensure time clock is checked regularly for accuracy and that it is adjusted for daylight savings time. Where GPS clocks are used, periodically inspect to ensure they are operational, otherwise such clocks are virtually maintenance-free.

5.5.4 TMC-Activated/Closed-Loop Systems

Closed-loop systems consist of a number of local intersection controllers that all connect to a master controller and then tie into a central computer. This central computer can be a municipal building or a Transportation Management Center. Closed-loop systems sometimes include video cameras not only for detection of vehicle as it relates to a signal's operation but also for the detection of vehicle queuing or incidents.

Maintenance of the closed-loop system is really covered through maintenance of all the individual components. The primary maintenance for closed-loop systems, however, is to ensure that communication between all components is functioning properly. Closed-loop systems are expensive and even a failure of one of its low-cost components can render the closed-loop system useless.

5.5.5 Traffic Signal Software and Firmware Upgrades

Regular updates to traffic signal software or firmware is important to avoid problems that manufacturers become aware of and address with the upgrades. Ensure that the municipality is on the manufacturers' mailing or email list so that they are notified of software or firmware upgrades.

5.6 VEHICLE PREEMPTION SYSTEMS

Vehicle preemption systems give priority to those vehicles considered a priority such as fire engines, ambulance, and police cars, or even mass transit vehicles. These priority vehicles preempt the right-of-way by interrupting the normal phase sequence of a signal or signals along a route to allow for their safe and rapid passage. After a preset time period, the signal returns to normal operation.

Each preemption system should be inspected routinely using the guidance materials provided in Forms TE-972 and TE-973 (see Appendices E and F). These documents will provide the necessary details to consider when providing both response and preventative maintenance. The Traffic Signal Permit, Publication 408 (i.e., "Highway Specifications"), and Publication 149 (i.e., "Traffic Signal Design Handbook") are key materials that should be used when evaluating emergency vehicle preemption systems.

If the preemption system needs to be replaced, please refer to Publication 35 (i.e., "Approved Construction Materials," also referenced as Bulletin 15) to determine what manufacturers and model numbers are approved to the Department's specifications. All installations shall follow Publication 408 (i.e., "Highway Specifications") and the manufacturer recommended procedures.

5.6.1 Optical and Acoustical Emergency Vehicle Preemption

As discussed in Section 5.2.6, optical emergency vehicle preemption (EVP) uses fail safe, or confirmation lights, to provide indication to the driver whether 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 ensuring 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, etc.).

For sound-based systems, periodically test the emergency vehicle sirens for compliance with Class A siren specifications.

5.6.2 GPS Emergency Vehicle Preemption

With global position system (GPS) EVP, vehicles are equipped with a driver's console, computer, global positioning system (GPS), and data radio. A driver inputs pertinent details about the current trip and the console notifies the driver of the time remaining to the destination. Priority request information is transmitted by the vehicle to a centrally located base station when the vehicle crosses a report line. Communication techniques include transmission of priority requests from emergency vehicle to a control center by digital channels and transmission of the signal priority command from the control center to the intersection using spread spectrum radio or optical links. There is little preventative maintenance for GPS EVP. Problems with communication links are identified during normal use.

5.6.3 Button Activated

Button activated emergency preemption operates typically from within a building such as a fire company/emergency building. Verify button operation and repair, replace, or clean as necessary.

5.6.4 Queue and Ramp Preemption

Queue and ramp preemption are used to clear a ramp or queue from the point of detection to clear a traffic signal. Typically this includes the off-ramp signal from a limited access route. This type of detection turns the signal green to clear traffic from a ramp or other roadway so that it does not back up onto a freeway or other major area of conflict.

Where adjacent traffic signals are within close proximity to the off-ramp traffic signal with ramp preemption, it may also be necessary to preempt these signals so that queuing does not occur from these locations such that it blocks the ramp signal should the ramp preemption be activated.

Maintenance is simply verifying that detection is functioning properly as discussed in Section 5.3.

5.6.5 Railroad Preemption

Railroad preemption is typically used when a highway-rail grade crossing is so close to a signalized intersection that queuing (i.e., traffic back-ups) from the intersection could encroach or extend beyond the rail crossing. The objective of standard railroad preemption is to detect the presence of an approaching train and then to have the traffic signal quickly provide a green signal indication to traffic on the approach with the rail crossing so that no vehicles will be standing on the grade crossing.

Another variation is the use of a pre-signal, i.e., a regular R-Y-G set of traffic control signals in advance of the highway-rail grade crossing that turns red before the traffic control signal at the nearby signalized intersection so that no traffic is ever stopped in the immediate grade crossing area. In order to ensure that

traffic is not queued in the vicinity of the grade crossing, standard vehicular detection is used on this section of highway. Refer to Section 5.3 for maintenance of these detection devices.

5.6.6 Transit Signal Priority

The objective of Transit Signal Priority (TSP) is maintaining schedules and improved transit travel time efficiency while at the same time minimizing impacts to normal traffic operations. A detection system lets the TSP system know where the vehicle requesting signal priority is located. This detection system communicates with a priority request generator which alerts the traffic control system that the vehicle would like to receive priority. Software processes the request and decides whether and how to grant priority based on the programmed priority control strategies. Software is used to manage the system, collect data, and generate reports. Maintenance is primarily related to software and hardware operation. It is recommended that maintenance be performed by an experienced technician.

5.7 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 could operate ineffectively. This section provides a general overview of what to look for when performing maintenance and inspection. Refer to Appendix G, TE-973, for more detailed preventative maintenance procedures. The Traffic Signal Permit, Publication 408 (i.e., "Highway Specifications"), and Publication 148 (i.e., "Traffic Standards – Signals, TC-8800 Series") are also key materials that should be used when evaluating electrical distribution.

When replacing electrical distribution components, please refer to Publication 35 (i.e., "Approved Construction Materials," also referenced as Bulletin 15) to determine what manufacturers and model numbers are approved to the Department's specifications. All installations shall follow Publication 408 (i.e., "Highway Specifications") and manufacturer recommended procedures.

Various electrical distribution components are summarized in the following table.

Junction Boxes Junction boxes should be inspected to ensure they remain sealed from water with the cover securely in place. Replace any cracked covers. Any junction boxes visibly cracked should be sealed or replaced. Ensure the junction box is flush with the ground elevation and that no erosion is occurring that could draw water. Also inspect inside the junction box and the inside of pole shafts for abnormal amounts of water or water damage. If water is present take measures to drain by installing weep holes.	
Conduit Ensure that any penetrations of conduit from equipment are sealed using electrical duct seal. Any exposed conduit should be buried. Any visible conduit that is crushed or cracked should be replaced.	

Emergency Generator Connection

An emergency generator can be used when the controller provides switchover capability through the use of a generator adaptor kit. It is essential that the plug on the controllers is compatible with the receptacle on the generator. Maintenance includes inspection of the disconnect enclosure, transfer switch, surge protection, and connector cable assembly.

Controller

Test for grounding, corrosion, and loose connections. Ensure fuses or power breakers are functioning. Clean or replace air filter as necessary.

Service Disconnect

The power service disconnect box is to be properly locked and free of rust.

Backup Power

For Uninterrupted Power Supply (UPS) or Battery Backup Unit (BBU), inspect to ensure no faults are present and that the unit is in proper working order. If any problems are identified, the unit shall be replaced in accordance with Section 954 of Publication 408 (i.e., “Highway Specifications) and manufacturer recommendations.

Surge Protection Devices (SPDs)

The use of SPDs will protect against damages caused by lightning or other electrical disturbances. The National Fire Protection Association’s NFPA 780 (installation of Lightning Protection Systems) standard is the standard, and 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.

Splices

All splices should be inspected to ensure they are all solidly connected and not degraded. If deterioration is identified, splices shall be replaced in accordance with Section 954 of Publication 408 (i.e., “Highway Specifications”).

5.8 TRAFFIC SIGNAL SIGNING

At traffic signals, signing is used to regulate traffic flows, designate the use of approach lanes, restrict certain movements, and guide motorists. Missing signs could confuse motorists or cause a conflict that may otherwise not occur if the appropriate regulatory signs were in place.

Each sign should be inspected routinely using the guidance materials provided in Forms TE-972 and TE-973 (see Appendices F and G). These documents will provide the necessary details to consider when providing both response and preventative maintenance. The Traffic Signal Permit, Publication 408 (i.e., "Highway Specifications"), Publication 111M (i.e., "Traffic Control Pavement Markings and Signing Standards," TC-8600 and TC-8700 Series), Publication 236M (i.e., "Handbook of Approved Signs"), and Publication 148 (i.e., "Traffic Standards – Signals, TC-8800 Series") are key materials that should be used when inspecting signs.

Transition from one to four lanes with no overhead lane use control signs

If signs need to be replaced, please refer to Publication 35 (i.e., "Approved Construction Materials," also referenced as Bulletin 15) to determine what manufacturers are approved to the Department's specifications. All installations shall follow Publication 408 (i.e., Highway Specifications") and manufacturer recommended procedures.

As a final item, signs must conform to the minimum sign retroreflectivity values in Section 2A.08 of the *MUTCD* 2009 Edition.

5.8.1 Overhead Signs

Overhead signing 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 SIGNAL, 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. These signs become especially important when snow covers the pavement and the markings which supplement these signs. 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. Mounting should follow the recommendations provided in Publication 148 (i.e., "Traffic Standards – Signals, TC-8800 Series").

Appropriate overhead lane use

Prior to adding additional signs or replacing existing signs with larger sizes, it is important to:

- Ensure that the sign structure is capable of accommodating the additional loading

(see Chapter 20.0 in Publication 149).

- Obtain a required revision of the traffic signal permit.

5.8.2 Ground Mounted Signs

Ground mounted signs also consist of turn restrictions and lane use control, as well as numerous other regulatory signing. Signs should be securely mounted with no evidence of damage. This signing should also be included on the traffic signal permit if it pertains to traffic signal operation. Field inspections should confirm there are no missing signs.

5.8.3 Signs on Traffic Signal Pedestal Supports

Signs on traffic signal supports include NO PEDESTRIAN CROSSING, push button signing, and sometimes RIGHT TURN SIGNAL signs. Signs should be securely fastened to supports using banding material.

5.8.4 Internally Illuminated Signs

Ensure that mast arm bracket connections are secure. Inspect wiring from Internally Illuminated Sign to service disconnect box. Ensure drain holes in the bottom of the sign are unobstructed and that no corrosion is present. Ensure the transparent reflective sheeting is internally illuminated and retroreflective when not energized. Inspect entrance junction box to ensure a weather-tight seal is still provided to the sign assembly. Inspect photocell and LEDs and replace as necessary. Ensure that any swing brackets allow the sign to swing freely.

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.

When used as a blank-out sign, problems are compounded because in order to review the functionality of the sign, the sign must be energized.

5.9 TRAFFIC SIGNAL PAVEMENT 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.

Markings should be inspected routinely using the guidance materials provided in Forms TE-972 and TE-973 (see Appendices F and G) when providing response and preventative maintenance. The Traffic Signal Permit, Publication 408 (i.e., “Highway Specifications”), and Publication 111M (i.e., “Traffic Control Pavement Markings and Signing Standards,” TC-8600 and TC-8700 Series) are key materials that should be used when reviewing pavement markings.

All pavement markings are required to be retroreflective. The Federal Highway Administration (FHWA) is also in the process of “raising the bar” on quality control by establishing minimum retroreflectivity values.

If pavement markings need to be replaced, refer to Publication 35 (i.e., "Approved Construction Materials," also referenced as Bulletin 15) to determine what manufacturers are approved to the Department's specifications. All installations shall follow Publication 408 (i.e., "Highway Specifications") and manufacturer recommended procedures.

5.9.1 Longitudinal Pavement Markings

These include markings that run in the direction of travel. Currently on State highways, the Department maintains longitudinal pavement markings.

5.9.2 Transverse Markings

Transverse markings are those which run perpendicular to direction of travel. They include stop and yield lines, and crosswalks. Maintenance of these markings is the responsibility of the municipality even if the traffic signal is on a State road at a traffic signal.

These markings need replaced frequently since they are driven over constantly. Municipalities are encouraged to specify preformed thermoplastic markings to reduce the frequency of replacing these markings.

5.9.3 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 municipality, even if on a State road at a traffic signal. These markings need replaced frequently since, like transverse markings, they are driven over frequently. Therefore, municipalities are encouraged to use preformed thermoplastic material.

Poorly maintained pavement markings

Example of pavement markings in good condition

Pavement marking legends need to conform to the plan sheet in the traffic signal permit. However, the word "ONLY" is currently required only on through lanes that become mandatory turn lanes. For example, ONLY is no longer required where it is obvious to motorists that a left-turn or right-turn lane is an added lane at an intersection. Therefore, if these words are included on the traffic signal permit for turn lanes, consider requesting a change in the permit to eliminate them.

5.10 SIDEWALKS AND ADA CURB RAMPS

Municipalities are also responsible for pedestrian accommodations, including sidewalks and curb ramps. Moreover, whenever an existing pedestrian facility is replaced, it must either be brought into compliance with PennDOT's standards or have an approved Technically Infeasible Form for any element that does not meet full compliance.

Publication 149 contains additional guidance on when the revisions must be made and what provisions must be followed (see Sections 19.4 and 19.5 in Publication 149, respectively).

6. TRAFFIC SIGNAL RETIMING AND EQUIPMENT UPGRADE ACTIVITIES

6.1 GENERAL

After traffic signals are installed, traffic volumes change and new technologies are developed. Therefore, the Department encourages municipalities to reexamine the traffic signal timing and the equipment about every 3 to 5 years to see if changes would be helpful to improve traffic flow and safety. The "retiming" of a traffic signal should reduce not only delays, but also reduce emissions and motorist fuel costs.

When traffic signal retiming activities are to occur, the Department recommends referring to the Federal Highway Administration's (FHWA) Traffic Signal Timing Manual. This Manual is a comprehensive guide of traffic signal timing concepts, analytical procedures, and applications based on current practices.

Traffic signal equipment upgrades, and phasing and timing changes usually require modification of the traffic signal permit. (See Chapter 9 for design modifications.)

6.2 REGIONALIZATION

Sometimes it is best to pursue retiming of traffic signals from a regional approach because it is desirable to coordinate cycle lengths and offsets at all traffic signals on the same corridor. It is also more economical to perform reviews on a regional basis due to economies-of-scale and the possible elimination of performing new traffic counts due to redundancies within a region. In addition, expediting traffic flow at one intersection may not produce the desired results if other bottlenecks remain.

Regionalization also helps to encourage consistencies within a region. A coordinated traffic signal system is in the best interest of the traveling public and municipal boundaries mean nothing to the motorist. For example, a three mile corridor with multiple traffic signals may involve several municipalities. Motorist delay should be minimized along the corridor by coordinating and retiming all traffic signals no matter where the traffic signals reside. Another example relates to equipment consistency. Instead of upgrading equipment to provide emergency vehicle preemption equipment or countdown pedestrian signals at random intersections, from a user standpoint there is merit in doing so at all intersections within a region.

Therefore, "regionalization" is an important component when considering the impacts of multiple traffic signals and the un-necessary congestion created by them not operating as a system. The congestion caused by their operation as fragmented systems or isolated intersections results in increased fuel consumption, driver delay, and emissions.

Regionalization can also bring the benefits of obtaining more affordable contracts, obtaining relationships with neighboring municipalities, and becoming more knowledgeable of proper and best practice timing and upgrading techniques. Regionalization requires multi-municipal maintenance and/or operational agreements as outlined in Chapter 11. Regional planning partners can assist with multi-municipal agreements.

6.3 RETIMING EFFORTS

Traffic signal timing can range from the very simple (e.g., pretimed operation at an isolated intersection)

to very complex (e.g., interconnected traffic signal system with adaptive traffic control system). In any case, it is important to maintain effective traffic signal timing plans. By providing motorists with efficient traffic signal timings, delay is reduced and complaints to the municipality relative to traffic signal operation are reduced.

The Federal Highway Administration (FHWA) has indicated that traffic signal retiming does not necessarily require a significant amount of effort. They have suggested that it takes approximately 40 hours of labor, at a cost of approximately $2,000 to $5,000 per intersection, which would include collecting the traffic volume data, evaluating those volumes to develop three timing plans (typically the peak traffic periods), and then implementing those timings in the field.

Additionally, FHWA has published a document entitled, "Signal Timing on a Shoestring," in which they note that the biggest cost for traffic signal retiming is for data collection. Therefore, FHWA has suggested a "short-count method" using the following steps:

1. Determine the beginning and ending time of the period for which the count is intended to represent.
2. Within this time window identified above, start a stop watch when the yellow ends for the through movement on the approach being observed.
3. Record the number of vehicles turning left, through, and right during the cycle measured from the end of yellow to the end of yellow during each cycle.
4. Continue recording the counts at the end of each cycle until at least 15 minutes have elapsed and at least eight cycles are recorded.
5. For the last cycle, add the number of vehicles in queue (if any) to the count for the last cycle.
6. Record the time on the stop watch (10 minutes or more).
7. Convert the counts to an hourly flow rate for each movement.

By using the above "short-count method," it is estimated that the cost of data collection is about one-half of the typical full peak-hour counts with tube automatic counts during the full day.

The need for traffic signal retiming is generally a result of changes in traffic demand since the intersection was last timed. This change in traffic demand could be related to land-use changes, general population growth, special event impacts, or other factors.

As congestion increases, traffic signal retiming can be the only effective way to increase capacity other than high-priced capacity-adding projects.

For that reason, both FHWA and the Department recommend retiming traffic signals every 3 to 5 years.

While the need for retiming can be identified in several different ways, calls from the public are one of the most common reasons for reviewing intersection operations. It is not possible for municipal officials to be present at every intersection each hour of the day to evaluate operations so motorist complaints are one of the best ways to identify problems. Most complaints involve motorists being annoyed by waiting at a red signal indication when there are no vehicles present on any other approach (which may be due to lack of or a malfunctioning detection), or when they have to stop at successive traffic signals in a corridor (coordination not present or operational). Motorists could be frustrated by having to wait several cycles at an intersection when they see other approaches to a traffic signal clearing in one cycle. These are all valid complaints that should not be ignored. Simple timing

adjustments can result in significant benefits.

Keep in mind that in some cases public complaints cannot be resolved because they are not aware of the other traffic signal operations constraints (involving pedestrian clearance times, progression, or other factors). When evaluating and responding to citizen calls or other correspondence, make sure to capture the following information to ensure that the issue is investigated appropriately:

- Name and contact information
- Location information
- Time-of-day of problem
- Description of problem

Ideally, all complaints should be entered into a spreadsheet or database that catalogues the date the complaint was received, the information outlined above, the date of the evaluation, and the date of the response to the citizen (if necessary).

Signal timing maintenance occurs not only due to motorist complaints but for other reasons as well:

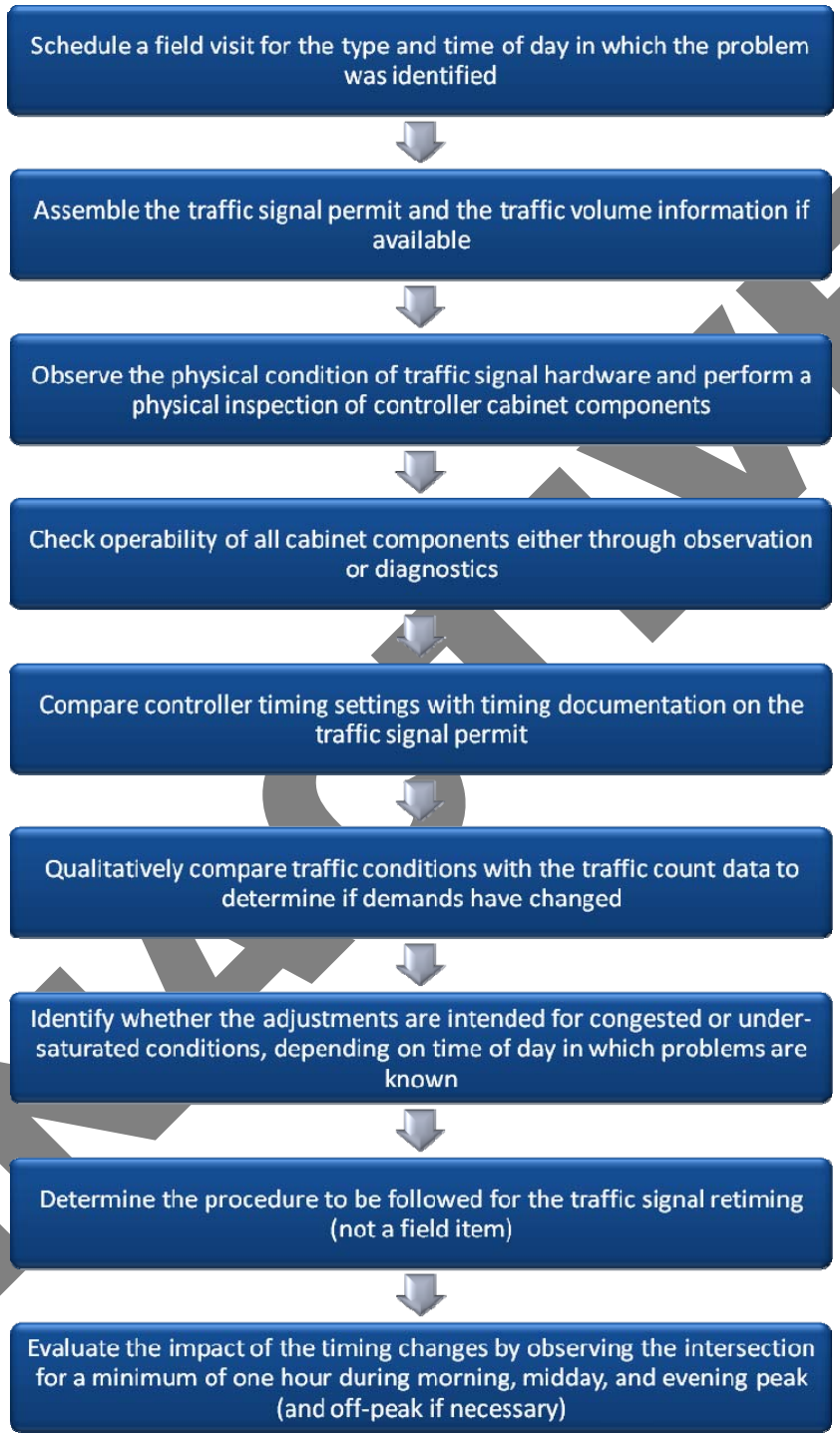
- Land use changes
- Population growth
- Change in flow profiles (volume and classification)
- Incident management
- Special Events
- Construction work zone or a temporary traffic signal
- Traffic signal equipment change
- Scheduled or periodic traffic signal retiming
- High frequency or rate of crashes

A Best Practice

It is good to keep a digital backup of all signal timings to ensure that the appropriate timings can be quickly restored if needed. In fact, Engineering Districts may request municipalities do this as part of an agreement.

Once the need for traffic signal retiming has been identified, follow the procedure in Exhibit 6.1 and document using Forms TE-972 and TE-973 (see Appendices F and G).

Exhibit 6.1: Signal Retiming Flowchart



The development of traffic signal timing plans can be accomplished through the use of a number of computer software packages including the Highway Capacity Software (HCS), Synchro and Simtraffic, and others. Since new software packages are being developed, municipalities are encouraged to review

Chapter 12 of Publication 46 or contact the local PennDOT District to identify the appropriate analysis tool to be used. All traffic signal timing modifications should be developed by an engineer and implemented by a traffic signal specialist or technician.

The Department is currently developing a traffic signal retiming program; therefore, a municipality may wish to contact their Engineering District Office for any updates.

6.4 UPGRADE OPPORTUNITIES

In addition to retiming efforts, equipment upgrades can also contribute to the efficient operation of a traffic signal. As part of routine maintenance or operational audits, the following potential upgrades should be identified, any modifications should be indicated to the appropriate District office.

- Replace incandescent bulbs with Light Emitting Diodes (LEDs)
- Replace inductive loop detectors with video detection
- Replace physical interconnection with spread-spectrum radio or other wireless applications
- Install emergency vehicle preemption (EVP)
- Install countdown pedestrian signals (now required in most situations in Publication 149) to improve safety for pedestrians or where no pedestrian accommodations present install countdown signals and push buttons
- Install adaptive traffic signal control that responds to changes in traffic demands
- Add an uninterruptible power supply (UPS) or battery backup Unit (BBU)
- Add surge protection devices to reduce the threat of lightning damage
- Safety-related upgrades such as the addition of a protected left-turn phase or the addition of a near-side traffic signal where, for example, truck traffic restricts view of primary traffic signals

6.5 BENEFITS OF UPGRADES

Studies around the country have shown that the benefits of area-wide signal timing outweigh the costs 40:1 (or more). The benefits of up-to-date signal timing include shorter commute times, improved air quality, reduction in certain types and severity of crashes, and reduced driver frustration. Specifically, the Traffic Signal Timing Manual indicates that improved traffic signal operations can:[3]

- Reduce traffic delay 15-40%
- Reduce travel time up to 25%
- Reduce stops 10-40%
- Reduce fuel consumption up to 10%
- Reduce harmful emissions up to 22%, resulting in cleaner air.

For example, traffic signal timing upgrades would result in a savings of almost 17 billion gallons of fuel per year on a nationwide basis.

[3] Traffic Signal Timing Manual, FHWA, FHWA-HOP-08-024, Section 1.1.5.

Numerous programs exist in the State which have proven the benefit of traffic signal upgrades as shown in Exhibit 6.2.

Exhibit 6.2: Signal Upgrade Programs

Program	Description/Benefits
PennDOT Congested Corridor Improvement Program (CCIP)	▪ Program which identifies immediate, short-term, and long-term improvements on a signalized corridor to reduce fuel consumption, emissions, and delay. ▪ Includes recommendations for traffic signal retiming as well as infrastructure upgrades. ▪ Goal of CCIP program is a 20 percent reduction in corridor delay.
PennDOT Traffic Signal Enhancement Initiative (TSEI)	▪ Program which evaluates traffic signal timings and the need for upgrades. ▪ May include coordination, upgrade of detection, and the use of new traffic signal technologies. ▪ Goal of TSEI program is a 10 percent reduction in corridor delay.
Southwestern Pennsylvania Commission (SPC) Signals In Coordination with Upgrades (SINC-UP) program	▪ SPC has developed a regional traffic signal program that includes technical assistance to municipalities as well as potential funding to assist in upgrading signal systems in the region. ▪ Travel time and delay studies performed as part of the program identified 5-year savings for one project[4] at just over $800,000 with a benefit-cost ratio of 43:1.

Equipment upgrades can also result in benefits by providing additional efficiency and safety components to the traffic signal. These equipment upgrades may also reduce the number of crashes and therefore increase the safety and reliability at the intersection. For example:

- Light Emitting Diodes (LEDs) can reduce energy consumption by almost 80%
- Implementing video detection would reduce the maintenance costs associated with replacing inductive loops which have a higher failure rate
- Spread spectrum radio interconnection can eliminate monthly utility attachment costs associated with physical interconnection
- Emergency vehicle preemption can reduce response times by 16-23%
- Countdown pedestrian signal heads can reduce confusion for pedestrians crossing the street
- Adaptive traffic control signal systems can reduce delay up to 22% over typical time-of-day timing.

[4] Evans City (S.R. 68/528) SINC-UP Project Before & After Study, Southwestern Pennsylvania Commission, 2008.

7. TRAFFIC SIGNAL MAINTENANCE AGREEMENTS

Traffic signals are owned and maintained by the municipalities. Moreover, when the Department issues a Traffic Signal Permit (PennDOT Form TE-964), the Department clearly indicates that it is the responsibility of the municipality to maintain the traffic signal in a safe condition at all times.

However, if the intention is to use any State or federal funds to construct the traffic signal, the Department also requires that the municipality enter into a Traffic Signal Maintenance Agreement with the Department prior to the design and construction of the signal. The purpose of this agreement is to fulfill the State's fiduciary responsibility to the citizens of the Commonwealth by ensuring that the limited State and federal funds are not wasted and the traffic signal equipment is transferred properly. After all, it would be an embarrassment to the Department and local residents if, after the traffic signal was installed, it was not properly energized or maintained.

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 purpose of this chapter is to discuss the Traffic Signal Maintenance Agreement.

7.1 GENERAL PROVISIONS

The *"Commonwealth and Municipal Traffic Signal Maintenance Agreement"* is between the Department and the municipality, and it addresses the required maintenance and operation of the traffic signal installation. This traffic signal maintenance agreement can be for a single intersection, or for multiple signalized intersections within the municipality. This document is a standard statewide agreement that contains very detailed maintenance responsibilities of the municipality, and requires the municipality to attach a copy of the municipal resolution that authorized the execution and attestation of the traffic signal maintenance agreement. A copy of the template for the traffic signal maintenance agreement is included in Appendix C. Additionally the traffic signal maintenance agreement should not be altered from the already approved language from the Department's Office of Chief Counsel.

The traffic signal maintenance agreement requires the municipality to also note if maintenance will be done with municipal personnel or via contract, and if by contract, it requires a municipality to provide the name of the contractor and a copy of the traffic signal maintenance agreement or contract that the municipality has with the contractor.

The "traffic signal maintenance agreement" includes the following five exhibits which are further clarified below:

A. Preventive and Response Maintenance
B. Recordkeeping
C. Signal Maintenance Organization
D. Contractor Integrity Provisions
E. The Americans With Disabilities Act
F. Contract Provisions – Right to Know Law 8-K-1532

7.2 EXHIBITS

Exhibit A, Preventative and Response Maintenance.

This exhibit defines the level of preventative maintenance and response maintenance that is required by the municipality as discussed in Chapter 3 of this publication.

Exhibit B, 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 municipality that enters into the Traffic Signal Maintenance Agreement is required to use the same basic recordkeeping forms unless first authorized by the Department. The following three forms are identified in Exhibit B and included herein in Appendices E, F, and G respectively:

- TE-971 – Master Signal Maintenance Log
- TE-972 – Response Maintenance Record
- TE-973 – Preventative Maintenance Record

Since municipalities sometimes contract with different maintenance contractors, the importance of maintaining good records cannot be overemphasized. Moreover, the forms should reside in separate intersection folders in the municipal building, signal maintenance shop, or some other weather-protected building.

Exhibit C – Maintenance Organization.

This exhibit addresses the personnel classifications that the municipality needs to maintain if they perform their own traffic signal maintenance. There is also a place for the Department and the municipality to mutually agree to specific training requirements, which would generally come into play when the municipality is exposed to new types of equipment or a higher level of complexity is involved.

Exhibit D – Contractor Integrity Provisions.

This exhibit establishes contractor integrity provisions that apply for any traffic signal maintenance contractor.

Exhibit E – Provisions Concerning the Americans with Disabilities Act.

This exhibit defines the requirements to comply with the Americans with Disability Act, to avoid discriminating against any person with a disability, and to absolve the Commonwealth of Pennsylvania of all actions due to failure to comply with the Act.

Specifically, a municipality should be aware of the requirements of the Department's Standard Drawing No. RC-67, which is in Publication 72M (i.e., "Standards for Road Construction"). These standard drawings define the details required for curb ramps and sidewalk features in order to satisfy the ADA requirements (see ftp://ftp.dot.state.pa.us/public/Bureaus/design/PUB72M/RC-67M_c3.pdf).

8. MUNICIPAL SERVICE PURCHASE CONTRACTS

Most municipalities do not have the in-house expertise, staffing, equipment, or inventory of parts necessary to service and maintain traffic signal equipment. Therefore, the preferred method of maintaining traffic signals is by a traffic signal contractor.

A number of options are available to select a traffic signal contractor:

- 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 municipality 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 is 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 municipality uses a contractor to perform the maintenance of the signals, Chapter 4 of the agreement between the Department and the municipality (see Page C-3 in Appendix C) requires that the municipality 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 municipality, there is no standard format for the document, which allows municipality and a maintenance contractor some creativity and flexibility. For example, municipalities 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 I as a *"Municipal Service Agreement for Maintenance of Traffic Signals."*

In general, a municipality is responsible for the maintenance of everything on the traffic signal permit plan including not only the traffic signal and all appurtenances (pavement markings, signs, and any advance warning signs). This is detailed in Section 5.9.

It is important to note that even if a municipality uses a maintenance contractor, the municipality is still ultimately responsible for traffic signal ownership, maintenance, and operations. For this reason, the Department will only communicate with the municipality if they observe any deficiencies, and not with the contractor.

8.1 TYPICAL PROVISIONS

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

- A minimum duration of the contract or agreement needs to be established (e.g., a 3-year contract with an option for renewal).

- What materials need 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).
- What additional charges are necessary for late payment?
- The applicable publications listed in Chapter 1 of Publication 191.

8.2 ACCREDITATION – DEPARTMENT / IMSA

As noted in Chapter 3, the contractor and the municipal 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 municipalities 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 http://www.imsasafety.org/ for additional training details.)

8.3 ESTIMATING PRICES

Exhibit 2.1 includes some of the most common unit prices related to traffic signals. However, municipalities are encouraged to use the unit prices from recent Department-administered projects to get a sense of current costs (see Publication 287). 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 municpality plan and budget for future upgrades.

8.4 SPECIFICATIONS

When available, municipalities should use Publication 408 (i.e., "Highway Specifications") for all replacement components for the following reasons:

- ✓ The original construction plans would have 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 simplifies 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, municipalities 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, municipalities 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.

8.5 MAINTENANCE CONTRACTS/AGREEMENTS

As a final item, if a municipality 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.

9. DESIGN MODIFICATIONS

Modifications to a traffic signal installation are sometimes necessary to accommodate changes in traffic, to improve a safety problem, or for a number of other reasons. Except during emergency traffic control or when otherwise authorized by the Department, proposed design modification must first be approved by the Department and the Traffic Signal Permit must be updated to reflect this modification.

For efficiency purposes, the Department is currently reevaluating the need to revise the signal permit before allowing changes in the field. It is, therefore, conceivable that minor changes and additional flexibility may be allowed in the near future.

9.1 INTRODUCTION

A design modification is a change to the approved design and operation of an existing traffic signal or traffic signal system. Changes can be initiated by the Department, the municipality, a developer, or the contractor to correct a recurring problem, accommodate changes in prevailing traffic or physical conditions, update the installation to current state-of-the-art design, or address a safety problem. For any change a traffic engineering study in accordance with Publication 46 is required. Typical modifications include: addition or removal of signal phases or special functions; changes in signal displays, configurations, or locations; detector modifications; and upgrading of Intelligent Transportation Systems (ITS) equipment and communication systems; plus sign revisions such as No Turn on Red restrictions and marking revisions due to lane configuration changes. However, a design modification cannot occur until the signal permit is revised.

This chapter discusses how to identify the need for design modifications and the typical solutions to resolve design deficiencies commonly occur. A checklist is included in the TE-974 form (see Appendix I) to facilitate the design modification process.

Problems with the design or operation of traffic signals and traffic signal systems sometimes develop or become apparent after the traffic signal is operational. Those performing preventive and response maintenance should continuously be alert for recurring maintenance issues that can be corrected or minimized through a design modification to the existing location. Maintenance personnel are in the best position to detect recurring problems or design deficiencies and to develop the most appropriate design solutions for the specific location. These problems may be detected through the follow-up inspections. This feedback assists designers in reviewing and making suggested improvements to improve the safety and operation of the traffic signals.

For example, traffic signal technicians should be aware if call-outs occur to correct damage from crashes and should be informed should missed phase calls exist. 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, technicians should also be aware of new technology and practices that ideally should be implemented and proposed to the municipality as a possible design modification. Examples include:

- Pedestrian countdown timers
- Video detection
- 12-inch traffic signals instead of 8-inch
- Backplates and/or the addition of retroreflective borders
- Emergency vehicle preemption
- Adaptive traffic control system
- Adding overhead street name signs
- ADA curb ramps and accessible pedestrian signals
- Adding positive offset between opposing left-turn lanes

9.2 SUGGESTED PROCEDURES FOR FUTURE DESIGN MODIFICATIONS

Although many design deficiencies can be identified and corrected through effective feedback from field personnel, a comprehensive review process is also required to ensure that necessary design modifications are detected. The design and operation of each signalized intersection and system should be reviewed on a regular schedule (e.g., every 2 to 3 years) for conformance with the approved plan, conformance with state-of-the-art design standards and features, and compatibility with prevailing traffic demands and physical conditions of the approved traffic signal permit. A safety review should also be conducted. There may be a hidden problem requiring a comprehensive review which makes evident a required change, for example, increasing a phase's split timing, or conversion of a protected/permitted left-turn phase to a protected-only phase.

Additional reviews should be conducted when major changes in land use or roadway systems have occurred at nearby locations. Maintenance records for all components should also be routinely reviewed to determine if problems exist that have not been detected and corrected through direct feedback from appropriate field personnel.

To facilitate the design modification review, use a checklist like the one provided below and provided in Appendix I. Each reviewer should conduct appropriate field investigations, records and data research, and technical studies to answer, at a minimum, the following questions for each of the operation and design features of the traffic signal below:

1. Do the maintenance records reveal recurring problems that a design modification could potentially correct?
2. Are the operation and design in conformance with the approved traffic signal permit?
3. Is the signal in conformance with current design standards and design features? Have changes to the design standards occurred since the approved traffic signal permit? Are new or improved equipment or products available that would consider a design modification? (For example, improved equipment could result in a reduction in life-cycle costs.)
4. Have changes in traffic patterns, volumes, speeds, or physical conditions at the intersection occurred that warrant a design modification?

Where appropriate, recommended improvements or improvement alternatives should be formulated, reviewed with the municipality to determine if it should be presented to the Department. For example,

prior to adding additional loading (signs, additional signal heads, etc.) on existing traffic signal span wire or mast arm structural support, further analysis may be necessary, in which the Department should be contacted for assistance.

9.3 DEPARTMENT ASSISTANCE AND APPROVAL

The Department is willing to assist a municipality with the review of any suggested changes, including an on-site field view with them and the maintenance contractor.

All design modifications must be approved by the Department, unless the Department has granted current municipal traffic engineering certification to the municipality as indicated in Chapter 205 of Title 67 of the Pennsylvania Code (67 Pa. Code Chapter 205). However, prior to the Department approving any design modification, the municipality must submit a written request to the Department, recommending the change and agreeing to fund and maintain the modifications.

10. MAINTENANCE CONTRACTS/AGREEMENTS

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 an inventory of traffic signal equipment allow a municipality to obtain a better understanding of their current practices.

The Department can provide technical assistance and ensure that the contracts are written properly. If there are any questions concerning their proposed contracts, municipalities should contact the appropriate Engineering District (see Exhibit 1.5).

10.1 DEPARTMENT MAINTENANCE AGREEMENT

The understanding of maintenance responsibilities are important for a municipality when it first accepts a traffic signal. Although it may seem very simple and practical, effectively managing safety and operations at a traffic signal may become a difficult task. The Department reaffirms the maintenance responsibilities with a municipality before approving any new or revising any existing traffic signals. An official document reaffirms the local authority's maintenance responsibilities, as specified in Chapter 212 of Title 67 of the PA Code (67, Pa. Code Chap. 212). This document must be prepared and accepted by the municipality for every traffic signal.

The basic "Commonwealth and Municipal Traffic Signal Maintenance Agreement" document is included in Appendix C. Exhibit C of this document requests specific information about the personnel that will be performing the maintenance. This agreement evaluates the maintenance capability of a municipality contemplating an agreement to maintain traffic signals, to be constructed with the aid of federal or state funds.

The Preventive Maintenance Record (Form TE-973 of Appendix G), contains a checklist that should be used to ensure that the signal maintenance personnel performs the proper maintenance responsibilities.

10.2 HIGHWAY OCCUPANCY PERMIT AGREEMENT WITH THE DEPARTMENT

Section 441.3 of Title 67 of the Pennsylvania Code (67 Pa. Code, Chapter 441) stipulates that a highway occupancy permit 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.

Department regulations also require that the owner, which would be a municipality for traffic signals, is the party responsible for submitting the application (Form M-945A), and that the application must be submitted to either the Department's District or County office.

This application should be submitted whenever new signal supports, curb radii, new loop detectors, or anything else alters the grade or things below grade within the right-of-way of any State highway. Additional requirements and guidance are defined within Publication 441 (see Chapter 441, i.e., "Access to and Occupancy of Highways by Driveways and Local Roads"). Moreover, the application should be submitted as soon as possible to avoid last-minute changes that may be required by the Department.

Since the Department has the oversight responsibility to maintain its roads, municipalities need to be fully aware of this requirement.

11. 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, it is very important that each municipality works with each another in a systematic manner in order to ensure that the traffic signal system works as designed. 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 that this happens, each municipality needs to enter into a *"Cooperative Memorandum of Agreement"* for the multi-jurisdictional signal or signal system. A sample agreement designed for an interconnected signal system is included in Appendix J with an electronic template available from the Bureau of Highway Safety and Traffic Engineering (BHSTE).

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
- 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

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

- Identify the costs shared between the respective municipalities or identify the components of a local traffic signals that each municipality is responsible for, and those components that are borne by an oversight organization (see Paragraph 2 in the sample agreement in Appendix J). If costs are shared between the municipalities, the rationale for the sharing should be defined. For example, the costs could be defined by percentages, or based on the prorated number of the intersections within each of the respective municipalities to help address future expansion.
- The location of the system computer and any adaptive controller (see Paragraph 3 in the sample agreement).
- A willingness to support future additions to the system (see Paragraphs 5 and 6 in the sample agreement).
- How to resolve conflicts (see Paragraph 8 in the sample agreement).

12. TRAINING RECOMMENDATIONS

Training provides those technical skills needed to effectively use and maintain the traffic signal features and components. This training should reflect the actual need of the agency and their 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 municipality more in the long run.

Another major benefit of training is the exposure to new hardware, software and concepts. In turn, this exposure helps agencies stay on the leading technological edge.

Therefore, the Department strongly recommends that all traffic signal municipal maintenance staff and/or Traffic Signal Municipal Maintenance Contractors should have International Municipal Signal Association (IMSA) training (see Exhibit 12.1). 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 http://www.imsasafety.org/ for additional training details.

Another source of training is from traffic signal equipment suppliers. Therefore, it is desirable to require equipment suppliers to commit an appropriate number of hours to train Department, municipal 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, preventive maintenance, diagnostic software, and repair. This is a good way to incrementally expand personal knowledge.

Periodically, the Department also has training on different aspects of traffic signals that is available to municipalities and contractors. These courses are identified on the ECMS website, http://www.dot14.state.pa.us/ECMS/ (after logging in, click on the "References" tab to see the "Training Calendar").

The Bureau of Highway Safety and Traffic Engineering also has a "Traffic Signal Resource Portal Page" at http://www.dot.state.pa.us/Portal%20Information/Traffic%20Signal%20Portal%20(9-14-2009).htm with a "Training Updates" tab.

Exhibit 12.1: Available 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, preventive 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.

APPENDICES

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 traffic control – A software program that is designed to modify the splits and offsets of in an interconnected "closed loop" signal system and make adjustments to the cycle time on a time-of-day schedule. At each optimization step, which occurs about every 10 minutes, the system changes the splits and offsets a small amount to accommodate changes in traffic flows.

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[5] –

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://www.dot7.state.pa.us/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 view point, 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

[5] Definition from Section 212.1 of Title 67 of the Pennsylvania Code.

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.

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.

Publication 13M – The Department's *Design Manual Part 2: Highway Design.* (see ftp://ftp.dot.state.pa.us/public/Bureaus/design/PUB13M/insidecover.pdf)

Publication 35 – The Department's listing of Approved Construction Materials, commonly referred to as Bulletin 15. (see ftp://ftp.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_35/BULLETIN_15.pdf)

Publication 46 – The Department's *Traffic Engineering Manual.* (see ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB 46.pdf)

Publication 70M – The Department's *Guidelines for the Design of Local Roads and Streets.* (see ftp://ftp.dot.state.pa.us/public/bureaus/design/pub70m/incover.pdf)

Publication 72M – The Department's *Roadway Construction Standards.* (see ftp://ftp.dot.state.pa.us/public/Bureaus/design/PUB72M/PUB72COV.pdf)

Publication 111M – The Department's *Traffic Control Pavement Markings and Signing Standards – TC-8600 and 8700 Series.* (see ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%20111M.pdf)

Publication 148 – The Department's *Traffic Standards (TC-8800 Series Signals).* (see ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%20148.pdf)

Publication 149 – The Department's *Traffic Signal Design Handbook.* (see ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%20149.pdf)

Publication 212 – The Department's *Official Traffic Control Devices*, that contains the regulation, Chapter 212 of Title 67 of the Pennsylvania Code (67 Pa. Code Chap. 212). The Chapter 212 regulation adopts and supplements FHWA's *Manual on Uniform Traffic Control Devices (MUTCD)* (see ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%20212.pdf)

Publication 213 – The Department's *Temporary Traffic Control Guidelines.* (see ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%20213.pdf)

Publication 236M – The Department's *Handbook of Approved Signs.* (see ftp://ftp.dot.state.pa.us/public/PubsForms/Publications/PUB%20236M/1-Nomenclature%20Index.pdf)

Publication 287 – The Department's publication showing the unit cost bid prices for construction

projects during recent years. (see ftp://ftp.dot.state.pa.us/public/bureaus/design/pub408/Pub%20408%20Chg%207/Pub%207%20&%207M/Pub287.pdf)

Publication 408 – The Department's *Highway Specifications.* (see http://www.dot.state.pa.us/Internet/Bureaus/pdDesign.nsf/ConstructionSpecs408and7?readForm)

Publication 441 – The Department's regulation entitled "Access to and Occupancy of Highways by Driveways and Local Roads." The regulation is available at http://www.pacode.com/secure/data/067/chapter441/chap441toc.html.

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.

Title 67 of the PA Code – The "Transportation Title" of the Pennsylvania Code, which contains regulations of the Department, typically in response to a legislative mandate. Any chapter in this title is available from http://www.pacode.com/secure/data/067/067toc.html.

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.

TRAFFIC SIGNAL OPERATION SELF-ASSESSMENT QUESTIONS FOR THE 2007 NATIONAL TRAFFIC SIGNAL REPORT CARD

as published by the National Transportation Operations Coalition (NTOC)

Section 6—Maintenance

Maintenance is one of the keys to effective signal operation. A well-timed system must be accompanied by effective maintenance if it is to provide high quality service to the motoring public. This section can be used to assess the effectiveness of the planning, management and execution of maintenance activities.

41	**Does your agency have established policies and processes and commit resources (in-house or contracted) to provide for timely response after a critical malfunction is reported?**	**(Score 1–5)**

Score using:

1. During regular business hours, a technician is at the intersection by the next business day, and no provisions exist for technician response outside of regular business hours.
2. During regular business hours, a technician is at the intersection within 8 hours and within 16 hours outside of regular business hours.
3. During regular business hours, a technician is at the intersection within 4 hours and within 8 hours outside of regular business hours.
4. During regular business hours, a technician is at the intersection within 2 hours and within 4 hours outside of regular business hours.
5. During regular business hours, a technician is at the intersection within 1 hour and within 2 hours outside of regular business hours.

42	**Does your agency commit maintenance resources and manage maintenance activities to ensure that traffic operations meet safety needs and customer requirement levels?**	**(Score 1–5)**

For a 5 score, your agency:

- Commits specific funding to repair, replace, or upgrade signal equipment, cabinets, controllers, detector cards, etc., based on their specific life cycle;
- Commits specific funding to repair, replace, or upgrade signal infrastructure: poles, junction boxes, conduit, cable and signal heads based on their specific life cycle;
- Scales its maintenance commitment to growth; as equipment, location and technology increase, funding increases proportionally;
- Has a policy for timely replacement of sensors/detectors that are destroyed or disabled by roadway maintenance or permitted utility activities. The replacement of sensors/detectors is included as part of the maintenance project scope or utility work;
- Does not commit funded traffic signal resources to unfunded non-traffic signal activities (ITS, CCTV, DMS, incident management);
- There is an easy way for customers to notify your agency of signal problems.

43	**Does your agency provide regular training programs for traffic signal maintenance personnel?**	**(Score 1–5)**

For a 5 score, your agency:

- Provides funding and encourages maintenance personnel to regularly attend technical training programs to familiarize themselves with the latest equipment and procedures associated with traffic signal maintenance;
- Training programs include courses offered by manufacturers and suppliers relevant to the specific equipment currently in use as well as courses dealing with the general theory of traffic signal and computer maintenance and operation.
- Certification: For example, the ITE Traffic Signal Operations Specialist (TSOS) certification and/or the IMSA traffic signal certification is required for traffic signal technicians.

44	**Does your agency have a process for performing regular preventative maintenance and operational reviews to assess the condition of the traffic control system?**	**(Score 1–5)**

Score using:

1. Your agency has no process; regular preventative maintenance and operational reviews are not performed.
2. Your agency has no defined processes; performs *limited* preventative maintenance and operational reviews only if time/man-power permit.
3. Your agency has defined processes; performs *limited* preventative maintenance and operational reviews when time/manpower permit, including verification of signal/pedestrian indications.
4. Your agency has defined processes; performs *regular* preventative maintenance and operational reviews at least annually with limited documentation for some or all equipment.
5. Your agency has a defined process for *regular* preventative maintenance and operational reviews, including comprehensive semi-annual maintenance review, quarterly operational reviews and annual conflict monitor/MMU testing; all including formal documentation for some or all equipment.

45	**Does your agency maintain complete configuration management (schematics, interconnection information, software documentation, etc.) and inventories of all traffic signal control equipment?**	**(Score 1–5)**

For a 5 score:

- Complete inventories include all intersection equipment, including traffic signal controllers, ancillary equipment such as flashers, conflict monitors, load switches, actuation sensors and system detectors, including detector locations, the number and types of sensors.
- Complete inventories also include all communications devices and communications facilities.
- Configuration management information includes the interconnection and disposition of all equipment located at field installations, the central system and in the maintenance facility.

46	**Does your system provide continuous malfunction monitoring notification of critical components?**	**(Score 1–5)**

(Score 1–5)

For a score of 5, your agency is provided with continuous malfunction notification of all critical components in less than 5 minutes, and agency personnel are prepared to effectively respond to these malfunctions as needed.

47	**Does your agency have a maintenance management system for evaluating equipment reliability and scheduling maintenance activities?**	**(Score 1–5)**

Score using:

1. There is no maintenance management system.
2. Maintenance management is accomplished through paper recordkeeping.
3. Maintenance management is accomplished through electronic spreadsheets.
4. Maintenance management is accomplished through a fully computerized system.
5. Maintenance management is accomplished through a fully computerized system, and the maintenance management system is actively used for evaluating equipment reliability and scheduling maintenance activities.

48	**Does your agency have battery backup or a plan for power outages, including emergency generators?**	**(Score 1–5)**

Score using:

1. No battery backups or emergency generators are provided.
2. Your agency is developing a plan to provide for operation during power outages.
3. Your agency has a plan to provide for operation during power outages.
4. Your agency is implementing a plan to provide for operation during power outages.
5. Your agency provides battery backups or emergency generators at all critical intersections.

49	**Maintaining the functionality of detection systems is an important component of an effective and efficient signal timing program. What percentage of your agency's detection is operating as designed?**	**(Score 1–5)**

Score using:

1. Less than 80 percent of detection is operational, or your agency does not directly monitor detection failures.
2. Between 80 and 85 percent of detection is operational.
3. Between 85 and 90 percent of detection is operational.
4. Between 90 and 95 percent of detection is operational.
5. 95 percent or more of detection is operational.

Results for Section 6—Maintenance (Transfer this score to Results Sheet)	**(Max. 45)**

AGREEMENT NO. _____
FEDERAL ID NO. _____

COMMONWEALTH AND MUNICIPAL
TRAFFIC SIGNAL MAINTENANCE AGREEMENT

MADE and entered into this _____ day of _____, 20__, by and between the Commonwealth of Pennsylvania, Department of Transportation, hereinafter called COMMONWEALTH,

and

_____, a political subdivision in the County of _____, Pennsylvania, by its proper officials, hereinafter called SUBDIVISION.

W I T N E S S E T H:

WHEREAS, the need for traffic signals at the following location(s) has been found to be warranted:

State Route (SR) _____ and _____ Road

WHEREAS, the cost of installing traffic signals at these locations is being partially or totally funded with state and/or federal funds; and,

WHEREAS, traffic signal equipment is installed to serve a specific purpose through a distinct mode of operations; and,

WHEREAS, the useful life of traffic signal equipment is defined as the time from

installation until it is either removed or replaced with signal equipment which better serves the need of the intersection; and,

WHEREAS, the COMMONWEALTH and the Federal Highway Administration have established policies which mandate that all traffic signal equipment installed with state or federal funds be properly maintained and operated throughout its useful life; and,

WHEREAS, the SUBDIVISION has indicated its willingness to accept ownership of the traffic signal installation(s) listed on this Agreement;

NOW, THEREFORE, the parties hereto, for and in consideration of the foregoing premises and of the mutual promises hereinafter set forth, and with the intention of being legally bound hereby, agree as follows:

1. SUBDIVISION shall, at its own expense, operate the traffic signal in accordance with the permit(s) issued by the COMMONWEALTH for the location(s) listed below:

State Route (SR) _____ and _____ Road

2. It is understood and agreed by the parties hereto that, upon final acceptance by the COMMONWEALTH, title to the traffic signal installation(s) listed above shall vest in the SUBDIVISION. In this connection, it is further understood that the SUBDIVISION shall provide preventive and response maintenance, at its own expense, for the installation(s) covered by this Agreement in accordance with the provisions of Exhibit “A” attached hereto and made

part a part hereof.

3. The SUBDIVISION further agrees to prepare and retain an accurate record of the preventive and response maintenance activities performed on the installation(s) covered by this agreement. In this regard, the SUBDIVISION agrees to keep these records in accordance with the provisions of Exhibit "B" attached hereto and made part hereof and shall make such materials available at all reasonable times for inspection by the COMMONWEALTH. It is further understood that the SUBDIVISION may use forms other than those specified in Exhibit "B" only if first granted written permission by the COMMONWEALTH.

4. It is understood and agreed to by the parties hereto that the required preventive and response maintenance functions shall be provided in the manner indicated below:

Maintenance Function	Method to be Employed*
Preventive Maintenance as specified in Exhibit "A"	____ Municipal Personnel ____ Contract Services
Response Maintenance as specified in Exhibit "A"	____ Municipal Personnel ____ Contract Services

* Check appropriate boxes

The SUBDIVISION agrees that the provisions of Exhibit "C" attached hereto and made part hereof shall apply if either maintenance function is performed using municipal personnel. In addition, if the SUBDIVISION employs a contractor to perform either maintenance function, the SUBDIVISION agrees to submit the name and address of the contractor to the COMMONWEALTH, together with a copy of the contract or agreement between the contractor and the SUBDIVISION. It is further understood that the use of a contractor does not relieve the

SUBDIVISION of any obligations included in the terms or conditions of this Agreement.

5. The SUBDIVISION hereby certifies that it shall make available sufficient funds to provide the maintenance program described in this Agreement and its attendant exhibits.

6. It is understood that if the SUBDIVISION fails to fulfill its responsibilities as described herein, the SUBDIVISION may be disqualified from future federal- or state-aid participation on those projects for which the SUBDIVISION has traffic signal maintenance responsibility until such time as the SUBDIVISION provides the required maintenance services to bring the improvements to a level of maintenance satisfactory to the COMMONWEALTH. It is also understood and agreed that if the SUBDIVISION fails to provide the required maintenance services within thirty (30) days of the receipt of written notice from the COMMONWEALTH, the COMMONWEALTH shall have the right to perform the required maintenance services in the SUBDIVISION's stead and at the SUBDIVISION's expense. Furthermore, it is understood and agreed that performance of the maintenance services by the COMMONWEALTH in the SUBDIVISION's stead shall not relieve the SUBDIVISION of its responsibility for continued maintenance of the improvements. It is further understood and agreed that federal- and/or state-aid participation may be withheld on all future projects until the SUBDIVISION demonstrates to the COMMONWEALTH and the Federal Highway Administration that all required maintenance and operation services are being provided by the SUBDIVISION without the necessity of the COMMONWEALTH's performing duties herein described as being the responsibility of the SUBDIVISION.

7. The SUBDIVISION agrees that it will indemnify, save harmless and defend (if

requested) the COMMONWEALTH, it agents, representatives and employees, from all suits, actions or claims of any character, name or description, damages, judgments, expenses, attorneys' fees and compensation arising out of personal injury, death or property damage, sustained or alleged to have been sustained in whole or in part by any and all persons whatsoever, as a result of or arising out of any act, omission, neglect or misconduct of the SUBDIVISION, its officers, agents, contractors or employees, during the performance of its obligations under this Agreement and thereafter.

8. The SUBDIVISION shall comply with the Commonwealth Contractor Integrity Provisions attached as Exhibit "D" and made part hereof.

9. The SUBDIVIDSION shall comply with the Provisions Concerning *The Americans with Disabilities Act* attached as Exhibit "E" and made part hereof.

10. The Pennsylvania Right-to-Know Law, 65 P.S. §§ 67.101-3104, applies to this Contract/Agreement. Therefore, this Contract/Agreement is subject to, and the SUBDIVISION shall comply with, the clause entitled Contract Provisions – Right to Know Law 8-K-1532, attached as Exhibit "F" and made a part of this Contract/Agreement. As used in this Contract/Agreement, the term "contractor" refers to the SUBDIVISION.

IN WITNESS WHEREOF, the parties have executed this Agreement the date first above written.

ATTEST

_____

Title: DATE

SUBDIVISION

BY_____

Title: DATE

SUBDIVISION's resolution authorizing execution and attestation must accompany this Agreement. Please indicate the signers' titles and date signatures.

DO NOT WRITE BELOW THIS LINE--FOR COMMONWEALTH USE ONLY

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF TRANSPORTATION

BY_____

District Executive DATE

APPROVED AS TO LEGALITY
AND FORM

BY_____

for Chief Counsel DATE

FUNDS COMMITMENT
DOCUMENT NO. _____
CERTIFIED FUNDS AVAILABLE UNDER
SAP NO. _____
SAP COST CENTER _____
GL ACCOUNT _____
AMOUNT _____

BY _____

for Comptroller DATE

Agreement No. _____ is split ___%, expenditure amount of $_____, for federal funds and ____%, expenditure amount of $_____, for state funds. The related federal assistance program name and number is _____; _____. The state program name and number is _____; _____.

Preapproved Form:
OGC NO. 18-K-392
Appv'd OAG 12/14/98 w/RTK

Exhibit "A"

PREVENTIVE AND RESPONSE MAINTENANCE

PREVENTIVE MAINTENANCE

The SUBDIVISION or its contractor will provide preventive maintenance for each individual component of the traffic signal installation covered by this agreement at intervals not less than those indicated in the Preventive Maintenance Summary, PA DOT Publication 191, current version. This is the recommended level of maintenance to keep the intersection control equipment and signals in mechanically, structurally and aesthetically good condition.

RESPONSE MAINTENANCE

The SUBDIVISION or its contractor will provide response maintenance in accordance with the provisions of the attached "Response Maintenance Schedule." It encompasses the work necessary to restore a traffic signal system to proper and safe operation. Includes Emergency Repair and Final Repair.

Final Repair:

Repair or replace failed equipment to restore system to proper and safe operation in accordance with permit within a 24-hour period.

Emergency Repair:

Use alternative means or mode to temporarily restore system to safe operation within a 24-hour period. Final repair must then be completed within 30 days unless prohibited by weather conditions or availability of equipment.

Response Maintenance Schedule:

KNOCKDOWNS	TYPE OF REPAIR PERMITTED
Support – Mast arm	Emergency or Final
Support – Strain pole	Emergency or Final
Span wire/tether wire	Final Only
Pedestal	Emergency or Final
Cabinet	Emergency or Final
Signal heads	Final Only
EQUIPMENT FAILURE	**TYPE OF REPAIR PERMITTED**
Lamp/signal burnout (veh. & ped.)	Final Only
Local controller	Emergency or Final
Master controller	Emergency or Final
Detector sensor	
Loop	Emergency or Final
Magnetic	Emergency or Final
Magnetometer	Emergency or Final
Microwave	Emergency or Final
Pushbutton	Emergency or Final
Sonic	Emergency or Final
Video	Emergency or Final
Detector amplifier	Emergency or Final
Conflict monitor	Final Only
Flasher	Final Only
Time clock	Emergency or Final
Load switch/relay	Final Only
Coordination unit	Emergency or Final
Communication interface, mode	Emergency or Final
Signal cable	Emergency or Final
Blank-out sign	Final Only

Exhibit "B"

RECORDKEEPING

Accurate and up-to-date recordkeeping is an essential component of a good traffic signal maintenance program. In recognition of this fact, the SUBDIVISION is willing to prepare, retain, and make available to the COMMONWEALTH, on request, a record of all preventive and response maintenance activities performed on the traffic signal equipment covered by this agreement.

The SUBDIVISION agrees to establish a separate file for each installation and keep its records in the municipal building, signal maintenance shop, or other weather-protected enclosure.

At a minimum, the following records will be kept by the SUBDIVISION or its contractor for each intersection. These forms can be found in Appendices E, F and G in Publication 191.

Form TE-971 – Master Signal Maintenance Log

This form, which lists all maintenance functions performed at the intersection, should be updated within one day of the activity but no more than one week later.

Form TE-972 – Response Maintenance Record

Each time response maintenance is required at the intersection, this form should be completed. Once the pertinent information is transferred to the master intersection record, this form is to be placed in the intersection file.

Form TE-973 – Preventive Maintenance Record

This form will be used to provide a record of the preventive maintenance activities performed at each intersection. The date, the activities performed, and the signature of the person in charge of the work must be recorded in the form.

This form may be kept at the intersection, if it is adequately protected from the weather. Form TE-971 must be updated at the central file, however, to reflect the date and activity.

Exhibit "C"

SIGNAL MAINTENANCE ORGANIZATION

Personnel Requirements

In order to properly maintain the traffic signal equipment covered by this agreement, the SUBDIVISION agrees to provide, as minimum, the following staff throughout the useful life of the equipment.

Classification	Number
1.	
2.	
3.	
4.	
5.	

Training

In order to upgrade the ability of its present staff to properly perform the required maintenance functions, the SUBDIVISION agrees to secure the following training for the listed personnel classifications.

Classification	Training Required
1.	
2.	
3.	
4.	
5.	

Budget Requirements

The SUBDIVISION agrees to provide, in its annual operating budget, dedicated funds which are sufficient to cover the cost of the personnel, training, contractors (if used) and specialized maintenance equipment which are required, by virtue of this agreement.

Personnel Classifications

When referred to in this agreement, the following definitions will be used to describe personnel classifications as they relate to the maintenance and operation of traffic signal equipment.

A. Traffic Engineer – The administrative position which has prime responsibility for the proper operation of traffic signal equipment. The principal function of this position is the supervision and control of subordinate personnel and the planning of their activities to ensure adequate preventive and response maintenance programs.

Minimum Position Requirements

1. A thorough understanding of traffic signal design, installation and maintenance.

2. A working knowledge of the interaction between the following traffic characteristics:

   (a) Intersection geometry
   (b) Traffic flow theory
   (c) Control type (fixed time, actuated, etc.)
   (d) Signal phasing and timing
   (e) Signal intersection

3. An ability to supervise subordinate personnel effectively in the assignment of their work.

4. Possession of a college degree in engineering, which includes course work in traffic engineering.

5. Either four years experience in the field of traffic engineering or its equivalent in graduate college work.

B. Signal Specialist – The individual responsible for the diagnostics and repair of all traffic signal equipment including solid state equipment.

Minimum Position Requirements

1. Extensive training and troubleshooting skills in electronics and software.

2. Ability to repair modules in the shop and to design test equipment needed to diagnose and repair a problem.

3. Ability to make design and modifications to implement or omit special functions.

4. Ability to implement a recordkeeping system to include maintenance activities, inventory control and identification of recurring problems.

5. Ability to perform all tasks required of a signal technician.

C. Signal Technician – Individual responsible for the operation and maintenance of traffic signals and electromechanical equipment.

Minimum Position Requirements

1. Ability to perform response maintenance on solid state equipment up to the device exchange level.

2. Capability to diagnose a vehicle loop failure and initiate corrective action.

3. Ability to tune detector amplifiers.

4. Ability to follow wiring schematics, check and set timings from plan sheet and check all field connections.

5. Ability to perform preventive maintenance on all equipment and to maintain accurate records of all work perform

EXHIBIT "D"

CONTRACTOR INTEGRITY PROVISIONS

1. For purposes of this clause only, the words "confidential information," "consent," "contractor," "financial interest," and "gratuity" shall have the following definitions.

   a. **Confidential information** means information that is not public knowledge, or available to the public on request, disclosure of which would give an unfair, unethical, or illegal advantage to another desiring to contract with the Commonwealth.

   b. **Consent** means written permission signed by a duly authorized officer or employee of the Commonwealth, provided that where the material facts have been disclosed, in writing, by prequalification, bid, proposal, or contractual terms, the Commonwealth shall be deemed to have consented by virtue of execution of this agreement.

   c. **Contractor** means the individual or entity that has entered into the Contract with the Commonwealth, including directors, officers, partners, managers, key employees and owners of more than a five percent interest.

   d. **Financial interest** means:

      1) Ownership of more than a five percent interest in any business; or

      2) Holding a position as an officer, director, trustee, partner, employee, or the like, or holding any position of management.

   e. **Gratuity** means any payment of more than nominal monetary value in the form of cash, travel, entertainment, gifts, meals, lodging, loans, subscriptions, advances, deposits of money, services, employment, or contracts of any kind.

2. The Contractor shall maintain the highest standards of integrity in the performance of the Contract and shall take no action in violation of state or federal laws, regulations, or other requirements that govern contracting with the Commonwealth.

3. The Contractor shall not disclose to others any confidential information gained by virtue of the Contract.

4. The Contractor shall not, in connection with this or any other agreement with the Commonwealth, directly, or indirectly, offer, confer, or agree to confer any pecuniary benefit on anyone as consideration for the decision, opinion, recommendation, vote, other exercise of discretion, or violation of a known legal duty by any officer or employee of

the Commonwealth.

5. The Contractor shall not, in connection with this or any other agreement with the Commonwealth, directly or indirectly, offer, give, or agree or promise to give to anyone any gratuity for the benefit of or at the direction or request of any officer or employee of the Commonwealth.

6. Except with the consent of the Commonwealth, neither the Contractor nor anyone in privity with him or her shall accept or agree to accept from, or give or agree to give to, any person, any gratuity from any person in connection with the performance of work under the Contract except as provided therein.

7. Except with the consent of the Commonwealth, the Contractor shall not have a financial interest in any other contractor, subcontractor, or supplier providing services, labor, or material on this project.

8. Contractor, upon being informed that any violation of these provisions has occurred or may occur, shall immediately notify the Commonwealth in writing.

9. The Contractor, by execution of the Contract and by the submission of any bills or invoices for payment pursuant thereto, certifies, and represents that he or she has not violated any of these provisions.

10. The Contractor, upon the inquiry or request of the Inspector General of the Commonwealth or any of that official's agents or representatives, shall provide, or if appropriate, make promptly available for inspection or copying, any information of any type or form deemed relevant by the Inspector General to the Contractor's integrity or responsibility, as those terms are defined by the Commonwealth's statutes, regulations, or management directives. Such information may include, but shall not be limited to, the Contractor's business or financial records, documents or files of any type or form which refers to or concern the Contract. Such information shall be retained by the Contractor for a period of three years beyond the termination of the Contract unless otherwise provided by law.

11. For violation of any of the above provisions, the Commonwealth may terminate this and any other agreement with the Contractor, claim liquidated damages in an amount equal to the value of anything received in breach of these provisions, claim damages for all expenses incurred in obtaining another Contractor to complete performance hereunder, and debar and suspend the Contractor from doing business with the Commonwealth. These rights and remedies are cumulative, and the use or nonuse of any one shall not preclude the use of all or any other. These rights and remedies are in addition to those the Commonwealth may have under law, statute, regulation, or otherwise.

Exhibit "E"

PROVISIONS CONCERNING *"THE AMERICANS WITH DISABILITIES ACT"*

During the term of this contract, the Contractor agrees as follows**:**

1. Pursuant to federal regulations promulgated under the authority of *The Americans With Disabilities Act, 28 C.F.R. § 35.101 et seq.*, The Contractor understands and agrees that no individual with a disability shall, on the basis of the disability, be excluded from participation in this contract or from activities provided for under this contract. As a condition of accepting and executing this contract, the Contractor agrees to comply with the "*General Prohibitions Against Discrimination," 28 C.F.R. § 35.130,* and all other regulations promulgated under *Title II* of *The Americans With Disabilities Act* which are applicable to the benefits, services, programs, and activities provided by the Commonwealth of Pennsylvania through contracts with outside contractors.

2. The Contractor shall be responsible for and agrees to indemnify and hold harmless the Commonwealth of Pennsylvania from all losses, damages, expenses, claims, demands, suits, and actions brought by any party against the Commonwealth of Pennsylvania as a result of the Contractor's failure to comply with the provisions of Paragraph 1.

Exhibit "F"

CONTRACT PROVISIONS – RIGHT TO KNOW LAW 8-K-1532

a. The Pennsylvania Right-to-Know Law, 65 P.S. §§ 67.101-3104, ("RTKL") applies to this Contract. For the purpose of these provisions, the term "the Commonwealth" shall refer to the contracting Commonwealth agency.

b. If the Commonwealth needs the Contractor's assistance in any matter arising out of the RTKL related to this Contract, it shall notify the Contractor using the legal contact information provided in this Contract. The Contractor, at any time, may designate a different contact for such purpose upon reasonable prior written notice to the Commonwealth.

c. Upon written notification from the Commonwealth that it requires the Contractor's assistance in responding to a request under the RTKL for information related to this Contract that may be in the Contractor's possession, constituting, or alleged to constitute, a public record in accordance with the RTKL ("Requested Information"), the Contractor shall:

1. Provide the Commonwealth, within ten (10) calendar days after receipt of written notification, access to, and copies of, any document or information in the Contractor's possession arising out of this Contract that the Commonwealth reasonably believes is Requested Information and may be a public record under the RTKL; and

2. Provide such other assistance as the Commonwealth may reasonably request, in order to comply with the RTKL with respect to this Contract.

d. If the Contractor considers the Requested Information to include a request for a Trade Secret or Confidential Proprietary Information, as those terms are defined by the RTKC, or other information that the Contractor considers exempt from production under the RTKL, the Contractor must notify the Commonwealth and provide, within seven (7) calendar days of receiving the written notification, a written statement signed by a representative of the Contractor explaining why the requested material is exempt from public disclosure under the RTKL.

e. The Commonwealth will rely upon the written statement from the contractor in denying a RTKL request for the Requested Information unless the Commonwealth determines that the Requested Information is clearly not protected from disclosure under the RTKL. Should the Commonwealth determine that the Requested Information is clearly not exempt from disclosure, the Contractor shall provide the Requested Information within five (5) business days of receipt of written notification of the Commonwealth's determination.

f. If the Contractor fails to provide the Requested Information within the time period required by these provisions, the Contractor shall indemnify and hold the Commonwealth harmless for any damages, penalties, costs, detriment or harm that the Commonwealth may incur as a result of the Contractor's failure, including any statutory damages assessed against the Commonwealth.

g. The Commonwealth will reimburse the Contractor for any costs associated with complying with these provisions only to the extent allowed under the fee schedule established by the Office of Open Records or as otherwise provided by the RTKL if the fee schedule is inapplicable.

h. The Contractor may file a legal challenge to any Commonwealth decision to release a record to the public with the Office of Open Records, or in the Pennsylvania Courts, however, the Contractor shall indemnify the Commonwealth for any legal expenses incurred by the Commonwealth as a result of such a challenge and shall hold the Commonwealth harmless for any damages, penalties, costs, detriment or harm that the Commonwealth may incur as a result of the Contractor's failure, including any statutory damages assessed against the Commonwealth, regardless of the outcome of such legal challenge. As between the parties, the Contractor agrees to waive all rights or remedies that may be available to it as a result of the Commonwealth's disclosure of Requested Information pursuant to the RTKL.

i. The Contractor's duties relating to the RTKL are continuing duties that survive the expiration of this Contract and shall continue as long as the Contractor has Requested Information in its possession.

As revised by OCC on February 1, 2010

TE -699 (3-09) pennsylvania DEPARTMENT OF TRANSPORTATION

TRAFFIC SIGNAL DESCRIPTION

Municipality _____ County _____

Intersection _____

_____ Permit No. _____

Type of Mounting: Post Mounted _____ Overhead _____ Post Mounted & Overhead _____

No. of Signal Faces _____ 200 mm (8 in) Lenses _____ 300 mm (12 in) Lenses _____

Arrows: Vert. _____ Right _____ Left _____

"WALKING PERSON/HAND" Indications: 152 mm (6 in)_____ 228 mm (9 in)_____

Type of Controller: Pretimed _____ Semi-Act. _____ Full Act. _____ Vol. Den. _____

Other _____

Make of Controller and Model No. _____ PennDOT Approval No. _____

Make of Conflict Monitor and Model No. _____

Is Installation: Isolated _____ In a system _____ Location of master controller _____

Flashing Operation: Emergency _____ Time Clock _____ Manual _____

Yellow On _____ Red On _____

Make of Flashing Unit and Model No. _____ PennDOT Approval No. _____

Type and number of Detector/s

Loop	Video	Radar	Magnetic	Sonic	Ped.	Other
_____	_____	_____	_____	_____	_____	_____

Make of Detector and Model No. _____ PennDOT Approval No. _____

Make of Detector and Model No. _____ PennDOT Approval No. _____

Make of Detector and Model No. _____ PennDOT Approval No. _____

Does installation & operation conform with permit? _____

Does installation & operation conform to present standards? _____

Have Stop Signs been removed? _____ Date signal placed in operation _____

REMARKS AND RECOMMENDATIONS (Include any additional facts necessary for full description. Use back of form if necessary.)

Signed _____

Date _____

TE-971 (07-10)

MASTER SIGNAL MAINTENANCE LOG

PLEASE COMPLETE ONE LINE FOR EACH EVENT

pennsylvania
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Date	Type of Maintenance (Check Type)				Work Performed by (Signature)
	Preventative	Response		Design Modification (Include Brief Description)	
		Emergency	Final		

TE-972 (07-10)

RESPONSE MAINTENANCE RECORD

PLEASE COMPLETE ALL INFORMATION

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Municipality	County	Date
Intersection:		
Reported by: When:	Police Notified: ☐ Yes ☐ No If "yes", When:	Officer's Name & Rank:
Reported Trouble:		
Weather Conditions: ☐ Clear ☐ Rain ☐ Snow ☐ Ice ☐ Fog Ambient Temperature (°F): _____		
Assigned To:	When:	Truck No.:
Time of Arrival:	Condition Found on Arrival:	
Work Performed:		

☐ 1. Lamp Out	☐ 12. Power Failure
☐ 2. Detector Failure	☐ 13. Signal Damaged
☐ 3. Detector Amplifier Failure	☐ 14. Pole Knockdown
☐ 4. Load Switch Failure	☐ 15. Controller Knockdown
☐ 5. Conflict Monitor Failure	☐ 16. Guy Wire Down
☐ 6. Timing Incorrect	☐ 17. Span Wire Down
☐ 7. Signal Stuck	☐ 18. Missing or Defective Sign
☐ 8. Signal Out	☐ 19.
☐ 9. Lack of Progression	☐ 20.
☐ 10. Interconnection Failure	☐ 21.
☐ 11. Systems Master Failure	☐ 22.

Condition on Departure:	☐ Emergency Repair ☐ Final Repair	Time of Departure:
Parts Replaced or Repaired:		
Signature of Repair Person:	Signature of Supervisor:	

TE-973 (07-10)

PREVENTIVE MAINTENANCE RECORD

PLEASE COMPLETE ALL INFORMATION

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Municipality	County
Intersection	
Intersection Continued	Permit Number

	Recommended Interval		
	6 Months	12 Months	As Required
Date Performed →			
Controller Cabinet			
Paint steel cabinet to prevent rusting			□
Lubricate door hinges and locks		□	
Clean air filter	□		
Replace air filter		□	
Check gasket around door		□	
Check for obstructions in drainage if evidence of water accumulating in cabinet		□	
Check the integrity of lightning arrestor		□	
Check grounding electrode (rod, clamp, wire)		□	
Test battery(s) for loss of charge – replace every 3 years	□		
Measure service voltage	□		
Check physical condition of meter/service disconnect	□		
Check fan operation (thermostat set to operate at 85-90 degrees Fahrenheit)		□	
Check relays for burned or pitted contacts		□	
Check flasher for proper operation		□	
Verify operation of each switch position		□	
Verify operation of conflict monitor – remove load switch to create red fail and observe response of monitor. Ensure stop timing is implemented.	□		
Verify operation of vehicle detectors (including timing of delayed or extended output)	□		
Clean/vacuum inside cabinet		□	
Visually check wiring and connectors	□		
Place insect and/or rodent poison in cabinet if infestation is present	□		
Check anchor bolts for rust or tightness		□	

	Recommended Interval		
	6 Months	12 Months	As Required
Controller Unit (Electromechanical)			
Check time settings	□		
Check dial assembly for wear, burned contacts, key positions		□	
Check cam assembly for wear, cracks, burned contacts, tension on contacts, and clean and lubricate as required		□	
Controller Unit (Solid State)			
Check timing settings	□		
Check response to detector input	□		
Check indicator lamp		□	
Check real time on clock	□		
Check battery(s)	□		
Upgrade equipment firmware as appropriate to address items affecting operational efficiency and safety			□
Vehicle Detectors			
Loop Sensors			
Visually inspect the sensor in the roadway for sealant failure, cracks or potholes.	□		
Check alignment for sonic, magnetic, video, and radar-type detectors, and verify call inputs to controller phases	□		
Check sensor/lead-in splices		□	
Loop Amplifiers			
Check for false actuations by vehicles in adjacent lanes, check amplifier for fail light indicator	□		
Tune the detector if necessary	□		
Check whether the connectors are tight and secure	□		
Check that necessary delays are functioning		□	
Video Detectors			
Verify detection zones are in proper location relative to lane(s) being detected	□		
Assess impact of changes in sun's seasonal position on detection accuracy	□		
Verify that video detection system is using the latest software version and upgrade	□		
Check camera lens for moisture or dirt buildup and clean as needed	□*		

	Recommended Interval		
	6 Months	12 Months	As Required
Pedestrian Push Buttons			
Verify the operation of each push button and visually verify pedestrian signal operation	□		
Check the time provided for the pedestrian crossing	□		
Check push button signs for location, legibility, damage	□		
Check audio operation and direction	□		
Check push button signs; clean or replace if necessary	□		
Supports (Mast Arm, Strain Pole, Span Wire)			
Paint			□
Inspect for rust and cracks especially at seams and joints		□	
Inspect anchor bolts verify that nuts have not loosened		□	
Span wires - check guy wire, anchors, guards, span sag, cable lashing, supporting brackets and hardware		□	
Inspect poles, transformer bases, and arms for damage caused by impact with vehicles		□	
Inspect joints for rust and cracks at arm/upright location and at base plate		□	
Inspect horizontal and vertical angles of arms		□	
Handhole - check integrity of splices in signal cable, check ground rod, clamp and ground wire connections		□	
Adequately secure handhole covers		□	
Check signal cable for wear at entrance of poles, brackets, signal heads and where it's lashed to span wire		□	
Check bonding of span wire and tether wire to strain pole		□	
Check for obstructions in drain at pole base		□	
Signal Heads			
Paint Exterior of metallic signal head			□
Clean lenses and reflectors		□	
Replace incandescent lamps with LEDs when possible, using products listed in Publication 35 *(no change required on the traffic signal permit, but suggest notifying the District Traffic Engineer)*		□	
Check mounting hardware		□	
Check alignment (aim toward center of approach at a point approximately 150 feet in advance of stop bar		□	

	Recommended Interval		
	6 Months	**12 Months**	**As Required**
Check the clearance between the roadway and the bottom of signals and/or signs located over the roadway		□	
Check for signals obscured by foliage		□	
Check security of louvers, visors and backplates		□	
Clean signs		□	
Check for wear on span wire and signal mounting hardware			□
Remove any strobe light installed in conjunction with a red signal indication			
Systems Equipment			
Ensure controller operates in mode selected by master, if applicable		□	
Check any special equipment for proper operation		□	
Disconnect controller from master and check for free or backup operation		□	
Pavement Markings			
Restore pavement markings			□
Junction Boxes and Handholes			
Check integrity of splices	□		
Check the ground rod, clamp connection, and bonding of conduits	□		
Check the insulation		□	
Check for abnormal amount of water		□	
Check lid for abnormal condition and fit		□	

* More frequent maintenance may be required during the winter months due to road salt spray

TE-974 (07-10)

DESIGN MODIFICATION CHECKLIST

PLEASE COMPLETE ALL INFORMATION

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Municipality	County
Intersection	
Intersection Continued	Permit Number

Item	Existing Design in Conformance With:								Recommended Improvements
	Recurring Maintenance Problem?		Approved Plan?		State-of-the-Art Design?		Traffic & Physical Conditions?		
	Yes	No	Yes	No	Yes	No	Yes	No	
CONTROLLER OPERATION									
Phasing									
Left-Turn Phase									
Timing									
Cycle Length									
Vehicle Change & Clearance Intervals									
Pedestrian Intervals									
Countdown Pedestrian Signals									
Green Intervals									
Free-Floating									
Flashing Operation									
Time-Based Coordinators									
SOFTWARE									
Computer-Controlled System									
System Configuration									
Central Algorithms									
Time Plans									
Data-Processing Routines									
Performance Reports									
HARDWARE									
Electrical Distribution									
Signal Heads (Housings)									
Light Emitting Diodes (LEDs)									
Layout & Placement									
Configuration									
Size									
Back Plates									
Retroreflective Back Plate Borders									
Signal Controller Location									
Signal Head Mounting Hardware									

Alternative Power Source									
Structural Replacement									
DETECTORS									
Amplifiers									
Relay									
Optic									
Loop Configuration									
Loop Spacing									
Loop Wire									
Video Detectors									
Pedestrian ADA Requirements									
PAVEMENT MARKINGS									
Stop and Yield Lines									
Center Lines									
Lane Lines									
Channelization									
Dotted Extension Lines									
Arrows and ONLY messages									
Thermoplastics									
Raised Pavement Markers									
SIGNS									
Guide/Destination									
Regulatory									
Warning									
Street Name									
Guide/Destination									

GENERAL COMMENTS:

Inspected By

Date

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**";

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 *Guidelines for the Maintenance and Operation of Traffic Signal*" (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

(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 two (2) hours of notification by any municipal agent, municipal police officer, State police officer, local or county emergency service manager or other duly authorized agent of **MUNICIPALITY**.

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: _____	xxxxxxxxxxxxxxxxxxxxxxxxxxx
	xxxxxxxxxxxxxxxxxxxxxxxxxxx
Address: _____	xxxxxxxxxxxxxxxxxxxxxxxxxxx
	xxxxxxxxxxxxxxxxxxxxxxxxxxx
Address: _____	

COOPERATIVE MEMORANDUM OF AGREEMENT
SR ____ MULTI-JURISDICTIONAL SIGNAL SYSTEM

THIS COOPERATIVE MEMORANDUM OF AGREEMENT, made this ____ day of _____, 20___, by and between

The _____, located at _____, PA _____, hereinafter called "Party #1",

and

The _____, located at _____, PA _____, hereinafter called "Party #2",

and

The _____, located at _____, PA _____, hereinafter called "Party #3",

and

The _____, located at _____, PA _____, hereinafter called "Party #4".

Make Party #1 the oversight organization. Insert municipal names and addresses as appropriate. Add or delete parties as necessary.

Make modifications throughout as necessary, especially relative to the types of equipment enclosed in {braces}.

W I T N E S S E T H :

WHEREAS, the Commonwealth of Pennsylvania hereinafter called the "Commonwealth", is about to upgrade traffic signals along SR ____ through the municipalities Party #2, Party #3, and Party #4 as part of the _____ County, SR _____ Congested Corridor Improvement Program hereinafter called the "Project"; and,

WHEREAS, the Project includes the installation of *{light emitting diodes, countdown pedestrian indications, emergency preemption, video and radar detection, and signal controllers as well as select replacement of traffic signal supports}*, hereinafter called the "Traffic Signal Enhancements". The Project also includes the installation of a communications system to interconnect traffic signals, the installation of *{adaptive signal control and a system-wide computer system and associated software}*, hereinafter called the "Communications and Adaptive Control System".

WHEREAS, the previous Traffic Signal Enhancements and the Communications and Adaptive Control System will become one multi-jurisdictional signal system, hereinafter called "MJSS".

NOW, THEREFORE, in consideration of the foregoing premises and the mutual covenants hereinafter contained, the parties, with intent to be legally bound, agree as follows:

1. The Commonwealth has made application to the Federal Highway Administration for certain federal funds to enable the Commonwealth to construct and implement the MJSS and to make operational refinements to the MJSS and associated signal timings during a contractually designated test period. The Commonwealth shall undertake such Project, only, if it receives Federal Highway Administration funding. The obligations of the parties set forth below are contingent upon the Commonwealth obtaining Federal Highway Administration funding and proceeding with the construction and implementation of the MJSS. If the Commonwealth determines that it shall not proceed with the MJSS, the parties shall have no further obligations under this Agreement, and the Agreement will be terminated.

2. Project construction will include a testing and operational support period. Construction documents will require the Contractor to provide operational oversight and Communications and Adaptive Control System maintenance during that period. Maintenance of specific traffic signals will be the responsibility of the permit holder as defined on each signal installation's current "*Application for Permit to Install and Operate Traffic Signals*" and will remain in effect until construction begins and the construction operational support period ends. Upon completion of the testing and operational support period, the parties will establish a collaborative maintenance support and operational oversight program for no less than a three-year period which will be directed and funded by Party #1. Requirements to be covered in this agreement include:

    a. MJSS Oversight Requirements:

        i. Biweekly confirmation to all parties and their traffic signal maintenance providers noting the system is functioning. This includes verification there is active two-way communication to all traffic signals, verification the system software and traffic responsive software is operational, and confirmation all detection zones are functioning.

        ii. Biweekly review of event logs and notification to impacted stakeholders and their traffic signal maintenance providers if the system is malfunctioning. Notification does not include authority to authorize repairs.

        iii. The implementation and coordination of timing plan revisions in areas covered by the MJSS due to other projects of the Commonwealth, any of the parties, or due to upgrades associated with approved highway occupancy permits.

            1. Timing modifications are to be reviewed and approved by the Commonwealth consistent with existing signal timing

modification procedures.

2. Approved timing plan modifications will be implemented within two weeks from time of notification.

iv. The implementation of the special events timing plan at the discretion of the parties and with input agreement from the Commonwealth.

v. Monthly status report to all parties and their traffic signal maintenance providers detailing system operations, timing modifications, and system maintenance activities.

vi. Participation in MJSS status meetings as noted in paragraph 7 below.

b. Communications and Adaptive Control System Maintenance Requirements:

i. Biannual preventive maintenance of system-wide communications systems, master controllers, central computers and system software in accordance with *PennDOT Publication 191, Guidelines for the Maintenance of Traffic Signal Systems* and manufacturer maintenance guidance.

ii. Response maintenance activities of system-wide communications systems, master controllers, central computers and system software within 24 hours of notification and in accordance with *PennDOT Publication 191, Guidelines for the Maintenance of Traffic Signal Systems.*

iii. Record keeping in accordance with *PennDOT Publication 191, Guidelines for the Maintenance of Traffic Signal Systems.*

iv. Provide and implement system-wide software updates as well as traffic signal controller and detection system software updates.

c. Traffic Signal Maintenance Requirements:

i. Biannual preventive maintenance of permitted traffic signals in accordance with *PennDOT Publication 191, Guidelines for the Maintenance of Traffic Signal Systems* and per manufacturer maintenance guidance.

ii. Response maintenance of permitted traffic signals within 24 hours of notification and in accordance with *PennDOT Publication 191, Guidelines for the Maintenance of Traffic Signal Systems.*

iii. Record keeping in accordance with *PennDOT Publication 191, Guidelines for the Maintenance of Traffic Signal Systems.*

iv. Other maintenance requirements to be agreed upon by the parties.

Electric utility fees will be the responsibility of each municipality. Communication fees will be the responsibility of the collaborative maintenance support and operational oversight program directed and funded by Party #1.

3. Party #___ will house the adaptive signal controller, the system-wide computer system and associated software as well as an antenna and other communications equipment required to provide communication to field controllers. Housing responsibilities will include:

    a. Providing minimal office table-top space for the adaptive controller and system computer.

    b. Permitting an antenna to be mounted at the office.

    c. Incidental costs associated with providing power to the adaptive controller and system computer to be located in the office.

4. Spare equipment provided by the Commonwealth as part of the Project will be used at the direction of Party #1, equipment may include: controllers, light emitting diode signal indications and countdown pedestrian indications.

5. The parties agree to support the interoperability and compatibility of MJSS by requiring future enhancements and upgrades to the MJSS to use emergency preemption systems, video and radar detection equipment, signal controllers and other equipment compatible with the existing MJSS. For all signal projects (Developer-led, Municipality-led, State-led), plans, specifications and estimates shall be provided to the Commonwealth and to each party for review.

6. The parties agree to require developers or other transportation enhancement projects to fund the following items at the discretion and direction of the Commonwealth and Party #1:

    a. Furnish and install adaptive control and communication equipment at the approval of the Commonwealth and the parties for all new signals installed within one-half mile of the MJSS or all new signals installed within one mile of the MJSS, if the proposed development will impact the intersection.

    b. Maintain system timing plan cycle lengths in traffic impact analysis, if the “impact” (defined below) of the development does not extend beyond four intersections within the MJSS coverage area.

    c. Analyze the impact on the entire MJSS, if the proposed development has an “impact” (defined below) on more than four intersections within the MJSS coverage area. Data collection would be required at only those intersections impacted and analysis for all other intersections would be conducted using

historic traffic volumes and approved adjustments.

d. Provide materials and equipment necessary to meet operational compatibility as defined in paragraph 5 above.

e. Impact is defined as a five percent increase in total intersection traffic volume during one or more peak hours, a drop in level of service by one letter, as governed in the municipal traffic engineering requirements, or as designated in a pre-traffic impact study coordination meeting.

7. The parties agree to coordinate as needed to maximize safe and efficient MJSS operations for the life of the system. Key coordination activities include:

   a. Implementation of timing plans.

   b. Implementation of a maintenance plan in accordance with paragraph 2 above. Party #1 will coordinate the implementation of this agreement.

   c. Agreement to support the interoperability and compatibility of MJSS as detailed in paragraphs 5 and 6 above.

   d. Agreement to have a MJSS status meeting on a quarterly (as needed) basis to be initiated by Party #1.

   e. Agreement to meet annually (as needed) to review MJSS operations and discuss future enhancements. Party #1 will coordinate these meetings.

   f. Agreement to address dispute resolution as detailed in paragraph 8 below.

   g. Coordination with any County Traffic Signal Program.

8. Disputes arising between the parties should be resolved in the following manner:

   a. Party #2, Party #3 and Party #4 agree to meet along with Party #1 to discuss the dispute and identify a resolution.

   b. If the dispute is not resolved or if there is a dispute with Party #1; the parties agree to meet with an arbitrator to resolve the dispute. The decision of the arbitrator shall be final and conclusive unless, within thirty (30) days after receipt of such written determination, Party #2, Party #3 and/or Party #4 then file a claim with the Court of Common Pleas. Pending a final judicial resolution of a controversy or claim, Party #2, Party #3 and/or Party #4 shall proceed diligently with the performance of the Agreement in a manner consistent with the interpretation of the arbitrator.

9. This Agreement is contingent upon the governing body of each party granting approval at a public meeting pursuant to and in accordance with the Intergovernmental Cooperation Act, 53 Pa. C.S. §2301 et seq. This Agreement is

also contingent upon its execution by all parties to the Agreement along with PennDOT moving forward with the Project and receipts of funds. This agreement shall remain in place for the life of the multijurisdictional signal systems unless discontinued by all parties. Removal by individual parties will be coordinated with the County such that adjustments to remaining MJSS elements can be made.

Technical issues regarding this agreement and the proposed MJSS maintenance and operations should be forwarded to:

Identify the contact person in Party #1, including their name, address and telephone number.

_____
_____
_____
_____
_____
_____

IN WITNESS WHEREOF, PARTY #1, PARTY #2, PARTY #3 and PARTY #4 have caused this Agreement to be duly executed, ensealed and attested by their proper officials, pursuant to due and legal action authorizing the same to be done, the day and year first above written.

==========

ATTEST: _____

by _____ by _____

Signature Date Signature Date

_____ _____

Title Title

Additional signatures:

Add an identical additional sheet for each party.

On each signature page, in bold capitals, insert the full name of the municipality or organization as used on the first page of the agreement in lieu of the underline to the right of the word "ATTEST."

If a Corporation, the President or Vice President must sign and the Secretary, Treasurer, Assistant Secretary or Assistant Treasurer must attest; if a sole proprietorship, only the owner must sign; if a partnership, only one partner need sign; if a limited partnership, only the general partner must sign.