Transportation Systems Management and Operations (TSMO)

Guidebook

PART II: DESIGN

TSMO





pennsylvania
DEPARTMENT OF TRANSPORTATION

PUB 852 (9-23)

Contents

Appendices

Figures

Tables

Chapter 1. Introduction

1.1 Purpose of the Guidebook

Publication 852, TSMO Guidebook, Part II: Design, focuses on the design process and guidelines for the deployment of TSMO Strategies, including Intelligent Transportation Systems (ITS). This publication supplements Publication 647, Civil and Structural Standards for Intelligent Transportation Systems. The purpose of this publication is to ensure the proper deployment of ITS field devices to support the Pennsylvania Department of Transportation (PennDOT or Department) operations program.

1.2 Acronyms

Many abbreviations and acronyms are used in TSMO, with several of the common ones listed below:

Abbreviation/Acronym	Term
AASHTO	American Association of State Highway and Transportation Officials
AC	Alternating Current
AMPS	Amperes
AMR	Automatic Meter Reader
ARLE	Automated Red-Light Enforcement
ASCII	American Standard Code for Information Interchange
ATMS	Advanced Traffic Management System
AWG	American Wire Gauge
AWZSE	Automated Work Zone Speed Enforcement
BOO	Bureau of Operations
BODD	Bureau of Design and Delivery
BPR	Bureau of Planning and Research
C2C	Center-to-Center
C2F	Center-to-Field
CAV	Connected and Automated Vehicles
CCTV	Closed Circuit Television
CE	Categorical Exclusion
CLD	Camera Lowering Device
CMS	Changeable Message Sign
ConOps	Concept of Operations
COPA	Commonwealth of Pennsylvania
C-VSX	Cellular Vehicle-to-Everything
DC	Direct Current
DFV	Design Field View
DM	Design Manual
DSRC	Dedicated Short-Range Communications
DTMF	Dual Tone Multi Frequency
ECMS	Engineering and Construction Management System
EVDO	Evolution-Data Optimized

Abbreviation/Acronym	Term
FCC	Federal Communications Commission
FDOM	Final Design Office Meeting
FHWA	Federal Highway Administration
FRE	Fiberglass Reinforced Epoxy Conduit
GHz	Gigahertz
GIS	Geographic Information Systems
GLG	Green-Light-Go
HAR	Highway Advisory Radio
HDPE	High-Density Polyethylene Conduit
HSPA	High Speed Packet Access
HSPA+	Evolved High Speed Packet Access
HSTOD	Highway Safety and Traffic Operations Division
IEDC	Infrastructure and Economic Development Delivery Center
IP	Internet Protocol
ITS	Intelligent Transportation Systems
JB	Junction Box
KHz	Kilohertz
LED	Light-Emitting Diode
LRTP	Long Range Transportation Plan
LTE	Long-Term Evolution
MAC	Media Access Control
Mbps	Megabits per second
MHz	Megahertz
MUTCD	Manual on Uniform Traffic Control Devices
NEC	National Electric Code
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NESC	National Electric Safety Code
NPDES	National Pollutant Discharge Elimination System
NTCIP	National Transportation Communications for ITS Protocol
OA/OIT	Office of Administration – Information Technology
PennDOT or Department	Pennsylvania Department of Transportation
PS&E	Plans, Specifications, and Estimates
PVC	Polyvinyl Chloride Conduit
RF	Radio Frequency
RFI	Radio Frequency Interference
RFID	Radio Frequency Identification
RFP	Request for Proposals
RFQ	Request for Qualifications
ROP	Regional Operations Plan
RSU	Roadside Unit
RTMC	Regional Traffic Management Center

Abbreviation/Acronym	Term
RTVD	RFID Tag Reader Vehicle Detector
SER	Systems Engineering Report
SFP	Small Form-Factor Pluggable
STMC	Statewide Traffic Management Center
TCP	Transmission Control Protocol
TE	Traffic Engineering (designation for a standard Form)
TIP	Transportation Improvement Program
TMC	Traffic Management Center
TSMO	Transportation Systems Management and Operations
UAT	User Acceptance Testing
UDP	User Datagram Protocol
UPS	Uninterruptible Power Supply
V	Volts
VDS	Vehicle or Video Detection Systems
VMS	Video Management System
VPD	Vehicles per Day
VPN	Virtual Private Network
VSL	Variable Speed Limit

1.3 References

TABLE 1: PENNSYLVANIA RESOURCES

Reference	Description
Publication 647, Civil and Structural Standards for Intelligent Transportation Systems	Establishes standards for the infrastructure elements that support ITS design and construction. The publication should be used by all Districts and their consultants for all ITS projects.
Publication 10A, Design Manual (DM) Part 1A: Transportation Engineering Procedures (Dual Unit)	Describes the engineering procedures required to support PennDOT's project development process. Although these procedures may be used in Planning, Prioritization and Programming, or Maintenance and Operations, their primary applications are in the Design and Construction phases of project development.
Publication 13M, DM, Part 2: Highway Design	Provides the current, uniform procedures and guidelines for the application and design of safe, convenient, efficient, and attractive highways that are compatible with their service characteristics and that satisfy optimally the needs of highway users while maintaining the integrity of the environment.
Publication 14M, DM, Part 3: Plans Presentation	Promotes uniformity in the preparation of plans by establishing the general format and presenting the detailed information which is required for each type of plan sheet required in the maintenance and construction of highway facilities. The guidance provided shall also assist the designer in avoiding errors and omissions which consequently would require excessive alterations and corrections.
Publication 15M, DM, Part 4: Structures	Establishes standard policies and procedures in the preparation of design and construction plans for highway structures.

Additional national ITS resources:

- Systems Engineering for Intelligent Transportation Systems

(https://ops.fhwa.dot.gov/publications/seitsguide/index.htm)

- Federal Highway Administration, Office of Operations Publication List (https://ops.fhwa.dot.gov/publications/publications.htm)
- ENTERPRISE, Warrants for the Installation and Use of Technology Devices for Transportation Operations and Maintenance (http://enterprise.prog.org/itswarrants/)

1.4 Manual Organization

This Guidebook includes six chapters and in organized as described below.

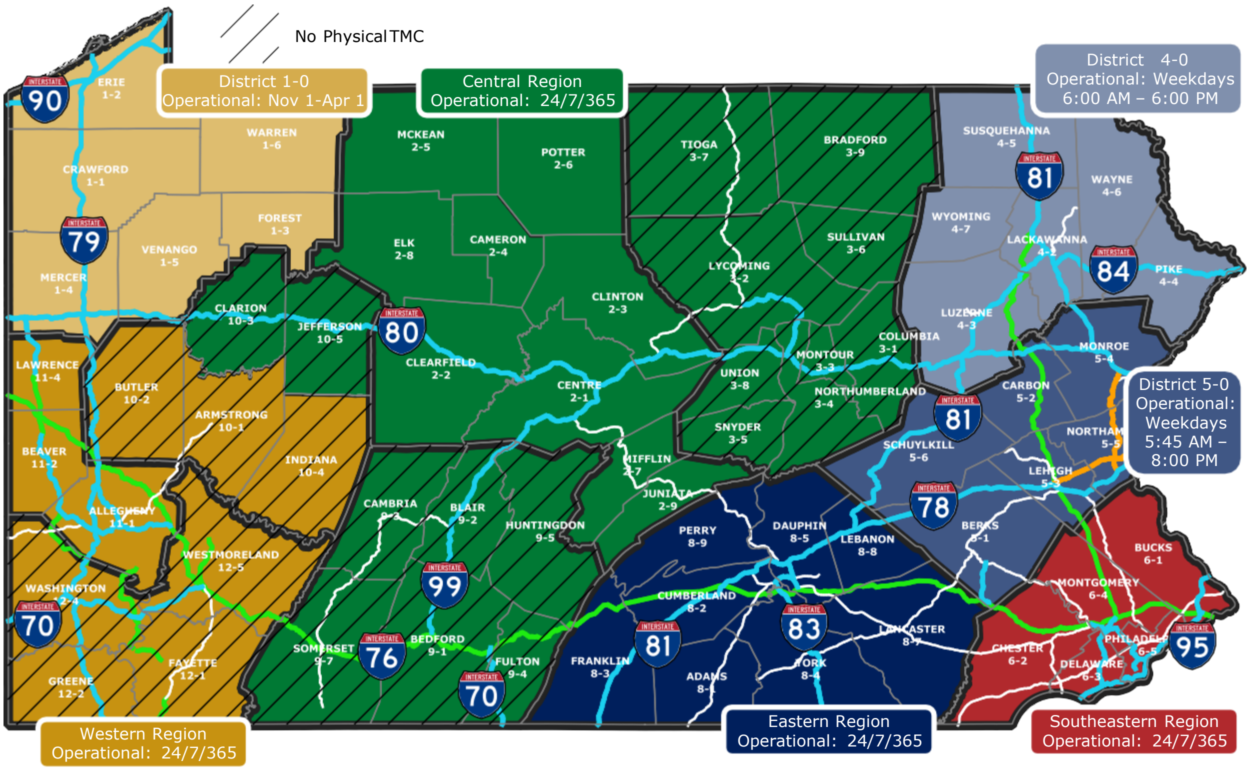
- **Chapter 1: Introduction:** Overview of the manual and its contents, list of acronyms, PennDOT organizational structure and contact information, and general document disclaimer
- **Chapter 2: Project Development Process:** Overview of the PennDOT ITS project development process
- **Chapter 3: Device and Infrastructure Design:** Design guidance for supporting ITS infrastructure including power service, communications, conduit, conduit access, and enclosures
- **Chapter 4: Maintenance Considerations:** Overview of the PennDOT maintenance processes and items to be considered during design
- **Chapter 5: Plan Preparation:** Typical ITS plans, specifications, engineer's estimate, and design guidance for common PennDOT ITS elements
- **Chapter 6: System Integration:** Overview of the process for integrating ITS devices into ATMS during the construction phase of a project

1.5 Department Organization

Districts & Operations Regions

PennDOT Engineering Districts are responsible for the state-maintained transportation network within their respective counties. Each District also works with local governments, elected officials, stakeholders, and the public on keeping people and goods moving safely and efficiently. The Districts are typically project owners and manage the project delivery process. From an operations standpoint, seven of the eleven engineering districts maintain some level of a Traffic Management Center (TMC). Regional Traffic Management Centers (RTMC) are located within four of the districts to ensure 24/7 operations statewide by supporting their member districts throughout the day or during off-hours for a local TMC. There are four Operations Regions: Southeast Region (District 6-0), Eastern Region (District 4-0, District 5-0, and District 8-0), Central Region (District 2-0, District 3-0, and District 9-0), and the Western Region (District 1-0, District 10-0, District 11-0, and District 12-0). Additionally, a Statewide Traffic Management Center (STMC), located in Harrisburg, is responsible for oversight, support, and coordination of issues and needs of statewide significance. Figure 1 illustrates the Districts and Operations Regions.

FIGURE 1: DISTRICTS AND REGIONS

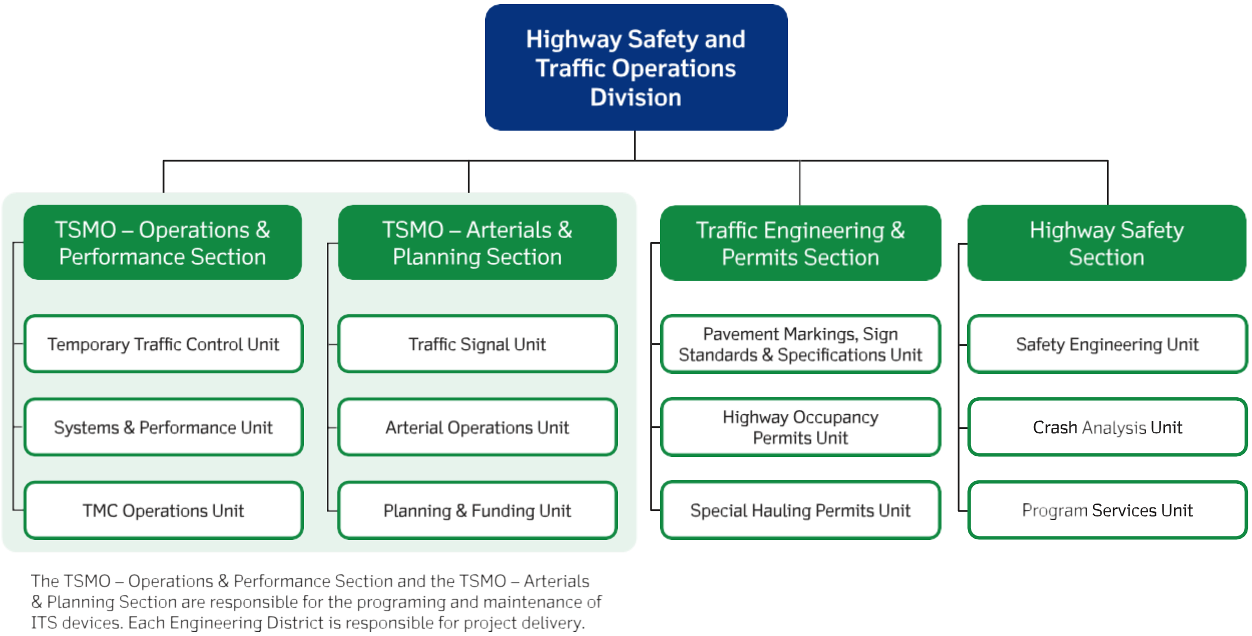


Each of the eleven Engineering Districts includes a traffic engineering unit that collaborates with project managers during the design process. If individual District contacts are not known, a request can be made by the designer through the Transportation Systems Maintenance and Operations (TSMO) resource account at TSMO@pa.gov.

Bureau of Operations

Within the Bureau of Operations (BOO), the Highway Safety and Traffic Operations Division (HSTOD) is responsible for the development of policies and guidance for traffic engineering and operations within Pennsylvania. HSTOD is also reasonable for managing statewide programs such as Automated Work Zone Speed Enforcement (AWZSE), Green-Light-Go (GLG), Advanced Traffic Management System (ATMS), and Automated Red-Light Enforcement (ARLE), Highway Safety, and Permits. There are four sections within HSTOD which are provided in Figure 2 below.

FIGURE 2: HSTOD ORGANIZATION CHART



Transformational Technology Program

The Transformational Technology Program within PennDOT is dedicated to furthering the state in the field of emerging technologies including Connected and Automated Vehicles (CAV). A link to PennDOT's program website has been provided below:

PennDOT's Transformational Technology program website and contact information:

https://www.penndot.gov/ProjectAndPrograms/ResearchandTesting/Autonomous%20_Vehicles/Pages/Automated%20Vehicle.aspx

Bureau of Design and Delivery and Bridge Office

The Bureau of Design and Delivery (BODD) and the Bridge Office provides policy and guidance for the design of bridges and highways within the Commonwealth. This includes environmental, right-of-way and utility requirements, bridge, and sign structure inspection, and CADD resources.

PennDOT's BODD website and contact information:
https://www.penndot.gov/ProjectAndPrograms/RoadDesignEnvironment/Pages/RoadDesignEnvironment.aspx

PennDOT's Bridge Office website and contact information:
https://www.penndot.gov/ProjectAndPrograms/Bridges/Pages/default.aspx

Planning

Planning leads many multimodal programs and initiatives and serves as a valuable resource to the Commonwealth's Metropolitan and Rural Planning Organizations, the State Transportation Commission, Transportation Advisory Committee, local governments, and the public. Planning consists of three bureaus: the Center for Program Development and Management, the Office of Public Private Partnerships, and the Bureau of Planning and Research

(BPR). The BPR provides big data and visualization tools, new products research, Geographic Information Systems (GIS) services, and transportation planning. BPR manages the PennDOT OneMap and provides much of the data used during the project development process.

The Center for Program Development and Management and BPR's website and contact information: https://www.penndot.gov/ProjectAndPrograms/Planning/Pages/default.aspx

To learn more about the planning process for operations projects refer to Publication 851 – TSMO Guidebook, Part 1: Planning.

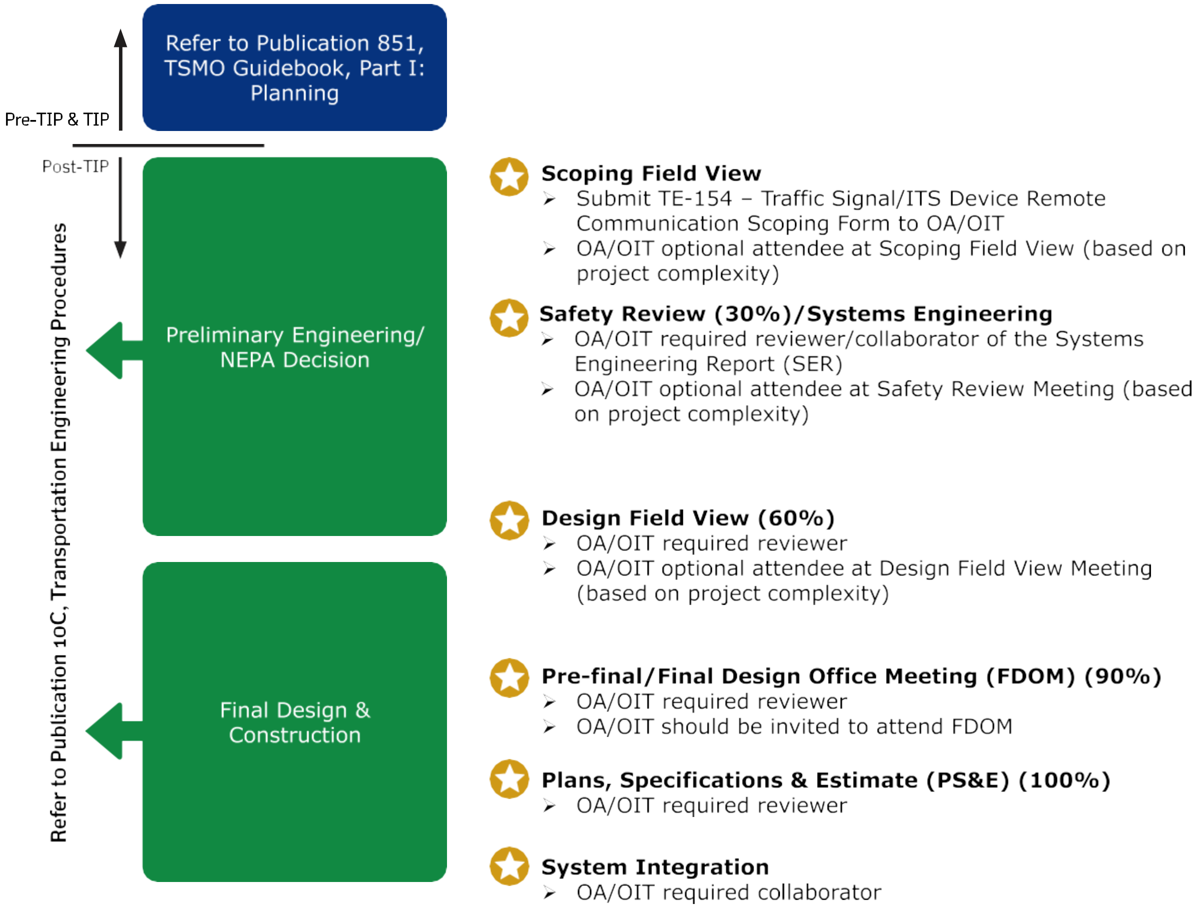
1.6 Office of Administration

Office of Administration - Information Technology (OA/OIT) oversees investments in and performance of all IT systems across the Commonwealth, which includes ITS deployments. OA/OIT establishes and implements policies, standards, and guidelines regarding planning, management, acquisition, and security of IT assets in all Commonwealth agencies under the Governor's jurisdiction. OA/OIT is responsible for the issuance and management of IT procurement, including hardware, software, services, and telecommunications. The office provides enterprise IT technology support, including direct oversight for large, enterprise-wide initiatives, such as IT consolidation, Commonwealth shared services, and cyber security. Coordination with OA/OIT's Infrastructure and Economic Development Delivery Center (IEDC) and the Network Operations Division is required during the planning, design, and integration phases of a project that will upgrade or change the existing ITS equipment or network communication infrastructure.

Coordination Process

Ongoing coordination with OA/OIT during the project delivery process allows for more efficient integration of the ITS deployment into the Commonwealth's network during construction and can help avoid project delays, costly change orders, and redesign. Figure 3 outlines the coordination process between the designer and OA/OIT.

FIGURE 3: OA/OIT COORDINATION PROCESS



At Project Scoping the designer is required to submit Form TE-154 – Traffic Signal/ITE Device Remote Communications Scoping Form **(Appendix A)** to the District including a project description and, if available, a conceptual plan. The District will route the form to OA/OIT for approval. Based on the project complexity, OA/OIT should be invited to the Scoping Field View as an optional attendee. Initial contact to OA/OIT should be done through the resource account: FiberReview@pa.gov. During Preliminary Engineering, OA/OIT is required to be a reviewer and/or collaborator in the development of the System Engineering Report (SER) and a required reviewer of the Design Field View (DFV) plans. OA/OIT should be an optional attendee at the Safety Review Meeting and the DFV meeting based on the project complexity. The project complexity should be determined by the designer and discussed with OA/OIT during the initial outreach at project scoping.

In Final Design and Construction, OA/OIT is a required reviewer of the Pre-final plan submission, the Plans, Specifications, and Estimates (PS&E) submission, and is a required collaborator during integration. Additionally, OA/OIT should be invited to the Final Design Office Meeting (FDOM).

General Guidance

The following information should be considered during the design process when connecting to the Commonwealth Network.

- No direct fiber connections are allowed by third parties not under the jurisdiction of OA/OIT into the Commonwealth Network due to OA/OIT security concerns. Municipalities and other third parties that need to connect directly to the Commonwealth must have a network with the capacity to either support a secure VPN or connection to a paid subscription to the Commonwealth's business partner network. Access to the Commonwealth Network is provided only to those with Commonwealth accounts with CWOPA credentials. CWOPA accounts may be established for stakeholders including municipalities, signal owners or their designees, consultants, contractors, and manufacturers.
- Desired video or other data from outside partners, including municipalities, needs to be brought back to a single headend location (the master location for receiving communications). The headend will be connected to the Commonwealth Network via a MPLS connection.
- Districts should not purchase any routers that rely on connecting devices, over the public internet, to the Commonwealth Network. All connection requests must be made through OA/OIT.
- Direct connections of field devices (including traffic signals) to the Commonwealth Network should be on a secure network such as a MPLS network connection. Cellular devices are approved for traffic signal, Highway Advisory Radio (HAR), and Changeable Message Sign (CMS) applications. All exceptions should be discussed with OA/OIT.

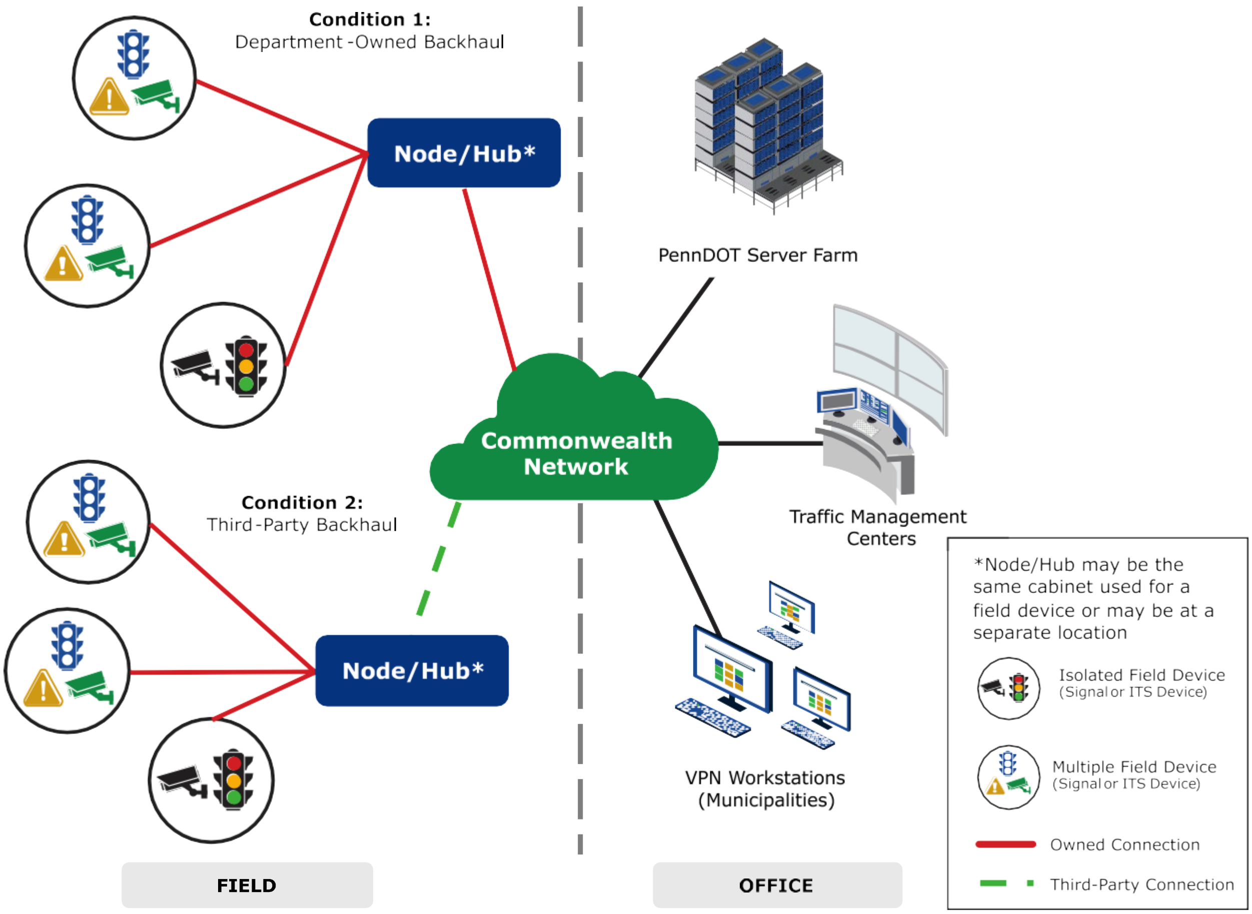
Network Connection Types

The typical network connection types are provided below and illustrated in Figure 4.

- **Condition 1** is the connection of a single isolated or multiple field devices back to the Commonwealth Network through a PennDOT-owned connection
- **Condition 2** is the connection of a single isolated or multiple field devices back to the Commonwealth Network through a single third-party connection

For Condition 2, devices should be connected within a field network to the maximum extent feasible to minimize the number of third-party connections due to the ongoing recurring costs to provide communication service.

FIGURE 4: NETWORK CONNECTION TYPES



Construction Deployment Options

- **Option 1 –** PennDOT-Owned Equipment and Connecting Back to PennDOT (PennDOT and Business Partners working on our behalf access the cabinet)
  - All Network Connection Types (Figure 4) are permitted
  - OA/OIT approved network router to connect to the Commonwealth Network
  - Commonwealth Network connection through the PennDOT telecom contract
- **Option 2 –** Connecting Municipal-owned field devices back to PennDOT Network (PennDOT and Municipal Business Partners access the cabinet)
  - Network Connection Type (Figure 4) Condition 2 is permitted if a secure MPLS network connection can be established
    - Only permitted if the ITS/Traffic Signal field network is physically isolated from all other networks
  - OA/OIT approved network router to connect to the Commonwealth Network
  - No direct connection of field network to municipality's network
    - The municipality must use OA/OIT VPN to access field devices
  - No direct connection to the Commonwealth Network
- **Option 3 –** Other
  - Coordination OA/OIT is required to develop an approach

To request a Department VPN, the designer should contact the Systems and Performance Unit (BOO, HSTOD). Contact information can be requested through the TSMO resource account: TSMO@pa.gov.

1.7 Disclaimer

Standards change rapidly in the field of ITS so portions of the manual may become outdated between updates. PennDOT assumes no liability for its contents or use thereof. All PennDOT ITS plans, specifications, and engineer's construction estimates should be prepared by or under the direct supervision of a professional engineer licensed to provide engineering services in the Commonwealth of Pennsylvania. PennDOT does not endorse products or manufacturers. Trademarks of manufacturers' names appear herein only because they are considered essential to the object of this manual. The contents do not necessarily reflect the official policy of PennDOT.

Chapter 2. Project Development Process

2.1 Project Types

Stand-Alone ITS Projects

Stand-alone ITS projects are typically led by the design consultant, who is responsible for all management tasks that would traditionally be handled by a roadway group on a roadway construction project. Significant coordination with other functional groups will be required as a part of design (survey, design, geotechnical, signals & lighting, structures, signing, right-of-way, utilities, etc.). The designer will also need to obtain required input from other groups for items including Safety Review, DFV, and PS&E submittals, which may require environmental documentation, right-of-way acquisition, and many other considerations. The designer will need to coordinate reviews with other functional groups at various milestones throughout the project and is responsible for the final submittal to the District. Since development of the ITS plans is not tied to a larger project, there is more flexibility in when the milestone submittals need to occur and in the ITS components that are included in the final design based on project budget considerations.

ITS as Part of a Larger Project

For ITS design that is part of a larger project, the designer is responsible for only the ITS plans and coordinates with other functional groups as needed. All management tasks are handled by the roadway group project manager, who will need to coordinate with all the other functional groups. The development of the ITS plans will be more prescribed in following the overall project schedule, where ITS design plans are typically not started until after Safety Review.

2.2 Project Delivery Methods

Design-Bid-Build

Design-Bid-Build is the traditional project delivery method in which PennDOT designs, or retains a designer to furnish complete design services, and then advertises and awards a separate construction contract based on the designer's completed construction documents. In Design-Bid-Build, PennDOT "owns" the details of design during construction and as a result, is responsible for the cost of any errors or omissions encountered in construction. ITS design is completed as part of the overall plan set and follows the traditional review process. The ITS design on a Design-Bid-Build project may be completed either by PennDOT or by a consultant and is the typical project delivery method.

Design-Build

Design-Build is a project delivery method in which PennDOT procures both design and construction services in the same contract from a single, legal entity referred to as the design-builder. The method typically uses Request for Qualifications (RFQ)/Request for Proposals (RFP) procedures rather than the Design-Bid-Build invitation for bids procedures. A RFQ is the process of pre-qualifying potential bidders for a project. Only those bidders who successfully respond to the RFQ and meet the qualification criteria will be included in the subsequent RFP solicitation process. An RFP is a funding announcement for which bidders compete for a project. The Department process for procurement is dependent on project requirements.

In Pennsylvania, a third party typically develops a conceptual 30% design package with items and specifications so the design-builder can bid to complete the design and construction. The design-builder controls the details of final design and is responsible for the cost of any errors or omissions encountered in construction. On Design-Build projects, each functional group design is typically developed and approved as a separate design package. There may be separate design packages for signing, traffic signals, pavement markings, maintenance of traffic, ITS, roadway, drainage, and many others. There may also be multiple ITS design packages that are constructed at different times according to the overall construction staging. PennDOT staff are heavily involved early in the project developing the ITS related components of the RFP for a Design-Build project. Once the Design-Build project is awarded, the ITS design is completed by the design-builder, so PennDOT provides an oversight role on these projects and conducts more reviews throughout the design process. The development of design packages on Design-Build projects is accelerated compared to Design-Bid-Build projects. PennDOT typically does not utilize Design-Build for Stand-alone ITS projects but may use this method on larger construction projects that may have an ITS component.

Public-Private-Partnership

Public-private partnerships involve collaboration between PennDOT and a private-sector company that can be used to finance, build, and operate projects. Financing a project through a public-private partnership can allow a project to be completed sooner or make it a possibility in the first place. Public-private partnerships often involve concessions of tax or other operating revenue, protection from liability, or partial ownership rights over nominally public services and property to private sector, for-profit entities.

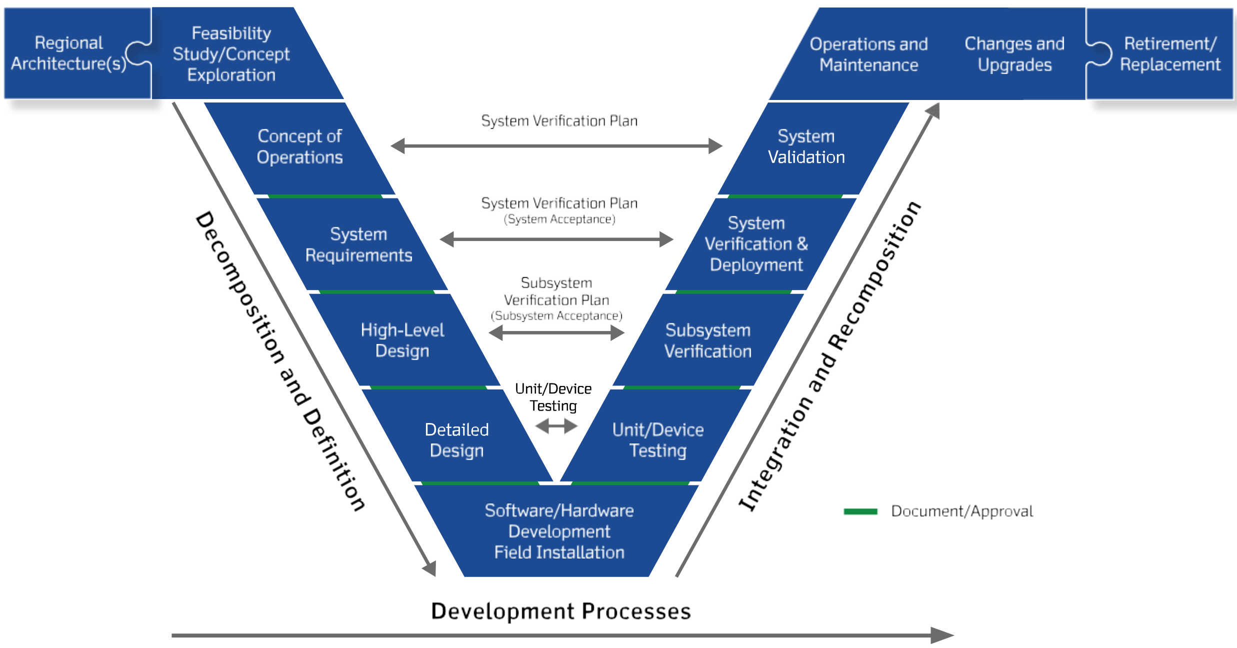
Department Led

Department led ITS projects are typically designed and constructed using one of the four regional ITS Maintenance contracts. Each Operations Region utilizes an ITS maintenance provider, or team, to maintain its devices in the field and in the TMC/RTMC/STMC. There are provisions in each contract allowing PennDOT to replace or add new equipment. The ITS Maintenance contractor will perform the design and construction. These projects are considered minor and may include deployment of a Type A mounted CMS or a CCTV camera using Department standards.

2.3 Systems Engineering Approach

All PennDOT ITS design projects must follow the Federal Highway Administration (FHWA) systems engineering process (23 CFR 940.11). In this recommended approach, the specification, procurement, design, operation, and maintenance needs are effectively and efficiently applied to implement advanced technologies to transportation. As shown in the V-Diagram (Figure 5), the systems engineering process begins with the study of the feasibility and conceptual overview of an ITS project. At this time, an initial project scope is developed based on the local and regional needs for the system. Continuing down the left side of the V-Diagram, the process progresses from the general definition of an initial concept and definition of system requirements through the detailed final design and ultimately arriving at the project construction phase. Progressing along the right side of the “V”, components of the completed ITS system are tested and integrated into the region’s overall ITS network. Finally, the completed system is validated to determine how well it is meeting the needs as defined during the development of the Concept of Operations. The lateral connections indicate the overlap between processes initiated in the early stages of the project with those that occur later. For example, the system verification and deployment phase of a project determines if and how well the system requirements are being met through system acceptance testing.

FIGURE 5: V-DIAGRAM



The Systems Engineering Process concludes with the approval of a Systems Engineering Report (SER). A SER should include the following sections: Project Overview/Scope, Description of Existing System (if applicable), Concept of Operations, System/Functional Requirements, Proposed Device Locations and Justification, ITS Architecture Conformance, Communications Plan, Systems Integration and Testing, Systems Operations and Maintenance, Preliminary Cost Estimate, and System Procurement. The SER should be discussed with the District and include input from OA/OIT during project scoping. A sample SER can be requested from the District/Region to assist the designer in preparation.

Regional ITS Architecture

All ITS design projects should be completed in accordance with corresponding regional ITS architecture. This guide will not cover the specifics of each regional ITS architecture. PennDOT expects that the designer will evaluate the regional architecture during the systems engineering phase and incorporate all necessary requirements in the overall design. There is no Statewide ITS Architecture; however, each regional ITS architecture was developed in consultation with statewide stakeholders to maintain a shared vision of how each region's systems work together by sharing information and resources to enhance transportation safety, efficiency, capacity, mobility, reliability, and security throughout the Commonwealth.

Regional Operations Plans

A Regional Operations Plan (ROP) is available for each of the four Operations Regions that were developed based upon the guidance from Publication 851, TSMO Guidebook, Part I: Planning. The ROPs allow each region to prioritize operations projects for funding. Each document will enable Pennsylvania to:

- Meet federal requirements related to ITS planning (23 CFR 940)
- Incorporate statewide TSMO goals for operations planning at the regional level
- Utilize an objective-driven, performance-based planning process for operations and congestion management planning

- Integrate ITS and operations planning into the overall transportation planning process
- Identify and prioritize TSMO capital projects as part of the Transportation Improvement Program (TIP)
- Manage funds for the TSMO operations and maintenance (O&M) in future years

It is anticipated that this ROP will be updated every four or five years. Similar to the Long-Range Transportation Plan (LRTP), the ROP should, at a minimum, identify which projects could be undertaken within the first four years, aligning these projects for potential inclusion in the TIP.

ROPs are available through the Departments TSMO website: https://www.penndot.pa.gov/ProjectAndPrograms/operations/Pages/default.aspx.

2.4 Planning and Pre-Design

Concept of Operations

The Concept of Operations (ConOps) is a description of how the system will be used. It is non-technical and presented from the viewpoints of the various stakeholders. Typical stakeholders include operators, users, owners, developers, maintenance, and management. The ConOps should be developed to be easily reviewed by the stakeholders. There are several reasons for developing a ConOps.

- Obtaining stakeholder agreement identifying how the system is to be operated
  - Who is responsible for what?
  - What are the lines of communication?
- Defining the high-level system concept and justification when compared to other alternatives
- Defining the environment in which the system will operate
- Developing high-level requirements, especially user requirements
- Providing the criteria to be used for validation of the completed system

The greater the expected impact on operations, the more detailed the ConOps needs to be. For example, automating operations that were formerly manual or integrating activities that were formerly independent will require the involvement of the various operators, clear and detailed description of their new procedures, and possibly examination of alternative approaches. This is especially true if modifications or new modules are required in ATMS.

The ConOps should include the following critical information

- Is the reason for developing the system clearly stated?
- Are all the stakeholders identified and their anticipated roles described?
  - This should include anyone who will operate, maintain, build, manage, use, or otherwise be affected by the system.
- Are alternative operational approaches described and the selected approach justified?
- Is the external environment described?
  - Does it include required interfaces to existing systems?
- Is the support environment described?
  - Does it include maintenance?
- Is the operational environment described?
- Are there clear and complete descriptions of normal operational scenarios?
- Are there clear and complete descriptions of maintenance and failure scenarios?
- Do the scenarios include the viewpoints of all involved stakeholders?

  - Do they make it clear who is doing what?
- Are all constraints on the system development identified?
- Coordination requirements with the Systems and Performance Unit regarding software

System/Functional Requirements

System requirements are the foundation for building ITS networks. The system requirements should be:

- Developed based on the ConOps
- Discrete (i.e., isolate requirements to minimize combinations)
- The basis for traceability of the system.

They determine what the system must do and drive the system development. System requirements are used to determine if the project team built the system correctly. The system requirements development process identifies the activities needed to produce a set of complete and verifiable requirements.

Traffic Signal System/Functional Requirements

Functional requirements identify what the traffic signal system should do. Consider the following functional requirements for accessing traffic signals through the Commonwealth network. The communication system may:

- Allow remote time synchronization among controllers to establish a common time reference to provide a common cycle length and to establish appropriate offsets
- Allow remote upload and download of timing plans and other database parameters to the field controller
- Allow remote monitoring of field equipment status and reporting of equipment malfunctions
- Allow remote selection and implementation of timing plans
- Support adaptive traffic signal control technology
- Allow remote monitoring and control of video information from the central location
- Allow remote configuration, monitoring and control of detectors
- Allow remote upload of logs developed by emergency vehicle signal preemption equipment
- Support transit signal priority
- Allow remote monitoring and control of traffic signal controller conflict monitor
- Allow remote retrieval of high-resolution event log for Automated Traffic Signal Performance Measures (ATSPM)

Device Placement and Justification

As projects identified in the ROPs progress through the planning process, the designer will start laying out preliminary locations for the proposed ITS devices. Included below are important components for developing the pre-design/conceptual ITS device locations. Device placement should be coordinated with the District and is finalized as part of the Systems Engineering process.

- **Freeways & Aerials:** At the initial planning stage for determining placement of proposed ITS devices, the designer should review aerial imagery to identify possible conflict areas and desired placement locations. These factors may include sight lines, bridges, and other geographical characteristics.
- **Preliminary Layout:** The designer should create a roll plot with an aerial background showing in place utilities and ITS infrastructure to start pencil-sketching proposed ITS device locations, possible fiber optic trunk line routing, possible source of power locations, and any other required elements.

- **Field Visit:** After completing the initial draft of the preliminary layout, the designer should perform a field visit to collect photos and review proposed ITS device locations. For example, a proposed cabinet may be shown on a steep slope while there is a flatter area nearby that would work better.

2.5 General Design Guidance

Clear Zone Requirements

Refer to Publication 13M (DM-2) – Highway Design, Chapter 12, for guidance on procedures and guidelines related to clear zone requirements. It is recommended that the designer not apply rigid adherence to the calculated clear zone distance. The designer should not use the clear zone distances as boundaries for introducing roadside hazards such as non-breakaway sign supports or poles. These should be placed as far from the roadway as practical. ITS devices should be placed outside the clear zone whenever possible, and in cases that it is not possible or feasible, the ITS devices must be placed behind guide rail except if breakaway supports are utilized. Use of breakaway supports within the clear zone in certain applications (e.g., Type A CMS) are acceptable in accordance with guidance provided in Publication 13M (DM-2) Chapter 12.

Survey and Core Borings

Whenever survey and soil borings are required, the designer will need to submit formal requests to the appropriate groups. Soil borings are required for every foundation of a proposed sign structure (Overhead, Center-mount, and Cantilever), and the geotechnical group will complete those requests and provide a report that recommends whether a special foundation be used or if the standard design is adequate. Additional geotechnical review is also recommended in areas where shallow bedrock is anticipated as a part of Type A sign design and Closed Circuit Television (CCTV) camera locations because special foundations may be required, or the sign location may be moved to avoid the bedrock. Additional geotechnical review may include a review of historic soil borings in the area, ground penetrating radar, or additional soil borings. Core borings are not typically required for CCTV camera foundations but may be necessary to verify soil conditions.

Utility Coordination

The utility coordination process is designed to help reduce the time that designers spend on utility relocation. By identifying early milestones for utility coordination meetings and follow up, project managers and designers can avoid time-consuming efforts to resolve utility issues that often occur later in the project delivery process. PennDOT staff members across multiple disciplines play important roles to execute successful utility accommodation and coordination. The process encourages early and ongoing communication with utility owners. PennDOT often collaborates with consulting engineers on the design of highway transportation projects. As a result, consulting engineers are involved with many aspects of utility coordination, including project management.

On ITS projects, the full utility coordination process is not typically followed. Most in-place public or private utilities will not be impacted, and under that scenario the utility listings in the plan set will note all in-place utilities as “XXXXXX”. The designer will need to perform a Pennsylvania One Call (pa1call.org) to locate and obtain a list of all utility owners in the project area. It should be noted that Pennsylvania One Call will not designate Department owned utility infrastructure. If power source modifications or new power sources will be required as part of the ITS design, the designer and PennDOT will need to coordinate with the power company to determine locations for obtaining power.

Environmental Coordination

National Environmental Policy Act (NEPA) requires the examination and avoidance, minimization, or mitigation of potentially adverse impacts to the social and natural environment when considering approval of proposed transportation projects. Stand-alone ITS projects generally do not require significant environmental coordination and typically requires a Categorical Exclusion (CE) Evaluation. The designer should consult Publication 10B (DM-1B) – Post-TIP NEPA Procedures and discuss environmental requirements with the District Environmental Manager during project scoping.

A National Pollutant Discharge Elimination System (NPDES) permit is required for any point source discharge to waters of the Commonwealth. Pennsylvania's Department of Environmental Protection (DEP) issues the majority of NPDES permits. For stand-alone ITS projects, the design should coordinate with DEP during project scoping to determine permit requirements.

Functionality

The proposed ITS device(s) should be designed to adequately address the existing problems that have been identified in the ROPs. For example, if a series of video cameras are proposed to be added, the designer needs to ensure that the proposed camera locations minimize blind spots (assuming they cannot be avoided), or for a proposed CMS, the designer needs to ensure that the CMS is located optimally to facilitate major traffic diversions due to a crash downstream of the CMS.

Constructability

The designer needs to consider the constructability of ITS devices when determining proposed ITS device locations. For example, all ITS infrastructure and construction equipment should have a minimum clearance to overhead power lines per utility service provider guidelines. The designer needs to consider common construction methods that contractors use to construct the ITS devices and make sure that the design is realistic and practical.

Maintainability

The designer should consider the maintainability of ITS devices when determining proposed ITS device locations. The two most important considerations are access and safety, and if possible, the designer should use standard PennDOT approved components so there is consistency in ITS devices throughout the entire system. The designer should assess the safest way to access an ITS device whether it is constructing a wide shoulder or access road, installing a lowering device, a ladder/catwalk, or utilizing a front access sign or walk-in. Maintenance access should be well planned and lane closures or restrictions to traffic should be avoided. Alternate locations should be considered if site-specific device maintenance creates unsafe conditions or impacts mobility. Another consideration regarding ITS device locations is the ease and complexity of underground utility locating.

Device Collocation

If multiple different ITS devices (CCTV camera, CMS, etc.) are proposed for a certain area, the designer should evaluate whether it would make sense to place them at the same site. This could reduce the number of communications and power source locations, the number of equipment enclosures, and the number of mounting structures. This could also simplify maintenance operations such as mowing.

2.6 Design Review Process

Publication 851: TSMO Guidebook, Part I: Planning covers the portion of the Department's project delivery process for identifying projects for the TIP. This manual provides design guidance for projects post-TIP. Project design is completed over two major phases: Preliminary Engineering and Final Design and Construction. Preliminary Engineering activities include scoping field view, engineering studies, NEPA documentation, and DFV. DFV approval indicates that all preliminary engineering requirements have been met and the preferred alternative is approved for final design (NEPA approval). Final Design and Construction activities include design development, plans preparation, and contract management. Typical design submissions include:

- Post-TIP Scoping - Scoping Field View
- Preliminary - Line, Grade, and Typical Sections
- Preliminary - Safety Review (30%)
- Preliminary - Design Exception Request
- Preliminary - Design Field View (60%)
- Final - Pre-Final/FDOM (90%)
- Final - PS&E (100%)

Refer to Chapter 1, Office of Administration, Coordination Process, for when the designer should coordinate with OA/OIT during the project delivery process.

Scoping

During initial design scoping between PennDOT and the designer, several items should be considered to ensure that all applicable integration coordination and required activities within the overall project are included:

- ITS Systems
  - Should be cross-referenced with capabilities and modules currently available in PennDOT's Video Management System (VMS) and Advanced Traffic Management System (ATMS).
  - If new types of devices and software systems are required, the additional effort to design and integrate these systems should be included in the design scope.
- ATMS Modifications/Enhancements
  - The designer should coordinate with PennDOT to determine if any aspects of the existing ATMS must be modified or enhanced as part of the project (e.g., deployment of new device type/system, or need for new ATMS module/capability, such as an algorithm or operational feature).

The Systems and Performance Unit manages the ATMS vendor contract. All coordination regarding design, enhancements, modifications, and integration related to ATMS, or related software platforms, must be coordinated through BOO, HSTOD.

The designer should make all efforts to utilize standard components, means, and methods during the design and integration process to maintain consistency to avoid cost impacts to projects.

Safety Review (30 percent)

Safety Review is one of PennDOT's primary review points for quality control on highway design projects. The purpose of Safety Review is to detect and correct safety deficiencies and incorporate necessary safety features into the design as early in the process as possible. Safety Review and Design Field View (DFV) submissions may occur simultaneously based on the project complexity and/or Engineering District. Locations of any proposed sign structures may be required at this phase; however, ITS elements of a design project are usually not required for Safety Review. For ITS projects the Safety Review phase is used for the development of the SER. During this phase, the design team will determine all operational use cases and functional requirements for each system to be included in the project. The design team should evaluate all requirements to integrate the project systems based on the requirements of the regional ITS architecture.

- **Coordination:** The design consultant should coordinate with PennDOT District ITS staff to determine if a streamlined process can be utilized for the development of any systems engineering documents, such as the ConOps, SER, or any functional or systems requirements documents. Often these documents include boilerplate language that may be able to be a reference rather than included in each document.
- **New ITS Systems:** If the systems engineering process determines that any new ITS systems must be deployed to meet PennDOT's operational or functional needs, the new systems should be coordinated with PennDOT District ITS staff, OA/OIT and the Systems and Performance Unit to determine if any additional requirements should be included in the design.
- **ATMS Modifications/Enhancements:** Once the systems engineering process has been completed for the project, the design team should again cross-reference the system requirements for the project against the current capabilities of PennDOT's ATMS. It is possible that the system engineering process will identify additional modifications or enhancements needed for ATMS that were not evident during project scoping.
    - If ATMS modifications/enhancements are required as a part of the project, these requirements should be developed during the system engineering process. In these instances, the design team should be coordinating with both OA/OIT and the Systems and Performance Unit. This will be critical in the determination of the performance requirements needed for successful development and integration of the ATMS enhancements during the integration phase of the project.

Design Field View (60 percent)

The DFV phase of an ITS project is typically when the design team will begin to develop high-level bid items that will be included in the project. The bid items will vary depending on what systems are included in the design. Some the of the key integration items that should be considered during the DFV phase are described below:

- **3rd Party Data Systems:** If the ITS project includes a system that requires ATMS to integrate directly with a 3rd party vendor system to obtain the system data, a memo should be developed outlining the various inputs and outputs, including protocols, that will be required for ATMS integration. An example of this is the inclusion of 3rd party travel time or speed data.
- **CMS:** If the ITS project includes CMS, the project team should refer to Publication 200 – Changeable Message Sign (CMS) Operating Standards for message requirements during the DFV phase of the project. Coordinate with the Systems and Performance Unit for any non-standard items (e.g., special graphics or colors).
- **CCTV:** If the ITS project includes CCTV, the design team should coordinate the optimal camera view with the District. This coordination allows for the desired performance of the CCTV.
- **New Systems:** If the project includes new ITS systems, the design team should coordinate with OA/OIT and the Systems and Performance Unit to determine what bid items are needed to procure the new systems as a part of the project. These bid items will likely require the development of special or modified items and system specific special provisions.
- **ATMS Modifications/Enhancements:** If the ITS project includes any software procurement or the modification/enhancement to the existing ATMS, these items should be finalized during the DFV phase. During this phase, the design team and PennDOT should make a final decision as to whether new software is required to operate the project systems or if an update can be made to existing ATMS.

- If a new software system is desired, coordination with the Systems and Performance Unit is required to determine whether that software will be procured and implemented under the construction contract or through separate procurement.
- If the project will modify/enhance existing ATMS, coordination with the Systems and Performance Unit is required to determine whether the updates will be procured under the construction contract or through the existing statewide ATMS contract.

Final Design (90 percent)

The Final Design phase of an ITS project is typically when the design team is developing the pre-final version of the design. It is during this phase that the design team should finalize the project bid items and special provisions to be included for the ITS system and integration requirements. Some of the key items for consideration during this phase of the project are noted below.

- **3rd Party Data Systems:** If the ITS project will require ATMS to integrate with a 3rd party system to obtain project data, the design team should have approval of the memo for direct connection to the 3rd party data source.
    - The project team will should coordinate integration into ATMS with the Systems and Performance Unit. For example, any bid items, specifications, or special provisions for travel time integration may not be required.
- **Special Provisions/Bid Items:** During Final Design, the design team should review the existing PennDOT standard specifications (Publication 408, Section 1200) to determine if any modifications to these specifications is required based on the system requirements. One of the key items that should be coordinated during this process is determining if the standard specifications for ITS Integration (Section 1202) covers all the information the ATMS vendor will need to integrate the project systems. The information required to integrate existing systems into PennDOT's ATMS are currently outlined in Section 1202. As previously noted, the project may need a special item to support the integration of complex deployments.
    - Another key item to be coordinated during this time is the item for ITS testing. The design team should be sure to coordinate with PennDOT to determine if any modified language needs to be added to Section 1201 to ensure all testing and operational support/maintenance is completed during the construction phase.
    - During this phase of the project, the design team should review the system requirements with the Systems and Performance Unit to determine if any additional information is required for integration. If additional information is needed, modified language would need to be developed as a special provision to be included in the integration bid item.
- **New Systems:** If the project includes new ITS systems, these systems will also need to be procured using special provisions and bid items. The final design submission should include these items in the submission. These items should be reviewed by OA/OIT and the Systems and Performance Unit to ensure compliance into the ATMS.
- **ATMS Modifications/Enhancements:** Based on the previous coordination that has occurred during the design phase, the project team should have decided by Final Design if new software is required or if the existing ATMS can be modified.
    - If new software is needed to be procured during construction to operate the project systems, then the project team will develop a project bid item and special provision covering the requirements, identified in the systems engineering process, to procure the software.
    - If modifications are required to the existing ATMS, then a scope should be developed by the Systems and Performance Unit identifying how the additional enhancements will be completed and at what

cost. This scope should also outline the milestones and schedule that the enhancements will be completed.
  - If any ATMS modification or new software is to be procured for a project, the design team will need to coordinate the scope and budget for this bid item. The scope of these services should be used to determine if a pre-determined amount (PDA) item should be used for the bid. The scope should be coordinated with the Systems and Performance Unit and include a detailed response to how the requirements are to be met as well as the milestones and schedules for all software design and development activities.
- **Proprietary Approval Letter:** If the project team determines that any proprietary systems will be required, the design team shall draft a proprietary approval letter to be submitted to PennDOT during the design phase. A proprietary approval could be required as a part of any ITS project based on the need to specify a specific product by name based on system requirements. Proprietary requests dealing with ITS devices shall be electronically submitted to the TSMO resource account, TSMO@pa.gov after being approved by the applicable Engineering District.

Plans, Specifications, and Estimate (PS&E) (100 percent)

The final PS&E submission should include all final design items, specifications, and documents necessary for the contractor to integrate the proposed systems during construction. Some of the key aspects that should be included are described below:

- **Special Provisions/Bid Items:** The final design document should include all required bid items and special provisions necessary for the contractor to integrate the systems into ATMS.
- **ATMS Modifications/Enhancements:** If a scope for the existing ATMS vendor was coordinated for a bid item, then the ATMS vendor scope should be included on ECMS in the bid documentation (less any information that is proprietary/needs to be redacted).
- **Proprietary Approval Letter:** If the project requires a proprietary approval, then the signed letter should be included on Engineering and Construction Management System (ECMS) in the bid documentation.

Additional Input and Reviews

Traffic Unit

If maintenance and protection of traffic, traffic signal, signing, or pavement markings are required as part of the project, the traffic group should review the plans at all submittals (Safety Review, DFV, Pre-Final, and PS&E).

Survey Unit

If right-of-way information is not available and needs to be obtained, or if there are any other concerns that may require surveying, the survey unit will need to review the plans. The survey unit should review the plans throughout the project delivery process/right-of-way process, preferably at the Safety Review, DFV, and Pre-Final submittals.

Construction and Maintenance Units

The construction and maintenance units should review the plans during constructability and value engineering submittals and throughout the process, preferably at the Safety Review, DFV, Pre-Final, and PS&E submittals.

Bridge Unit

If there are any new bridge-mounted structures, such as a CMS installation, the structures unit should review the plans at the DFV, Pre-Final, and PS&E submittals.

If there is any proposed structural steel work on any existing or proposed structures, the structures unit should review the plans at the DFV, Pre-Final, and PS&E submittals.

If soil borings are required for sign structures (Overhead, Center-mount, and Cantilever) and the geotechnical report recommends that a special foundation design is required, the bridge group should review the plans in the Pre-Final submittal.

Coordination with Other Disciplines and Projects

When the ITS design is being done as part of a larger project, the designer will need to coordinate with other disciplines including drainage and utilities. This coordination needs to occur so the proposed ITS design does not conflict with wetland areas, proposed ponds, drainage structures, and other utilities.

The designer needs to ensure that early in the design process all disciplines are aware of each other's proposed design and that regular coordination happens throughout. Any groups that need to be coordinated with should also participate in the review process described above.

The designer must be aware of other projects that are being designed by others that may affect their own project, so any items that may require coordination during design or construction are addressed and incorporated into the plans and Special Provisions.

2.7 Construction Support Services

As part of the project, contractors are required to submit as-built plans. Preferably, these as-built plans should have GIS location for all new devices installed. The Department requires that the contractor submits an as-built plan set that includes mark-ups showing additions, deletions, and other changes made during construction. As-built plans are to be prepared in accordance with Publication 408 Section 1201.2(i), Documentation. The 60-Day Test will not end until the as-built drawings are submitted and approved by the Department.

The Engineering District is responsible for updating the ITS asset inventory in TSAMS when the as-built information is received.

2.8 General Design Steps

As described in the Design Review Process section of Chapter 2: Project Development Process, the key stages of a PennDOT ITS design project are as follows:

- Scoping
- Safety Review (30%)
- Design Field View (60%)
- Final Design (90%)
- Plans, Specifications and Estimate (100%)

The following figures illustrate the critical items that the designer should evaluate during the project development process.

- Figure 6: Design Process for a Project with Typical ITS System Deployments

- Figure 7: Design Process for a Project with New ITS System Deployments
- Figure 8: Design Process for a Project with ATMS Modification/Enhancement

It should be noted that more than one flowchart may need to be referenced, depending on the systems included in a project. Each flowchart follows the same key milestones during the design process.

FIGURE 6: DESIGN PROCESS FOR A PROJECT WITH TYPICAL ITS SYSTEM DEPLOYMENTS

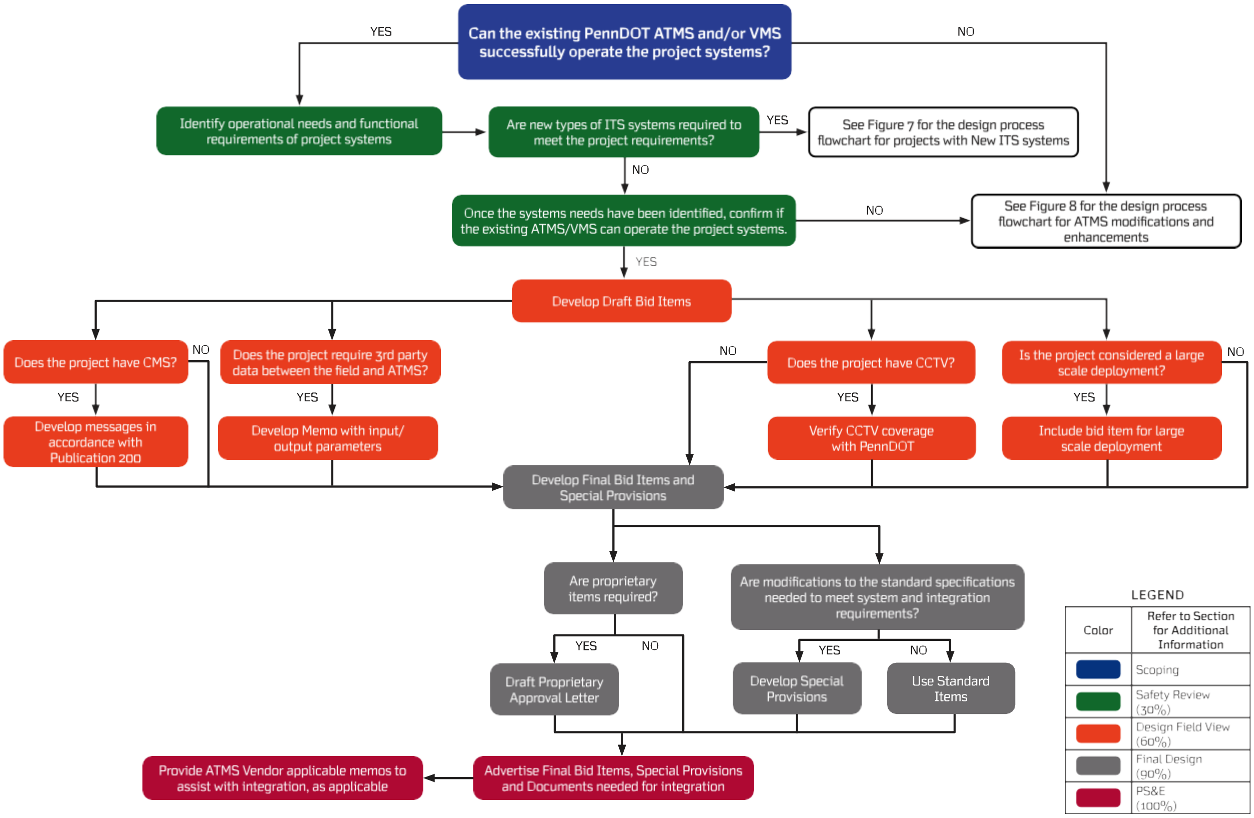


FIGURE 7: DESIGN PROCESS FOR A PROJECT WITH NEW ITS SYSTEM DEPLOYMENTS

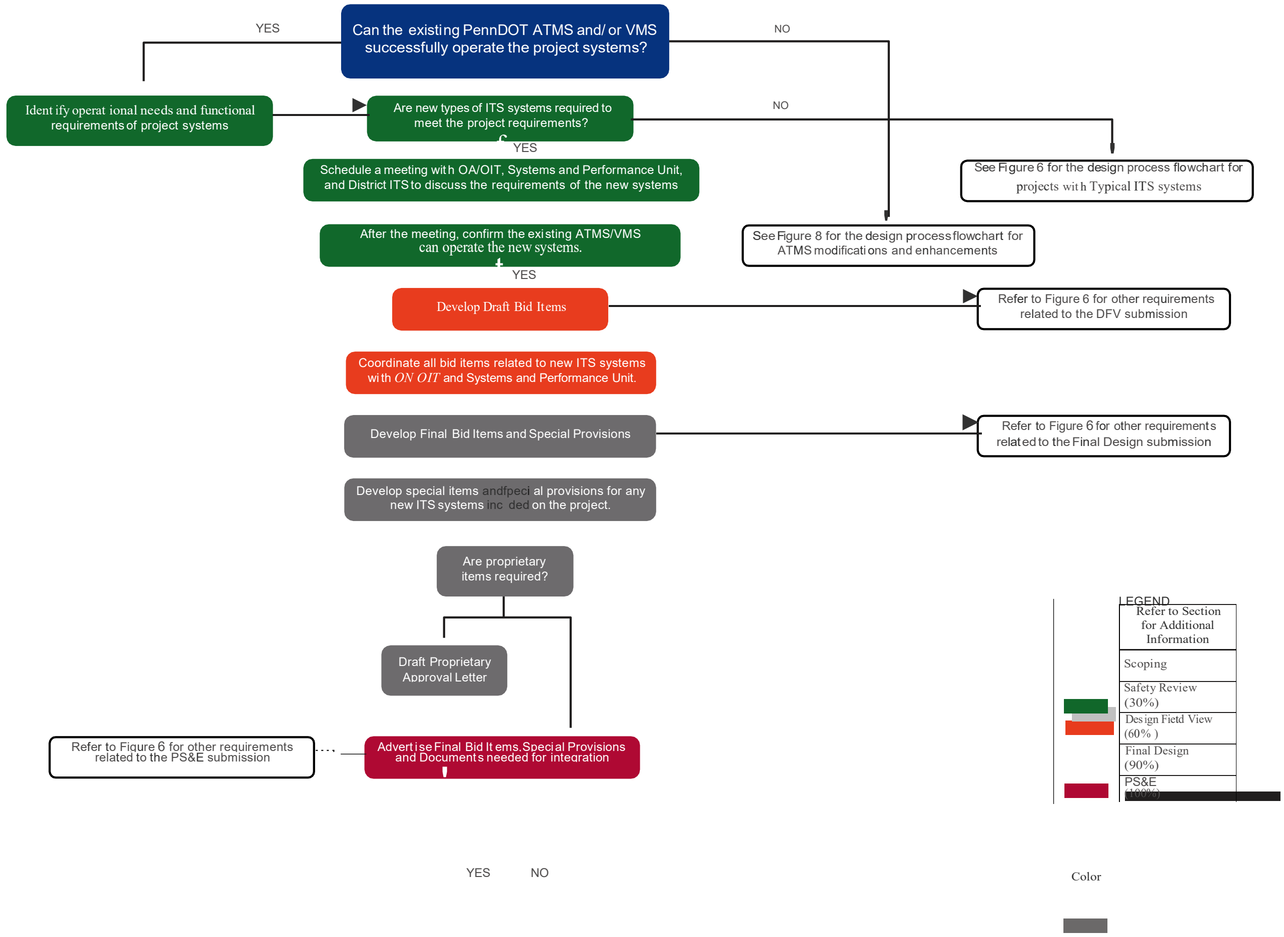
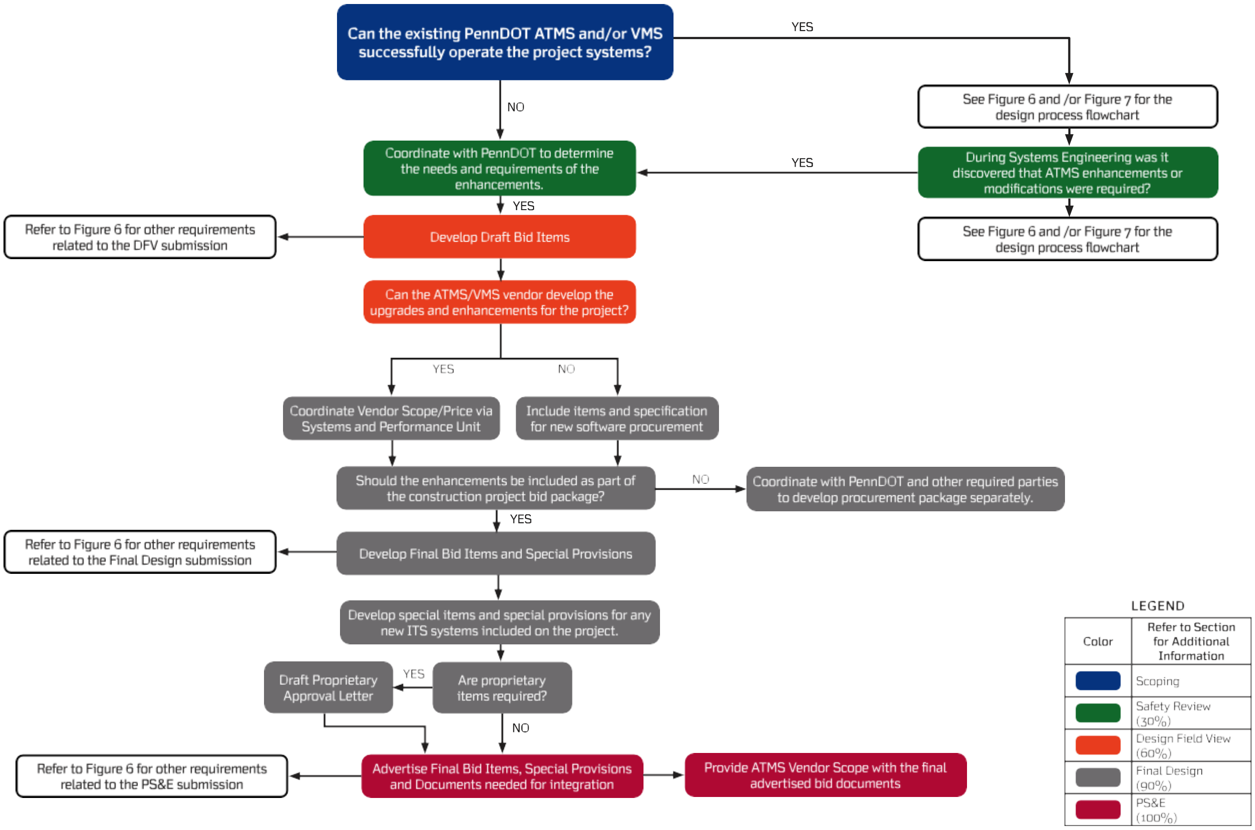


FIGURE 8: DESIGN PROCESS FOR A PROJECT WITH ATMS MODIFICATION/ENHANCEMENT



2.9 Durations

There are multiple timelines that need to be considered throughout all projects, including letting schedules, construction timeframes, and lead times for materials such as steel or fiber optic cable. When a project is initially setup in the Department's project scheduling software, there are minimum time periods inputs that are required for project letting. If the design falls behind schedule, it could have significant impacts on the project letting and award dates, procurement of materials, and when construction of the project occurs.

This section provides a typical timeline for each phase in the ITS design process and is intended to be used as a scheduling guide as all design schedules will vary based on the project. ITS design projects are often not stand-alone and are instead included as an ALSO plan set within a larger design project. Overall project schedules and deliverable dates should always be coordinated with the Department.

Design timelines for minor, moderate, and complex ITS projects are provided in Table 2. For the purposes of this guidebook, these categories are defined as follows:

- Minor Project
  - Consists of only a small number of device installations.
  - Device types have been deployed previously (e.g., CCTV, CMS, Detector, or HAR).
  - Deviations from design standards are not anticipated.
  - Requires very little coordination between design disciplines and with other projects (e.g., may be a standalone ITS project).
- Moderate Project

  - Consists of 10 or more ITS device installations.
  - May require minor deviations from design standards.
  - Requires relatively straightforward communications and integration elements to be detailed.
  - May or may not be part of a moderately complex roadway or bridge project.
- Complex Project
  - Consists of many ITS device installations.
  - Most likely includes new device types and/or systems.
  - Significant modifications to design standards are anticipated.
  - Requires communications network and TMC integration design elements.
  - Device deployments, integration, and testing may be phased and dependent on other aspects of the project.
  - May or may not be part of a large roadway or bridge project.
  - May or may not require substantial change to or creation of a new software module in ATMS.

TABLE 2: ITS DESIGN TIMELINE

Phase	Minor	Moderate	Complex
Scoping	0-1 Months	1-2 Months	2-4 Months
30% / Safety Review	1 Month	1-2 Months	3-6 Months
60% / DFV	3 Months	3-6 Months	3-12 Months
90% / FDOM (Pre-final)	2 Months	2-3 Months	3-12 Months
100% PS&E	2 Months	2-3 Months	3-6 Months
Total Design Time	**8-9 Months**	**9-16+ Months***	**14-40+Months***

*Phasing for ITS projects that are a component part of roadway and bridge projects may be subject to the submission schedule of the overall roadway/bridge design.

2.10 Deliverables

This section provides the project deliverables and stakeholder responsibilities during each stage of the ITS design process. It should be noted that some of these indicated deliverables may not be required on every ITS design project; however, this should be used as a starting point when developing the design scope and budget with PennDOT. Table 3 provides general ITS project deliverables and Table 4 provides deliverables specific to certain ITS devices.

TABLE 3: PENNDOT ITS DESIGN DELIVERABLES

Phase	Deliverables/Steps	Responsibility	Reviewer	Approval Agency
Scoping	Design Scope/Budget	Designer / PennDOT PM	District ITS staff	District ITS staff Central Office FHWA
30% /Safety Review (Systems Engineering Process)	Systems Engineering Report (SER)	Designer	District ITS staff Central Office OA/OIT	District ITS staff Central Office FHWA OA/OIT
	30% Plans	Designer	District ITS staff	District ITS staff
60%/DFV Submission	Device Locations Staked / Finalized	Designer	District ITS staff	District ITS staff OA/OIT
	Communication / Power Identified		District ITS staff	District ITS staff OA/OIT
	Utilities Identified		District ITS staff	District ITS staff

Phase	Deliverables/Steps	Responsibility	Reviewer	Approval Agency
	Draft Quantities and Bid Items Identified		District ITS staff	District ITS staff OA/OIT
	Proprietary Items Identified		District ITS staff	Central Office OA/OIT
	Safety Report Completed		District ITS staff	Central Office
	Environmental Clearance Documents Submitted	District ITS staff Designer to Support	District ITS staff	DEP
	Software Modifications or Procurements Identified	Designer	District ITS staff, Central Office	District ITS staff Central Office OA/OIT
90%/FDOM Submission	Draft Special Provisions	Designer	District ITS staff	District ITS staff Central Office OA/OIT
	Draft Proprietary Item Letter		District ITS staff Central Office	Central Office FHWA OA/OIT
	Draft Bid Tabs, Item List		District ITS staff	District ITS staff Central Office OA/OIT
	Power and Communications Details (equipment, wiring, routing, architecture, integration)		District ITS staff Central Office	District ITS staff Central Office OA/OIT
	Utility Conflicts Identified / Resolved		District ITS staff	District ITS staff Central Office
	TS&L Approved	Designer	District ITS staff	Central Office
	Draft Cost Estimate	Designer	District ITS staff	District ITS staff Central Office
	Software Modifications or Procurements Finalized with Vendor	Designer	District ITS staff Central Office	Central Office OA/OIT
100%/PS&E	All FDOM Comments Addressed and Included in Final Bid Package	Designer	District ITS staff Central Office	District ITS staff Central Office
	Software Modification Procurement Incorporated into Bid Package	Designer	Central Office	Central Office OA/OIT
	Proprietary Items Approved		Central Office	Central Office FHWA OA/OIT
	Bid Package Uploaded to ECMS	District ITS staff CM	District ITS staff	Central Office
	All Required Forms, Pre-bid Schedules, etc. are Completed and Uploaded to ECMS as Needed	Designer and District ITS staff CM	District ITS staff	Central Office

Note: ROW and Utility clearance documents should be completed prior to 90%/FDOM Submission

TABLE 4: DEVICE SPECIFIC DESIGN DELIVERABLES

Device Type	Phase	Deliverables/ Steps	Responsibility	Reviewer	Approval Agency
3rd Party Data Integration	60%/DFV Submission	Memo outlining the various inputs and outputs, including protocols.	Designer	District ITSstaff Central Office	District ITSstaff Central Office OA/OIT

Chapter 3. Device and Infrastructure Design

This chapter provides design guidance for various ITS devices and related infrastructure. This includes power distribution, communications, conduit and junction boxes, equipment enclosures, ITS devices, and supporting infrastructure.

3.1 Power Distribution

Overview

The purpose of this section is to familiarize the designer with the National Electric Code (NEC), the National Electric Safety Code (NESC), and PennDOT standards and guidelines for power distribution systems for ITS infrastructure. Electric service demarcation must be located within PennDOT right-of-way and easily accessible for servicing by both the provider and the user. All power distribution shall be coordinated with the Department. All power distribution projects shall consider:

- Power calculations
- Coordination with power companies
- Decision tree to determine best power option

The four basic physical characteristics of electricity are voltage, current, resistance, and power. Voltage is the difference in electrical potential between two points of an electrical circuit, expressed in volts. Voltage measures the potential energy of an electric field to cause an electric current in an electrical conductor. Current is the rate of flow of electricity through an electrical conductor and is measured in amperes, or amps. Resistance, measured in ohms, is the resistance of an electrical conductor to the flow of electricity. Power is the rate at which work is done or energy is transferred. Work can be measured using many different units but is most often measured in watts when used in calculations for ITS infrastructure.

Electrical current can be characterized as alternating current (AC) or direct current (DC). Power supplied by an electric company is typically AC while power provided by a battery is DC. Power can be converted from AC to DC using a rectifier and from DC to AC using an inverter. A majority of the ITS enclosures, and subsequently ITS devices, used by the Commonwealth are supplied by an AC power source. A smaller number of Commonwealth ITS enclosures and ITS devices are supplied by low voltage DC power sources that may include batteries and a solar array.

Generally, the key design steps for an ITS electrical power systems are:

- Determine the total power requirement
- Select a suitable power source based on availability
- Determine wire size, conduit size, and step-up/step-down transformer requirements, if applicable
  - The need for transformers will be based on voltage drop calculations
- Determine meter options
  - Where possible, arrange a flat rate fee with the electric utility provider

Compliance with Electric Codes and Standards

The design of all PennDOT electrical systems, including all power infrastructure for ITS elements, should adhere to the standards and requirements included in the current version of the NEC and the NESC. The NEC is typically updated every three years, and the NESC is updated every five years. Prior to beginning any PennDOT ITS design project, the designer should verify they are using the latest versions of the NEC and NESC. The designer should notify the PennDOT project manager of all variances to the NEC and NESC, which must be reviewed and approved by the Department. As a base, a maximum voltage drop of 3% is used for all ITS devices.

The NEC and NESC include standards for:

- Conductor properties
- Conductor insulation
- Maximum recommended voltage drops and current requirements
- Maximum conduit fill
- Junction box sizing

For additional information refer to the links below:

- NEC: https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70
- NESC: https://standards.ieee.org/products-programs/nesc/

Electric Service Providers

Power for ITS infrastructure within Pennsylvania is provided by many electric service providers, and the electric service provider for each ITS device will depend on the electric service provider that covers the specific area in which that device is located. The following companies provide power in the state:

https://www.puc.pa.gov/electricity/electric-companies-suppliers/

In some instances, new ITS devices may be located near or adjacent to the dividing line between two electric service provider service areas. There are several factors that may impact which of the two electric service providers is preferred, including service provider reliability, rates, policies, service levels, and existing service agreements with PennDOT. When multiple service providers are available, the designer should contact the PennDOT project manager to determine the preferred electric service provider. In addition to the service provider, the designer should consider several different factors when selecting an available power source to utilize. This should include:

- Location of the power source
- Difficulty in connecting to the power source
- Voltage available from the power source
- Difficulty and timeline for obtaining service from the electrical service provider

Distribution versus Transmission

Electric service providers deliver electricity to consumers in two separate phases: transmission and distribution. The transmission phase includes the bulk movement of electrical energy from the power generation facility to a power substation. The core difference between transmission and distribution power lines is that transmission power lines are for long-distance, high-voltage electricity transportation, whereas distribution power lines are for shorter distances and lower voltage electricity transportation. Power for all PennDOT ITS devices is obtained from electric services that are installed off an overhead or underground electric distribution line.

Power Supply

When electric power supply from a utility company is used for roadside ITS deployment, the most common power service is 240/120 Volts (V) AC (VAC), single-phase, 100A service. Higher voltage/amp service may be used at collocated device locations, where multiple CMS or other devices with high power demand draw from the same power source. A higher voltage/amp service may be required when the point of service is located a significant distance from the ITS device. Along major interstates, it is often difficult to locate a device near a power source and meet all the operational requirements. Secondary disconnects may be required based on distance from point of service to device. A voltage drop calculation must be performed by the designer to determine the appropriate means of supplying power to the site.

An electrical disconnect must be available at each site and for each ITS device. For example, in most CMS installations, the power needed to operate the CMS board (display portion of the CMS) is fed from the related CMS controller cabinet, and an electrical disconnect switch is typically installed outside the CMS controller cabinet. Designer shall always contact District and power company for power coordination and spans.

Although the electric utility company is required to provide electric power service where requested, it may do so by merely bringing the electric service to the edge of the user property, or in the case of ITS applications, the edge of related PennDOT right-of-way. The Department is then responsible for all installations required to continue the electric service from the point of service drop to the point of use. Where power metering is involved, the customer is required to provide the meter base at the point of service drop, excluding the power meter itself. It is often advantageous to include a field view with the Utility Unit as well as the Service Provider to determine upfront where power can be obtained from and where the utility company will provide a service drop. Once power supply is made available in the ITS device enclosure, the electric power must be converted to the voltage and format (AC or DC) as appropriate for the used electronic devices. The designer may consider several different options to provide power to an ITS device. Every attempt to obtain power from the electric service provider should occur during the design process. Power runs over 1,000 feet are discouraged and require prior PennDOT approval. The following power source options can be utilized:

- **Existing Electric Service:** When available and evaluated for condition (rust, enclosure's structural integrity, space for additional circuit breakers), the designer may obtain power from an existing PennDOT ITS electric service. The designer will be required to verify that the existing service has sufficient capacity to provide power to the new ITS device without negatively impacting the power being supplied to any of the existing infrastructure currently supplied by the service. The designer should consider the distance between the proposed ITS device and the existing service to determine if using the existing service will be more cost effective and maintainable than the installation of a new electric service located closer to the proposed ITS device. The designer is also required to verify there is space in the distribution enclosure and conduits, and if the power system is on a photocell. If the electric service is through a photocell, the designer will need to determine if the photocell can be bypassed.
- **New Electric Service:** If an existing ITS power service is not available, power can be obtained from a new electric service. The point of service drop should be located as close to the ITS device as possible to minimize the length and size of the electric conductors.
- **Alternative Power Source:** When power service is unavailable in the immediate vicinity of the proposed ITS infrastructure and installing a long electric cable run is not feasible, the designer may consider an alternate power source such as solar. Use of an alternate power source will require installation of batteries to store electricity when the solar equipment is unable to provide sufficient power. The use of an alternate power sources is strongly discouraged. The designer shall consider the most suitable solution and coordinate with PennDOT and power utility companies to determine the best route for power lines.

Metering

In locations that do not use automatic meter reader (AMR) systems, safe and convenient meter reader access for utility personnel is an important consideration in selecting the deployment location. Roadways with small or no shoulders should not be considered for meter location. One way to circumvent this limitation is to arrange for non-metered (flat rate) electric service through the utility company. However, this option is not necessarily available at all utility companies, and the ones that do support it often impose limitations on how the deployed systems may be designed and used. Some AMR systems use short range radio-frequency (RF) communication systems, which allow drive-by meter data collection using mobile RF units. Some AMR systems use cellular data service, which allows utility offices to poll the meters from greater distances. Considerations for meter reading access may no longer be necessary if an appropriate AMR system is available from the local utility company. Coordinate with the power utility early in the design process to determine metering options. Consider the following power metering options:

- Metered, with safe and convenient personnel access
- Non-metered, flat usage rate
- Metered with AMR, using a drive-by RF data reader
- Metered with AMR, using a cellular data service.

Obtaining Power Service

Power for ITS infrastructure is obtained by the contractor in coordination with the utility provider. However, the ITS designer shall include the location of the point of service drop on the design plans. This location should be coordinated with the Department and the utility service provider during the design process. Utility service providers coordinate with the Department at varying levels during the design process depending on the District and locality. The process noted below is recommended as a standard practice, but the designer should coordinate with the District to determine project requirements for obtaining power service.

- Electric service coordination is initiated at the DFV development milestone.
- Designer creates a Utility Coordination Spreadsheet (**Appendix B**) and inserts information as determined.
- Designer determines the electric service provider and follows the service provider's standard process for obtaining the power company's designer information and initiating the service coordination process with the service provider. Contact the power company's designer and provide a copy of the 60% plan sheet(s) and fill out any necessary load sheets or other forms that the service provider requires.
- Designer coordinates a field meeting with the power company designer and the Department to discuss the following:
    - Project milestones, let date, and construction start date. Discuss milestones for when power company designer needs to provide information to the designer (assume 1-2 months for power company designer to determine and provide costs, easements, and design information)
    - Discuss the availability of 240/120VAC electric service.
    - Determine access requirements to meter (gate may be needed for access)
    - Discuss what PennDOT will furnish and install at the point of service.
    - Discuss that stepdown transformers are not allowed unless approved by the Department.
    - Discuss power risers, as needed.
    - In situations where there is a noise wall between the transformer and the meter, the designer will need to install an access door into the noise wall so the power company can access the meter (if needed).
- Designer obtains meter address, account number, and identification number from the power company designer.

- Designer updates the Utility Coordination Spreadsheet with all information determined up to this point and provides a copy of it to the Department, power company designer, etc.
- Designer determines all equipment loads for calculating voltage drop and determines the appropriate conductor sizes.
- Designer updates the Utility Coordination Spreadsheet with costs provided by power company designer.
- Designer provides 100% plans and the Utility Coordination Spreadsheet to the power company designer for final written approval. At this point, all information in the spreadsheet should be filled out except which contractor was awarded the electrical work.
- Power company designer provides a service contract with costs and scope of work that will be signed by the contractor.
- After the project has been let and awarded, the construction contractor will need to contact the power company and provide the project start date so the power company can get their portion of the work scheduled and coordinated. The construction contractor must pay the power company to get the project onto the power company's construction schedule.
- Any electric service work performed by the power company on PennDOT right-of-way will need a permit. The power company is responsible for acquiring any required permits from PennDOT.
- The service address, account number, and identification numbers have already been determined and are included in the special provisions for the project. The construction contractor does not need to submit new applications for service.

The designer should refer to Chapter 2, Project Development Process, Durations, and develop a timeframe for coordination activities based on project complexity and durations.

Design Considerations

There are several principles that need to be applied when determining conductor size and required breakers for the circuits included in an ITS design. Below is a description of several electrical principles followed by an example problem.

Wire Gauge/Wire Size

American wire gauge (AWG) is a standardized wire gauge system used in the United States and other countries, especially for nonferrous, electrically conductive wire. Increasing gauge numbers give decreasing wire diameters, which is like many other non-metric gauging systems. This seemingly counterintuitive numbering is derived from the fact that the gauge number is related to the number of drawing operations that must be used to produce a given gauge of wire; very fine 30-gauge wire requires far more passes through the drawing dies than does a 0-gauge wire. Note that for gauges 5 through about 14, the wire gauge is effectively the number of bare solid wires that, when placed side by side, span 1 inch. That is, 8-gauge wire is about 1/8 inch in diameter. An AWG of 14 is the minimum size used by PennDOT for ITS applications. Conductor sizes should be sized by design between service disconnect and the ITS infrastructure.

Ampacity

Ampacity is defined as the maximum amount of electric current a conductor or device can carry before sustaining immediate or progressive deterioration. The circuit breaker must not be rated for a larger current than the ampacity of the conductors used in the circuit. Ampacities are listed in Table 5.

TABLE 5: ELECTRICAL WIRE CHARACTERISTICS

Wire Size (AWG) Copper	Ampacity (Amps)	Resistance of Copper Wire (Ohm/ 1000 ft)
14	15	2.57
12	20	1.62
10	30	1.02
8	45	0.64
6	65	0.41
4	85	0.26
3	100	0.21
2	115	0.16
1	130	0.13
0	150	0.10
00	175	0.08
0000	200	0.06

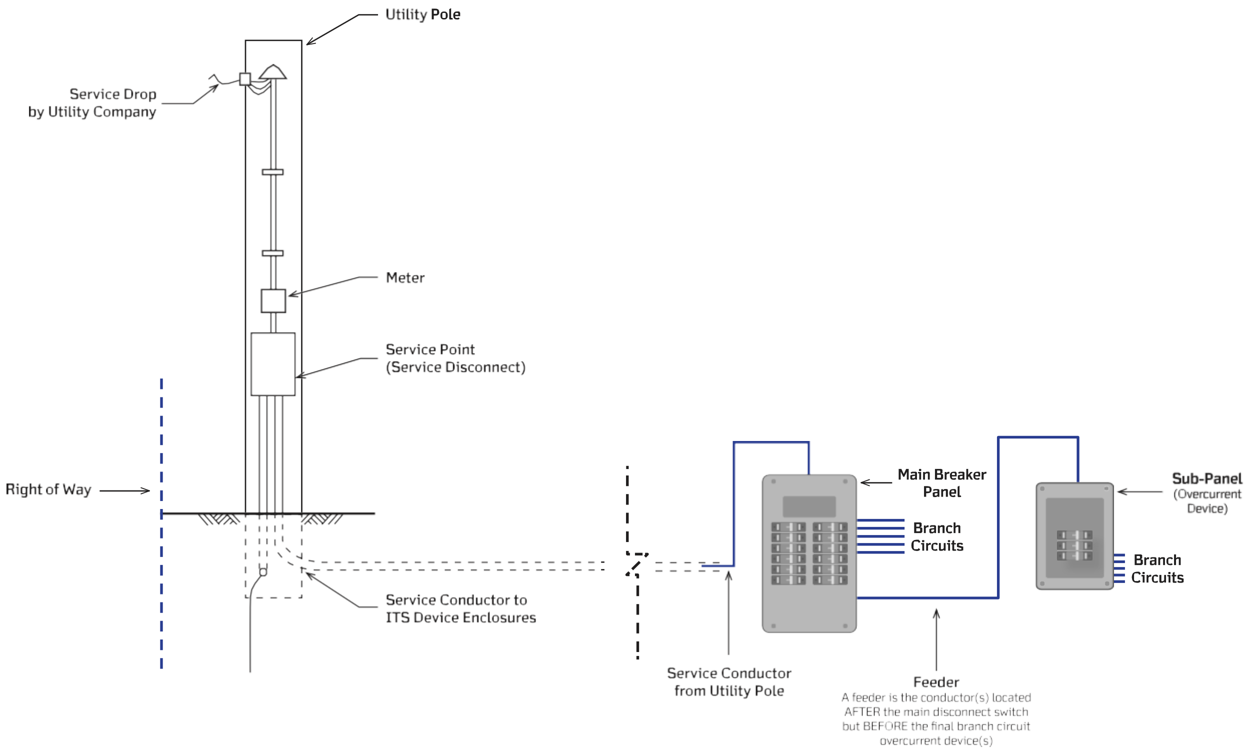
Typical Wire sizes for PennDOT installations are AWG 8, 6, 4, and 2

Circuit Types

Below are the definitions for service conductors and circuit types which are also illustrated in Figure 9:

- **Service Point –** The demarcation between the utility provider and the Department. Usually, electric company is responsible for conductors between meter and disconnect (main breaker)
- **Service Drop (overhead)/Lateral (underground) –** The electric conductor between the utility distribution lines and the service point.
- **Service Conductors –** The conductors that run from the service point with the electric utility to the service disconnect (main breaker).
- **Feeder Circuit –** The conductor(s) located after the service disconnect switch but before the final branch circuit overcurrent device(s) (e.g., Sub-panel).
- **Branch Circuit –** The circuit conductors between the final overcurrent device(s) (e.g., Main Breaker Panel or Sub-Panel).

FIGURE 9: TYPES OF CIRCUITS



The electric utility company is responsible for conductors to the service point. The Department is responsible for conductors between the service point and the ITS device. It is important that the utility coordination spreadsheet is completed because not all power companies provide power in the same fashion.

Current Requirements

The total power requirement for an ITS application is the sum of the following:

- Device(s) (e.g., CMS, CCTV camera, detectors, signals, etc.)
- Controller components (see Publication 408, Section 1201.2(b), for all devices and Publication 408, Section 1230.2(h), for additional CMS requirements)

Power cables and the circuit breakers should be sized based on the total current required for all ITS devices and enclosure components being served when operating at full capacity. When determining the total current required, do not factor both devices when those devices perform opposing functions and are not expected to operate simultaneously (e.g., heater and air-conditioner). When determining total current required, assume that the expected load drawn from the convenience outlet to be 12-amp at 120-volts. See Table 6 below for typical power requirements for each device.

TABLE 6: TYPICAL POWER REQUIREMENTS (DEVICE-ONLY, NO ENCLOSURE)

Device Type	Power Requirements
CCTV	**Typical**
Camera without heater	0.5A-2A (depending on PTZ usage)
Camera with heater	3A-5A
CMS (12” RGB LED characters) (Color)	**Typical**

Three 12-character lines	60A
CMS (18" RGB LED characters) (Color)	**Typical (see vendor's recommendation)**
Three 15-character lines	60A-75A
Three 18-character lines	60A-75A
Three 21-character lines	60A-75A
HAR	**Typical**
HAR Transmitter antenna	0.15-0.5A
HAR Beacon Signal Set (LED)	0.15-0.5A
Detector	**Typical**
Detector	0.1-5A (depends on detection system used)
Ramp Meter	**Typical**
Detector	0.1-5A (depends on detection system used)
Signal Head (LED)	5A
Wireless Radios	**Typical**
Wireless Radio	7A-15A

Power requirements are for estimating purposes. Actual power requirements should be obtained from the related manufacturer(s) including devices not identified in the table. For calculating purposes utilize the greater power requirements (manufacturer vs. typical).

Voltage Drop

To properly size the electrical conductors that will supply power to ITS infrastructure, the voltage drop across each conductor should be calculated. It is typically not necessary to calculate voltage drop across the service conductors since it is the electric utility company's responsibility to provide the voltage at the service point. The voltage drop calculation will determine the amount of voltage lost along the conductors. Calculating the voltage drop across the system is important because it ensures the voltage is sufficient to properly operate all ITS devices, components, and related enclosures.

The electrical conductors carrying current to the enclosures and devices have resistance. The resistance of the conductor depends on the length of the conductor, size (gauge) of the conductor, and material. When current flows through a conductor, the voltage drops along the length of the conductor, which results in a lower voltage at the end of the circuit. A similar voltage drop occurs in the return current of the neutral wire which is additive to the total voltage drop for a 2-wire circuit or unbalanced 3-wire circuit. If the resistance of the conductor is too high for the current flowing through it, the voltage lost will impact the performance of the ITS device. General steps for designing power supply arrangements:

1. Determine the total power requirement (Watt or VA) for the whole cabinet, including devices which are powered from the cabinet.
2. Determine the current load and voltage capacity for the circuit and any devices to be designed. Select a wire size from the applicable table in the NEC that has a higher ampacity rating than the current calculated above.
3. Determine the required current (amperes) that will flow through the power conductors when all devices are operating at full capacity. In the case of 120V single-phase electric system, the current (I) is calculated as Total Power requirement (in VA) divided by the product of applicable power voltage and the power factor. Power factor is the ratio of active power and the total power. Generally, a power factor of 0.8 is assumed, so the equation would be Power (VA) = Voltage (V) * Current (A) * Power Factor (0.8)
4. Voltage drop is calculated by using the following formula: The equation for calculating VD is:

- VD=2*K*I*(D/CM) where:
  - K = 12.9 for copper wire and 21.2 for aluminum
  - I = Current (amperes)
  - D = Distance (feet)
  - CM = Circular Mils of the wire (see NEC Chapter 9, Table 8)

5. Some of the utility power voltage is lost (voltage drop) through the power conductor. The longer the conductor, the higher the voltage drop. When providing power to an ITS device, the NEC recommends that the maximum voltage drop across the combined feeder and branch circuits not exceed 5% and the maximum individual voltage drop across the feeder circuit, or the branch circuit not exceed 3%.
6. Make sure that the conduit is large enough for the power conductors. Per NEC, with three or more conductors, the total cross section of all enclosed wires must be less than 40% of the actual cross section area of the conduit. Average cross section of conduit and wire of different sizes are listed in NEC.

When the voltage drop across an electrical circuit exceeds the maximum recommended value, the designer may increase the size of the electrical conductors or increase the voltage of the circuit. When the size of electrical conductors is increased, the overall electrical resistance of the circuit will decrease, which results in a corresponding drop in the voltage lost across the circuit. Increasing the voltage at which electrical current is transmitted through the electric conductors will require use of a step-up transformer placed near the service drop and a step-down transformer placed near the ITS device location. Use of step-up and step-down transformers requires PennDOT approval.

Breaker Sizing

Per the NEC, all electrical circuits require overcurrent protection (breakers). Circuit breakers help protect against excess current as the result of an overload or short-circuit. When the power reaches a certain level, the circuit breaker is designed to automatically interrupt the flow of power to prevent fires, damage to wiring or electronics, and personal electrocution. To function properly, the circuit breaker must be sized appropriately. To be sized appropriately, the circuit breaker should be designed to handle a minimum of 125% of the maximum continuous load and 100% of the non-continuous load. Continuous loads are loads that are expected to last three or more hours while non-continuous loads are those lasting less than three hours. Refer to Publication 408, Section 1201.2(b), for all devices and Publication 408, Section 1230.2(h), for additional CMS requirements for circuit breaker requirements.

Surge Suppression

Lightning strikes are the most common cause of power surges to the ITS field system. The resulting voltage surges can propagate long distances along the cable to the connected devices. To protect the related ITS deployment, appropriate surge protection measures must be provided for ITS devices. These measures can be broken down into four components:

- Lightning rods at the top of or near the support structure
- Grounding system, usually consisting of one or more grounding rods
- Surge suppression hardware in the control cabinet
- Grounding conductor bonding the three above components

The provision of lightning rods is preferred for deployments involving great heights, such as CCTV cameras and radio antenna at the top of tall poles, or CMS boards on structures that “stand out” among the surrounding landscape and vegetation. The use of lightning rod is usually omitted for deployments involving relatively low heights and where taller structures are present nearby.

In general, surge suppressors provide protection from energy (electric) surges by diverting and draining the excess (surge) energy to surrounding soil. It is therefore pertinent to combine the use of surge suppressors with a properly designed grounding conductor and a grounding system.

The provision of one or more lightning rods over the ITS device, in conjunction with one or more grounding conductors, can often help to divert the lightning discharges away from the field device assembly. Lightning abatement measures such as this are only effective if the lightning rod, related terminations, and the grounding conductors are sufficiently robust to conduct and to survive lightning discharges.

Telecommunications cables and sensor cables from nearby locations, just like the utility power cable, are subject to the same possibility of lightning strikes. The requirement for appropriate surge protection measures must therefore be extended to all cables brought into the enclosure of all ITS deployments.

A proper grounding arrangement must be provided at the support structure, and at the controller cabinet for the system. Where the controller cabinet is installed at or close to the base of the support structure, both the support structure and the cabinet may be bonded to the same grounding system.

It is important that the related grounding system can disperse the electric charge from the lightning strike quickly to the surrounding soil. This requirement is translated in the performance requirement on the grounding system to have grounding resistance of 25 Ohms or less.

The industry standard is to use ¾-inch 10-foot solid copper (or copper-clad steel) ground rod for grounding. When multiple rods are needed to achieve the required maximum ground resistance (25 Ohms), space the ground rods at least as far apart from each other as the length of the rods.

Grounding rods, systems, and testing procedures for each device and/or component are specified in Publication 408, Section 1200. The designer should assess the site environmental conditions to determine if the grounding system identified in Publication 408 is sufficient for the device location. Some devices require more robust grounding requirements, such as highly exposed HAR transmitters or CCTV cameras located at the tops of hills and mounted to high structures.

Power Over Ethernet

Power over Ethernet (PoE) is an alternate method used to power a device or infrastructure using direct current over twisted-pair copper Ethernet cabling. PoE allows a single cable to transmit both data and power, eliminating the need for two separate cables. This allows for powered devices in locations that lack electrical circuits. The Institute of Electrical and Electronics Engineers (IEEE) has developed a series of standards that define different types of PoE technology. Publication 408, Section 1200 provides PoE specifications for ITS applications.

Cat 5E twisted-pair copper cable used by PennDOT supports PoE. To utilize PoE, the switch port that the twisted-pair copper cable is connected to must also be capable of supporting PoE. Many wireless radios utilize PoE, as do a few different ITS devices including video cameras and vehicle detectors. Pan-tilt-zoom (PTZ) cameras need PoE++ (upgrade of PoE+ technology) while static cameras use PoE+ (upgrade of PoE technology).

Sample Calculation

Several factors need to be considered when locating an ITS device including the power source location and resulting conductor and conduit sizes required to serve the ITS devices at their locations. If the cables become too large, it is often desirable to obtain a source of power located closer to the site. Design of the power system required for an individual ITS location will generally follow the design steps and calculations outlined below.

1. Identify an available power source and determine its suitability to provide power to the proposed ITS site. Factors that impact suitability of the power source include whether it is located on PennDOT right-of-way and if the required voltage can be provided. The power source may be an existing electric service or require the installation of a new electric service.
2. The following needs to be determined for the feeder and branch circuits:
   - Current load required for each device
   - Combined current load of each circuit
   - Minimum conductor and circuit breaker size for the current load
   - Any increase in conductor size required to address excessive voltage drop

Example: If there is an electric service enclosure (metered) located just on PennDOT property that provides power to a hub enclosure located 400 feet away where branch circuits serve a device enclosure (located 250' from hub enclosure) and CMS (located 200' from hub enclosure), the following circuits need to be considered as a part of the design:

- Feeder circuit #1 is a 120/240 VAC circuit that serves a main 2-pole circuit breaker in the electric service enclosure.
- Branch circuits from hub enclosure are as follows:
  - Branch circuit #2 (CMS) is a 120/240VAC branch circuit that serves the CMS with a 2-pole circuit breaker located in the hub enclosure.
  - Branch circuit #3 (device enclosure) is a 120VAC branch circuit that serves the device enclosure with a 1-pole circuit breaker located in the hub enclosure.

3. Determine the total current load required for the feeder circuit and each branch circuit including the cabinet, all internal equipment, and all ITS devices connected to the cabinet.

   Determine the current load required for the branch circuits:

   - Branch circuit #2 (CMS): 35 amps on each leg
   - Branch circuit #3 (device enclosure): 2 amps (including all internal components)
   - Calculate the current required for an unbalanced 3-wire circuit (based on this example):
   - Feeder circuit #1 current load on highest current leg = current on branch circuit #2 + current on branch circuit #3
   - Feeder circuit #1 current load on highest current leg = 35 amps + 2 amps = 37 amps
   - Feeder circuit #1 current load on other leg = current on branch circuit #2
   - Feeder circuit #1 current load on other leg = 35 amps (the 2 amps from branch circuit #3 only is applied to 1 leg since branch circuit #3 is a 120 VAC 2-wire circuit
   - Feeder circuit #1 current load on the neutral = current load on highest current leg – current load on other leg
   - Feeder circuit #1 current load on neutral = 37 amps - 35 amps = 2 amps

   For items with unknown current, load needs to be determined by contacting the manufacturer, reviewing product cut sheets, or taking actual measurements.

4. Calculate the voltage drop across the electrical conductors. If the voltage drop exceeds recommended values, the size of the electrical conductors should be increased.

5. Calculate the voltage drop and size the conductors to not exceed the maximum preferred voltage drop for the feeder and branch circuits as follows:

   Branch circuit #2 (CMS):

   - Assume a #6 AWG wire initially (see Wire Gauge for minimum conductor size).
   - Voltage drop on highest current leg = 35 * [(210)/1000] * 0.41
   - Current load = 35 amps from step 3
   - Distance factor = Distance/1000
   - Distance = 200 feet so use 210 feet to account for slack
   - Resistance of wire = 0.41 using value for #6 AWG

   Voltage drop on highest current leg = 3.01 VAC

   - Voltage drop on neutral = 0 VAC
   - Total voltage drop = 3.01 VAC + 0 VAC

   Total Voltage drop = 3.01 VAC

   Does the voltage drop exceed the preferred maximum voltage drop?

   - Preferred maximum voltage drop = .03 * 120
   - Preferred % drop = 3% since this circuit is a branch circuit
   - Voltage of circuit = 120/240 volts for this DMS

   Maximum preferred voltage drop = 3.60 VAC

   Since 3.01 is less than the maximum preferred voltage drop of 3.60, the #6 AWG wire size is adequate.

Alternative Energy Options

Solar

In remote rural areas, obtaining a service drop can be very expensive if there are no electrical utilities in the area. For some low power ITS applications, solar power is an option. Factors include:

- Amount of power the system needs
- Percent of time the system is operating
- The amount of time the system must operate in the absence of any sunlight
- The geographic location, which affects the amount of sunlight received

A solar power system is typically comprised of solar panels, a battery bank, cabling, and a power convertor/charging system that converts power generated from the solar panel to storage, and then converts this battery power to the connected operating loads. A solar power system such as this may be used as a stand-alone power source, or as a supplement to installations where the electric power, from the utility company, is only available during part of the day (such as the case with a highway lighting circuit which is collectively controlled based on a day-light sensor or timer).

A solar power system may only be used in areas where sufficient sun light is generally available. Solar power systems must therefore not be used for areas with less than three 8-hour sun lit periods per week. If the longitude and latitude coordinates of the deployment site are known, related average insulation data can be acquired from the NASA Surface Meteorology and Solar Energy (SSE) division (https://power.larc.nasa.gov/data-access-viewer/).

To receive the maximum amount of sunlight each day and throughout the year, deployment sites in the Northern Hemisphere must include solar panels oriented to face south. The inclination of the solar panel(s) should roughly correspond to the latitude of related deployment site. As an example, the solar panels used near Philadelphia (approximate latitude 39.9N) should be mounted at approximately 39.9 degrees from the azimuth, facing south.

The battery bank and the solar-panel assembly of a solar powered system must be of sufficient sizes to support full operation of the connected loads for the time periods listed in Publication 408, Section 1200. If operating requirements are not provided in Publication 408, Section 1200, the battery bank and solar panel assembly should be sized to support full operations for a minimum of 24 hours for applications where daily maintenance service is performed, and for a minimum of seven days for other conditions.

Due to the above sizing requirements, the use of a solar power system is generally limited to devices requiring 100 Watts or less to operate. Devices requiring higher wattage for brief periods may also be considered. In all cases, credible solar panel and battery sizing calculations for power requirements, at all expected usage patterns, must be provided by the system provider prior to acceptance of the design.

Devices which are potential/feasible candidates for solar power are:

- HAR beacons
- HAR Transmitters
- Detectors
- Portable devices (HAR, Detectors, CMS)
- CCTV cameras (typically portable) that do not include a heater

Typical battery voltage used in ITS deployments is 12 Volts per unit; if higher voltages are needed, the simplest way to achieve it is by connecting batteries in series. Where feasible, choose a voltage equal to a whole number multiplied by 12 Volts (e.g., 12V, 24V, 36V, 48V, etc.) as the main operating voltage of the device enclosure.

Foliage grown over the solar panel reduces the amount of solar energy received by the solar panels. Foliage that obstructs solar panels must be trimmed. Such trimming must be repeated at least once a year, especially in the summer.

Energy-delivery performance of the batteries diminishes at extreme high and low temperatures and rapid temperature swings. Ensure that explicit mechanical measures are provided to isolate the batteries from extreme ambient temperatures.

Note that solar power should ONLY be used as a last resort; use it where points of service are extremely expensive, or where there is no power available. Perform detailed calculations to determine the required load of the device and the appropriate number of batteries. Obtain explicit approval from the Department prior to proceeding with a solar installation. Solar installations shall also consider snow accumulations and will require a design that limits the amount of snow in the panels and will require additional maintenance.

Batteries

ITS applications that utilize solar to generate power will require an array of batteries connected to the power generation system to capture and store power for future use. The total number of batteries required for an individual ITS application will vary depending on the power required to operate the ITS application, the number and type of batteries utilized, the duration of time the ITS application will need to remain fully functional under 100% battery power, the ambient temperature and battery correction factor, the age of the battery, and the depth and duration of battery discharge cycles. When selecting and designing an ITS application that will require battery power storage, the designer should consider long term battery maintenance costs and life cycle replacement. The estimated life of a typical 100A-hour battery will vary but, on average, it has been observed an average lifespan of three years. Trailers use 6V batteries in a 12V array and static equipment uses 12V batteries in a 24V array.

Back-up Power

Frequent shutdowns and restarts of the electronic devices generally cause the electronic device to fail prematurely. Intermittent device shutdowns are generally triggered by low power-supply voltage, which are often the result of brief drops in supply voltage (brownouts) lasting seconds, and to lesser degrees complete power outage (blackouts) lasting more than a few minutes.

An Uninterruptible Power Supply (UPS) is required as part of the ITS Enclosure specification in Publication 408, Section 1201. The provision of a UPS is part of the power-supply arrangement to help bridge periods of short and intermittent drops in power voltages. Most commercial UPS products also include other desired features such as power conditioning. Power conditioning helps to filter out unwanted fluctuations in power quality and delivers "clean" power to the connected loads.

The Publication 408 specification for UPS requires that the UPS be capable of powering all critical enclosure equipment at 100% for a period of 30 minutes. UPS can also be used to bridge power outages at the site until maintenance can be notified. To provide the appropriate UPS, coordinate with the District to determine the length of time necessary for a UPS to power the device location. Consideration should be given to any ITS maintenance contract response timeframes for system outages.

The following guidance must be followed when designing the UPS component of the power conditioning system:

- Is the UPS only required for the purposes of "power conditioning", keeping the controller and communication interface in operation? If so, the Publication 408 UPS specification is adequate.
- The Department may consider additional back-up power requirements for critical devices (e.g., along key detour routes or tolling equipment).

Back-up Power Generators

Consider adding a provision for an ITS deployment to include the means of accepting power from a mobile generator as an alternate, temporary power source. This provision usually involves the following:

- A twist-lock power receptacle behind a lockable window to accept the power cord from this alternate power source
- A selector switch behind the lockable window that allows the choice between regular and alternate power sources
- A notch at the lower edge of the lockable window to allow passage of the extension cord with the window closed and locked

Utility Billing

In most ITS construction projects, the utilities are set-up in the contractor's name since the ownership of the device/system resides with the contractor until the project is complete. Once the 60-day Operational Test has been conducted and accepted, ownership and billing will be transferred from the Contractor to the Department.

These utility subscription accounts must be transferred officially and properly to PennDOT when the period for which the contractor is responsible expires. Such transfers may require official endorsement by the existing account holder, and therefore cannot be arranged by PennDOT, even though the latter may be more expedient. At this stage, the contractor is usually most interested in receiving the related payment, so small outstanding contract scopes such as transferring the account may be forgotten. Include submission of documented proof of official transfers (to PennDOT) of subscription to power, communication, and other utility services as a payment condition for the related contract phase. To ensure that the transfer of the utility subscription account is completed in an expedient manner, documented proof of such transfers could be included as a payment condition for the related contract phase.

3.2 Communications

Design Considerations

Generally, the key design considerations for Center-to-Field (C2F) or Center-to-Center (C2C) communications system for an ITS deployment are:

- Determine the required bandwidth (in Kbps or Mbps)
- Determine the communication interval (real time vs. non-real time)
- Investigate what telecommunication options are available at/near the planned deployment site(s)
- Coordinate with the District to ensure that their requirements are being met
- When using 3rd party telecommunications options, the Department must perform all coordination to establish the connection through the statewide contract. The District must coordinate with OA/OIT to establish these connections
- Compare the related costs, benefits, redundancy, reliability, and security aspects of different communications options. Select a suitable communication means based on the options available at the deployment site.
- Incorporate the chosen communication means into the overall design.
- Communications routed through the public networks are acceptable only on a case-by-case basis. Any connection using public networks must be coordinated through OA/OIT.
- Any new communication systems for ITS project requires a review to determine the communication type preferred by PennDOT.
- To avoid technology obsolescence, routers for communication shall be procured through OA/OIT rather than being bid as part of the construction contract. The construction contract will only include the installation of these devices.

Traffic Signal Communications

Remote communication connection between traffic signal system(s) and any central location established with State or Federal funds must use the Commonwealth communications network. Any traffic signal owner in Pennsylvania can leverage the Commonwealth’s communications network for remote communication.

For projects funded with State or Federal Funds, PennDOT is responsible for assessing the needs for remote traffic signal system communication with input from the signal owner. For other projects, signal owners are responsible for assessing the needs for remote signal system communication with input from the PennDOT District during the scoping meeting. Factors including traffic volume and congestion at the intersection/corridor and the importance of the corridor to the region should be considered during the needs assessment. Once it is determined that a particular traffic signal system requires remote access, the PennDOT District will inform the Arterial Operations Unit (BOO, HSTOD) of the need for remote communication, which in turn will communicate the need to OA/OIT.

The field network for traffic signal systems is typically maintained by the signal owner, and the remote communication system (backhaul) will be operated and maintained by OA/OIT.

Types

Serial

Many older ITS devices utilize serial communications. Serial communications can be either uni- or bi-directional and transmit one communication bit at a time. Some ITS devices utilize serial communications but can be connected via an Ethernet cable when a serial to Ethernet converter is used. Detector cards in some traffic signal and ITS enclosures utilize serial communications. ITS devices that utilize serial communications typically use communication cables that include several different types of connectors including RS-232, RS-422, and RS-485. The Department no longer utilizes this communication type.

Transmission Control Protocol (TCP)/Internet Protocol (IP)/User Datagram Protocol (UDP)

All new ITS devices installed by PennDOT are connected to the statewide communications network using TCP/IP communications. TCP/IP or Transmission Control Protocol/Internet Protocol is a series of communications protocols used to connect devices on a network. TCP/IP governs how the data is exchanged. It also includes information on how that data is to be broken up into smaller packets and how that data should be addressed, transmitted, and routed through the network to its destination. Each ITS device on the network is then assigned a specific IP address. A UDP device on the other hand is a communications protocol that is primarily used to establish low-latency and loss-tolerating connections between applications on the internet. UDP speeds up transmissions by enabling the transfer of data before an agreement is provided by the receiving party. TCP is a connection-oriented protocol, whereas UDP is a connectionless protocol. A key difference between TCP and UDP is speed, as TCP is comparatively slower than UDP.

Network Topology

Physical

The physical network layer, often referred to as Layer 1, includes physical network hardware (repeater, media converter, etc.) and communications cables that have no knowledge of the data bytes or frames being transmitted. Data in a Layer 1 network is transmitted to all hardware ports and across all communications cables.

Logistical

The Layer 2 and Layer 3 differences are mainly in the routing function. A Layer 2 switch works with Media Access Control (MAC) addresses only and does not care about IP address or higher layers. A Layer 3 switch, or multilayer switch, can do all the jobs of a Layer 2 switch and additional static routing and dynamic routing as well. Beyond the physical network layer, more advanced networks utilize Layer 2 and Layer 3 technology. Layer 2, often referred to as the data link layer, provides direct data transfer between two devices within a network. Layer 3, often referred to as the network layer, includes the addition of network routing. The following sections are isolated instances of common topologies; however, topologies are typically combined to develop the actual network. The designer shall also consider potential leased communication services from internet providers and coordinate with PennDOT on preferred alternatives.

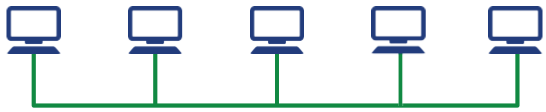
POINT TO POINT

Point to point is the simplest topology and is simply two points connected with a direct connection. Point to point is of limited use in larger installations as it is non-redundant and only connects two points.

DAISY CHAIN

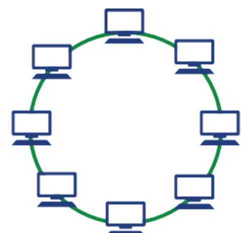
Daisy chain is a type of topology that involves chaining of point-to-point networks to connect additional devices. In a daisy chained network, all devices except the end devices pass communications along to the next device until the information gets to the intended recipient. Daisy chains are non-redundant and simple. It can also form as a ring by connecting the first and the last devices.

MULTI-DROP



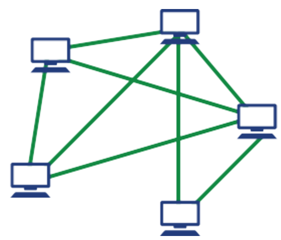
Multi-drop is like a daisy chain, except that all devices communicate on a common line. Multi-drop systems require a method to address collisions as multiple devices are attempting to “talk” at the same time. Multi-drop has been used to connect devices but is not being used moving forward in favor of topologies that support Ethernet – TCP/IP communications.

RING



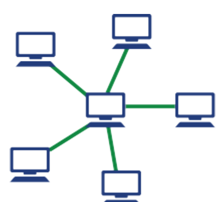
Ring topology is like a daisy chain except the ends are connected back either through a loop back or both ends being connected to a router. Rings are redundant; when a device or link is disabled working devices are kept online. When a ring is “broken,” it becomes two daisy chains. A ring is only redundant for a single failure. A second failure isolates devices between the breaks.

MULTI-POINT/MESH



A multi-point topology consists of devices that have multiple connections to many other devices. Multi-point topology is common in newer wireless devices to allow redundancy if a device becomes unavailable. Multi-point is the most redundant topology as each connection has multiple redundant paths; however, it requires multiple connections to each device and is impractical for field devices on fiber optic communications in an ITS system.

STAR



A star topology consists of one central device being connected to multiple other devices by a direct connection. A star is non-redundant; however, when an outage occurs, only devices on that leg of a star are affected. For systems, only one or two devices are placed on a leg of the star so that the impact is limited if an outage occurs. A star requires less cable as only one line is required for outlying devices.

CLOUD

Using the “cloud” is not a topology in the same sense as the others discussed, but for the ITS designer, it can be thought of in a similar manner. Using the cloud through either a wired or wireless internet service provider allows communication back to the ATMS or another device through the internet with a leased service for F2C Connections. Cloud based connections allow for a connection where there is no existing owned infrastructure; however, it does place reliance on a third party to maintain the connection. In addition, there are recurring costs for the connection in the form of a monthly service fee. Many connections are also limited in available bandwidth. It works well for small clusters of isolated devices, or as a temporary connection.

The pros, cons, and typical applications by PennDOT of each topology reviewed is provided in Table 7.

TABLE 7: COMPARISON OF COMMON COMMUNICATION TOPOLOGIES

Topology	Pros	Cons	PennDOT Example Uses
Point to Point	Simple	No redundancy, only 2 devices connected	Single isolated camera using MPLS
Daisy Chain	Simple	No redundancy can have bandwidth issues	Traffic signals/ITS field device networks
Multi-Drop	Allows for devices to be offline without disabling the network	Lower bandwidth, not compatible with Ethernet	Traffic signals/ITS field device networks
Ring	Redundant as one device going offline allows communication in the other direction	Rings are limited in size due to spanning tree issues in the deployment	ITS field device network or an ITS backbone network
Multi-Point	Highly redundant	Requires lots of ports and independent connections	Wireless Network
Star	Fairly simple	No redundancy, but impacts of an outage are limited	Field Hub to devices
Cloud	Accommodates lack of owned communications infrastructure	Lower bandwidth than typical fiber connection, monthly fee, reliant on ISP	Cloud based systems/Future

Technologies

Copper

Although PennDOT does not typically install new copper communications for long range, twisted pair copper is still used by PennDOT to communicate with some legacy devices in the field.

Fiber Optic Cable

All new trunk fiber optic communications installed by PennDOT are single-mode fiber optic cables. Single mode fiber has a smaller core than multimode and is suitable for long haul installations. Single mode systems are generally more expensive. Multimode fiber has a larger core and is recommended for fiber runs less than 1,300 feet. It is typically used for traffic signals and found in older ITS systems. The designer shall always coordinate with PennDOT to note requirements for fiber assignments. There are several locations in the field where PennDOT is still using legacy multi-mode fiber optic communications. All PennDOT fiber optic cable assemblies for fiber optic cable shall comply with USDA RUS CFR 1755.900 (Specification for Filled Fiber Optic Cables) (https://www.govinfo.gov/content/pkg/CFR-2009-title7-vol11/pdf/CFR-2009-title7-vol11-sec1755-900.pdf). The designer should refer to Publication 408, Section 1204 (ITS Communications) for PennDOT fiber optic cable specifications.

Designer shall also consider the type of connector (LC, SC, or ST) to be used. LC was designed as a push-pull connector that locks in place with a latch. While being faster and easier to operate is an advantage, the main draw of LC is its small size. Being about half the size of other fiber optic connectors, LC can be used on devices that would otherwise have too little room to support a fiber optic connection. SC is arguably the most common type of fiber optic connector used today. Designed to be simple to use and inexpensive to produce, SC uses a push-pull design like LC, but utilizes a locking tab instead of a latch to secure the unit. The cost-effective design of SC makes it a popular choice with industries that frequently use fiber cables, such as telecom and datacom. ST uses a locking mechanism like coax connectors but is starting to see less and less use in favor of LC and SC. LC is the current standard on all new field equipment for the Commonwealth.

For all fiber optic cable installations, refer to statewide PennDOT Fiber Details (**Appendix C**).

Ethernet

IEEE 802 Ethernet is a standard communications protocol, or set of rules, used for connecting devices in a Local Area Network (LAN). Many ITS devices and infrastructure used in traffic signal and highway management systems utilize Ethernet communications. These devices and equipment often include Ethernet ports and are connected using Ethernet cables. Ethernet ports allows a direct connection to a device or piece of equipment without the need for a protocol converter (e.g., serial to Ethernet). The maximum allowable transmission distance for Ethernet cables is 300 feet. A field hardened ethernet extender can be used to lengthen the maximum allowable transmission distance. The designer should ensure all network equipment used is field-hardened when not installed in a climate-controlled environment. Some devices might also be powered over ethernet (PoE) and shall be considered during the design.

Wireless

There are three main types of wireless radio systems: 900 MHz, 2.4 GHz, and 5 GHz. The 900 MHz radio system works at a lower frequency and has a larger range and travels through surfaces more easily. In comparison, 2.4 GHz systems are more reflective and tend to be affected more by bodies, foliage, or moisture that can attenuate the signal. 5 GHz systems provide less coverage than a 2.4 GHz system but transmits data at faster speeds.

UNLICENSED SPREAD-SPECTRUM RADIO

Spread-spectrum radio wireless communications are commonly used for ITS applications because they are often cost effective when compared with wired communications. Radios using spread-spectrum wireless communications do not require Federal Communications Commission (FCC) paperwork or licensing to deploy, which allows them to be easily and quickly installed.

With spread-spectrum wireless communications, the designer must perform a site survey to examine the line of sight between each radio pair. If the site survey is done in the winter, conditions are liable to change in the spring when foliage returns to trees. The designer should be careful to consider things that are likely to change in the future, like annual growth of trees and/or places where new buildings or infrastructure could be built in the line of site between radios. One additional consideration for spread spectrum wireless communications is Radio Frequency Interference (RFI). As the number of wireless devices exponentially increases over time, the area in which the wireless devices are installed may be competing with various other sources of ”noise” that will diminish the communication capabilities.

LICENSED WIRELESS RADIO

In some scenarios, the RFI in an area may be so severe that licensed wireless radio communications are required in lieu of standard spread-spectrum radios. Licensed wireless communications are generally reserved for use on backhaul links, over long-distance, or on communications links that require a large amount of bandwidth. The advantage of a licensed wireless radio is that for the frequency (or frequencies) used, the spectrum must be licensed for a limited use in the area in which the device will be operating. This prevents other wireless radios from operating on the same frequency and limits the amount of RFI. Licensed wireless communications are part of an evolving field with multiple competing technologies. ITS devices currently used by PennDOT that qualify as licensed wireless radios include Dedicated Short-Range Communications (DSRC) and tolling antennas. If either of these devices are proposed on a project, the designer will need to follow the FCC Part 90 filing process (47 CFR Part 90 – Land Mobile Radio Service (https://www.ecfr.gov/current/title-47/chapter-I/subchapter-D/part-90)).

24 GHZ WIRELESS RADIO

In areas that do not require long distances but require higher bandwidths and constant latency, a 24 GHz radio can be considered. These devices are capable at longer distances and allow for multiple radios to reach field devices due to higher bandwidths. The 24 GHz band is much less prone to interference compared to 2.4 GHz or 5.8 GHz bands

Cellular

In many places, especially in rural areas, point-to-point wireless communications infrastructure may not be feasible. In these situations, cellular communications may be utilized to provide connectivity to ITS devices without having to deploy an extensive communications network. Current cellular technology relies mostly on Evolution-Data Optimized (EVDO), High Speed Packet Access (HSPA), Evolved High Speed Packet Access (HSPA+), and Long-Term Evolution (LTE) technologies to deliver download speeds of up to 50 Megabits per second (Mbps) and upload speeds up to 20 Mbps. Cellular coverage may not be available in some areas and will vary by cellular carrier. Another possible limitation to cellular communications is data usage caps set in place by carriers, which can limit applications that can use cellular communications technology (e.g., video streaming, large data drops, etc.). Cellular devices are approved for traffic signal, HAR, and CMS applications. All exceptions should be discussed with OA/OIT.

3.3 Conduit and Junction Boxes

Conduit

Types

PennDOT utilizes several different conduit types and sizes for ITS related applications. The type and size of conduit is dependent on the specific location and case for which the conduit will be installed. The following list includes different types of conduits used by PennDOT:

- Rigid Steel Conduit
- Fiberglass Reinforced Epoxy (FRE) Conduit
- Polyvinyl Chloride (PVC) Conduit
- High-Density Polyethylene (HDPE) Conduit
- Multi-Duct Conduit
- UV Rated Fiberglass Conduit

For underground applications, Schedule 40 PVC satisfies the specifications. For above ground (i.e., exposed) or concrete encased, PennDOT utilizes a rigid steel conduit as the standard. PennDOT utilizes conduit sleeves (rigid steel) for application that are jacked, augured, or bored beneath a roadway. The designer must coordinate with the District Bridge Unit when conduit will be attached to an existing or proposed bridge structure.

The designer should review the individual specifications and dimensions for each conduit type to make sure it meets the requirements of the application and the cables that will be installed inside it. For conduit under railroad, the designer should use conduit as specified by the railroad authority. Power and communication cables should be installed in separate conduits except in extreme or unique circumstances. In these circumstances and with PennDOT approval, power and communication cables may be combined. No conductors besides power company conductors are allowed on the power company side of the service equipment. Any conduit crossing a railroad will also require coordination with the District and the railroad company. Designer must follow procedures outlined in the Underground Utility Line Protection Law (PA One Call Law).

Fill Ratio

Per the NEC, for conduits with three or more conductors, the total cross-sectional area of all enclosed wires must be less than 40% of the actual cross-sectional area of the conduit. Therefore, the maximum conduit fill ratio for all PennDOT power and communications conduit should not exceed 40% of the cross-sectional area of the conduit. A sample conduit fill calculation is provided in Table 8 for determining the conduit diameter by type (rigid steel conduit or PVC) based on the total number of wires of each type to be included in a conduit. The maximum fill requirements are primarily driven by NEC standards and the need to provide a means of dissipating the heat produced by power cables inside a conduit.

TABLE 8: EXAMPLE CONDUIT FILL CALCULATIONS

Total # of Wires/Cables	Type of Wire/Cable	Wire/Cable Diameter (inches)	Wire/Cable Cross-Sectional Area (sq. in)	Total Cross-Sectional Area (sq. in)
16	2/C No. 14	0.36	0.10174	1.6278
	3/C No. 8	0.67	0.35239	
	3/C No. 20	0.30	0.07065	
	3/C No. 12	0.46	0.16611	
1	3/C No. 14	0.40	0.12560	0.1256
	4/C No. 14	0.45	0.15896	
	4/C No. 18	0.33	0.08549	
	5/C No. 12	0.59	0.27339	
	5/C No. 14	0.48	0.18095	
2	6/C No. 14	0.53	0.22051	0.4410
	12/C No. 12	0.79	0.48992	
	12/C No. 14	0.71	0.39572	
	6PR No. 19	0.55	0.23746	
	FO cable	0.91	0.65037	
	Microfiber	0.26	0.05309	
	Cat 6	0.27	0.05725	
	No. 3/0	0.67	0.35239	
	No. 2/0	0.59	0.27326	
	No. 1/0	0.55	0.23746	
	No. 1	0.51	0.20418	

Total # of Wires/Cables	Type of Wire/Cable	Wire/Cable Diameter (inches)	Wire/Cable Cross-Sectional Area (sq. in)	Total Cross-Sectional Area (sq. in)
	No. 2	0.43	0.14515	
	No. 4	0.35	0.09616	
	No. 6	0.30	0.07065	
	No. 6 Bare	0.16	0.02010	
	No. 8	0.28	0.06154	
	No. 10	0.20	0.03140	
			Total	**2.1944**

Minimum rigid steel conduit size = 3.0" diameter / Minimum PVC conduit size = 3.0" diameter

Dimensions

For new underground construction, Schedule 40 PVC should be used. Although 4-inch conduit can be used, PennDOT typically uses a maximum conduit size of 3 inches. If 3-inch conduit is not large enough for the power or communications cables, additional conduits may be utilized. The standard conduit size used for power cables is 2-inch PVC. For aboveground conduit connecting underground conduit to a pole cabinet, schedule 40 PVC should be transitioned to rigid steel conduit (with appropriate expansion fittings and risers). In all cases, contact the District for specific requirements for the project because some installations may require microduct to be installed (also See High Density Polyethylene Pipe for areas with limited access to right of way). For all conduit related to fiber installations refer to the statewide PennDOT Fiber Details (**Appendix C**).

TABLE 9: TYPICAL CONDUIT DIMENSION FOR POLYVINYL CHLORIDE (PVC) CONDUIT

Trade Size (in)	Inside Diameter (in)	Total Area (sq. in)	40% Area (sq. in)
1/2	0.60	0.28	0.11
3/4	0.80	0.50	0.20
1	1.03	0.83	0.33
1-1/2	1.59	1.98	0.79
2	2.04	3.27	1.31
2-1/2	2.44	4.67	1.87
3	3.03	7.21	2.88
4	3.99	12.50	5.00
5	5.01	19.70	7.88

TABLE 10: TYPICAL CONDUIT DIMENSION FOR RIGID STEEL CONDUIT

Trade Size (in)	Inside Diameter (in)	Total Area (sq. in)	40% Area (sq. in)
1/2	0.632	0.314	0.125
3/4	0.836	0.549	0.219
1	1.063	0.887	0.355
1-1/2	1.624	2.070	0.828
2	2.083	3.406	1.362
2-1/2	2.489	4.863	1.945
3	3.090	7.495	2.998
4	4.050	12.876	5.150

5	5.073	20.202	8.081

TABLE 11: TYPICAL CONDUIT DIMENSION FOR HIGH DENSITY POLYETHYLENE PIPE (HDPE) CONDUIT

Trade Size (in)	Inside Diameter (in)	Total Area (sq. in)	40% Area (sq. in)
1/2	0.59	0.273259	0.109303
3/4	0.73	0.418327	0.167331
1	0.92	0.664424	0.26577
2	1.66	2.163146	0.865258
3	2.44	4.673576	1.86943
4	3.14	7.739786	3.095914
5	3.88	11.817704	4.7270816

Structure Mounted

There are many situations which require installing power or communications conduit on existing bridge structures. In these situations, coordination with the District Bridge Unit is required. The designer needs to consider the appropriate number of expansion and deflection fittings required to accommodate the expansion and contraction rates of both the conduit and bridge. Longer structures may need locking expansion joints instead of slip joints. An adequate number of hanger brackets must be included to ensure maximum allowable conduit deflection rates are not exceeded. For structure mounted details and preferences, the designer should coordinate with the District. Power and communications conduit/cable should be installed within the bridge barrier or beneath the bridge, per design standards, in new structures.

Boring

The designer should identify on the plans all locations where directional boring will be required to place the conduit, including below roadways (include sleeve if under live traffic), ponds, slope paving, and storm sewer. All bores under roadways must follow Publication 408 specifications and should not interfere with existing infrastructure such as storm sewer pipes or gas mains. The bore depth, if non-standard, should be called out on the plan sheets if this will be required at a particular location. Directional boring is preferred due to its cost-effectiveness over trenching.

Innerduct

Innerduct is not typically used by PennDOT for ITS applications, although PennDOT may use innerduct when installing communication cables within rigid steel conduits such as beneath railroads or on/within bridges.

Pull Tape

Pull tape should be specified in the plans whenever it is to be included with the conduit installation. Pull tape should also be included with the conduit installation when PennDOT is to install the communications cable after contractor installation of the conduit or when the electric service provider will install the power conductors after contractor installation of the conduit. Pull tape should be called out in the plan as flat nylon, as rope tends to cut into non-metallic conduit.

Warning Tape/Tracer Wire

Metallic warning tape shall be included with all conduit installations containing fiber optic cables, except for bored conduits. Warning tape should be at least 3 inches wide, stretchable, orange in color, and bear a permanent legend to warn about PennDOT cable. The designer should include a tracer wire in the conduit whenever an empty non-metallic conduit will be used for future purposes, or the conduit contains only fiber optic cable so that it can be easily located.

Delineators

Installation of delineators is required at each power and communication junction boxes. Refer to Publication 647, Civil and Structural Standards for Intelligent Transportation Systems, and Publication 408 Section 1200.

Future Needs

When designing conduit for ITS applications, the designer should consider the need to install additional power or communications cables in the future. If future power or communications cables will likely be needed, additional space should be provided in the conduit to accommodate these additional cables without exceeding the maximum conduit fill ratio. If the future cables to be installed exceed the maximum fill capacity of the conduit, a larger size conduit should be used.

Junction Boxes

PennDOT utilizes different types of junction boxes (JB) for ITS deployments. There are different JBs for different applications that are based on expected loads, location (in-road, in-shoulder, on-structure), and type of cable. For example, JB-1 and JB-2 junction boxes should be installed in locations subject to loads no heavier than pedestrian traffic, and JB-11 and JB-12 junction boxes should be installed in shoulders and other locations subject to vehicular loads. Installation across a structure would utilize a JB-25 which would need to be modified at fiber splicing locations. Refer to these standards for JB details:

- Publication 647, Civil and Structural Standards for ITS
- PennDOT Fiber Details (**Appendix C)**

Standard junction boxes are typically modified for ITS use to include standard labels on the lid. Select junction boxes based on location, application, slack, and type of cable being accessed (bend radius). Designer should also be aware of construction sequencing when selecting junction boxes to avoid potential constructability issues and/or change orders.

- If junction boxes are subject to live traffic during construction when the final condition is not subject to traffic (e.g., temporary road).
- Standard junction boxes cannot be raised and lowered, but a standard utility hole can be raised and lowered. Consider the use of a utility hole when construction staging places live traffic over a junction box prior to final paving.

Junction boxes perform several important functions, they:

- Provide drainage for the conduit system to prevent freezing water from damaging the conduit and/or cables
- Provide a location for bending the conduit run without damaging the cables
- Provide a junction for conduits coming from different directions
- Facilitate pulling cables over long distances
- Provide access to the system for maintenance

Refer to Publication 408, Section 1204 – ITS Communications and the statewide PennDOT Fiber Details (**Appendix C**) for junction box spacing. In general, for non-fiber optic cable runs, junction box spacing used by

PennDOT is in the range of 300-500 feet. Junction box spacing for fiber optic backbone is in the range of 700-1,100 feet and 250-500 feet for lateral placement. The designer may use their judgment for final spacing determination but should refer to the District for guidance specific to each project. When locating conduit runs and junction boxes, the designer should consider the total number of conduits entering and exiting the junction box. Whenever possible, the designer should make sure that no more than six conduits enter/exit an individual junction box as it becomes increasingly challenging to maintain and reduces the likelihood the junction box could be used to connect a new conduit as part of a future project. Junction boxes should not be in wet areas (e.g., ditch bottoms).

3.4 Equipment Enclosures

General

All equipment enclosures must be provided per National Electrical Manufacturers Association (NEMA) standards. Size the enclosure to accommodate the equipment to be installed inside. In addition, the enclosure's size should account for ease of access to the equipment and the ability to achieve proper ventilation. The placement of devices in the enclosure must be consistent throughout a project. If a specific enclosure orientation or door swing is required, this can be shown in the plans. All enclosures need to be placed in the safest possible location, generally along the right shoulder of the road. The cabinet itself should be oriented so that the maintainer is facing the roadway while performing maintenance. When it comes to designing the enclosure, there is no "standard" size. There is a wide variety of component manufacturers to choose from, and this will usually impact the enclosure interior space requirements. In some cases, co-located ITS devices may also share the same enclosure. This will further influence the design of the enclosure size. Standard Specifications for an ITS enclosure can be found in Publication 408, Section 1200.

Ambient Temperatures

Generally, the operating ambient temperature range shall be from -40°F to +167°F and the storage temperature range shall be from –40°F to +185°F, during which the relative humidity shall not exceed 95 percent. Refer to Publication 408, Section 1200 for environmental requirements for each ITS device, component, and enclosure. All devices should be field hardened. Field hardened devices are designed to operate under harsh environmental conditions.

Ethernet Switches

Ethernet switches are used in wired and wireless networks to connect devices located on that network. PennDOT uses field hardened Ethernet switches in ITS and traffic signal enclosures to connect one or more IP addressable devices located inside or connected to the cabinet. A field hardened Ethernet switch is designed to withstand the extreme weather conditions often found in unconditioned environments, like that of an ITS or traffic signal enclosure. The number of small form-factor pluggable (SFP) points in the fiber optic ethernet transport depends on the number of pigtails being terminated (i.e., whether daisy-chaining method being used). Switches can be either field edge switches or hub cabinet switches. The designer should contact the District to determine the best type of switches for the design.

Remote Power Switch

The purpose of a remote power switch is to provide a remotely accessible web interface that can be used to remotely reboot or power cycle the ITS device. In certain scenarios, rebooting an ITS device that is malfunctioning or that is locked-up may restore functionality to the device. By remotely resolving the issue, the user can reduce maintenance costs and the staff time required for site visits and field maintenance. Remote power switches are standard in all PennDOT ITS deployments.

Mounting Type and Maintainer Pad

Based the location of the enclosure related to safety of the motorist, visibility of roadside devices, and safe access by maintenance staff, ITS field enclosures can be base mounted on a concrete pad, structure mounted, or pole mounted. A leveled concrete pad should be provided at the front of the enclosure for the maintenance worker to stand on while accessing the enclosure. Additionally, a maintainer pad should be designed with consideration of maintenance at access points to the enclosure and the hand hole. Where possible, there should be adequate and safe parking conditions present for parking of a maintenance vehicle in the vicinity of the enclosure. Where this is not possible, locate the camera where it is accessible by on-foot maintenance personnel. Do not place cabinets in flood prone areas. Consider safety features such as service slabs and railings for cabinets placed on slopes steeper than 1:2. For additional guidance, refer to Publication 647, Civil and Structural Standards for Intelligent Transportation Systems.

3.5 Supporting Infrastructure

Sign Structures, Poles, and Posts

When a proposed CMS will be installed on a sign structure, the design may include either a new sign structure or the modification of an existing sign structure. If modifying an existing sign structure, a structural analysis and design will be required, and the designer will need to coordinate with the District Bridge Unit to incorporate all necessary structural components. Refer to Publication 15M (DM Part 4 – Structures) for additional details related to sign structures. For all structural steel components, the designer must take fabrication lead times into consideration. Typical structural steel lead times vary but may exceed 26 weeks. If a project is on an accelerated schedule, the designer should consider whether PennDOT should furnish the structural steel components independently and provide them to the contractor for installation.

The designer will also need to consider whether a Federal Aviation Administration (FAA) airspace review (FAA Form 7460-1 Notice of Proposed Construction or Alteration) filing will need to be completed for proposed ITS structures. The requirements for filing with the FAA for proposed structures vary based on several factors including height, proximity to an airport, location, and frequencies emitted from the structure. The FAA provides a Notice Criteria Tool that may be utilized by the designer to receive a preliminary determination from the FAA as to whether an FAA airspace review is required for the proposed structure. See the following link: https://oeaaa.faa.gov/oeaaa/external/gisTools/gisAction.jsp?action=showNoNoticeRequiredToolForm

The airspace review submittal to the FAA should be filed with adequate lead time prior to the final submittal date. It is desirable to obtain preliminary determinations from the FAA as soon as device locations are determined. The designer is required to have an account set up with the FAA airspace review website to file with the FAA and is also required to input relevant client/sponsor contact information into the airspace review database. One can register as a new user and manage air space review cases through the FAA website at the following link: https://oeaaa.faa.gov/oeaaa/external/userMgmt/permissionAction.jsp?action=showLoginForm

Depending on the specific situation, it may also be warranted for a separate FAA airspace review to be filed for construction equipment that will be utilized to install the proposed permanent structure.

Foundations

Most new ITS device installations will require a foundation to be installed for the pole or sign structure that the ITS device will be mounted on. The designer will need to consider whether a standard PennDOT foundation design will be adequate for the ITS application or if a special design is required.

For a new CMS sign structure, there are two standard footing design types: a spread footing and a caisson. When the CMS and sign structure installation is part of a roadway reconstruction project, a spread footing is typically used. If the CMS and sign structure installation is over an existing roadway, a caisson is typically used. All new sign structures will require that a soil boring be performed at each foundation location to determine whether the standard design is adequate. It should be noted that the soil boring location typically be within 10 feet of the foundation; therefore, locations must be approved prior to obtaining a soil boring. Poles required for detection and video cameras typically utilize a standard foundation and do not require a soil boring. In areas with unique or poor-quality soil conditions, a special foundation design may be required.

Guide Rail and Barrier

When a new sign structure or non-breakaway support is required for an ITS device installation, guide rail will be required to protect the structure from one or both directions. Coordination with the District Safety Engineer may be required to determine the appropriate recommendation. Refer to Publication 13M (DM Part 2 – Highway Design) for guide rail and barrier requirements.

Pull-off Area and Grading

There are a variety of situations where roadway design and related quantities need to be provided in the plans. A few examples include:

- Fill in an area for an ITS or enclosure so it does not end up in a wet area.
- ITS devices such as cameras or detector poles within the clear zone area.
- Creating a level work area so a ladder can be safely used by workers to service the ITS devices.
- Pull-off area that is level and located farther away from the active traffic lanes to provide a safer area to park work vehicles including bucket trucks.
- Erosion control measures need to be considered when work is adjacent to rivers, wetlands, and other environmentally sensitive areas. Depending on the level of impacts, the plans may require erosion control details.

The designer needs to include the appropriate pay items and quantities in the plans to allow for these features to be constructed when required.

3.6 Device Design

Closed Circuit Television Camera

System Purpose

Current video camera technology allows for a field of view of one to two miles in each direction if the camera mounting, topography, road configuration, and weather are ideal. In urbanized areas, camera placement may need allow for continuous coverage, but in rural areas camera placement may be placed at interchanges/intersection or congested areas (i.e., bottleneck). The primary function of the CCTV camera is to provide surveillance of the transportation system and enhance situational awareness. CCTVs enable the Department to perform monitoring, detection, verification, and response activities either manually or utilizing analytics. Applications for CCTV cameras include:

- Detecting and verifying incidents
- Monitoring traffic conditions
- Monitoring incident response and clearance
- Monitor work zone operations and temporary traffic control
- Verifying messages on CMSs
- Assisting emergency responders
- Monitoring environmental conditions (visibility distance, wet pavements, etc.)
- Monitoring assets (Homeland Security)

To maximize the effectiveness of a CCTV camera to maintain driver safety, the camera type and location must be carefully considered when deploying a CCTV camera. First, the operational requirements of the camera must be considered. This will determine the camera type and the general camera location required to achieve system requirements. Table 12 lists relevant standards and requirements related to CCTV deployments.

TABLE 12: CCTV STANDARDS

Criteria	Relevant Standard
Camera Type	• Publication 408, Section 1210 – Closed Circuit Television Camera
Communication and Software	• NTCIP 1205 • Publication 408, Section 1202 – ATMS ITS Device Integration • Publication 408, Section 1204 – ITS Communications
Structure	• American Association of State Highway and Transportation Officials (AASHTO) • Publication 647 – Civil and Structural Standard Drawings, ITS-40
Enclosure	• NEMA standards • Publication 408, Section 1201 – ITS Devices - General

Design Considerations

The guidance provided in this publication should be followed when designing new CCTV cameras. There will be instances where all the criteria in these guidelines cannot be met. Justification for deciding to go through with an installation, despite not being able to meet all criteria, should be detailed in the SER by the designer. Table 13 provides an overview of the design considerations for CCTV camara deployments.

TABLE 13: CCTV CAMERA DESIGN GUIDANCE

Detection Purpose
• Is this deployment consistent with needs outlined in the SER? • Is this deployment consistent with the ITS architecture?
Location/ Placement Guidelines
• Has the camera location been chosen/designed with consideration to maximizing visibility? • Has a site for the camera been chosen that considers the available utilities and the cost/constraints associated with connection to those utilities? • Has the site been chosen with consideration to protecting the camera structure and ensuring that it can be maintained with standard maintenance practices at the structure and surrounding site? • Has a site been chosen that makes the best use of the operational needs of a CCTV camera system (e.g., Incident Management)? • Has a site been chosen that considers maintenance?
CCTV Type
• Is the camera type appropriate for the desired location? • Does the District require the camera to be compatible with a legacy analog system?

Mounting Structure
• Has Publication 647, ITS-40, ITS-43, ITS-44, ITS-45 been followed in the design of the mount/structure?
Enclosure
• Is an enclosure required at this location? • Has the enclosure placement considered future camera relocation? • Is the enclosure located within 150 feet of the camera? • Is the enclosure mounted on the camera pole or on an existing structure (where possible)? • Has a site been chosen that considers maintenance?
Power Requirements
• Have the power requirements for the camera and all the system components been determined?
Power Availability
• Has an appropriate power source been located and confirmed with the utility company within a reasonable distance from the camera site? • Have Step-Up/Step-Down requirement calculations been performed? • Have the metering options been determined?
Power Conditioning
• Have the UPS and power back-up options been determined and accounted for?
Communication
• Have the communication requirements for the camera been determined? • Has an appropriate communication infrastructure been located and confirmed within a reasonable proximity to the site? • If there are multiple communication options, have the pros/cons been studied? • If using public communications infrastructure, has service been coordinated with OA/OIT and the District?
Environmental
• Have all the necessary environmental, community, and cultural impact studies, processes and concerns been addressed?

Site Location Guidance

CCTV camera locations should be determined based on the operational and maintenance requirements. The desired coverage should be the primary design consideration when determining the camera location; however, local topography may also impact design. CCTV camera locations should provide a clear line of sight with minimal obstructions between the viewing area and the camera. When possible, utilize a camera equipped van or bucket truck to validate CCTV camera placements prior to installation. Table 14 provides camera site selection and placement guidelines.

TABLE 14: CAMERA SITE SELECTION AND PLACEMENT GUIDELINES

Criteria	Guidance
Visibility	• Cameras in low light conditions, such as tunnels, should be located so that the main view is away from bright light. • Near horizontal curves, install on outside of curve. • Near vertical curves, install at the crest. • At the intersection of two major routes or an interchange, place camera so that secondary roads can also be monitored. • The blind spot created from the pole should be oriented at a location non-critical to viewing.
Utility Availability	• Consider proximity to power and communications. • If fiber optic communication is available, place the camera on the same side of the roadway to eliminate lateral crossings (this is secondary to visibility guidance).

Criteria	Guidance
Safety and Device Protection	• Protect CCTV pole with guide rail inside the clear zone and consider lateral deflection and maintenance vehicle access. • Medians are not the preferred location, but wide medians may be considered if suitable roadside locations are not available. • To reduce site erosion, reduce construction costs, and provide longer pole life, avoid locating on sections that have a fill slope of greater than 1V:3H.
Operational Considerations	• Install at locations with recurring congestion and other high-volume areas. • Install at locations known to have adverse weather conditions. • Install at locations with recurring crashes. • If possible, position cameras to view nearby CMS for message verification. • Large interchanges of two major freeways may require more than one camera to obtain all desired views of roadways and ramps. • Avoid mounting a CCTV camera onto a bridge structure due to the potential of vibrations affecting the image. Camera manufacturers do have dampening systems which may be considered but must be specified in the contract documents.
Maintenance Considerations	• Refer to Chapter 4 – Maintenance Considerations

In urban areas, corridor wide camera coverage is considered full build. Full camera coverage of a roadway results in CCTV camera placement so that an operator can view and monitor the entire corridor, with no blind spots. Full build is warranted on certain roadways in urban areas, given the high usage of the roadway. To provide full and continuous coverage of a roadway (subject to the operational requirements), cameras should be placed no more than one mile apart depending upon the curvature of the roadway.

In rural areas, corridor wide camera coverage is typically not necessary. CCTV camera coverage is typically preferred at interchanges of limited access roadways (interstate-to-interstate or interstate-to-major limited access) or at interchanges with highly traveled arterials. Other considerations besides high traffic volumes may be justification for full camera coverage in rural areas. Full camera coverage may be implemented on a case-by-case basis where coverage could be useful, such as a segment that experiences regular regional events, high winds, or extreme weather events.

Urban and rural areas are established through the US Census and planning organizations within the Commonwealth. The BPR provides the following:

- **Urban Area:** Urban places of 5,000 or more population and designated by the Bureau of Census
- **Small Urban Area:** Places having a population of 5,000 or more, not in an urbanized area
- **Rural:** The area outside the boundaries of small urban & urbanized areas.

Roadway designations can be found at BPR's website here:
https://www.penndot.pa.gov/ProjectAndPrograms/Planning/TrafficInformation/Pages/default.aspx

Types of Cameras

Most of the necessary CCTV camera features are standard with the common commercial products. A camera should meet Publication 408, Section 1210 – Closed Circuit Television Camera specifications. The standard camera includes a pan/tilt/zoom (PTZ) subsystem, providing STMC/RTMC/TMC Operators the functionality of panning the camera a full 360-degrees and adjusting the tilt up or down 180-degrees. Together with a zoom lens, PTZ allows operators to view a scene within any direction within the lens field-of-view and distance ranges. The PTZ subsystem allows for preset positions or can be moved manually by an Operator.

Publication 408, Section 1210, specifies a dome style camera that transmits video in IP video format only. The need to deploy analog cameras may be necessary due to legacy infrastructure. The designer should coordinate with the Department on the type of camera. Currently, some Districts have developed specifications for deployment of other types of cameras (e.g., top mount).

Mounting Type

The overriding factor in determining a CCTV camera location is the site's fitness for performing the operational role that it is designed for. If all other factors are equal, the ITS designer may possibly have more than one option on the type of camera mount to design. The three possible choices are:

- Pole-mounted
- Existing sign structure (requires coordination with the District Bridge Unit)
- Traffic signal support
- Inside a Tunnel or on a Wall

The most prevalent structure for CCTV cameras is a hollow steel pole. The practice of installing pole mounted CCTV cameras in combination with Camera Lowering Device (CLD) is preferred for all CCTV installations, but there are situations that may not warrant a CLD. The inclusion of a CLD will increase the overall cost of the system but allows for easier access to the camera; in many cases eliminating the need to use a bucket truck or similar vehicle for maintenance and reduce the need for lane closures. For a pole mounted cabinet, do not place the cabinet on the same side as the hand hole for a camera lowering tool or under the camera to be lowered. Standard Specifications for a CCTV CLD can be found in Publication 408, Section 1210 - Closed Circuit Television Camera.

Enclosure Placement

When the CCTV camera system includes devices that will be designed, constructed, and maintained, as Department-owned assets, the enclosure and its associated components must be included in the design process. Design criteria for a suitable ITS enclosure location includes the following:

- When possible, the enclosure for the CCTV controller should be pole mounted on the CCTV pole or existing structures to maximize cost savings.
- In locations where the pole is difficult to access, the enclosure may be ground-mounted at a more convenient location with easier access, such as adjacent to a frontage road.
  - The enclosure is to be placed in the safest possible location, generally along the right shoulder.
  - A ground-mounted enclosure should be located at a minimum distance from the barrier, based on the design and type of barrier used. See standard drawings for placement of enclosure behind a barrier.
  - The enclosure should be oriented so that the maintainer is facing the roadway, while performing maintenance at the cabinet location.
  - The enclosure should be located less than 100 feet from the camera, but no more than 300 feet based on restrictions of the communications cable. If greater than 100 feet, equalizing amplifiers for video should be provided.
- See manufacturer's specifications to determine the maximum distance between the enclosure and the field device it services.

When it comes to designing the enclosure, there is no standard size. There is a wide variety of component manufacturers to choose from and this will usually impact the enclosure interior space requirements. In some case, co-located ITS devices may also share the same enclosure. This will further influence the design of the enclosure size. Standard Specifications for an ITS enclosure can be found in Publication 408, Section 1201 – ITS Devices - General.

Changeable Message Signs

System Purpose

The primary function of the CMS is to provide traveler information. The nature of this information is varied, but the goal is to disseminate roadway condition information to travelers so that they can make informed decisions regarding their intended trip and/or route. A CMS must be utilized in accordance with Department policy, refer to Publication 200, Changeable Message Sign (CMS) Operating Standards. Typical CMS uses include notifying travelers of:

- Road closure
- Impacts to traffic (Incident, Maintenance/Construction, Events, etc.)
- Weather or road conditions
- AMBER Alert
- Special events
- Travel times (Automated, Real-time)
- Future road work or impacts to traffic
- Scheduled Safety Messages (Formerly Public Service Announcements)
- Sign testing
- Supplemental warning and regulatory signing

To maximize the effectiveness of a CMS and to improve driver safety, the sign type, placement, and the supporting structure must all be carefully considered when designing and deploying a new sign. First, the operational requirements of what purpose the sign will satisfy must be considered. This will determine the general location and the type of sign. These operational requirements and the location will determine the required support structure. Table 15 lists relevant standards and requirements related to CMS deployments.

TABLE 15: CMS STANDARDS

Criteria	Relevant Standard
Sign Type	• Manual on Uniform Traffic Control Devices (MUTCD), See Section 2L. Changeable Message Signs • Publication 408, Section 1230 – Changeable Message Signs
Communication and Software	• NTCIP 1203 • Publication 408, Section 1202 – ATMS ITS Device Integration • Publication 408, Section 1204 – ITS Communications
Structure	• AASHTO • Publication 647 – Civil and Structural Standard Drawings for ITS, ITS-60 & ITS-61 • Publication 218M – Standards for Bridge Design, BD-649M & BD-650M
Enclosure	• NEMA standards • Publication 408, Section 1201 – ITS Devices – General • Publication 408, Section 1230 – Changeable Message Signs

Design Considerations

The criteria contained in this publication should be followed when designing a CMS system. There will be instances when the criteria in these guidelines cannot be met. Justification for the installation, despite not being able to meet all the criteria, should be detailed by the designer. The goal of this process is to provide practitioners with guidance as well as providing the Department consistency with respect to CMS installations. Table 16 provides an overview of the design considerations for CMS deployments.

TABLE 16: CMS DESIGN GUIDANCE

Pre-Design Planning
• Is this deployment consistent with the needs outlined in the SER? • Is this deployment consistent with the ITS architecture?
Longitudinal Placement
• Is the CMS visible and not obscured? • Is the CMS placed sufficiently in advance of any interchanges that would be used for diversions? • Is the CMS properly spaced away from existing or proposed guide signs?
Lateral Placement
• Is the CMS structure located beyond the clear zone or protected by a suitable safety barrier? • Has the lateral offset of the CMS been accounted-for when calculating the length of the Reading and Decision Zone?
Vertical Placement
• Is the approaching segment of roadway relatively flat (between 0-4% vertical grade)?
Sign Matrix Type
• Has a sign matrix type been chosen that is consistent with the visibility and message requirements of the roadway being deployed on?
Sign Viewing Angle
• Has a sign viewing angle been chosen that complements the roadway alignment and structure?
Sign Access
• Are there any traffic, environmental, or safety factors that warrant a specific type of sign access?
Structure
• Have visibility, road speed/volume, right-of-way, and maintenance/cost issues all been considered when selecting a type of sign structure? • Is there sufficient vertical clearance for the sign and the structure?
Enclosure
• Is the enclosure located within a reasonable distance of the sign? • Is the sign face visible from the enclosure location? • Does the location and orientation provide adequate protection for the enclosure? • Has a site been chosen that considers maintenance?
Power Requirements
• Have the power requirements for the CMS and the system components been determined?
Power Availability
• Has an appropriate power source been located and confirmed with the utility company within a reasonable distance from the CMS site? • Have Step-Up/Step-Down requirement calculations been performed? • Have the metering options been determined?
Power Conditioning
• Have the UPS and power back-up requirements been determined and accounted for?
Communication
• Have the communication requirements for the CMS been determined? • Has an appropriate communication infrastructure been located and confirmed within a reasonable proximity to the site? • If there are multiple communication options, have the pros/cons been studied? • If using public communications infrastructure, has service been coordinated with OA/OIT and the District?

Environmental
• Have all the necessary environmental, community, and cultural impact studies, processes and concerns been addressed?

Site Location Guidance

The site characteristics in the vicinity of the planned CMS must be investigated. Site characteristics dictate the amount of information that can be displayed to a driver and comprehended. Relevant geometric and environmental characteristics include:

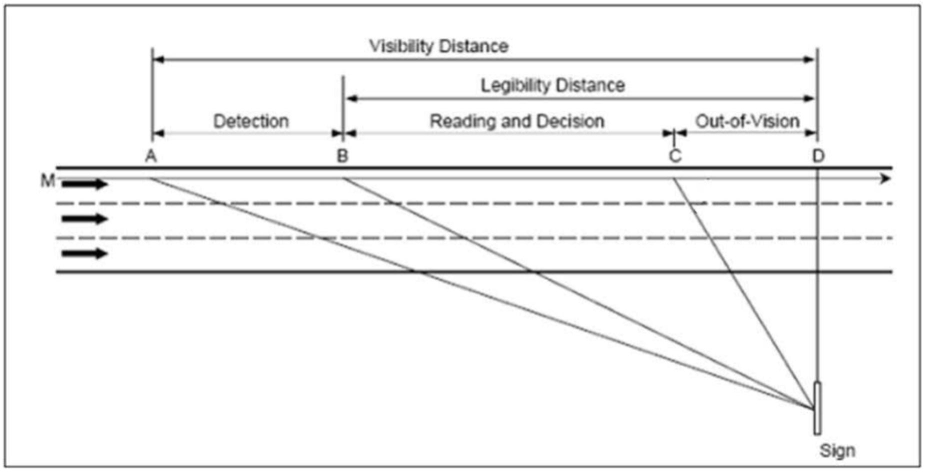
- Operating speed of the roadway
- Presence of vertical curves impacting sight distance
- Presence of horizontal curves impacting sight distance
- Location relative to the position of the sun
- Static guide signs spacing
- Frequency of dense fog

LONGITUDINAL PLACEMENT

The main considerations related to longitudinal placement of a CMS are to minimize obstructions of and by the CMS, provide for the maximum visibility of the CMS message, and allow the driver ample time to read, process, and react to the message. The approach to a sign consists of three zones (See Figure 10)

- Detection Zone
- Reading and Decision Zone
- Out-of-Vision Zone

FIGURE 10: CMS VISIBILITY ZONES



Detection Zone: At typical (65 mph) highway speeds, the sign board should be visible to the approaching driver from 1,000-2,000 feet away. The visibility distance should also be increased if the CMS is placed at an offset from the travel lane.

Reading and Decision Zone: As a rule, the message panels on a highway deployed CMS usually contain room for three lines of 18 to 24 characters each. Approximate sight distances for different font sizes are provided below:

- Individual 12-inch-high characters can be seen from ~650 feet under normal conditions.

- Individual 18-inch-high characters can be seen from ~1,100 feet under normal conditions.

Table 17 lists the minimum reading and decision zone distances recommended for CMS placement.

TABLE 17: READING AND DECISION ZONE MINIMUM DISTANCES

Legibility Distance Requirements	Freeway	Limited Access Arterial	Major Arterial
Less than 45 mph	N/A	650′	650′
45 mph to 55 mph	850′	850′	850′
Greater than 55 mph	1,000′ or more	1,000′ or more	N/A

Drivers need approximately one second per word to read and comprehend a message. Travelling at 65 mph, this translates into roughly time enough to read and comprehend a 10-word message. The character height, cone of vision and lateral placement must all be considered when determining the placement of the sign to meet the sight distance requirements.

Out-of-Vision Zone: Once the driver gets close to the sign, they will not be able to read the message. The distance is determined by the viewing angle of the sign, the structure that the sign is placed on and the lateral placement of the sign.

Table 18 provides design guidance for the longitudinal placement of a CMS.

TABLE 18: CMS LONGITUDINAL PLACEMENT GUIDANCE

Criteria	Guidance
Visibility	• Provide detection distance of at least 800 feet, and optimally 1,000-1,200 feet • On freeways, should be placed at least 800-1,000 feet from static guide signs • Should be placed on straight sections of roadway, where/when possible • If the sign must be located on a curve, should be angled towards the roadway
Reaction Time	• Two CMS should be placed more than 1,000 feet apart, ideally a half mile or more • Should be placed more than 1,000 feet upstream of lane merge or add lane • Should be placed 1-4 miles in advance (1 mile minimum) of an alternate route or major decision point on Freeways • Should not be placed at a signalized intersection on Arterials
Cost	• Should be placed as close to existing communications and power to minimize cost • Cell Modems could be considered for depended on distance to communications. • Should avoid locating on sections that have a fill slope of greater than 1V:3H (to reduce site erosion, reduce construction costs, provide longer service life)

LATERAL PLACEMENT

The lateral offset for overhead sign supports must comply with the MUTCD, Section 2A.19 – Lateral Offsets, and Publication 13M (DM2) – Highway Design. Sign supports are to be placed behind guide rail or barrier, as required. Confirm guide rail type when placing sign support behind existing guide rail. A Type A mounted CMS with breakaway supports is not required to be placed behind guide rail or barrier.

The further the offset from the travel lane the more sight distance is required to clearly view and react to the sign. Figure 11 provides guidance for the additional distance that must be factored into the longitudinal sign placement of a CMS.

FIGURE 11: LATERAL OFFSET VS. REQUIRED SIGHT DISTANCE

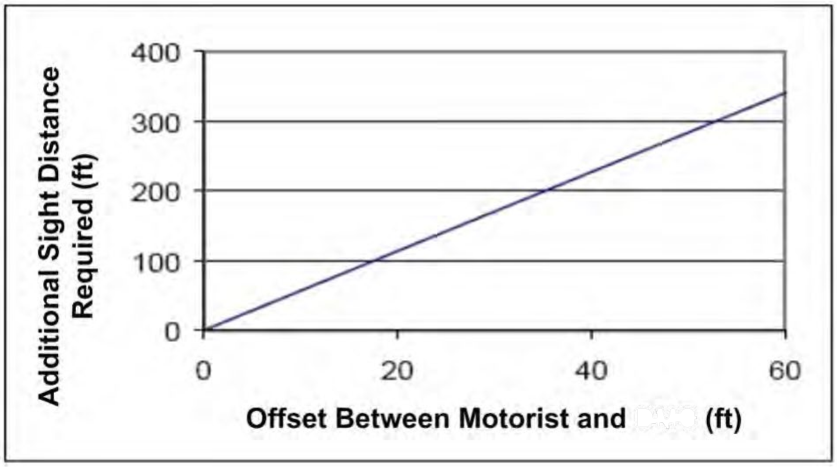


Table 19 provides design guidance for the lateral placement of a CMS.

TABLE 19: CMS LATERAL PLACEMENT GUIDANCE

Criteria	Guidance
All Signs	• CMS must be placed outside the clear zone or shielded with a crashworthy barrier within the clear zone, except Type A mount with breakaway supports • The distance between the center of a CMS and the driver's forward line of vision (offset) must be factored into the CMS placement • For roadways with a speed limit of 65 mph or greater, the center of the CMS should be no more than 30 lateral feet from the driver's forward line of vision

VERTICAL PLACEMENT

A roadway's vertical alignment impacts the visibility of the CMS. If there are a limited number of potential locations available, a slight upward grade is desirable. Figure 12 illustrates the vertical sight envelop for a typical CMS installation on flat roadway segment. The sight envelop will reduce as the roadway grade increases.

FIGURE 12: CMS VERTICAL SIGHT ENVELOPE

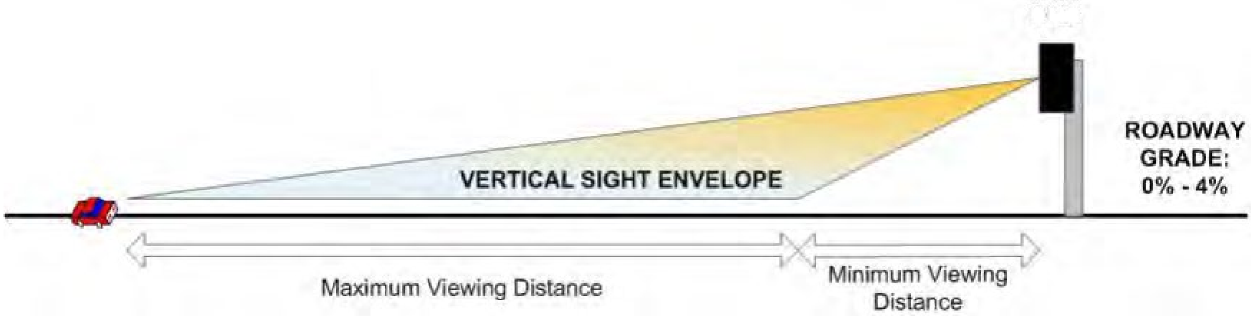


Table 20 provides design guidance for the vertical placement of a CMS.

TABLE 20: CMS GRADE GUIDANCE

Criteria	Guidance
All Signs	• Where possible, place on roadway segments that with a grade less than 1% • May be placed on segments with up to a 4% grade • Should NOT be placed on roadway segments that have a grade of 4% or more (this may be waived if sign is placed on positive grade immediately following a similar negative

	grade. In these situations, expanded cones of vision should be considered to compensate for the reduction of visibility distance caused by the grade)

Types of Signs

The selection of the sign type, the configuration of the display, and the technology employed all have direct or indirect impacts on the visibility of the message that will be displayed on the CMS.

MATRIX CHARACTERISTICS

CMS display characters and symbols in a matrix format, which are generally designed in one of the following three patterns:

- Character Matrix
- Line Matrix
- Full Matrix

The Department's standard, and the one designated in Publication 408, Section 1230 – Changeable Message Signs, is Full Matrix. Full matrix CMS displays can display graphics and symbols. Varying matrix types are acceptable on a case-by-case basis but are discouraged. If a line or character matrix configuration is used, a special provision would have to be used, or a standard item modified. The industry standard CMS matrix technology is:

- **Light-Emitting Diode (LED)** signs based on AllnGaP technology. LEDs are semiconductors that emit light when current is applied. Typically, several individual LEDs are clustered together to create each pixel. LEDs have the added benefit of being able to display signs in full color with the appropriate LED type. The reliability of LED lamps is very high.

Table 21 provides design guidance for CMS displays.

TABLE 21: CMS DISPLAY RECOMMENDATIONS

Criteria	Recommendation
General	• Provide a minimum of 18 characters per line, and a maximum of 24 characters per line, as indicated. Provide 12-inch or 18-inch-high display characters with a standard character size ratio of 5:7, width vs. height. • Sign should be limited to three lines of text • Provide signs capable of displaying American Standard Code for Information Interchange (ASCII) characters 32 through 126, including all uppercase and lowercase letters and digits 0 through 9, at any location in the message line.
On Freeways	• Character height should be 18 inches • A minimum of 18 characters per line should be provided
All Signs	• Photocell to auto adjust illumination intensity of display to the ambient light

VIEWING ANGLE

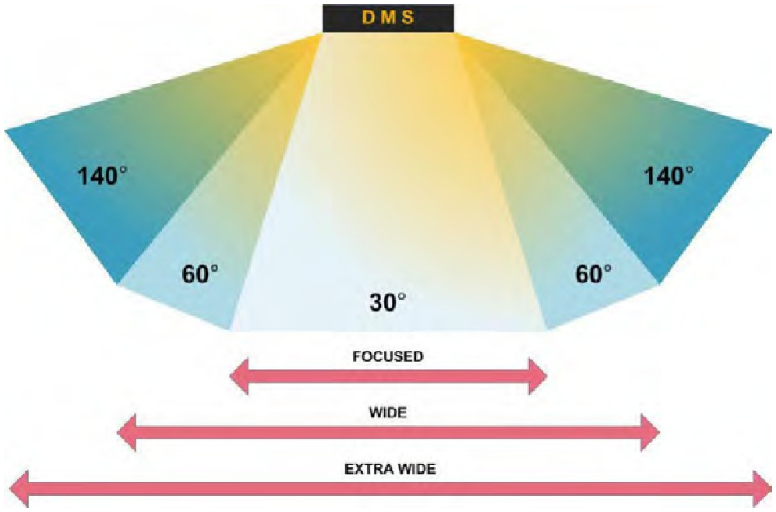
Viewing angle is an important aspect and depends upon the mounting location of the CMS and the curvature of the roadway. There are three standard angles available from CMS manufacturers: 15 degrees (required minimum per Publication 408), 30 degrees, and 70 degrees. The 30-degree viewing angle is typical; however, Table 22 provides guidance on viewing angle based on CMS placement. Signs with varying viewing angles can be procured using the appropriate bid item number, or by modifying the standard specification.

TABLE 22: CMS VIEWING ANGLE GUIDANCE

Criteria	Guidance
15 Degrees	• Overhead placement and on straight lengths of roadways
30 Degrees	• Roadside placement and on slightly curved lengths of roadways
70 Degrees	• Wide highways and on curved lengths of roadway

Figure 13 illustrates the different viewing angles and the impact to developing the overall visibility distance. For example, when the lateral offset of a CMS with a viewing angle of 15-degrees shifts further from the travel lane the visibility distance is significantly impacted. Therefore, these types of signs are recommended for overhead (over lane) locations only.

FIGURE 13: CMS VIEWING ANGLE ILLUSTRATION



SIGN ACCESS

The Department specifies access requirements for both walk-in and front access CMS. Rear access signs cannot be accessed based on current design standards for CMS support structures. Rear access CMS should only be considered in very rare special situations and require Department approval. Figure 14 illustrates the different CMS maintenance access options.

FIGURE 14: CMS ACCESS OPTIONS

Table 23 is a brief examination of the pros/cons of each type. Where a walk-in sign is utilized, provide a sign housing door that is fabricated from aluminum. Equip sign with a minimum of two vertically hinged access doors located at the right and left sides (while facing the front of the sign) of the CMS housing.

TABLE 23: CMS ACCESS TYPE CONSIDERATIONS

Access Type	Pros	Cons	Other Considerations
Rear Access	• Smaller and lighter sign allows for a smaller structure	• Current sign structure standards prohibit access	• Type A mounted CMS may be able to accommodate access type (modified).
Walk-in	• Provides safe environment for worker over live traffic	• Highest in installed and recurring costs	• Catwalk or platform required to access the CMS
Front Access	• Smaller and lighter sign allows for a smaller structure	• Sign mounted overhead would require a lane closure	• A bucket truck is typically used to access the sign • Consider installing catwalk to avoid need for bucket truck
Type A	• Cost effective installation • No core borings, standard foundations	• Placement may allow sign to be easily hit by a vehicle.	• Enclosure location • May need ladder to access sign

Selection of Structure

The four types of permanent structures that PennDOT allows for mounting CMS are Center-mount, Overhead, Cantilever, and Type A. Figure 15 illustrates the different CMS support structures.

FIGURE 15: CMS SUPPORT STRUCTURES

Install CMS at locations that provide maximum visibility to the driver and on a structure that does not interfere with the visibility requirements. The lateral placement guidelines and the nature of the roadway are the two main factors in determining the type of structure that the CMS is mounted on. Generally, the wider the roadway the greater likelihood that the sign will need to be placed on a structure that spans the roadway. Table 24 provides the mounting guidelines.

TABLE 24: CMS MOUNTING GUIDELINES

Roadway Type	Guidance
1-2 lanes, single direction	• Roadside center-mount or Type A signs
3-4 lanes, single direction	• Full-span or mid-span, overhead signs, or cantilevered signs

The number of lanes, the speed characteristics, and the available ROW determine the placement and structure type of the CMS. Portable CMS should not be considered as an acceptable long-term substitution for permanent CMS. Portables should only be deployed as temporary installations. Table 25 provides guidance on use of the different types of support structures.

TABLE 25: CMS SUPPORT STRUCTURE CONSIDERATIONS

Support Type	Pros	Cons	Other Considerations
Center-mount	• Best benefit-to-cost • Easy to maintain • Lower structural cost	• Visibility can be an issue on tangent sections • Visibility can be an issue if truck volumes are high	• This is the Department preferred option • Can be used best if located on outside of curve or on tangent sections • Can be used on any roadway type
Overhead	• Best for visibility	• Highest in cost • Requires more preventative maintenance than offset CMS	• Good alternative if limited ROW available • Can be used on any roadway type • Utilize on high volume roadways
Cantilever	• Less expensive than overhead • Alternative if center mount or full span cannot be installed	• Structural issues, including failures, have occurred in some states • Visibility can be an issue on tangent sections • Visibility can be an issue if truck volumes are high	• Alternative if limited ROW available • Can be used on any roadway type • Requires approval by Chief Bridge Engineer to be considered. The submittal is to include site justification.
Type A	• Arterial and Pre-Entry • Lowest cost • Minimal Design, No Bridge Unit review • Enclosure often not needed	• Susceptible to damage: vehicular and snow removal activities • Visibility can be an issue due to lower mounting height	• Can be used best if located on outside of curve or on tangent sections
Portable	• Good temporary alternative	• Smaller display • More susceptible to damage during snow removal activities • Typically requires the most preventative maintenance	• Suitable for construction activities and temporary emergency measure

STRUCTURAL DESIGN GUIDANCE

The following outline contains the information which shall be submitted for each CMS sign structure. The outline contains aspects of the CMS design required by the PennDOT Bridge Office. Type A mounted CMS do not require review and approval by the Bridge Office. The Department's sign structure computer program, SIGN, shall be used for all structure types. All design calculations, plans, and details shall be in accordance with the ITS Standard Drawings (Publication 647), as well as the applicable Standards for Bridge Design (Publication 218M), and Standards for Bridge Construction (Publication 219M). Each CMS structure will be assigned its own S-number. Coordinate work with PennDOT and the proposed CMS Manufacturer on final configuration and options. The Department's order of preference for CMS support structures is:

1. Center-mount
2. Overhead truss (4 post - 4 chord)
3. Cantilever

Cantilever support structures supporting CMS require written justification and Chief Bridge Engineer approval at the Type, Size and Location (TS&L) stage. Cantilever support structures are only permitted when it can be demonstrated that a Center-mount or an Overhead truss is not feasible. Refer to ITS-61 for Cantilever Structures, BD-649M for Center-mount Structures, and BD-650M for Truss Sign Structures for design assumptions, notes to the designer, and connection details for the sign structure and related foundations.

Enclosure Placement

When the CMS system includes devices that will be designed, constructed, and maintained, as Department-owned assets, the enclosure and its associated components must be included in the design process. Design criteria for a suitable ITS enclosure location includes the following:

- The enclosure should be ground-mounted, approximately 50-100 feet upstream of the CMS.
  - A ground-mounted enclosure should be located at a minimum distance from the barrier, based on the design and type of barrier used. See standard drawings for appropriate minimums.
  - The enclosure should be oriented so that the maintainer is facing the roadway, while performing maintenance at the cabinet location.
- If no suitable location is available for the enclosure to be ground mounted, it may be pole-mounted on the support structure to maximize cost savings or reduce ROW impacts.
- See manufacturer's specifications to determine the maximum distance between the enclosure and the field device it services.

Standard Specifications for an ITS enclosure can be found in Publication 408, Section 1201 – ITS Devices – General. Supplemental requirements are included in Publication 408, Section 1230 – Changeable Message Signs.

Vehicle Detectors

Vehicle Detection Systems (VDS) are no longer being deployed for collecting travel time data; however, some District may deploy VDS for Variable Speed Limit (VSL) deployments. Additionally, vehicle detectors may be used as part of a larger ITS deployment such as a Ramp Metering System. It is necessary to coordinate any VDS deployments with the Department and justification for use must be presented in the SER.

System Purpose

VDS are standalone point detectors that detect the presence of vehicles and their characteristics. They can detect and provide valuable real-time and historical data, including speed, volumes, vehicle presence, occupancy, gaps, and incident occurrence. The Department can then utilize this data to complete a variety of functions, including:

- Real time traffic and incident management

- Traveler information
- Historical analysis
- Origin-Destination information
- Roadway capacity analysis
- Performance measures
- Planning and design purposes

Detectors are used for two primary purposes: data collection and incident detection. To design a detection location consideration must be paid to detector purpose and system needs, selecting the appropriate technology, and deployment criteria such as structure type and orientation of the sensor. Table 26 lists relevant standards and requirements related to vehicle detector deployments.

TABLE 26: VEHICULAR DETECTOR STANDARDS

Criteria	Relevant Standard
Detector Type	• Publication 408, Section 1240 – Vehicle Detector Subsystem
Communication and Software	• NTCIP 1206 • Publication 408, Section 1202 – ATMS ITS Device Integration • Publication 408, Section 1204 – ITS Communications
Structure	• AASHTO • Publication 647 – Civil and Structural Standard Drawings for ITS, ITS-40 & ITS-61 • Publication 218M – Standards for Bridge Design, BD-649M & BD-650M
Enclosure	• NEMA standards • Publication 408, Section 1201 – ITS Devices - General

Design Considerations

The guidance contained in this publication should be followed when designing new VDS. However, there will be instances where all the criteria in these guidelines cannot be met. Justification for deciding to go through with an installation, despite not being able to meet all criteria, should be detailed by the designer. Table 27 provides an overview of the design considerations for VDS.

TABLE 27: VEHICLE DETECTOR DESIGN GUIDANCE

Detection Purpose
• Is this deployment consistent with the needs outlined in the SER? • Is this deployment consistent with the ITS architecture?
System Needs
• Does the detector deployment satisfy the precision considerations established in the system needs? • Does the detector deployment satisfy the spacing considerations established in the system needs? • Does the detector deployment satisfy the accessibility considerations established in the system needs?
Detector Technology Selection
• Does the detector technology satisfy the accuracy, accessibility, and cost requirements established in the system needs?
Deployment Guidelines
• Does the detector deployment take steps to minimize new structures and collocate devices where possible? • Does the detector deployment include sufficient detector coverage to satisfy system needs?
Enclosure
• Is an enclosure required at this location? • Can personnel safely access the enclosure? • Is the enclosure located within 150 feet of the detector?

• Is the enclosure mounted on an existing structure (where possible)? • Does the location and orientation provide adequate protection? • Has a site been chosen that considers maintenance?
Power Requirements
• Have the power requirements for the detector and all the system components been determined?
Power Availability
• Has an appropriate power source been located and confirmed with the utility company within a reasonable distance from the detector site? • Have Step-Up/Step-Down requirement calculations been performed? • Have the metering options been determined?
Power Conditioning
• Have the UPS and power back-up options been determined and accounted for?
Communication
• Have the communication requirements for the detector been determined? • Has an appropriate communication source been located and confirmed within a reasonable proximity to the site? • If there are multiple communication options, have the pros/cons been studied? • If using public communications infrastructure, has service been coordinated with OA/OIT and the District?
Environmental
• Have all the necessary environmental, community, and cultural impact studies, processes and concerns been addressed?

Detection Purpose

For operations purposes, vehicle detectors are typically deployed for either data collection or incident detection purposes. The need for the detection system must stem from the user needs established in the Concept of Operations or Regional Operation Plan for the project, and the functionality of the system must come directly from the project's operational requirements.

- **Data Collection:** Vehicle detectors for data collection are deployed in two methods:
  - **Single Point Detection:** Deployed at specific points along the roadway to gather and store data such as vehicle volumes, speeds, and occupancy. This is the most common VDS deployment.
  - **Roadway Corridor Detection:** Deployed along whole corridors to gather data such as vehicle volumes and speeds. These data are used to generate maps or other graphical representations of corridor speeds, typically called speed maps.
- **Incident Detection:** Incident detection is a traffic management function that provides automated alarms and notifications of potential incidents to TMC operators. These systems require vehicle detectors at regular intervals along a corridor that have the capability to detect vehicle presence, volume, and speeds. The detector data is then fed to a software program that employs an algorithm to determine the presence of an incident on the roadway.

System Needs

This section identifies and prioritizes the needs of the Data Collection and Incident Detection systems as they relate to vehicle detectors. The detector technology and the placement of the detectors must satisfy these needs. The comprehensive list of system needs is as follows:

- Location Precision
- Comprehensive Data Capabilities
- Detector Accuracy

- Detector Spacing
- Detector Cost
- Detector Accessibility

These six needs are prioritized for each system below. One (1) is most important and Six (6) is least important, comparatively. The system needs identified in this section should be used as considerations when selecting the appropriate detector technology in the next section.

SINGLE POINT DATA COLLECTION

The goal of single point data collection is to obtain highly accurate data at specific points of interest on the roadway. Primary considerations for the placement of point data collection systems are, in order of importance:

1. Location Precision: Position the detectors at the location of interest. Varying from the intended location may leave the detector useless.
2. Comprehensive Data Capabilities: The detector must be capable of collecting the appropriate data. The data type requirements are defined in the Concept of Operations and/or the Systems Engineering Report. Comprehensive data is usually required for point detectors, including vehicle classification.
3. Accuracy: Detectors used to gather historical and operational data require a high level of accuracy.
4. Cost: Minimize the overall cost of installation by collocating sensors on existing structures where possible and minimizing the number of sensors required to collect the data.
5. Accessibility: Detectors should be accessible for maintenance and installation purposes. Avoid the use of technologies that require lane-shutdown to perform maintenance.
6. Spacing: Spacing is not applicable for a single point configuration.

CORRIDOR DATA COLLECTION

The goal of corridor data collection is typically to obtain speeds along the corridor and provide this data to motorists as real-time traveler information. Note that this configuration is like Incident Detection, with the exception that the detector spacing requirement is not as stringent. Primary considerations for the placement of corridor data collection detectors are:

1. Spacing: Corridor data collection devices should be spaced from 0.5 to 1.5 miles apart. Spacing of 1 mile or less is optimal to effectively capture corridor characteristics. A greater quantity of devices increases the amount of corridor data.
2. Cost: Because multiple detectors are necessary for corridor detection, the cost of the system can quickly escalate. Choose detector types, locations and communication methods that minimize the overall cost of the system. Collocate detectors on existing structures where possible to minimize the need for new structures.
3. Accessibility: Accessibility of the device for maintenance and repair purposes is of high importance, especially when many devices are necessary for a system. Inaccessible devices lead to higher costs and the potential need to close lanes to perform maintenance, which increases the potential for disruption of traffic.
4. Accuracy: Speed data must be accurate within 10% of the travel speed. Accuracy of other data such as volume and occupancy are secondary to the accuracy of speed data unless the detector is to be used as a point detector as well as part of a corridor detection system.
5. Comprehensive Data Capabilities: For corridor data collection, only speed and volume are typically necessary.
6. Location Precision: Precision is secondary to detector spacing. The exact location of the detector is not of high importance unless the detector is to be used as a point detector as well as part of a corridor detection system.

When placing corridor detectors to generate corridor speed data, spacing is the key design consideration. Optimal spacing is every 1 mile or less, but a range of 0.5 - 1.5 miles can be used.

INCIDENT DETECTION:

The purpose of an incident detection system along a corridor is to provide an automated alert to the STMC/RTMC/TMC and response personnel of potential roadway incidents. The system uses an algorithm that considers speed, volume, and occupancy to determine the presence of an incident. This configuration can serve in a dual function. Primary considerations for the placement of incident detectors are:

1. Spacing: Incident detectors should be spaced every 0.5 miles or less to be effective. The quantity and frequency of detectors correlate with the effectiveness of the overall system.
2. Cost: Due to the need for multiple detectors for incident detection, the cost of the system can quickly escalate. Choose detector types, locations, and communication methods that minimize the overall cost of the system. Collocate detectors on existing structures (e.g., CCTV poles) where possible to minimize the need for new structures, provided the 0.5 mile detector spacing remains.
3. Accessibility: Accessibility of the device for maintenance and repair purposes is of high importance, especially when many devices are necessary for a system. Inaccessible devices lead to increased costs and the potential need to close lanes to perform maintenance, which impacts traffic.
4. Accuracy: Speed data must be accurate within 10% of the travel speed. Accuracy of other data such as volume and occupancy must provide data within a 5% accuracy level.
5. Comprehensive Data Capabilities: For incident detection, only speed and volume are typically required.
6. Location Precision: Precision is secondary to detector spacing. The exact location of the detector is not of high importance, provided the 0.5 mile detector spacing remains.

Detection Technology

Use the system needs to select the appropriate technology. The detector technologies predominantly used for vehicle detection are – inductive loops, microwave/radar, Radio Frequency Identification (RFID) tag readers, Bluetooth, and video image detection systems. Table 28 lists advantages and disadvantages of each technology and Table 29 provides design guidance. Microwave/Radar is the preferred detector type by the Department; however, in certain applications inductive loops may be more accurate.

TABLE 28: DETECTOR TYPE ADVANTAGES AND DISADVANTAGES

Detection Technology	Design Advantages	Design Disadvantages
Induction Loop	• Mature, tested technology • Provides an array of data: volume, presence, occupancy, gap, and speed • Is not affected by inclement weather • Flexible design that satisfies a variety of applications	• Installation requires pavement cut • Cannot perform maintenance without interrupting traffic • Can reduce pavement life • Loops are required for every travel lane, increasing costs and complexity • Requires software system to interpret data feed • May require series of detectors to provide vehicle classification capabilities

Detection Technology	Design Advantages	Design Disadvantages
Microwave/Radar	• Widely used and tested technology • Non-intrusive technology – no pavement work is necessary • Multiple lanes can be detected using a single detector • Can be mounted to existing structures • Low installation costs	• Can be affected by rainy/snowy conditions • May require calibration after storm events • Obstructions such as guide rail, jersey barriers, roadway cut sections, and retaining walls may decrease accuracy • Requires setback from roadway – may cause problems in situations where ROW is limited • Requires software system to interpret data feed
Video Detection	• Widely used and tested technology • Non-intrusive technology – no pavement work is necessary • Can provide video images of the roadway to a TMC	• When mounted above roadway, traffic may be interrupted during installation • Can be affected by shadows and fog • Requires processing technology that can be expensive • Requires software system to interpret data feed

TABLE 29: DETECTOR TECHNOLOGY OPTIONS

Detector Technology	Structure Type	Available Data	Accuracy	Accessibility	System Cost
Inductive Loop	None (In pavement)	• Speed • Volume • Occupancy • Classification (special software and additional detectors required)	Moderate/ High	Difficult/ Intrusive	Low (single point)/ High (multiple lanes)
Microwave /Radar	35' Pole or Existing Structure	• Speed • Volume • Occupancy (special software required) • Classification (special software required)	Moderate	Easy	Low-Moderate
Video Detection	35' Pole or Existing Structure	• Speed • Volume • Occupancy • Classification	Moderate/ High	Moderate	Moderate-high (Also must consider additional hardware/ software needed)

Deployment Guidance

This section identifies deployment guidelines and criteria for each detector technology. The designer should use this section as a guide for deployment of the detector or system of detectors.

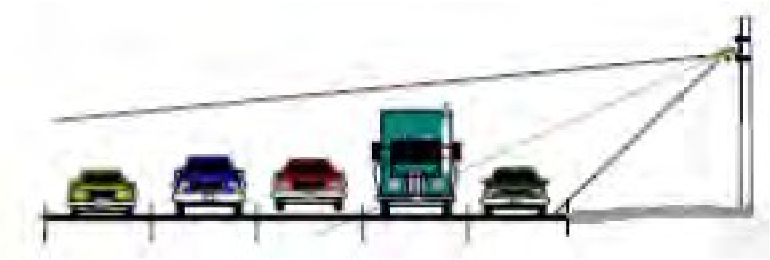
LOOP DETECTION

Loop vehicle detectors consist of a metal loop buried several inches beneath the pavement surface of the roadway and are positioned in the center of the traveling lanes. They utilize electrical induction from vehicles passing over the loop to detect vehicle presence. For specifics concerning the size and placement of the loop within the travel lane, the designer should adhere to the guidelines for Short Zones (non-sequential) in Chapter 7 of Publication 149 – Traffic Signal Design Handbook. For additional guidance concerning the placement of the loop within the travel lane, the designer should refer to Chapter 4 – Traffic Signals – Construction, Section 4.9 (Detectors) of Publication 46 – Traffic Engineering Manual.

MICROWAVE/RADAR DETECTION SYSTEMS

Radar detectors consist of a sensor mounted on the side of the road, angled down towards the travel lanes of the roadway. These sensors use a beam of microwave energy to collect vehicle data, including speed, and volume, and sometimes occupancy depending on the manufacturer and signal type. See Figure 16 for an illustration of a radar detector and its detection area. The detector software then divides this area into user-definable detection zones, where one zone corresponds to one lane.

FIGURE 16: MICROWAVE/RADAR DETECTOR ORIENTATION



When designing a microwave/radar detector location the designer must follow the steps below. Determine:

1. Detector Location (Detector location will vary based on their application)
    - If the detector is used for point data collection, the system needs may require a very specific detection area (e.g., a specific lane or entrance ramp, or a point on the main line). The designer should not place the detector outside of this detection area.
    - Corridor data collection system detectors must be spaced approximately 0.5-1.5 miles apart.
    - Incident detection system detectors must be spaced at a maximum 0.5 miles apart.

2. Detector Quantity
    - Radar detectors have a range of approximately 150 feet from the detector structure to the farthest detection point. At locations where the detection zone exceeds 150 feet, multiple detectors must be used. This typically occurs at locations where two directions of travel must be captured. For example, an expressway with three 12-foot lanes in each direction, two 10-foot shoulders, and a 75-foot median is a total of 157 feet. This exceeds the detection capabilities of a detector, so one detector on either side of the roadway is necessary to capture all travel lanes.

3. Mounting Height and Setback
    - **Mounting Height:** For a standard detection range of approximately 150 feet, the sensor should be mounted approximately 25 feet above the roadway. If the detector structure is located on an embankment or hill, the mounting height may be more or less than 25 feet from the base of the structure, depending on the structure elevation. Where installing MVD in forward-looking orientation above the roadway, mount the MVD at a minimum height of 17 feet 6 inches above road surface.
    - **Setback:** Detector setback is the distance from the edge of the nearest travel lane in the detection area to the detector itself. This setback is required so that the detector's radar beam can expand to cover the detection area. Newer radar detectors do not require a setback. However, a 20-foot setback from the edge of the closest detection lane is recommended.

Table 30 provides the recommended setback and height requirements as a function of lanes. This will vary, depending on the actual equipment used, so manufacturer's recommendations must always be considered during the site design.

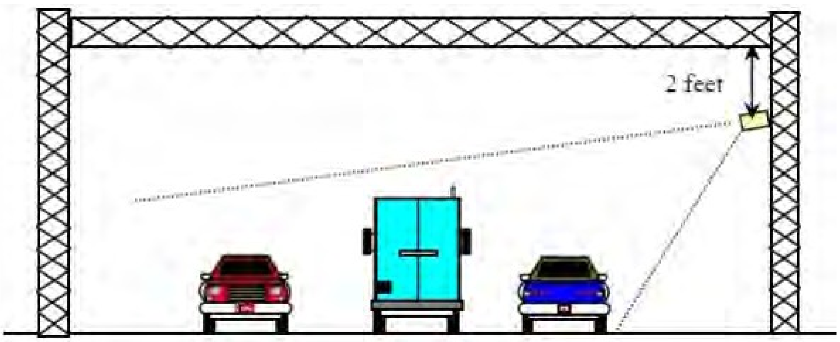
TABLE 30: MICROWAVE/RADAR DETECTION RECOMMENDED HEIGHT AND SETBACK

# of 12-ft. lanes including median	Minimum Set-back (Feet)	Recommended Height (Feet)
1-3	10-13	17
4	15	17
6	20	17
8	25	20
8+ Median	> 30	>23

4. Structure Type
    - Microwave detectors can be either free-standing on a 35-foot steel pole (as seen in Figure 17), or collocated with many existing structures such as:
        - Type A Sign Structures
        - Overhead Truss Structures
        - Bridge Structures
        - CCTV Poles
        - CMS

Microwave detectors are amenable to mounting configurations that vary from those listed above, including being mounted over a lane on a traffic signal mast arm, if the situation warrants this kind of deployment. This could include curve warning system detectors or other varying ITS systems. In mast arm configuration, follow the design guidelines for ETC tag reader mounted in this similar configuration. The designer should collocate radar sensors on any of the above structures where the structures coincide with required detector spacing, and where the structure satisfies the mounting height and setback guidelines. Mounting sensors on existing or new wooden poles is not acceptable.

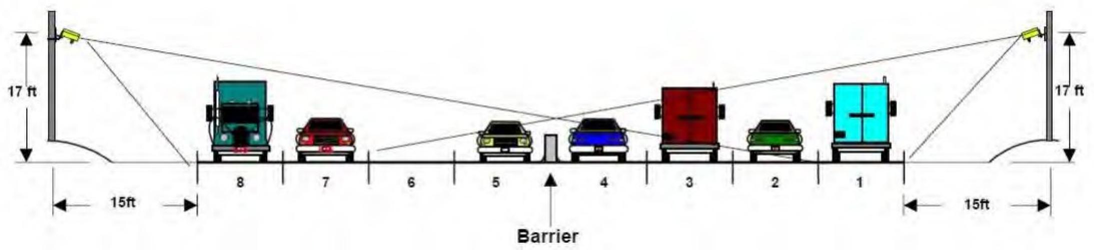
FIGURE 17: MICROWAVE/RADAR ON SIGN STRUCTURE



5. Obstructions

Microwave sensors can experience interference and disruption when obstructions such as guide rail, Jersey barriers, or high retaining walls are within the detection area. To minimize this interference, locations should be selected that minimize these obstructions. If obstructions are unavoidable, the designer should consider using multiple detectors to avoid the conflict. For example, if a roadway is separated by a jersey barrier median, one detector on either side of the roadway may be needed to capture all travel lanes. Figure 18 provides an illustration of deployments on roadways with obstructions.

FIGURE 18: MICROWAVE/RADAR DETECTORS ON ROADWAYS WITH BARRIER



VIDEO DETECTION SYSTEMS (VDS)

A Video Detection System (VDS) consist of a video camera mounted above the roadway, angled down towards the travel lanes. The system is configured using proprietary software to collect data only from predetermined zones within the travel lanes. This video image is then run through software processing to detect vehicle presence, speed, and volumes. When designing, the designer should follow the steps described below.

1. Detector Location (Detector location will vary based on their application)
   - If the detector is used for point data collection, the system needs may require a very specific detection area (e.g., a specific lane or entrance ramp, or a point on the main line). The designer should not place the detector outside of this detection area.
   - If the detectors are part of a corridor data collection system, they must be spaced approximately 1-1.5 miles apart.
   - If detectors are part of an incident detection system, they must be spaced at 0.5 miles or less.

2. Detector Structure
   - Since VDS cameras are located above the roadway, it is recommended that they are collocated on existing structures such as:
     - Bridges
     - Truss Structures
   - If collocation is not possible because of spacing or other system needs, new overhead structures must be constructed. Traffic signal mast arms are the preferred structure for mounting VDS cameras. Above-lane structures must provide a minimum of 17'- 6" clearance, including mast arms.

3. Detector Vertical Clearance and Quantity
   - VDS can detect vehicles on as many lanes as are contained in the video image. At a height of 30 feet, VDS can detect up to three lanes simultaneously. At a height of 20 feet, VDS can detect up to two lanes simultaneously. At heights less than 20 feet, only one lane can be detected per VDS camera.

4. Configure Detection Zones
   - VDS detect vehicles on the roadway based on a detection zone established within the detector software. Once installed, these zones must be defined for each travel lane that data is to be collected. Each proprietor of VDS technology utilizes a proprietary software system to define the detection zones.
   - Each detection zone must be defined such that only vehicles within the detected lane cross the zone. This will make certain that each detection zone gathers lane-specific data, and that vehicles are not counted more than once.

There are also video detection systems that utilize existing CCTV cameras, adding analytics to the back end of the CCTV image. These systems require additional hardware (video servers) in which the analytics are added prior to being used by a STMC/RTMC/TMC Operator. These systems have no adverse effect on the actual video but can provide input into the existing ATMS in which, once an incident has been detected, it would generate an alarm through ATMS or simply route the image to the video wall/monitor, thus notifying the Operator of the incident. These systems are very comprehensive, where the analytics re-learn the image every time the CCTV camera is adjusted through PTZ. Most new CCTV cameras have processing units included as a standard feature allowing for detection and analytics.

Enclosure Placement

When the VDS system includes devices that will be designed, constructed, and maintained, as Department-owned assets, the enclosure and its associated components must be included in the design process. Design criteria for a suitable ITS enclosure location includes the following:

- The enclosure for the VDS controller should always be pole-mounted on the VDS pole or existing structures to maximize cost savings.
- If possible, collocate the VDS cabinet components within another device enclosure.
- The enclosure should be oriented so that the maintainer is facing the roadway, while performing maintenance at the cabinet location.
- See manufacturer's specifications to determine the maximum distance between the enclosure and the field device it services.

When it comes to designing the enclosure, there is no standard size. There is a wide variety of component manufacturers to choose from, and this will usually impact the enclosure interior space requirements. In some case, co-located ITS devices may also share the same enclosure. This will further influence the design of the enclosure size. Standard Specifications for an ITS enclosure can be found in Publication 408, Section 1201 – ITS Devices – General.

Ramp Metering Systems

System Purpose

Ramp metering systems are installed on expressway on-ramps to control the frequency at which vehicles enter the flow of traffic on the mainline. The goal of the ramp metering system is to prevent multiple vehicles from entering an expressway when sufficient gaps for merging do not exist. When multiple vehicles enter the expressway mainline when space to merge is not ideal, they cause traffic to slow or change travel lanes, which disrupts traffic flow and ultimately causes congestion. Meters utilize traffic signals to space out vehicles on the ramps before they merge with the main line. Meters can separate vehicles by a matter of seconds or longer based on prevailing traffic conditions. Spacing of approximately two seconds is typical.

Ramp metering systems vary significantly in complexity. The simplest systems use a standard meter rate that operates regardless of traffic conditions. More complex, traffic-responsive systems consider traffic patterns in real-time, and adjust to meet the demands. The complexity of the system depends on the type of interchange, interchange geometry, and the volume and intensity of traffic on the ramp and mainline. Ramp meters are utilized in highly congested corridors or in urban areas. They are generally only installed at interchanges between limited access roadways and arterial roadways.

As part of the design of a ramp meter system, a comprehensive study must be completed prior to the development of the SER. These systems cannot be installed without sufficient justification. The design study will:

- Evaluate the interchange or corridor to determine the need for ramp meters

- Determine the net impact the meter will have on traffic flow
- Identify key design parameters

Table 31 lists relevant standards and requirements related to ramp metering deployments.

TABLE 31: RAMP METERING STANDARDS

Criteria	Relevant Standard
Ramp Meter Systems	• Ramp Management and Control Handbook, FHWA
Signs and Signals	• MUTCD • Publication 149 – Traffic Signal Design Handbook • Publication 236 – Handbook of Approved Signs
Communication and Software	• NTCIP 1207
Structure	• AASHTO • Publication 148 – Traffic Standards - Signals
Enclosure	• NEMA standards • Publication 408, Section 1201 – ITS Device Enclosure • Publication 408, Section 952 – Controller Assembly

Design Considerations

The criteria contained in this publication should be followed when designing a Ramp Metering System (RMS). There will be instances when the criteria in these guidelines cannot be met. Justification for the installation, despite not being able to meet all the criteria, should be detailed by the designer. The goal of this process is to provide practitioners with guidance as well as providing the Department consistency with respect to RMS installations. Table 32 provides an overview of the design considerations for RMS deployments.

TABLE 32: RMS DESIGN GUIDANCE

Pre-Design Planning
• Is this deployment consistent with the needs outlined in the SER? • Is this deployment consistent with the ITS architecture?
Ramp Meter Study
• Has a comprehensive Ramp Meter Study been performed? • Do the results of the study support continuing with the deployment project?
Lane Configuration
• Do the number of lanes and the vehicles per green design support the projected ramp volume?
Ramp Meter Location
• Is the meter placed such that enough stacking space is available on the ramp to accommodate the queues it will generate? • If the ramp meter consists of more than one lane, does it provide a sufficient distance for the lanes to merge prior to the merge with the mainline?
Ramp Meter Signals
• Are the signals vertically spaced such that the driver can see the signal heads while stopped at or just past the stop bar? • Are the signals in compliance with MUTCD Section 4I. Traffic Control Signals for Freeway Entrance Ramps? • Are the signals designed in compliance with Department requirements for Mast Arm Signal Poles, Signal Placement, and Signal Heads?
Vehicle Detectors
• Does the system design include all the necessary detection areas, demand, ramp, and mainline? • Does the complexity/configuration of the system require the additional detection area; passage, exit ramp, and entrance ramp?

Signing and Pavement Markings
• Do the signs and marking meet the MUTCD standards in Sections 2B.56 – Ramp Metering Signs and 2C.37 – Advance Ramp Control Signal Signs?
Enclosure Placement
• Is an enclosure required at this location? • Can personnel safely access the enclosure? • Is the enclosure located within 150 feet of the detectors? • Is it positioned such that maintenance personnel can view ramp meter signal heads? • Does the location and orientation provide adequate protection for the enclosure? • Has a site been chosen that considers maintenance?
Power Requirements
• Have the power requirements for the detector and all the system components been determined?
Power Availability
• Has an appropriate power source been located and confirmed with the utility company within a reasonable distance from the detector site? • Have Step-Up/Step-Down requirement calculations been performed? • Have the metering options been determined?
Power Conditioning
• Have the UPS and power back-up requirements been determined and accounted for?
Communications
• Have the communication requirements for the detector been determined? • Has an appropriate communication source been located and confirmed within a reasonable proximity to the site? • If there are multiple communication options, have the pros/cons been studied? • Has the chosen communications option been reviewed by OA/OIT? • If using public communications infrastructure, has service been coordinated with OA/OIT and the District?
Environmental
• Have all the necessary environmental, community, and cultural impact studies, processes and concerns been addressed?

Ramp Meter Study

To fully evaluate the impact that ramp meters have on a corridor, the designer must complete a comprehensive ramp metering study prior to development of the SER. This study will document the following:

- Need for the ramp metering system (traffic analysis)
- Anticipated benefits of the system (traffic analysis)
- Design parameters of the system (high-level concept)

The results of the study will determine if the system should or should not be deployed. If the study recommends deployment, the designer should utilize the study and the guidance contained in this document as a basis for development of the system requirements, design, and operation of the system. While it will not answer all design or installation questions, it will serve as a foundation for the system, and provide the parameters for operating the system. The specific design details that should be determined through the ramp meter study include:

- Lane Configuration/Number of Lanes
- Signal Location on Ramp
- Signal Type
- Detector Quantity and Type
- Detector Configuration
- Metered Rate

- Number of Vehicles per Green
- Advanced Traveler Warning Signage and Systems

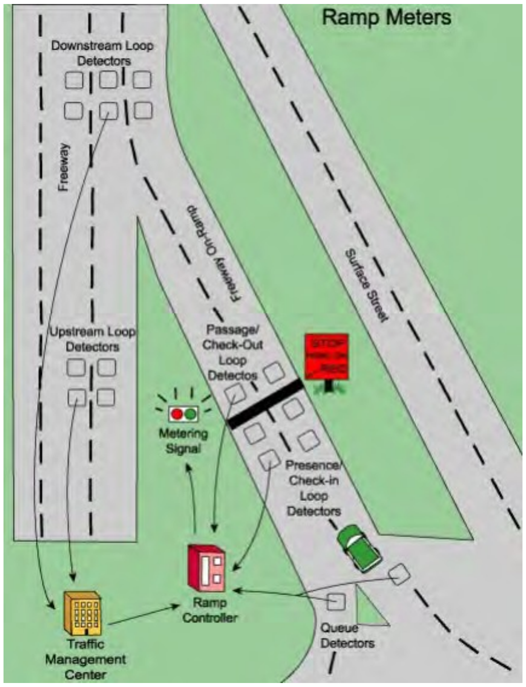
Ramp Meter System Components:

A ramp metering system consists of various components. Often these components are elements within larger freeway management architectures. These components are:

- **Ramp Metering Signal and Controller:** The signal is typically located to the drivers left, or on both sides of the ramp. Each ramp meter typically has one nearby weatherproof control cabinet which houses the controller, modem(s), and inputs for each loop.
- **Advanced Warning Signage:** MUTCD recommends one or two advance warning signs with flashing beacons indicating that ramp metering is active.
- **Check-In Detector:** Also known as the demand detector the check-in detector is located upstream of the ramp metering cordon line. The check-in detector notifies the controller that a vehicle is approaching and to activate the green interval.
- **Check-Out Detector:** Also known as the passage detector the check-out detector is located downstream of the ramp metering cordon line. The check-out detector notifies the controller that a vehicle has passed through the ramp meter and that the signal should be returned to red.
- **Merge Detector:** This is an optional component which senses the presence of vehicles in the primary merging area of the ramp.
- **Queue Detector:** Located on the ramp, upstream of the check-in detector. The queue detector prevents spillover onto the surface street network.
- **Mainline Detectors:** Located on the freeway upstream, and downstream of the on-ramp.

Ramps themselves must possess characteristics suitable for metering, namely the availability of vehicle storage space on the ramp and adequate acceleration and merge distance downstream of the meter cordon line. Storage requirements to prevent queues from backing up onto the arterial network can be estimated from the projected metering rate and ramp demand. Figure 19 illustrates a typical ramp meter system site layout.

FIGURE 19: TYPICAL RAMP METER SYSTEM SITE LAYOUT



Ramp Meter System Design

LANE CONFIGURATION

Ramp metered entrance ramps can be comprised of single or multiple lanes. To determine the number of metered lanes, the designer must take two factors into account: vehicle volumes and the number of vehicles per green period. The number of lanes must be determined in the ramp metering study. However, the Ramp Management and Control Handbook published by the FHWA provides guidelines to determine the number of lanes based on ramp volumes. The handbook also contains guidelines for the number of vehicles to allow per green period which is provide in Table 33.

TABLE 33: RAMP METER LANE DETERMINATION

Ramp Volumes	Number of Metered Lanes	Vehicles per Green
<1,000 veh/hr	One Lane	Single
1,000 – 1,200 veh/hr	One Lane	Dual
1,200 – 1,600 veh/hr	Two Lanes	Single
1,600 – 1,800 veh/hr	Two Lanes	Dual

The FHWA Ramp Management and Control Handbook recommends that ramp lanes have a width of at least 12 feet, an inside shoulder width of 4 feet and an outside shoulder width of 8 feet. These guidelines should be used as rules of thumb when determining the appropriate number of ramp metered lanes. Other considerations such as project budget, environmental disturbance, existing structures, and other factors may influence the final design.

RAMP METER LOCATION

The location of the ramp meter and ramp meter signal stop bar must be placed at a location on the entrance ramp that balances the need for upstream queuing area and downstream acceleration and merge area. The meter must be placed such that enough stacking space is available on the ramp to accommodate the queues it will generate. The designer should utilize the methods of calculating queue storage requirements as described in the Ramp

Management and Control Handbook - Chapter 9. As a rough estimation, queue lengths can be calculated by subtracting the metering rate from ramp volume over a specific period. A commonly utilized rule of thumb is that the ramp should accommodate a queue of 10% of the peak hour volume. For example, if the peak hour volume is 1,000 Vehicles per Day (VPD), the approximate stacking area should accommodate 100 vehicles.

Special consideration should be given to multi-lane ramp meter locations. Ramp meters consisting of more than one lane must provide a sufficient distance for the ramp lanes to merge prior to its merge with the mainline. This may increase the distance required from the meter to the mainline/ramp merge point to accommodate acceptable acceleration distance. The exact location of the ramp meter on the entrance ramp will come from the ramp meter study. Information included here are to be used to determine general placement areas but will not address the needs of each unique situation.

RAMP METER SIGNALS

Single lane ramps should utilize a signal pole (vertical pole) with two mounted signal heads, placed on the left side of the stop bar. The signals should be vertically spaced such that the driver can see the signal heads while stopped at or just past of the stop bar. A duplicate pole on the right side of the ramp can supplement the left side signal if deemed necessary.

Two lane ramps should utilize two signal poles, one on either side of the ramp. For multi-lane ramps using staggered or multi-vehicle green periods, FHWA recommends that two signal heads be used per lane. The MUTCD, 2009 edition, provides standards for all traffic signal applications. Ramp meter designers must follow the standards in Section 4I. Traffic Control Signals for Freeway Entrance Ramps of the MUTCD. The following items should be considered when placing signal supports:

- Signal supports should be placed as far as practical from the edge of the traveled way without adversely affecting the visibility of the signal indications
    - Refer to Publication 13M – DM Part 2 – Highway Design for roadside design elements

VEHICLE DETECTOR

Ramp metering systems require a series of vehicle detectors to provide input on various pieces of motorist information. While inductive loops have typically been used as the primary method of detection, other technologies can be used for detection as well, provided they produce all the input information required by the ramp meter controller. Viable technologies for vehicle detection include inductive loops, microwave detection, and VDS. However, many controller algorithms are designed to incorporate and utilize loop or loop imitator (such as VDS) data. Extra calibration may be required if non-loop detectors are used in the ramp metering system. See **Vehicle Detectors** chapter for more information regarding vehicle detection options and installation guidelines.

Ramp metering systems employ a series of detectors at key locations. Depending on the complexity of the system, some or all the detector locations may be deployed. Table 34 provides a summary of the ramp metering system detectors that may be used in a deployment.

TABLE 34: DETECTOR TYPES

Purpose	Description
Demand Detector	Located at the stop bar. Detects the presence of vehicles at each ramp meter lane. Also referred to as a check-in detector.
Passage Detector	Located just across the stop bar. Detects when vehicles pass the ramp meter. Also referred to as a check-out detector.
Ramp Queue Detector	Located at the intersection of the ramp and the surface street. Detects when the queue is at or exceeding ramp capacity. Intermediate ramp queue detectors may also be utilized.

Purpose	Description
Mainline Detector	Located at one or more location on the expressway/freeway mainline. Detects capacity of mainline, existing congestion, and speeds of each travel lane. Data can be used for data collection, and/or fed into the controller algorithm for traffic-responsive ramp metering systems.
Exit Detector	Located on exit-ramp at the metered interchange. Provides volume information to be used for system-wide, traffic-responsive ramp meter operations.
Entrance Detector	Located on non-metered entrance-ramps. Detects volumes entering the mainline of a ramp metered roadway. Volume information is entered into a corridor wide traffic-responsive ramp metering system.

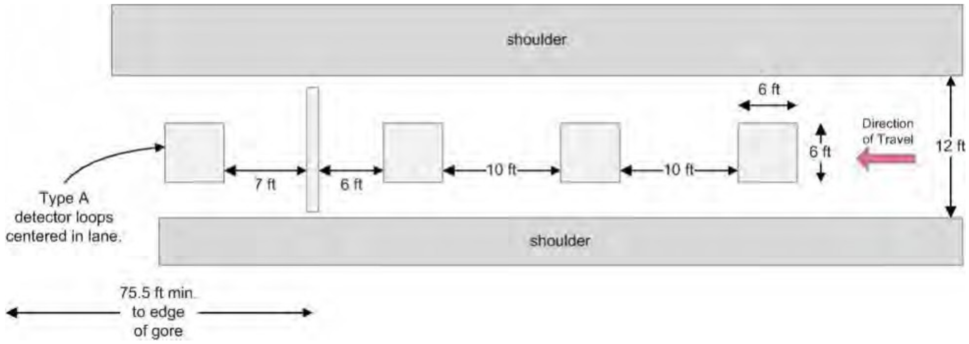
DEMAND DETECTION AREA

The demand detector detects the presence of vehicles at the ramp meter stop bar. These detectors are essential for ramp meter operation because they tell the system when to activate. The detection area for the demand detector should be approximately 45 feet, or the length of approximately two vehicles. The demand detection area must cover all metered lanes.

PASSAGE DETECTION AREA

The passage detection area is used to detect vehicles passing through the ramp meter system. This provides the system with vehicle volumes entering the roadway and provides confirmation that the vehicles are obeying the ramp meter signals. Depending on the type of system, this detection area may or may not be essential to ramp meter operations. Figure 20 displays a typical inductive loop passage detector/demand detector configuration.

FIGURE 20: TYPICAL DEMAND AND PASSAGE LOOP DETECTOR CONFIGURATION



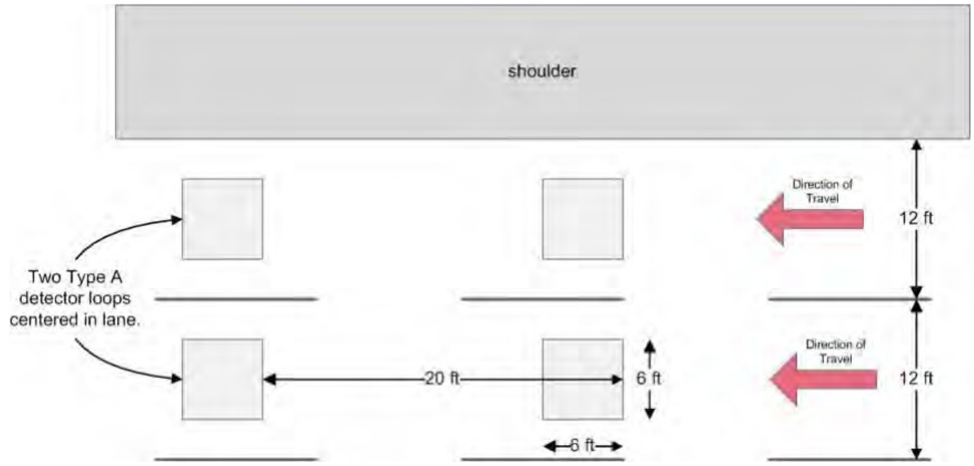
RAMP QUEUE DETECTION AREA

Ramp queue detection area is essential to a traffic-responsive ramp metering system. The detector is located at the top of the ramp, near the intersection with the surface street. It senses when a ramp is at capacity, and if the queue is in danger of reaching or backing up onto the surface street. Additional detection zones may be set up at midway points on the ramp to detect general queue size. Queue detection is a crucial input for a traffic-responsive system algorithm and must be included in the ramp meter system.

MAINLINE DETECTION AREA

Mainline detection areas are located on the freeway thru lanes just upstream of the ramp gore area. The zone must include all thru lanes. This detection zone provides essential mainline traffic operation data such as speed and volume. These data are inputs to the ramp meter algorithm that are necessary to determine the available capacity of the main line. Available capacity in turn determines the meter rate. If using loops, multiple loops must be installed in sequence to accurately detect speeds and vehicle queues. Figure 21 displays a typical inductive loop mainline detector configuration.

FIGURE 21: TYPICAL MAINLINE INDUCTIVE LOOP DETECTOR CONFIGURATION



EXIT RAMP DETECTION AREA

Exit ramp detection area is located at some point on the exit ramp of an interchange equipped with a ramp metering system. The intent of this detection area is to collect vehicle volume data, which is used in many ramp metering system algorithms. While exit ramp detection is desirable, it may not be a requirement for a functional, traffic-responsive ramp metering system. The need for exit ramp detection will be determined by the ramp metering algorithm selected for the project.

ENTRANCE RAMP DETECTION AREAS

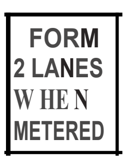
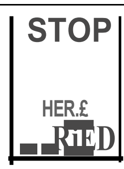
Entrance ramp detection areas can be located on ramps that are not metered but are within a ramp metered corridor or system. These detection areas are intended to collect volume data from vehicles entering the mainline, which decreases its available capacity. While these volumes are not required, they are inputs to many ramp meter algorithms.

RAMP METER SIGNING AND PAVEMENT MARKINGS

Ramp meter technology is currently not a typical traffic management method utilized in the Commonwealth. Drivers are generally not accustomed to ramp meters, so any installation may cause confusion and unsafe conditions if not properly announced to motorists. If motorists do not expect ramp meters, they may swerve, make other erratic motions, or brake abruptly causing unsafe conditions. Abundant, well placed, clear signage and pavement markings are critical to effective and safe ramp meter installations. The need for signage increases with the complexity of the system. For example, ramp meters at high-volume or freeway-to-expressway interchanges require a network of signage that includes overhead signs equipped with flashing beacons.

Ramp Management and Control Manual signs must adhere to Publication 236 – Handbook of Approved Signs as well as MUTCD standards (see Section 2B.56 – Ramp Metering Signs, 2C.37 – Advance Ramp Control Signal Signs, and 4I – Traffic Control Signals for Freeway Entrance Ramps for specifics on Ramp Metering signs) (See Figure 22). These signs may be equipped with flashing beacons that activate upon ramp meter operation to increase the visibility of the sign. The use of flashing beacons should be determined on a project-by-project basis and must be approved by the Department.

FIGURE 22: FHWA RAMP MANAGEMENT AND CONTROL MANUAL RAMP METER SIGNAGE

Sign	Location	Application
	Can be optionally placed either on the signal pole or with the "Stop Here on Red" regulatory sign under a mast arm configurati on. There area also signs that state "Two vehicles per green" for dual release.	This regulatory sign is used to inform motorists of the intended traffic control method under ramp metering operations.
	Can be places on the signal pole.	This regulatory sign is used when converting a nonmetered HOV bypass lane to a metered operation . Also may be used on new installations where potential for confusion exists.
	Placed upstream of the ramp meter and downstream of the "Meter On" sign.	This advance warning sign informs the motorist that the ramp meter is turned on.
	Placed upstream of the ramp meter.	This warning sign is used to inform motorists that a traffic signal is ahead and to be prepared for the potential to stop.
	Placed approximately 100 feet downstream of the stop bar on the right side of the ramp when there are two ramp lanes that merge prior to entering the freeway.	This warning sign is used to inform motorists of the need to merge with another ramp lane prior to entering the freeway mainline.
	Placed on the arterial approximately 200 feet up-stream of the ramp entrance point. The sign should generally be placed on the right side of the arterial	The warning sign is used when ramp metering is in continuous use to alter the motorist of the upcoming controlled ramp.
	Placed on the arterial approximately 200 feet upstream of the ramp entrance point. The sign should generally be placed on the right side of the arterial.	This warning sign is accompanied by a yellow flashing beacon that is activated during metered period to alert motorists of the upcoming controlled ramp.
	Positioned near the beginning of the dual-lane queue storage reservoir on the right side of the on-ramp (or positioned on both sides of the ramp).	This regulatory sign is used to convert the single lane on-ramp into a dual-lane queue storage reservoir during ramp meter operati ons.
	Placed on both sides of the on-ramp at the signal stop bar. This sign is placed on the signal pole under the post-mounted configuration.	This regulatory sign identifies the signal stop bar location and is used to align drivers over the demand detectors placed upstream of the stop bar.

Ramp metering systems should utilize pavement markings consistent with standard signalized intersections and freeway ramp operations, including stop bar, merge lines, and dashed lane separator lines. All pavement markers should conform to the guidelines set in Publication 111 – Pavement Markings and Signing Standards as well as the MUTCD, Part 3 – Markings.

Enclosure Placement

The ramp controller system consists of a cabinet, controller, load switches, input files, loop amplifiers, and other miscellaneous devices, very similar to traffic signal systems. The controller must be capable of meeting the needs and functions outlined in the ramp metering study. Many standard off-the-shelf controllers are available that meet the general needs of a ramp metering system. The most common controllers are Type 170s or Type 2070s. The Model 170 controllers are becoming obsolete, so new installations should utilize the Advanced Transportation Controller (ATC), except in cases where it will conflict with existing systems and/or system software. All ramp controller equipment should be housed in a standard NEMA cabinet. See manufacturer's specifications to determine the maximum distance between the control cabinet and the field device it services.

The cabinet must be positioned at the ramp meter location and must satisfy the following requirements:

- Easily accessible for maintenance, access should not require special vehicles or equipment.
- Positioned so maintenance personnel can access the cabinet and view ramp meter signal heads.
- Does not obstruct vehicle sight distance of the ramp or the ramp meter signal head.
- Either located outside of clear zone or behind a barrier such as guide rail.
- Connection to the STMC/RTMC/TMC or other location that controls and monitors the ramp meter.
- A concrete pad should be provided at the front of the cabinet for the maintenance worker to stand on while accessing the cabinet.

3.7 Other and Antiquated Devices and Systems

This section describes other and antiquated devices and systems that are no longer deployed as new or are being retrofitted with newer technology. Design guidance is provided here should an existing device need to be replaced.

Highway Advisory Radio

The Department is currently in the process of retrofitting its existing Highway Advisory Radio (HAR) systems with a virtual HAR. Instead of broadcasting traveler information over the radio, alerts will be received through PA511 or through a traveler-initiated phone call. Design guidance for virtual HARs will be provided once policies and procedures are developed and approved. Design guidance for a traditional HAR system is provided herein. Prior to designing any new HARs, contact the Planning and Funding Unit.

System Purpose

The primary function of the HAR is to provide traveler information. The nature of this information is varied, but the goal is to disseminate roadway condition information to travelers so that they can make informed decisions regarding their intended trip and/or route. Some typical HAR uses include notifying travelers of:

- Incidents and roadway/lane closures
- Adverse conditions
- Construction and maintenance operations
- Amber Alerts

- Homeland Security issues
- Scheduled Safety Messages
- Special event conditions

To maximize the effectiveness of a HAR and to reduce impacts to driver safety, placement must be carefully considered when designing and deploying any new HAR system. The design must satisfy the system purpose established in the operational requirements. For example, deploying the HAR to serve an interchange or along a corridor affects components of the design. The most important design consideration is the correct placement of the transmission structure and the HAR signs. Table 35 lists relevant standards and requirements related to HAR deployments.

TABLE 35: HAR STANDARDS

Criteria	Relevant Standard
Sign	• MUTCD, See Chapter 4L – Flashing Beacons • Publication 408, Section 1220 – Highway Advisory Radio System
Communication and Software	• Publication 408, Section 1202 – ATMS ITS Device Integration • Publication 408, Section 1204 – ITS Communications
Transmitter	• Publication 408, Section 1220 – Highway Advisory Radio System
Structure	• AASHTO
Enclosure	• NEMA standards • Publication 408, Section 1201 – ITS Device Enclosure

Design Considerations

The criteria contained in this publication should be followed when designing a new HAR. It is important to note/clarify however, that there will be instances where all the criteria in these guidelines cannot be met. Justification for deciding to go through with an installation, despite not being able to meet all criteria should be detailed by the designer. The goal of this process is to provide practitioners with guidance as well as provide the Department consistency with respect to HAR installations. Table 36 provides an overview of the design considerations for HAR deployments.

TABLE 36: HAR DESIGN GUIDANCE

Pre-Design Planning
• Is this deployment consistent with the needs outlined in the SER? • Is this deployment consistent with the ITS architecture?
Control Software
• Is the HAR compatible with the RTMC/TMC device control software?
Site Selection
• Are there any adjacent existing HAR systems and, if so, has coordination taken place with them? • Has a frequency search taken place? • Has an onsite listening survey been performed? • Has reception of the NOAA All-Hazards Alert System been verified? • If in an urban setting, have existing traveler information stations (e.g., AM news radio) been considered when justifying the new HAR placement?
Transmitter Location
• Is the potential transmitter site free of significant vertical (25 feet or higher) obstructions? • Is power (120VAC) and communication (telephone) service available at the site? • Is there sufficient open ground (at least 40-foot x 40-foot) for the cabinet and antenna installation? • If there are adjacent HAR transmitters, has message synchronization been built into the design?
Beacon Sign Location

• Have MUTCD sign standards been followed? • Are the signs visible and unobstructed? • Is the sign placed at the edge of the proposed broadcast range of the HAR transmitter? • Does the location of the sign allow the traveler to safely tune and then react to the message? • Are the signs placed sufficiently in-advance of any interchanges that serve detour routes? • Is it possible to collocate the sign/beacon with an existing CCTV camera for visual verification?
Licensing and Permits
• Has consideration been given to other HAR transmitters (not adjacent to the new site) along a particular route so that the same frequency can be used?
ITS Enclosure (Transmitter and Beacon locations)
• Is the enclosure located within 150 feet of the device? • Does the location and orientation provide adequate protection for the enclosure? • Has a site been chosen that considers maintenance?
Power Requirements
• Have the power requirements for the HAR and all the system components been determined?
Power Availability
• Have the power requirements for all the system components been determined? • Has an appropriate power source been located and confirmed with the utility company within a reasonable distance from the detector site? • Have Step-Up/Step-Down requirement calculations been performed where necessary? • Have the metering options been determined?
Power Conditioning
• Have the UPS and power back-up options been determined and accounted for?
Communications
• Have the communication requirements for the HAR been determined? • For wired communication, has an appropriate source been located and confirmed within a reasonable proximity to the site? • For cellular communication, has the required signal strength been verified at the site? • If there are multiple communication options, have the pros/cons been studied? • If using public communications infrastructure, has service been coordinated with OA/OIT and the District?
Environmental
• Have all the necessary environmental, community, and cultural impact studies, processes and concerns been addressed?

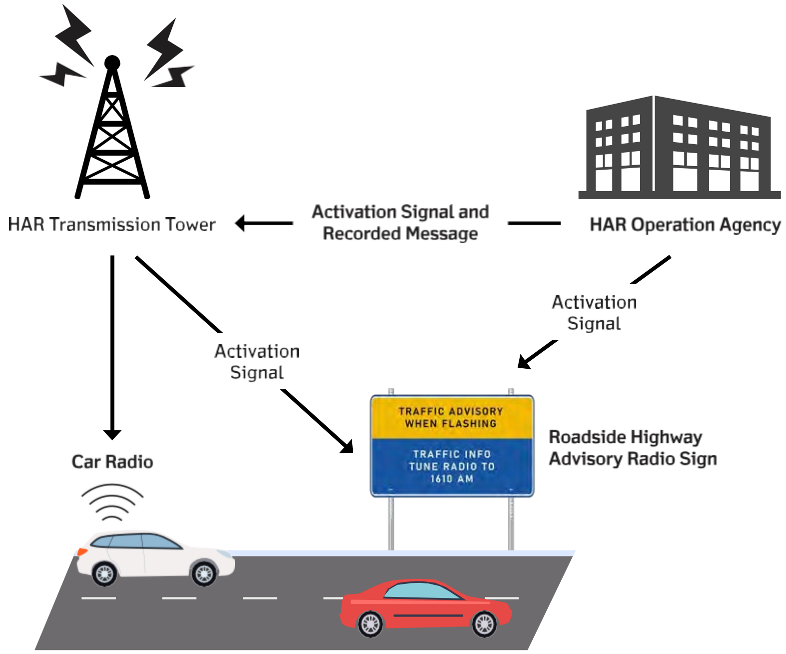
Highway Advisory Radio Components

The HAR system consists of three basic components:

- The device control software (located at the STMC/RTMC/TMC)
- A transmitter and antenna assembly
- Roadside signs

When an operator at the controlling agency activates the HAR system, a signal is sent to the HAR transmission tower, which then begins to broadcast either a custom or a standard message on the pre-designated frequency. The sign/beacon assembly contains a receiver which receives this same broadcast and activates the flashing beacons, alerting drivers that there is a message. The driver then tunes their car radio to the frequency posted on the sign to listen to the traveler advisory/warning. Figure 23 illustrates the components and high-level system overview.

FIGURE 23: HAR SYSTEM MODEL



Note: Communications can be Dual Tone Multi-Frequency (DTMF) or cellular.

HAR TRANSMITTER

The transmitter site setup typically consists of the following equipment:

- **Pole:** the HAR antenna and control cabinet must be installed on a 30-foot (minimum height) wooden utility pole. The pole must be in accordance with HAR system manufacturer's specification and Publication 408, Section 1220 – Highway Advisory Radio.
- **Antenna:** The antenna is center or top loaded vertical featuring a low loss embedded, weatherproof loading coil. The antenna system includes a ground plane consisting of #8 non-insulated copper conductors placed in a horizontal plane radiating from the center of the antenna, a minimum of 100 feet in radius, and at approximately equal angles from each other (See photo).
- **Antenna Cabinet:** The cabinet is an anodized aluminum, weatherproof enclosure. The cabinet should be lockable using contractor supplied construction cores and keys.
- **AM Transmitter:** The Transmitter is in the control cabinet. The amplitude modulated transmitter must be FCC type approved.
- **Voice Storage Unit:** Voice Storage unit is in the control cabinet. The voice storage unit shall digitally store messages. The unit should be equipped with dual tone multi frequency (DTMF) control capability where other communications are not utilized. With the limited availability of the RC-200 Receivers, this will be less of a requirement in the future. Industry vendors are moving forward with a different type of receiver that will allow for bi-directional communications, but no longer utilizes DTMF tones.
- **Digital Communications Controller:** Required for all digital communications to the HAR Transmitter (cellular, Ethernet over fiber, etc.).

- **GPS Synchronization Unit:** Utilized to synchronize adjacent HAR systems to accommodate corridor-wide broadcasts using 2 or more transmitters.
- **Weather Receive Module:** Receives weather condition reports directly from the National Oceanic and Atmospheric Administration.
- **Relay Panel and Power Supply:** Relay panel and power supply are in the control cabinet. The power supply must be capable of operating on 120 volts AC with an output of 12 volts.

There are a few options available for HAR transmission:

- 10-Watt AM Transmission (FCC License Required)
- Digital Highway Advisory Radio (FCC License Required)
- Low-Power AM Transmission (No FCC License Required)
- Low-Power FM Transmission (FCC License Required)

The most common method, and the one currently prevalent in Pennsylvania, is the 10-Watt AM transmission. All new HAR deployments should utilize this transmission method.

The maximum broadcast range, operating under ideal conditions (no buildings, flat terrain, etc.) is usually six to ten miles in diameter. Actual broadcast distance, for HAR currently deployed, is in the range of three to five miles in diameter. This is highly dependent on topography, atmospheric conditions, and the time of day.

HAR BEACON SIGNS

HAR signs direct motorists to tune to the HAR broadcast frequency when beacons above the sign are flashing. HAR signs (See photo) are typically located on major roadways and the approaches to major freeway interchanges, thus giving the motorist ample warning to avoid an incident or closure.

Flashing beacons and advisory signs are required at any new HAR system installation where a CMS cannot be utilized to alert motorists to tune into the HAR transmitter. However, beacons and signs are encouraged for all locations, despite the presence of CMS, to allow the CMS to disseminate other travel information not provided in an HAR broadcast.

The entire sign/beacon assembly consists of the following components:

- **Sign:** Must comply with Publication 111 – Pavement Markings and Signing Standards, the MUTCD, and be mounted on breakaway posts. Furnish beacon mounting hardware constructed of stainless steel. See fabrication details in Publication 647 – Civil and Structural Standard Drawings, and Publication 408, Section 1220 for details.
- **External Illumination and Flashing Beacons:** These are activated, either remotely or from the sign when there is a HAR broadcast to be heard. All beacons should be 12” amber LED.
- **Flashing Units:** Controls the flashing of the beacons, which should be between 50-60 flashes per minute.
- **Antenna and Mount (for radio-controlled signs):** Use a 3-element beam antenna fastened to a signpost with a mast mount.
- **Control Cabinet:** The control cabinet is a rain proof, lockable enclosure, anodized aluminum, with a hinged door, accessible from ground level.
- **Transmitter/Receiver:** The transmitter/receiver is in the control cabinet and must be capable of transmitting at the frequency licensed by the FCC.
- **Relay Panel and Power Supply:** The relay panel and power supply are in the control cabinet. HAR Beacon can also have solar panels for power when direct connection to power is not accessible.

- **Key Switch:** The key switch allows for control at the HAR sign and is mounted below the sign on a signpost. The key switch has three positions: "manual on" for control of the beacons at the HAR sign, "off" to turn the signs, beacons, and equipment off, and "auto on" to remotely control the sign.

HAR CONTROL SOFTWARE

Most PennDOT STMC/RTMC/TMC's utilize the DR2000TM Platinum HAR control software through the statewide ATMS. For the purposes of statewide standardization, it is required that any new HAR deployments be compatible with the existing software.

Highway Advisory Radio Design

Correctly locating the HAR system components is the key to its success. There are six steps that must be followed. They are:

- **Step 1: Coordinate with adjacent systems:** If there are existing HAR in the deployment area, coordinate the design and deployment of the new HAR with these other systems, even if they are in adjacent Districts or States. This can be done in one of two ways depending on the location of the device. The first option is to utilize a GPS synchronization unit within the HAR rack that coordinates the message between two or more transmitters. This allows a seamless transmission of the message when going from the coverage area of one transmitter to another. The second option is to turn down the broadcast range of the transmitter by decreasing the power of each transmitter. This will allow for each transmitter to play a different message without an overlap area in which neither of the messages can be distinguished when tuning into the radio station.
- **Step 2: Conduct a frequency search:** Develop a list of AM frequencies that are available. Consider what frequencies are currently utilized within the District, and in neighboring Districts along the same route. To maintain consistency for drivers, determine if these frequencies can be used on the proposed device. This should be written into the Contract for the Contractor to verify the available AM frequencies using site survey equipment.
- **Step 3: Survey onsite listening:** Survey the highway where listening is required with an automobile digital AM radio tuned to the candidate frequencies from Step 1. Monitor all the candidate frequencies throughout the listening area at least once during daylight hours and at least once after dark. Again, this should be performed by the Contractor so that the responsibility of obtaining the correct frequency is theirs. The Contractor should provide the Department a list of available frequencies at the site location, and the Department can direct the Contractor which frequency to obtain the license for.
- **Step 4: Choose a general location for coverage:** Find the approximate geographic center of the desired listening area. The HAR signal will propagate to a radius of 2-5 miles from this point in all directions (highly dependent on the terrain and topography). If this coverage does not encompass the highways that require coverage, consider the possibility of adding repeater stations. Consider where the system signs will be placed to announce to motorists entering the area that the signal is available.
- **Step 5: Determine the desired NOAA All-Hazards Alert System notification coverage:** Verify reception of a National Weather Service channel (162.400-162.550 MHz) at the desired location. See coverage areas online at this NOAA web link: https://www.weather.gov/nwr/county_coverage?State=PA
- **Step 6:** Choose a specific antenna location: See site guidance.

TRANSMITTER LOCATING CONSIDERATIONS

For best transmission coverage, the immediate location should be free of tall buildings, trees, terrain features, lighting, power and communication poles and towers, overpasses, and highway signs. Make certain that 120VAC power and communications are available at the site and that there is a 40-foot by 40-foot area of open ground for cabinet and antenna installation where possible. The preferred location is within an interchange loop or infield. Table 37 provides HAR transmitter site guidance.

TABLE 37: HAR TRANSMITTER SITE GUIDANCE

Criteria	Guidance
Site Obstructions	• Provide a 50-foot radius clear zone around the antenna • Should be on the highest ground possible to aid in reception of the transmission • Transmitter site should be free of objects that exceed 25 feet (two stories)
Interchanges	• Preferred sites for deployment, taking advantage of existing utilities and ROW • An opportunity to provide coverage on two roadways (highway and arterial) with one transmitter
Adjacent Transmitters	• Important to avoid overlaps so that conflicting messages are not transmitted • GPS Synchronization Units can be utilized to synchronize messages on overlapping HAR frequencies to avoid conflicting messages • Should be placed as close as possible, so that there is no significant gap in coverage

SIGN/BEACON LOCATING CONSIDERATIONS:

Strategic placement of the signs announcing the HAR is a key factor to its success. If signs are positioned poorly in relation to the transmitter radio waves, motorists are likely to think the station is not working and might be tempted to tune out, missing crucial information. Table 38 provides HAR sign and beacon siting guidance.

TABLE 38: HAR SIGN/BEACON SITING CONSIDERATIONS

Criteria	Guidance
Activation Signal	• Preliminary design/investigation of proposed sign sites must include a signal strength test (if wireless communication being used)
Sign Visibility	• Signs should be placed on straight sections of roadway where possible • Should be placed at least 800 feet from other static or changeable signs or other visual obstructions
Sign Placement	• Should be located at the edge of the broadcast range of the HAR transmitter. • Should be located far enough from the alternate route to give the motorist time to locate the radio channel (15-20 seconds), listen to message twice (approximately 120 seconds), and divert to alternate route • The distance from sign to alternate route on a 55 mph freeway should be a minimum of 1.5 to 2 miles, if the coverage area will allow this • The motorist should not have to take their attention from a difficult stretch of roadway (sharp curves, merges, etc.) to tune their radio to the HAR frequency
Device Collocation	• Where possible, design a HAR sign within sight of an existing (or planned) CCTV camera that can visually confirm the status of the flashing beacons • Not necessary, if designing the HAR system to have bi-directional communications with the STMC/RTCM/TMC

URBAN LOCATING CONSIDERATIONS

Prior to deploying HAR in urban areas, the designer should consider two factors: Channel availability and existing traveler information providers.

- Availability of useable, clear channels that provide reasonable radio coverage free of interference: The designer should determine that no adjacent frequencies interfere with the desired frequency broadcast. The selected frequency should encounter as little interference as possible from existing stations. This may be more difficult in urban areas due to the number of radio frequencies already being utilized by private media.

- Existing, private radio traveler information providers: If numerous private traveler information stations exist, the usefulness of an additional radio source may be minimal. The designer should determine the number of existing stations in the area that are providing traveler information at regular intervals and determine if the HAR is still necessary. Even if many traveler information stations exist, HAR are still effective tools for disseminating real-time, site-specific information that can be tailored by the Department to meet the needs of roadway users.

Licensing and Permits

An FCC Radio-Frequency (RF) license is issued specifically for the RF band, RF transmission level, related antenna type, and location (including height). An FCC RF license is required for each HAR application, including additions based on RF bands used in existing HARs. Traditionally, the choice of a HAR RF band has been left to the system supplier because HAR system suppliers are typically more familiar with the process of FCC RF license acquisition. The designer should note the following considerations:

- The RF band at 1640 KHz AM is used for all Pennsylvania Turnpike Commission (PTC) HARs throughout the turnpike toll-way system. Do not utilize this RF band to avoid interference with the PTC HAR system. Operating frequency should be in accordance with the FCC license application and research (530-1700 KHz inclusive).
- FCC license for RF bands at or near the bottom and top ends of the AM radio band is usually easier to obtain as these are commercially least desirable. However, avoid accepting RF band outside of the standard AM frequency range (530 KHz to 17000 KHz) because not all AM radios used in vehicles have the extended AM range (below 530 KHz, and between 1610 KHz to 1700 KHz). HAR broadcast at 1680 KHz is for example useless for many travelers as this frequency band is not available on most car radios.
- Where existing HARs are deployed along a corridor, give preference to the same RF band used in the existing system so related HAR signs along the same road are uniform.
- If possible, standardize a frequency along an entire route. Coordination with adjacent Districts may be necessary.
- FCC licensing is typically completed by the Contractor during construction, as the FCC will only issue a permanent license once the HAR transmitter is fully constructed. The FCC may issue a temporary license for a 3-month period before issuing a permanent license.
- Furnish HAR transmitter subsystem compliant with CFR Title 47, Section 2.901 (Part 2, Subpart J); Section 68, Connection of Terminal Equipment to the Telephone Network; and Section 90.242, Travelers' Information Stations.

Enclosure Placement

When the HAR system includes devices that will be designed, constructed, and maintained, as Department-owned assets, the enclosure and its associated components must be included in the design process. Design criteria for a suitable ITS enclosure location includes the following:

- The enclosure for the HAR controller should be pole-mounted on the antenna pole.
- The enclosure for the beacon should be mounted on the sign structure.
- The enclosure should be oriented so that the maintainer is facing the roadway, while performing maintenance at the cabinet location.

- See manufacturer's specifications to determine the maximum distance between the enclosure and the field device it services.

Standard Specifications for an ITS enclosure can be found in Publication 408, Section 1201 – ITS Devices - General.

Travel Time Systems

The Department purchases probe data from 3rd party entities and utilizes this data for congestion detection and/or travel times. This is the preferred method of the Department. Deployment of a new travel time system (detector based) may be considered on a case-by-case basis and requires Department approval.

System Purpose

The primary function of Travel Time Systems (TTS) is to provide motorists with an estimated travel time to a destination(s). Travel times may be displayed to the public in a variety of ways, including CMSs, PA511, mobile applications, and news/radio broadcasts. Travel time systems should be considered along freeways in urban areas, key commuter routes, and areas of frequent recurring congestion. The type of information distributed to the public varies greatly depending on the ownership of the data/equipment, detection method and reporting needs. A typical travel time system may consist of the following elements:

- Travel time detectors or probe data
- Travel time detector equipment (in enclosure in field)
- CMS's
- Static Travel Time Signs with changeable parts
- CMS control equipment (in enclosure in field)
- Communications cable/conduit
- Electrical cable/conduit
- Travel time software/hardware in STMC/RTMC/TMC
- CMS software/hardware in STMC/RTMC/TMC
- Control workstation in STMC/RTMC/TMC
- Travel time calculation algorithm

Figure 24 provides an example of a travel time display on a CMS.

FIGURE 24: TRAVEL TIME DISPLAY EXAMPLE

CMS location(s) and capabilities must be considered during the design of a travel time system. All CMS travel time display messages must comply with the Publication 200 – Changeable Message Sign (CMS) Operating Standards. To maximize the effectiveness and minimize the construction costs of a travel time system, the reporting needs, data ownership, detection method, and device placement must all be carefully considered when designing and deploying any new system.

First, the operational requirements and system reporting needs must be considered. These needs will specify the route on which the system will be implemented, and the key routes/locations that will be identified by the travel time notifications. Second, the Department must determine if it wishes to install, operate, and maintain the data collection equipment and the travel time calculation algorithm, or if it wishes to acquire this data through private 3rd party providers. The upfront capital costs and ongoing maintenance are the largest difference between approaches. Third, once ownership has been determined; the detection method (i.e., technology choice) may be selected with consideration to the reporting needs. The final step in this design process is the placement of the detection device; this is often dictated by the reporting needs and the detection method. The upfront capital costs and ongoing maintenance are the largest difference between approaches.

Design Considerations

The criteria contained in this publication must be followed when designing new TTS. It is important to clarify that there will be instances when all the criteria in these guidelines cannot be met. Justification for deciding to go through with an installation, despite not being able to meet all criteria should be detailed by the designer. The goal of this process is to provide practitioners with guidance as well as providing the Department consistency with respect to TTS installations. Table 39 provides an overview of the design considerations for TTS deployments.

TABLE 39: TRAVEL TIME DESIGN GUIDANCE

Pre-Design Planning
• Is this deployment consistent with the needs outlined in the SER? • Is this deployment consistent with the ITS architecture? • Have CMS display capabilities been considered in selecting the reporting needs?
Data Ownership/Acquisition
• Have departmental capabilities, reporting needs, funding, data quality, and existing infrastructure been considered in deciding data ownership/acquisition?
Detection Method
• If an RFID Tag Reader Vehicle Detector (RTVD) system has been selected; has a penetration study been completed? • Has RTVD or point vehicle detection been selected? • If not, has a plan for data capture and verification been created? • Has a cost-effective detection method been selected?
Detector Placement
• Have the reporting needs been used in selecting the locations to be monitored? • Have the CMS display capabilities been used to determine the number of travel time destinations? • Do the selected locations conform to spacing requirements? • Are existing structures, power, and communications being used wherever possible? • Are all field devices protected by guide rail and/or located outside of roadway clear zone?
Enclosure
• Is an enclosure required at this location? • Is the enclosure located within 150 feet of the detector? • Is the enclosure mounted on an existing structure (where possible)? • Does the location and orientation provide adequate protection for the enclosure? • Has a site been chosen that considers maintenance?
Power Requirements

• Have the power requirements for the detector and all the system components been determined?
Power Availability
• Has an appropriate power source been located and confirmed with the utility company within a reasonable distance from the detector site? • Have Step-Up/Step-Down requirement calculations been performed? • Have the metering options been determined?
Power Conditioning
• Have the UPS and power back-up options been determined and accounted for?
Communications
• Have the communication requirements for the detector been determined? • Has an appropriate communication source been located and confirmed within a reasonable proximity to the site? • If there are multiple communication options, have the pros/cons been studied? • If using public communications infrastructure, has service been coordinated with OA/OIT and the District?
Environmental
• Have all the necessary environmental, community, and cultural impact studies, processes and concerns been addressed?

Data Ownership/Acquisition

A key decision in the design of a travel time system involves the acquisition and ownership of travel time data. Private service providers can offer flexibility to the Department and is the preferred approach. The Department must decide between outsourcing its travel time data and collecting the data on its own. This decision must be based on several factors including Department capabilities, reporting needs, data quality, funding, and existing infrastructure (e.g., overhead structures, communications, electrical service, etc.). Table 40 provides considerations for each of the factors.

TABLE 40: DATA OWNERSHIP CONSIDERATIONS

Consideration	PennDOT Owned	Service Provider
Department Capabilities	• In house staff or consultant required to operate travel time system • IT staffing or consultant needed to maintain travel time calculation algorithms	• Can minimize the staff required to operate system
Reporting Needs	• New, travel time detectors are more easily installed along roadways with existing structures, communications, and electrical service.	• A large and diverse travel time network may be more easily facilitated by a service provider • PennDOT may not own the data acquired by a service provider
Funding	• Department-owned devices may represent a significant initial cost	• May represent a low initial cost, followed by a recurring service fee
Data Quality	• High data quality can be achieved where desired	• Data quality dependent on outside factors (ridership, sensor locations)
Existing Infrastructure	• Significant infrastructure may be required	• Service providers require little/no additional infrastructure

While considering these factors, the Department must decide who will own, operate, and maintain the travel time data acquisition system. If the Department chooses to outsource this, a private service provider must be selected based on the reporting needs defined in the SER. If the Department chooses to design and install a Department-owned travel time data acquisition system, a proper detection method must be selected. Department ownership and operation of travel time data, and in-house travel time calculations are most suited to situations such as:

- Districts with in-house IT staff and resources capable of maintaining the devices and software.
- Areas with extensive existing infrastructure, where the need for new infrastructure is minimized.
- Districts that prefer the use of internal staff.

Department outsourcing or contracting of services to provide travel time data is most suited to situations such as:

- Areas where an expansive network of fixed traffic sensors does not exist.
- Regions where a combination of freeway and arterial travel times is desired.
- Districts where the reporting needs extend beyond the urban area.

Detection Methods

The detection method is determined through careful consideration of the reporting needs, system ownership, cost, and existing infrastructure. The most prominent technologies are summarized in Table 41. Probe data service from INRIX is the preferred option, the Department currently is under contact for these services. The Department must provide approval to utilize other detection methods.

TABLE 41: DETECTION METHODS

Detection Methods	Method	Components	Example
RFID Tag Reader Vehicle Detector	Direct origin-to-destination detection of travel time using RFID transponder	• Lane kit (1 per 2 lanes) • Tag Reader (in cabinet) • TRANSMIT Software housed in RTMC/TMC*	• EZ Pass Readers - PennDOT District 6-0
Point Vehicle Detection	Fixed detection of traffic volume and capacity	• Pole mounted detectors spaced at a fixed interval • NO cabinet in field • Software - ATMS	• Traffic.com, RTMS, Wavetronix
Bluetooth Technology	Cell phone/ GPS/Bluetooth devices as probes	• Base unit • Cellular modem • Mounting pole	• TraffiCast/Blue Toad - PennDOT District 6-0
Probe Data Service Provider	Fleet GPS data collected to determine travel times	• None-Data feed is provided and is then incorporated into control software	• INRIX

*PennDOT owns a user’s license for the TRANSMIT software.

Due to the RTVD system’s reliance on RFID tag usage, it may be necessary to first complete a Penetration Study along the selected route. The purpose of the Penetration Study is to determine if there is sufficient tag usage along the targeted route; ensuring that there will be enough data to provide accurate travel times. A penetration rate greater than 10% is recommended. Due to the proliferation of RFID tags throughout the state, this should be easily satisfied. Each detection method presents various advantages and disadvantages, some of which are presented in Table 42.

TABLE 42: DETECTION METHOD ADVANTAGES AND DISADVANTAGES

Detection Methods	Advantages	Disadvantages	Ideal Situation
RFID Tag Reader Vehicle Detector	• Accurate, proven technology • Currently implemented	• Limited to overhead installations • Only 2 lanes of coverage per detector	• Freeways with existing infrastructure (e.g., overhead structures, communications, electrical service, etc.)

Detection Methods	Advantages	Disadvantages	Ideal Situation
Point Vehicle Detection	• Low cost when co-located with other devices • Proven technology	• Multiple detectors required • Requires advanced software algorithm for travel time calculation	• Small monitoring area with existing infrastructure
Bluetooth Technology	• Large area can be monitored with one installation • Low cost	• Data accuracy not guaranteed and needs verification	• Multi-lane freeways (due to large monitoring range) and all typical roadways
Probe Data Service Provider	• No infrastructure required • Large coverage area	• Data sharing issues • Dependence on third party data	• Areas without existing infrastructure. Where arterial travel times are desired. Rural areas

Detector Placement

Once the detection method has been selected, it is possible to begin the device placement phase of design. Device placement is most heavily dependent on the reporting needs and detection method. The reporting needs will specify the key destinations that will be part of the travel time system. Table 43 provides guidance on typical detector placement scenarios.

TABLE 43: DETECTOR PLACEMENT

Detection Method	Detector Placement
Origin to Destination (Refer to Figure 25)	• At the message display point (i.e., CMS) • Number of destinations should not exceed CMS display capabilities • At key destinations (e.g., major interchanges)
Point Vehicle Detection	• Detectors placed at a fixed interval (maximum spacing of ½ mile) along the roadway segment
Probe Data Service Provider	• No field devices required

FIGURE 25: ORIGIN-DESTINATION TRAVEL TIME SYSTEM LAYOUT

Ideally, travel time field devices are located on existing structures, and utilize existing communications and power connections. If this is not possible, the considerations outlined in the table below (Table 44) should be referred to when selecting the site and placing field devices.

TABLE 44: SITE SELECTION CONSIDERATIONS

Criteria	Guidance
Utility Availability	• Consider proximity to power and communications • If fiber optic communication is used, try to place the device on the same side of the roadway to eliminate lateral crossings
Safety and Device Longevity	• Ideally, locate devices outside of roadway clear zone • Protect mounting structure with guide rail inside of clear zone, but consider lateral deflection and maintenance vehicle access • Medians are not the preferred location, but wide medians may be considered if suitable roadside locations are not available • To reduce site erosion, reduce construction costs, and provide longer device structure life, avoid locating the mounting structure on sections that have a fill slope of greater than 1V:3H.
Operational Considerations	• Install in urban areas, along key commuter routes, and other areas of frequent recurring congestion
Maintenance Considerations	• Refer to Chapter 4 – Maintenance Considerations
CMS Display Capabilities	• If the CMS is only capable of displaying one destination, only one destination detector is necessary. If the CMS can display multiple destinations (2-3), more detectors may be deployed.

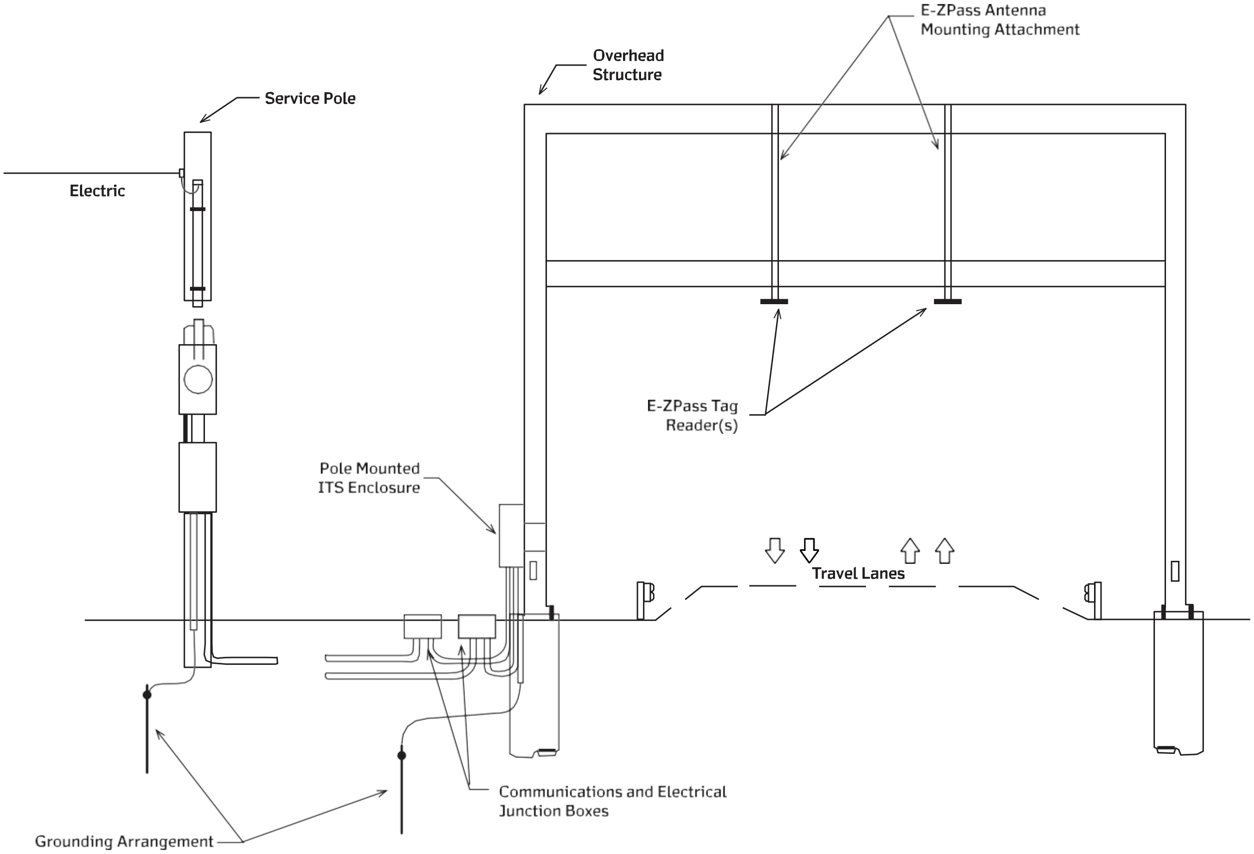
RFID TAG READER VEHICLE DETECTOR

RFID Transponder based Vehicle Detectors involve an overhead lane kit and an RFID tag reader that is in a roadside cabinet. One lane kit, when mounted directly over the roadway (over the center line), is capable of monitoring two lanes. The lane kit mounting techniques, in order or preference are:

1. On an existing overhead sign structure
2. On an overhead bridge (with coordination from the District Bridge Unit)
3. Mounted on a new traffic signal mast arm

All installations must maintain a minimum vertical clearance of 17’-6” (max height of ~18’, see manufacturer specifications). Figure 26 provides a typical RTVD system layout on an existing structure.

FIGURE 26: RTVD INSTALLATION ON EXISTING STRUCTURE



An RTVD installation requires a cabinet. Consider the following when selecting cabinet location and mounting:

- The cabinet must be installed in the vicinity of the lane kit (within 150 ft; for larger distances consult manufacturer).
- Mount on existing structures (where possible) to maximize cost savings.
  - These cabinets are of considerable size and pole mounting may not be possible.
- If no suitable poles/structures are available, the cabinet may be ground mounted at a more convenient location with easier access, such as adjacent to a frontage road.

POINT VEHICLE DETECTION

Point vehicle detection systems consist of a series of roadside detectors (typically pole mounted) located at a fixed interval along the route. Point vehicle detectors can be somewhat hampered by typical roadway obstructions (e.g., sound walls, median guide rail, etc.), which frequently limit their ability to monitor all lanes in both directions of travel. However, when mounted correctly, and in an obstruction free environment, they are often capable of monitoring a complete roadway.

Detectors should be located on existing structures and should utilize existing power and communications connections, wherever possible. To provide accurate travel time data from one point to another, it is necessary to place point detectors along the entire segment (at ½ mile spacing). If device placement exceeds this allowed spacing, the quality of the data will be diminished, to the extent that it may not be fit for public dissemination.

Point vehicle detector installations often require a cabinet located in the general vicinity of the detector; however, they are not required for all installations. Consider the following when selecting cabinet location and mounting:

- The cabinet must be installed in the vicinity of the detector (within 150 ft; for larger distances consult manufacturer).
- Cabinets should be mounted on existing structures (where possible) to maximize cost savings.
- If the existing structure is not suitable, the cabinet may be ground mounted at a more convenient location with easier access, such as adjacent to a frontage road.

BLUETOOTH TECHNOLOGIES

Bluetooth technologies involve a pole mounted wireless base unit with no other field equipment. One Bluetooth base unit has a sensing range of 175 feet and is thus capable of monitoring many lanes in both directions, often covering full roadways. The large sensing range of a Bluetooth base unit allows flexible site placement. The device needs to be positioned along the side of the roadway at a height of six to ten feet. The device does not require an overhead structure, and can be mounted on a new pole, or on an existing structure.

PROBE DATA SERVICE PROVIDERS

If a probe data service provider is selected as the travel time data provider, no device placement is required. Probe data service providers collect private data from a variety of GPS-enabled devices (cell phones, transponders, GPS navigation devices, etc.) and provide travel times in the following manner:

- The probe data service provider establishes a data sharing relationship with various companies (e.g., UPS, FedEx, etc.).
- The provider collects data from GPS enabled devices on fleet vehicles from these companies
- The service provider then utilizes this data from their fleet vehicles, crowd sourced data, mobile app data, and other sources to generate average travel times.
- This data can then be provided directly to the Department via an XML feed (other formats are typically available).

Enclosure Placement

When the travel time system includes devices that will be designed, constructed, and maintained, as Department-owned assets, the enclosure and its associated components must be included in the design process. Design criteria for a suitable ITS enclosure location includes the following:

- When possible, the enclosure for the travel time controller should be pole-mounted on the detector pole or existing structures to maximize cost savings.
- In locations where the pole is difficult to access, the enclosure may be ground-mounted at a more convenient location with easier access, such as adjacent to a frontage road.
  - The enclosure is to be placed in the safest possible location, generally along the right shoulder.
  - A ground-mounted enclosure should be located at a minimum distance from the barrier, based on the design and type of barrier used. See standard drawings for appropriate minimums.
  - The enclosure should be oriented so that the maintainer is facing the roadway, while performing maintenance at the cabinet location.
- See manufacturer's specifications to determine the maximum distance between the enclosure and the field device it services.

When it comes to designing the enclosure, there is no standard size. There is a wide variety of component manufacturers to choose from and this will usually impact the enclosure interior space requirements. In some case, co-located ITS devices may also share the same enclosure. Standard Specifications for an ITS enclosure can be found in Publication 408, Section 1201 – ITS Devices – General.

Chapter 4. Maintenance Considerations

An important consideration in the design of ITS device locations is providing access to the device, the associated enclosure, and the electrical service point for on-going maintenance activities during the life of the device. Each device will be visited several times per year on average for activities ranging from basic preventative maintenance to complicated repairs or replacement. Maintenance personnel must have a safe and functional area to perform such activities. Provision for maintenance access must be designed into the device site and in some cases, may drive site selection. If a suitable site cannot be located as is, grading, paving, and/or other features may need to be included in the site design. As ITS device locations are necessary in a wide variety of geometric locations, it is not likely that a standard maintenance access can apply to all sites. Each site will be somewhat unique. The basic design principles outlined in this section should be applied to each site to provide the most functional access possible.

4.1 Philosophy

- **Safety:** First and foremost, in the consideration of maintenance access is safety for PennDOT personnel and the traveling public. Parking areas should be behind barrier or outside the clear zone. Access or parking on the freeway shoulder should be avoided whenever possible.
- **Efficiency:** Maintenance access must be convenient for PennDOT personnel to park near the device, access the cabinet on foot, and carry tools and equipment to the repair site. Enough workspace must be provided to perform needed activities, open cabinet doors, and observe the device being serviced from the cabinet.
- **Access:** Access for the required vehicles must be provided, along with the ability to perform required activities. On pole mounted devices, for instance, a bucket truck must be able to park near the base of the pole and extend its outriggers which requires a minimum of 14 feet of width.
- **Proximity:** Maintained activities are challenged when devices and cabinets or electrical services are separated by distance. Thoughtful design will place these devices close to each other.

4.2 Vehicle Access

Three considerations are important when providing vehicle access for ITS maintenance activities:

- **Parking for Crew Access:** Maintenance workers will arrive at the site by vehicle and must have a safe place to park, ideally out of the clear zone or protected by barrier. They will also need to be able to safely unload equipment and supplies. The ITS infrastructure should be placed in a location where it is possible to meet these requirements. On a freeway with continuous barrier, it may be necessary to park on the shoulder. These areas should have barrier break or a reduced height barrier for crew access.
- **Parking for Bucket Trucks (maintenance pull outs):** ITS devices on poles and structures must be accessed by lift or bucket trucks. Consequently, parking areas for vehicles must be provided so that they can access the device. Parking should be at the base of the pole or structure to minimize the height of the bucket required to reach the device. This space should be provided without the need for traffic control other than closing a shoulder. For a 60-foot pole, 18 feet of width should be provided. On a freeway with a 12-foot shoulder and continuous barrier, a widened maintenance pullout must be provided at device locations to provide 14-foot minimum. A break in the barrier or a reduced height barrier (32” step-over height) should be provided for personnel access to the device cabinet. At locations without barrier, a graded parking pad should be provided at the base of the pole. Additionally, a 12-foot-wide access road may be needed to reach the parking pad. Bucket truck parking locations must be paved or have a compacted base.
- **Power Line Clearances:** An important consideration for aerial operations with bucket trucks, is clearance from power lines. Required clearances are controlled through PennDOT requirements, power company policies, and the National Electrical Safety Code. The best practice is to avoid locating ITS devices needing

aerial access near power lines of any sort. There are likely alternate locations that meet project requirements. If such a location is not avoidable, the designer should work with maintenance personnel to meet all applicable requirements.

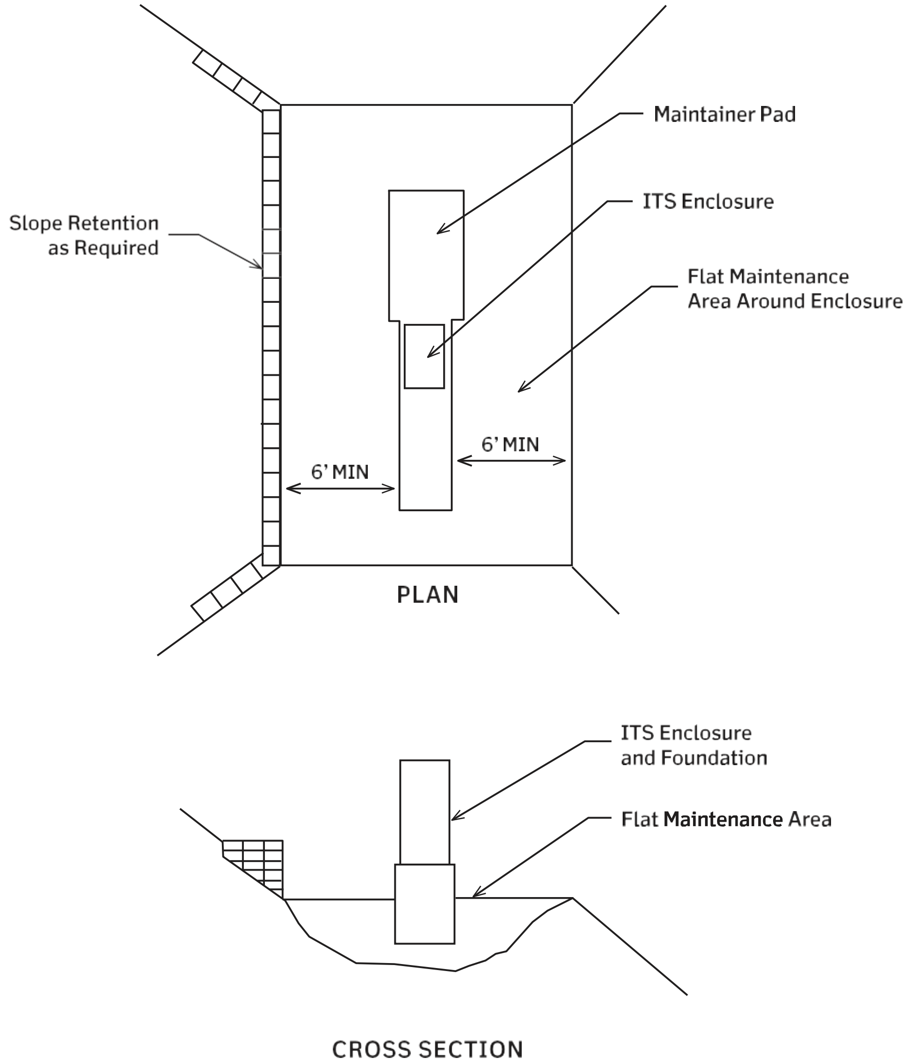
4.3 Personnel Access

Maintenance workers must be able to safely access the site on foot after having parked their vehicle. Often, they will need to carry heavy toolboxes and replacement equipment from the truck to the site. As such, the site design should keep the walking distance from the safe parking area to the cabinet or device site to a maximum of 100 feet. Any slopes that need to be traversed on foot should be no steeper than 4:1. The path or walking surface to the cabinet must be paved or have a compacted base. Keep wet and snowy weather conditions in mind during the design.

4.4 Work Areas

Maintenance workers should not have to balance on a slope to work in junction boxes or enclosures. Enough flat area should be provided around each device, pole, enclosure, and junction box to provide a safe workspace. Work areas should be out of the clear zone or protected by barrier. Ensure that ROW fencing lines or gates do not interfere with work areas. Do not place enclosures or pole bases in landscape areas that use large cobles as a visual feature. They are difficult to walk in and can be a hazard in winter months. Figure 27 illustrates a desirable site layout at an ITS enclosure located on a slope.

FIGURE 27: ITS ENCLOSURE ON A SLOPE

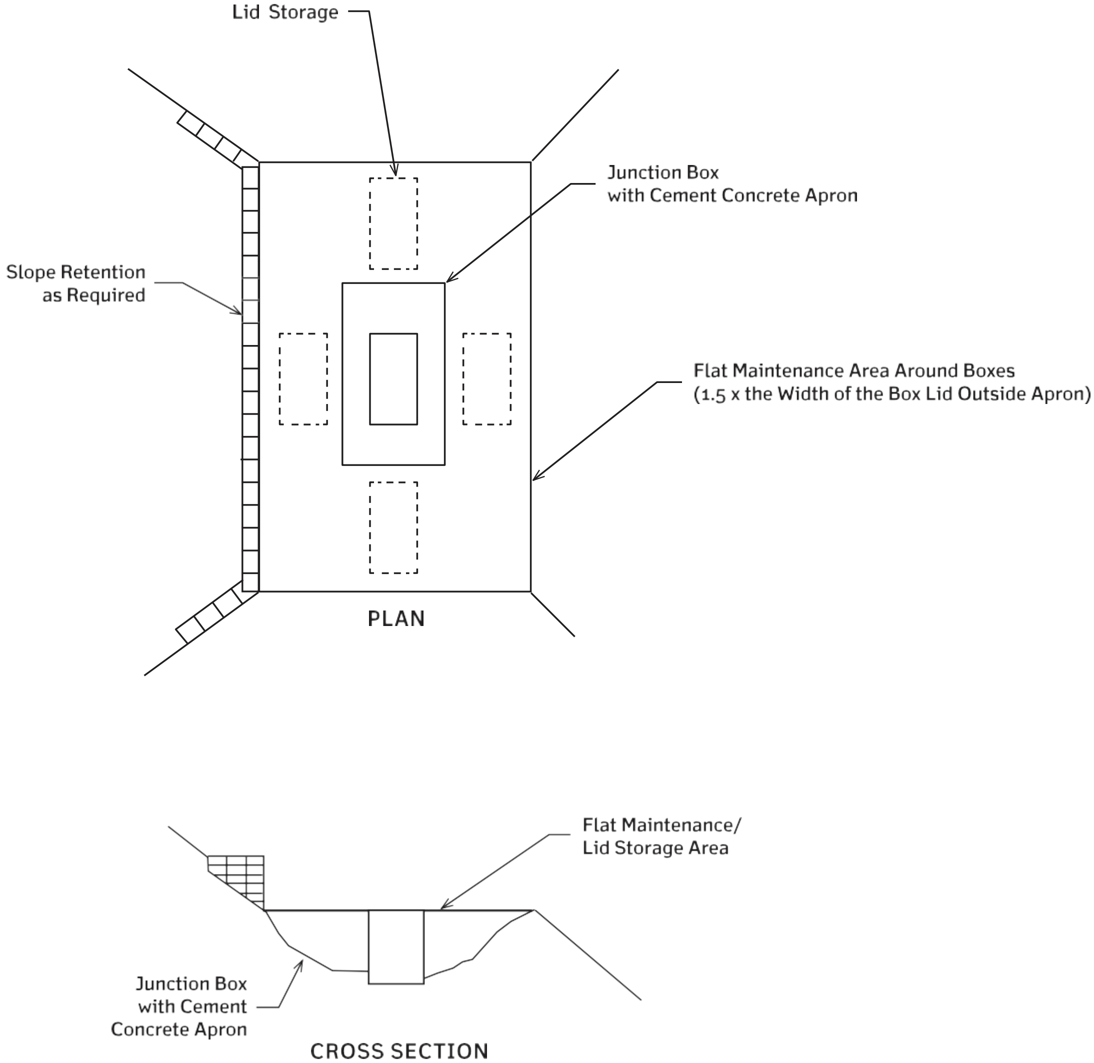


Source: Utah Department of Transportation

4.5 Junction Box Lid Access/Storage

An often-overlooked aspect of maintenance activities are the provisions to remove, store, and replace large lids on polymer concrete junction boxes. Some lids can weigh up to 70 pounds and take a significant effort to remove. Because of the orientation of the pull slots, they are most often removed by sliding off the long end of the junction box. This requires that enough space be available to stand and slide the lid, but also to safely store the lid on a flat area. Sloped lid storage areas are dangerous for maintenance workers and must be avoided. If junction boxes in sloped areas cannot be avoided, grading should be specified to create enough flat area around the junction box. This may require the use of a short block wall around the junction box. Figure 28 illustrates a desirable site layout of a junction box on a slope.

FIGURE 28: JUNCTION BOX ON A SLOPE



Source: Utah Department of Transportation

4.6 Drainage

Devices, cabinets, and junction boxes should not be placed in low lying areas or areas with poor drainage. Doing so creates a maintenance problem as the areas are hard to access when wet and soft. Furthermore, the junction boxes and conduits will fill up with water and mud, which must be removed before working on the equipment and shortens the life of the infrastructure. Barrier breaks can also create drainage issues if not properly designed. Ensure water does not flow through the break and create runoff or erosion issues.

4.7 Snow Removal/Storage

Cabinets and devices close to the highway are subject to being hit by flying snow coming off the snowplow. If cabinets can be placed where this is avoidable, they should be. Do not place pole mounted cabinets immediately behind roadside barrier; if possible, specify a clearance of at least 10 feet from the plowed area. In areas where thrown snow is likely to impact a cabinet, specify the cabinet be turned so that it does not face the plow path.

4.8 References

The Department does not perform ITS device maintenance. ITS device maintenance is performed by ITS maintenance contractors. Each Operations Region has one contract for performing ITS maintenance. Below is a list of references defining responsibilities of PennDOT maintenance and ITS maintenance contractors.

- Publication 697 – Intelligent Transportation Systems Maintenance Standards
- Publication 408 – Specifications
    - Section 1206 – Maintenance, ITS Devices – General
    - Section 1216 – Maintenance, Closed Circuit Television (CCTV) Camera
    - Section 1217 – Maintenance, Portable Closed Circuit Television (PCCTV) Camera
    - Section 1226 – Maintenance, Highway Advisory Radio (HAR) Subsystem
    - Section 1236 – Maintenance, Changeable Message Signs (CMS)
    - Section 1237 – Maintenance, Portable Changeable Message Signs (PCMS)
- Publication 23 – Maintenance Manual

Chapter 5. Plan Preparation

The objective of this chapter is to present the fundamental procedures and standard practices related to ITS design. The final product of the pre-construction activities in ITS design is the PS&E. Supporting plans preparation are project delivery manuals, standard drawings, highway construction specifications, and other applicable national and local standards.

5.1 General

Plan Sheet Development Standards

PennDOT ITS plan sets should be developed according to Publication 14M (DM-3) – Plans Presentation. The objective of DM-3 is to promote uniformity in the preparation of plans by establishing the general format and presenting the detailed information which is required for each type of plan sheet required in the maintenance and construction of highway facilities. Utilizing these standards guarantees a consistent plan set on every project. The expected benefits are far reaching and include, but are not limited to:

- Improving uniformity
- Creating accurate GIS products
- Creating consistency between Districts and consultant designers
- Creating logical plan set organization for construction
- Setting the foundation to create a plan set that can be used from project development, passed to contractors at advertising, and returned to PennDOT as as-built drawings at the end of construction.

This design manual will not duplicate information found in DM-3 but will add detail to requirements unique to ITS projects. Plan sheet development standards are to be incorporated in conjunction with Department CADD Standards (Publication 14M (DM-3) – Plans Presentation, Chapter 12, 13, 14, and 15).

Required Sheets

Standard design plans may include the following sheets:

- Title Sheet
- Index Sheet(s)
- Typical Section Sheet(s)
    - General Notes
    - Location Map
    - Tabulation of Overall Length and Construction Length
    - List of All Equalities
    - Earthwork Summary
    - List of Public Utilities
    - Tabulation of Project Coordinates
    - Special Details
    - Typical Sections
- Summary of Quantities Sheet(s)
- Tabulation of Quantities Sheet(s)
- Plan Sheets
- Structure Plan(s)

- Signing Plan(s)
- Final Design Cross Sections

The standard design plan components referenced above is all inclusive and represent a typical plan set for a Stand-alone ITS project. When ITS projects are included as part of a larger project, some of the sheets referenced above may not be included. Refer to Publication 213 - Temporary Traffic Control Guidelines for maintenance and protection of traffic requirements.

5.2 Typical Plan Sets and Components

Title Sheet

A Title Sheet is required for all Stand-alone ITS projects. A title sheet is not required when an ITS project is part of larger infrastructure project. When ITS projects are part of a larger project, the ITS plans will be referred to by the Construction Plan similar the Traffic Control Plan or Traffic Signal Plan. Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.1, for guidance on development of a Title Sheet.

Index Sheet(s)

The requirements for the Index Sheet are in Publication 14M (DM-3) – Plans Presentation, Chapter 2.2. The Index Sheet provides context to the project location. For ITS plans all the existing and proposed devices should be clearly identified and labeled. Proposed devices should also be provided in a summary table. Refer to **Appendix D (D-1)** for a sample Index Sheet with a device summary table and **Appendix D (D-2)** for a sample Index Sheet showing existing and proposed devices.

Typical Section Sheet(s)

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.3, for guidance on development of the Typical Section Sheet(s). Not all the elements are included in ITS design plans and the total number of sheets is dependent on the complexity of the project. The following sections will discuss any deviations from standard Construction Plans.

General *Notes*

In addition to the standards notes refenced in Publication 14M (DM-3) (Chapter 2.3, A), there are notes required that are provided in Publication 647 – Civil and Structural Standard Drawings for ITS. Plans should also include clear and concise notes regarding utilities and structures. Contact the District Traffic Unit for any region-specific General Notes that need to be included on the plans.

Location Map

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.3, C. Refer to **Appendix D (C-3)** for a sample Location Map.

Tabulation of Overall Length and Construction Length

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.3, D. These elements may be required for a Stand-alone ITS project; however, the Tabulation of Overall Length and Construction Length is typically shown on the Construction Plan when ITS is part of a larger project.

List of All Equalities

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.3, E. This element may be required for a Stand-alone ITS project; however, the List of All Equalities is typically shown on the Construction Plan when ITS is part of a larger project.

Earthwork Summary

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.3, F. An Earthwork Summary may be required for a Stand-alone ITS project; however, the Earthwork Summary is typically shown on the Construction Plan when ITS is part of a larger project. Earthwork summary would be required if, as part of the Stand-alone ITS project, a slope needed to be flattened to improve a CCTV camera view or increase the visibility of a CMS.

List of Public Utilities

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.3, G. A List of Public Utilities may be required for a Stand-alone ITS project; however, the List of Public Utilities is typically shown on the Construction Plan when ITS is part of a larger project.

Tabulation of Project Coordinates

Typically, Tabulation of Project Coordinates are not required for a Stand-alone ITS project or ITS that is part of a larger project. Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.3, H.

Special Details

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.3, I. For ITS projects, Special Details would include:

- Civil Schematic(s)/Detail(s)
- Electrical Schematics(s)/Detail(s)
- Communications Schematic(s)/Detail(s)

CIVIL SCHEMATIC(S)/DETAIL(S)

Civil details may include conduit attachments to bridges, device attachments to non-standard support structures, junction box modifications, modified maintainer pad, etc. Refer to Publication 647 – Civil and Structural Standard Drawings for ITS and Publication 408 – Highway Construction Specifications for standard details and references used in ITS projects. Standard civil details should not be placed in ITS plans because Department standards may be revised during the project development process of the ITS project. Refer to **Appendix D (D-4)** for a sample Civil Details sheet.

ELECTRICAL SCHEMATIC(S)/DETAIL(S)

Electrical details may include electric service point wiring diagrams, branch and feeder circuits to the enclosures and devices, and detailed wiring diagrams within the enclosures. Refer to Publication 647 – Civil and Structural Standard Drawings for ITS and Publication 408 – Highway Construction Specifications for standard details and references used in ITS projects. Standard electrical details should not be placed in ITS plans. Refer to **Appendix D (D-5)** for a sample electric wiring detail for an ITS device deployment and **Appendix D (D-6)** for a sample electrical detail for an ITS enclosure.

COMMUNICATION SCHEMATIC(S)/DETAIL(S)

Communications details must include the overall communication schematic. The communication schematic shows the communication type (or types) and how each ITS device is connected back the Departments network. Refer to **Appendix D (D-7)** for a sample Field-2-Center system block diagram for connecting a new ITS devices to the RTMC. **Appendix D (D-8)** is a sample Field-2-Center system block diagram that connects to the existing PennDOT fiber network. Refer to **Appendix D (D-9)** for a sample communication detail that shows the connection of ITS devices to an existing hub. It should be noted that non-complex deployments may not require detailed communications schematics (e.g., use of a cellular modem).

The communication details should also include fiber splice schematics and enclosure communication wiring diagrams. Refer to **Appendix D (D-10 and D-11)** for sample fiber splice schematics that show splicing details and **Appendix D (D-12)** for a sample wiring diagram for communication within an ITS enclosure. All fiber splice assignments in a splice detail should be coordinated with the Department as part of the design process. Refer to Publication 647 – Civil and Structural Standard Drawings for ITS and Publication 408 – Highway Construction Specifications for standard details and references used in ITS projects. Standard communications details should not be placed in ITS plans.

Typical Sections

Typical Sections are generally not included in ITS plan sets; however, they may be necessary to detail maintenance areas adjacent to a roadway or access roads from the roadway to the ITS device. Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.3, J, for guidance on development of Typical Sections.

Summary of Quantities Sheet(s)

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.4. This is required for a Stand-alone ITS project; however, the Summary of Quantities Sheet(s) is typically shown on the Construction Plan when ITS is part of a larger project. Refer to **Appendix D (D-13)** for a sample Summary of Quantities Sheet.

Tabulation of Quantities Sheet(s)

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.5. A Tabulation of Quantities Sheet(s) is required for both Stand-alone ITS projects and ITS plans developed as part of a larger project. Refer to **Appendix D (D-14)** for a sample Tabulation of Quantities Sheet. For ITS projects the Department prefers that each plan sheet be tabulated across one row. Additionally, tabulation remarks should call out the ITS device with stationing and conduit runs should be tabulated with stationing including callouts for JB's and roadway borings and crossings.

Plan Sheets

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.6. The Plan Sheets for ITS design projects require significantly less detail than are required for traditional roadway Construction Plan sheets. Roadway design elements may be included on the ITS design plan if they are important to the ITS infrastructure. ITS plan sheets are typically at a scale of 1:50; however, a scale of 1:25 can be used if more detail is required. All ITS design plans must include Construction Notes and Schedules (cable and conduit). The Department prefers that the designer include a stand-alone master Construction Notes and Schedules Sheet that is inclusive of all Construction Notes and Schedules used in the plans. Each individual plan sheet should only include the Construction Notes and Schedules relevant to that plan sheet. Refer to **Appendix D (D-15)** for a sample master Construction Notes and Schedules sheet. Provided in **Appendix D (D-16 and D-17)** are typical plan sheets that show only the relevant Construction Notes and Schedule.

For Stand-alone ITS projects the background topography could be a high resolution, scaled-back, aerial photograph with minimum additional details other than in-place utilities or as-built roadway plans. For ITS deployments as part of a larger project, the background topography should be referenced roadway design files (roadway plan, stormwater plan, etc.). Designers should contact the District to determine what would be the preferred background topography. Do not combine ITS sheets with other design features (except an outline of roadway features to show relationship to ITS infrastructure). Refer to **Appendix D (D-18)** for a typical plan sheet sample that incorporates many of the following elements that should be considered in the development of ITS plan sheets.

- **Blow-ups:** Use a magnified view or "blow-up" to show additional detail around enclosures and device locations when it is difficult to identify all details. Make sure conduit paths in and out of pole bases and cabinet foundations can be seen. Show conduit paths to mimic the actual path in the field. Do not show unnecessary turns or right angles.
- **Roadway Features:** Show the roadway features, of sufficient detail, on the ITS sheets to illustrate relative location to the device, but do not show design callouts or labels. Specific design elements of the grading, flatwork, maintenance pull-off areas, barrier, and guide rail should only be shown on the roadway Construction Plan sheets.
- **Cross Sections:** For projects that include significant new grading near ITS devices and enclosures, and for projects that place enclosures and devices on or near existing slopes, show a cross section of the device's location to clarify grading or flatwork required for personnel and vehicle access. Include on the ITS sheets if space allows, or alternatively include on roadway Typical Section sheets.
- **Utility Information:** Include sufficient utility information on plans to enable locating ITS devices to avoid conflicting with existing utilities. A balance must be struck between cost of obtaining utility information and the accuracy and completeness required. Judgment must be exercised when determining the scope and scale of the necessary utility investigation. In the past, many plan sets included no utility information and called for the contractor to "field locate devices to avoid utility conflicts". This approach is not acceptable. The designer has the responsibility of doing due diligence and identifying all known utilities to minimize the likelihood of change orders due to conflicts. Coordination with the Department is required because PennDOT owned utilities are not in PA One-Call.

Additionally, staged projects that span several construction seasons may require individual staging plan sheets and may even require temporary ITS plans to maintain situational awareness. The Department requires a final plan set that shows a comprehensive view of the completed ITS deployment.

Structure Plan(s)

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 11. Structure plans are required for ITS device support structures. Final structure plans for ITS support structures can either be incorporated into the ITS plan or as an also plan set for larger more complex projects.

Signing Plan(s)

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 8. Signing plans may be required for ITS deployments that also include static signing such as a Truck Rollover System or ITS device identification. Additionally, Type A CMS elevation plans would be included as part of a signing plan.

Final Design Cross Sections

Refer to Publication 14M (DM-3) – Plans Presentation, Chapter 2.7. Final Design Cross Sections may be required for a Stand-alone ITS project; however, the Cross Sections area typically shown on the Construction Plan when ITS is part of a larger project. On a Stand-alone ITS project, final design cross sections may be necessary to detail a maintenance pull-off or barrier installation.

5.3 Specifications for Construction

Specifications detail the work and quality needed to complete a construction project. There are four types of specifications used by the Department (listed in order of preference): Standard Specification, Modified Standard Specification, Standard Special Provision, and a Special Provision. **All ITS design projects should utilize Standard and Modified Specifications whenever possible.** Standard Specifications control project costs, improve estimating, and allow for consistency. For additional information regarding specifications refer to Publication 51 – Bid Package Preparation Guide.

Standard Specifications

The PennDOT standard specifications for construction are in Publication 408 – Highway Construction Specifications. Publication 408 is updated semiannually, and future updates are available prior to the effective date to allow designers to incorporate future updates into projects. Publication 408 is located on the PennDOT website at https://www.dot.state.pa.us/public/PubsForms/Publications/Pub_408/PUB%20408.pdf

Specifications for ITS Devices are in Section 1200. Specificationsfor Traffic Signals are in Sections 950-958. Specifications are complemented by Department manuals and standard drawings. Section 1200 references to other Publication 408 sections relatedto ITS devices such as Section 910 (Highway Lighting) and Section 1101 (Highway Lighting). Due to the update cycle, Publication 408 is consistently the most current publication regarding ways and means.

Other Standards

For Department standards and design process for construction projects refer to:

- Publication 10 - DM 1 – Transportation Program Development and Project Delivery Process
- Publication 13 - DM Part 2 – Contextual Roadway Design
- Publication 13M - DM Part 2 – Highway Design
- Publication 14M - DM Part 3 – Plans Presentation (Dual Unit)
- Publication 15M - DM Part 4 – Structures
- Publication 16 - DM Part 5 – Utility Relocation

There are other national and local standards which are applicable to ITS plans and specifications. The following are some of the standards specified in the Publication 408:

- Manual on Uniform Traffic Control Devices (MUTCD)
- American Association of State Highway and Transportation Officials (AASHTO)
- American Society of Testing and Materials (ASTM)

- Institute of Transportation Engineers (ITE)
- Insulated Cable Engineers Association (ICEA)
- National Transportation Communications for ITS Protocol (NTCIP)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- Rural Utilities Service (RUS)
- Underwriter Laboratories, Inc. (UL)

Modified Standard Specifications

A modified standard specification is a standard specification as presented in Publication 408 that includes edits/additions to either the description, material, or construction processes. The designer will typically add, remove, or modify the materials or construction requirements to address non-standard deployments. An example of a modified standard specification is provided in **Appendix E (E-1 and E-2)**. Typically, the item name is the standard bid item name with the word "modified" added or an additional descriptor (e.g., CCTV Camera Pole – Painted Red) that indicates the modification.

Special Provisions

Special Provisions are categorized as either a Standard Special Provision (SSP) or Special Provision.

Standard Special Provision

PennDOT SSPs are maintained in the Engineering and Construction Management System (ECMS) and accessible by both PennDOT Business Partners and Public Users. SSPs may or may not be included in future updates to Publication 408 but are approved to be utilized on projects. To search SSPs go-to the ECMS website (login or access as guest), then navigate to "Construction Projects" > "Resources" > "Special Provisions". Refer to **Appendix E (D-3)** for a sample SSP for Fiber Optic Contractor Coordination.

Special Provisions

Special Provisions are developed by the designer using standard industry acceptable practices and specifications for the non-standard ITS device or component. **The Special Provision should not include proprietary requirements unless approval for propriety items has been formally granted by the Department in writing**. Propriety items should be identified as early in the design process as possible and must be approved by PS&E. Special Provisions for non-standard ITS deployments must be developed from scratch and must be in the same format as a Publication 408 Standard Specification including the following sections: Description, Material, Construction, and Measurement and Payment. When developing a Special Provisions for a non-standard ITS deployment, the ITS designer should reference existing PennDOT standards whenever possible. Refer to **Appendix E (E-4, E-5, E-6, and E-7)** for sample Special Provision from PennDOT projects.

Addendum

At times it may become necessary to provide additional information, corrections, or deletions to the Special Provisions, Plans, and/or Specifications after the project is advertised, but before the actual letting of the project. This information is provided to bidders via an addendum. This addendum is then sent out to contractors, suppliers, etc. that have obtained the contract documents for the specific project. This addendum is sent out with enough lead time to allow bidders the opportunity to consider the addendum as they prepare their bid. The ITS designer may have to provide input or revise plans and/or specifications to address bidder questions and addendum items.

5.4 Approved Products List

Refer to the Bulletin 15 (Publication 35) for the Qualified Products List for Construction: https://www.dot.state.pa.us/public/pdf/BOCM_MTD_LAB/PUBLICATIONS/PUB_35/Current_Edition/Bulletin15.pdf

5.5 Bid Items

All standard bid items for Department projects are provided in the Engineering and Construction Management System (ECMS): https://www.eCMS.penndot.gov/ECMS/.

The format of a bid item is the Item Prefix followed by an Item Number. For example, a CCTV Camera Subsystem, Pole Mount is item 1210-0001. The Item Prefix coincides with the Publication 408 section the item is related. Components related to a CCTV Camera deployment will always have an Item Prefix of 1210. The Item Number is arbitrarily assigned by the Department. For modified standard items, the Item Prefix will start with either a 4 or a 5. For Item Prefixes less than 1000, the first digit will be a 4 and for Item Prefixes greater than 1000 the first digit of the Item Prefix will be a 5. All other bid items will begin with a 9 (Special Provisions).

5.6 Tabulation of Quantities and Cost Estimate

To develop a cost estimate for the ITS project, the designer needs to develop a Tabulation of Quantities for all system component parts. Development of the Tabulation of Quantities is required if the system is part of a larger plan or if it is a stand-alone ITS project. When developing quantities, the designer should determine quantities on a by-sheet/by-location basis for discrepancies to be more easily checked. Certain bid items require adjustments to increase quantities to appropriately consider factors such as wire slack and changes in grade on conduit length.

For cost estimates, the designer should use bid items from ECMS. Using ECMS, any designer can access costs of bid items and filter by dates, specific item and get results for the lowest three bids in each project where the item was presented. Designers shall compare different bids to assess engineering judgement on pricing and to ensure consistency. Designers shall also consider inflation factors to determine net present value costs for any cost information provided in past years. For non-standard items, cost estimates shall be documented and justified.

Chapter 6. System Integration

This section discusses the important items to be coordinated between the ATMS vendor, the contractor, and the construction services team (PennDOT and consultants, as applicable) during the project integration phase. All coordination with the ATMS vendor is to be via the Systems and Performance Unit (BOO, HSTOD).

6.1 Integration Process

Equipment Submittals

Prior to the physical construction of any systems taking place, the contractor is required to submit information of all the project's system equipment hardware and software for review and approval. These submittals will be reviewed against the requirements from the standard specifications along with the project special provisions. Once the contractor submits this information, the construction services team should coordinate with OA/OIT and the Systems and Performance Unit to confirm the compatibility of the specific make and model of the equipment, as applicable. If the ATMS vendor has not previously integrated the specific manufacturer's equipment submitted by the contractor into the ATMS platform, the ATMS vendor may need to develop a new equipment configuration for the system. In these instances, the project team should give the Systems and Performance Unit as much notice as possible to allow the vendor to develop the configuration. Completing this coordination as early as possible during project construction helps mitigate possible delays related to system integration later in the project. Some specific items to consider during the equipment submittal phase are listed below.

- **ATMS Modifications/Enhancements:** If the project requires the procurement of any new software required to operate any project systems, all software design and integration submittals from the software vendor should be included as an equipment submittal. The construction services team will need to ensure that the software submitted by the contractor meets all the functional and performance requirements to successfully operate the project system(s).
  - If the project is modifying the existing ATMS platform, the construction services team should ensure that any equipment submittals required in the ATMS vendor's scope are provided for review and approval.
- **New Systems:** If the project is procuring any new types of systems that are not currently in use by PennDOT, the construction services team shall coordinate during the equipment submittals period to ensure the system is compatible with the system integration requirements. During this stage, the project team should also coordinate the submittal of any new testing protocols or pre-deployment testing requirements that may be needed for these systems.

Integration Requirements

Once the equipment submittals for all the project system materials have been approved, the contractor shall provide all the required information needed to integrate each of the systems. The construction services team should coordinate with the contractor to have this information submitted through the project. The construction services team should share this information with OA/OIT and the Systems and Performance Unit. This information is what the vendor and OA/OIT will utilize to integrate the project systems into the ATMS platform. The information that the contractor is required to provide should follow the example spreadsheet **(Appendix F)**, which has previously been developed and approved by the Systems and Performance Unit. Once the integration information has been submitted by the contractor, a mandatory Integration Kick-Off Meeting should be scheduled.

If additional information is required to integrate a system, the contractor should add this information to the example spreadsheet **(Appendix E)** as a part of the submission. The information included in the submittal should meet the requirements provided in Publication 408, Section 1202, and applicable project special provisions.

When the construction services team provides the integration information to the Systems and Performance Unit, they should also include any project specific information that will be required to integrate and/or test the project system(s). Some additional information related to the integration requirements is provided below.

- **ATMS Modifications/Enhancements:** If the project requires the procurement of any new software required to operate any project systems, the construction services team should coordinate with the appropriate staff to determine what information is needed to integrate the project system(s). It is the role of the construction services team to ensure that this information is submitted by the contractor early in the construction phase to avoid potential delays during integration of the new software.
  - If the project is modifying the existing ATMS platform, the construction services team should be sure to have the contractor coordinate directly with the ATMS vendor to see if any additional information will be needed to integrate the project system(s) into the enhanced/modified functionality/modules.
- **IP Addressing:** The contractor should coordinate with OA/OIT to determine the IP address scheme to be utilized by the project systems. The contractor is responsible for configuring the IP address and network settings in each of the field devices in accordance with the IP address scheme approved by OA/OIT. The contractor is responsible for documenting assigned IP addresses for ITS Devices and Traffic Signals within the associated component record in TSAMS.

Field Installation

It is critical that the construction services team and the ATMS vendor coordinate throughout the construction phase of the system deployment. The construction services team should provide project and schedule updates to the Systems and Performance Unit. This coordination will help mitigate potential delays that could occur when the project systems are ready to be integrated. It is during this phase that the project construction services team ensures that the project systems are deployed in accordance with the bid package. Several system specific items that should be coordinated during the construction phase are provided below.

- **MPLS Circuits:** If the project requires the use of leased circuits for any systems communication, it is important that this is coordinated during the construction phase of the project. These leased services will need to be coordinated with the District ITS staff as well as the Systems and Performance Unit. These services will be required to be coordinated and connected prior to the ATMS vendor being able to successfully integrate the project systems. It should be noted that an e911 address will be required before service can be ordered.
- **3rd Party Data Systems:** If a project is deploying a system that will require the ATMS vendor to integrate with a 3rd party, the construction services team and contractor will need to ensure that the 3rd party integration occurs once the equipment, if any, has been installed in the field.
- **CCTV:** If the project is deploying CCTV systems, the construction services team should make sure there is coordination between the contractor and District ITS staff to ensure that the installation is completed to enable the proper viewing angle/coverage is provided.
- **CMS:** If the project is deploying CMS systems, the construction services team will verify if any work needs to be completed by the CMS vendor prior to scheduling the on-site standalone testing. Some vendors require a commissioning of the equipment to be completed prior to the CMS being ready for operational use.

- **New Systems:** If the project is deploying any new types of ITS systems, the constructions services team will verify if any pre-deployment tests that were required, such as the Factory Demonstration Test, have been completed. Typically, the Department does not require these pre-deployment tests on equipment that is already installed within the Commonwealth. However, when new systems are being deployed, these tests should be completed as required.
- **ATMS Modifications/Enhancements:** If the project requires the procurement of any new software necessary to operate any systems, the construction services team should coordinate with the contractor to have the software installed on all required hardware prior to testing and integration. All software installation must be coordinated through OA/OIT and BOO, as applicable, and be in accordance with the approved vendor proposal/contract.
    - If the project is using the ATMS vendor to modify or enhance any aspects of the existing ATMS, the construction services team should monitor these modifications to ensure the ATMS vendor is following the enhancement scope and schedule. The construction services team should coordinate these items with BOO as needed.

Final Integration

After the contractor completes all the physical construction and on-site standalone testing for each of the ITS systems, the project team should coordinate with the ATMS vendor and OA/OIT to allow them to begin the integration process. The ATMS vendor and OA/OIT will need all field communications to be established prior to starting the integration process. The ATMS vendor and OA/OIT typically require 4-6 weeks to complete all project integration work, but this timeline should be coordinated on a project-by-project basis. This integration work must be completed prior to the contractor being able to complete the final system testing. The construction services team should facilitate coordination between the contractor, ATMS vendor, District ITS staff, the Systems and Performance Unit, and OA/OIT to schedule the system testing date based on the ATMS integration. Several system specific items that should be coordinated as a part of the system integration are provided below.

- **3rd Party Data Systems:** If the project is installing a system that requires 3rd party integration, the contractor is responsible for coordinating the integration of the system with the 3rd party vendor. The 3rd party vendor will establish the necessary inputs and outputs required for the ATMS vendor to directly pull any data needed to operate the system within the ATMS platform. It should be noted that often the 3rd party vendor will need to monitor the input and output data from the project over a period of a few weeks and complete any necessary calibrations to ensure the accuracy of the data.
    - Once the 3rd party vendor indicates that the data has been calibrated, the ATMS vendor can begin to integrate the data into the ATMS platform.
- **CCTV:** If the project includes CCTV cameras, the project team will need to coordinate that each CCTV is integrated into PennDOT's VMS. This platform is separate from the ATMS integration and should be coordinated directly with OA/OIT.
    - As noted in the Field Installation Section, if the project is also integrating the CCTV video feeds into the ATMS, then OA/OIT will need to create a CCTV media stream and provide it to the ATMS vendor. PennDOT typically needs one to two weeks to create a media stream, based on its current backlog. Once the CCTVs are ready for integration, the project team should instruct the ATMS vendor to request a ticket to OA/OIT to create the media stream.
- **CMS:** If the project includes CMS, the project team should coordinate with ATMS vendor to see if any travel time messages need to be created during final integration to support the final systems acceptance testing. The construction services team should also determine if any special graphics need to be provided to the ATMS vendor to support the integration effort.

- **New Systems:** If the project is integrating new types of ITS systems, make sure all system documentation has been provided to the ATMS vendor to assist with integration. The ATMS vendor may need additional time to integrate new systems because additional User Acceptance Testing (UAT) will need to be performed prior to final acceptance testing.
- **ATMS Modifications/Enhancements:** Any new software or software enhancement will follow its own testing schedule (typically a factory demonstration test and user acceptance testing) prior to the final integration of all the devices. If possible, it would be best to perform user acceptance testing on live data/devices, which needs to be coordinated with the construction contractor to determine which devices will be available per the schedule. It also may be required for the contractor to provide the software vendor with device equipment for their use in developing and configuring the software/enhancement.

System Acceptance Testing

Once the final integration has been completed, the final Systems Acceptance Testing can take place. The contractor should coordinate with District ITS staff and the Systems and Performance Unit to schedule a system acceptance testing date. The project team should utilize the system acceptance testing protocols provided by the ATMS vendor to confirm the operational and performance requirements of each system using the ATMS platform. The project team should coordinate with Department and the ATMS vendor to see what level of support will need to be provided (on-site, phone conference, not needed, etc.) by the ATMS vendor during the testing.

Once each system on the project has passed the acceptance tests, the construction services team should ensure the testing documentation is signed by the appropriate project personnel (contractor, PennDOT, consultant, ATMS vendor, etc.). The construction services team should also coordinate with the contractor to ensure all operational support and maintenance requirements are followed. Several system specific items that should be considered as a part of the system testing are provided below.

- **3rd Party Data Systems:** If the project will be testing data in ATMS that is coming from a 3rd party, the project team will need access to both the ATMS data and the 3rd party data during the testing. To test the 3rd party data, the project team will need to compare the 3rd party data to the data generated in ATMS. It should be noted that some of the ATMS modules and engines may be adjusting the data that it receives from the 3rd party vendor. Because of these adjustments, it is likely that the data from the 3rd party may not exactly match the data in ATMS. The project team should coordinate with the ATMS vendor to get an understanding on what an acceptable threshold is for the difference in ATMS and 3rd party data.
- **CCTV:** If the project includes CCTVs, the project team should coordinate with District ITS staff to determine how the CCTV testing will be completed.
  - If PennDOT would like to test the CCTV video using the ATMS platform, the project team shall complete the test protocols within ATMS. It should be noted that the video feeds through ATMS will experience a lag based on communications with the ATMS servers.
  - If PennDOT would like to test the CCTV video through the Genetec VMS, the project team shall verify that all the functionality outlined in the ATMS test procedures is working properly. It should be noted that everything outlined in the ATMS testing procedures can be verified through the VMS, but some of the language may not be applicable.
  - If PennDOT wants to test the CCTVs in both platforms, then the language outlined above should be utilized.
- **CMS:** If the project requires testing of any special CMS messages, such as graphics, then these messages should also be verified during the final acceptance test. The development of any special graphics should have been coordinated earlier in the construction phase when the project team provided the CMS message memo to the ATMS vendor.

  - If travel time messages are to be tested, then all travel time links should be configured and tested prior to testing the travel time messages.
  - When completing certain test steps, the project team should coordinate with the ATMS vendor to see if any steps are only applicable for certain manufacturer equipment. Potential examples of this include the pixel test step (test pixels vs test all pixels), lamp test, and color text test. It should be noted that the standard testing protocols are generic, so every step may not be applicable to the project systems.
- **New Systems:** If the project is procuring any new types of systems that are not currently in ATMS, new testing protocols will need to be used for the testing.
- **ATMS Modifications/Enhancements:** All systems acceptance testing should be conducted through the vendor software utilizing live devices and data. Following completion of the Systems Acceptance Test, and if previously coordinated in the vendor scope of work, final acceptance testing, and/or any required performance testing of the software system will follow the completion of the systems acceptance testing.

Sample test plans for a CMS and CCTV camera deployments are provided in **Appendix G**.

6.2 General Integration Steps

The key aspects during the integration phase for s ITS project is, as described above, are:

- Equipment Submittals
- Integration Requirements
- Field Installation
- Final Integration
- System Acceptance Testing

The figures below provide a flowchart of critical items the construction team will encounter during the ITS integration process:

- Figure 29: Integration Process for a Project with Typical ITS System Deployments
- Figure 30: Integration Process for a Project with New ITS System Deployments
- Figure 31: Integration Process for a Project with New ATMS Modifications/Enhancements

It should be noted that more than one flowchart may need to be referenced depending on the systems that are included in a project. Each flowchart follows the same key milestones during the design process.

FIGURE 29: INTEGRATION PROCESS FOR A PROJECT WITH TYPICAL ITS SYSTEM DEPLOYMENTS

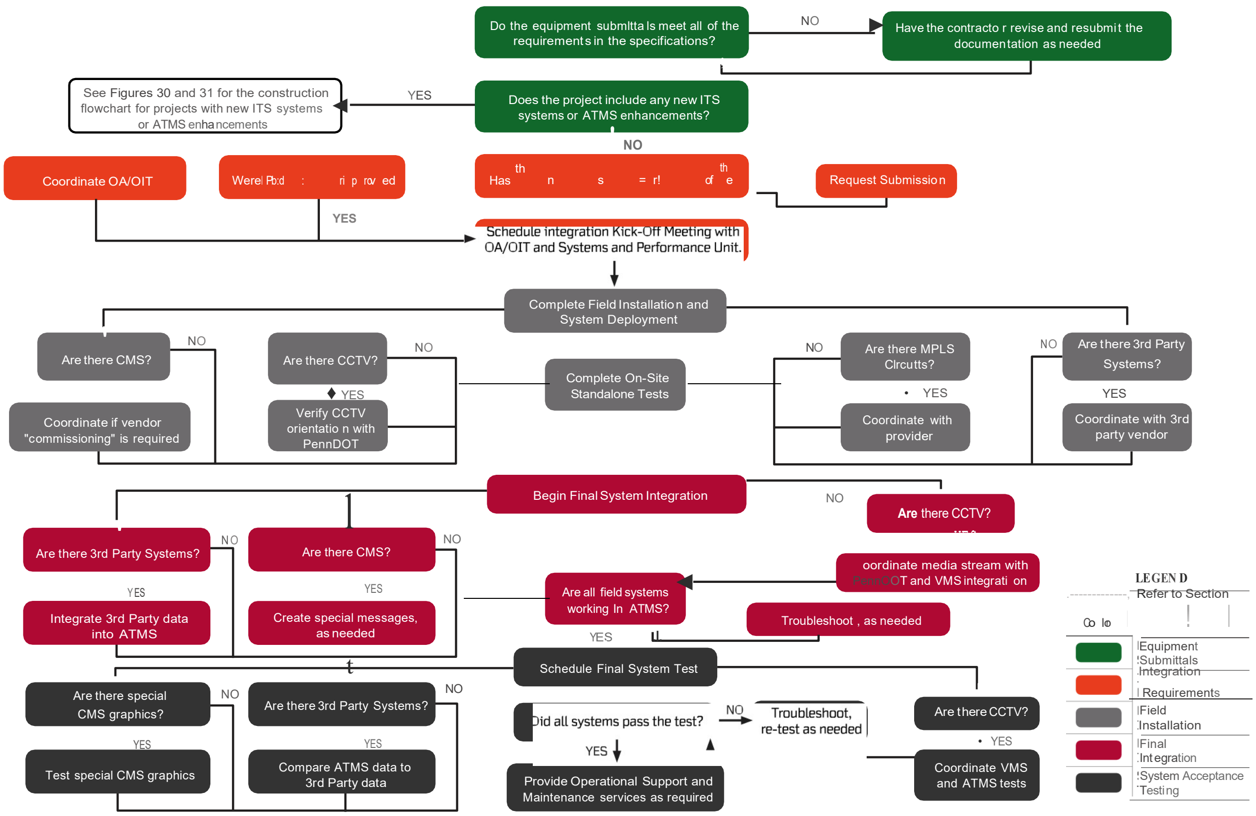


FIGURE 30: INTEGRATION PROCESS FOR A PROJECT WITH NEW ITS SYSTEM DEPLOYMENTS

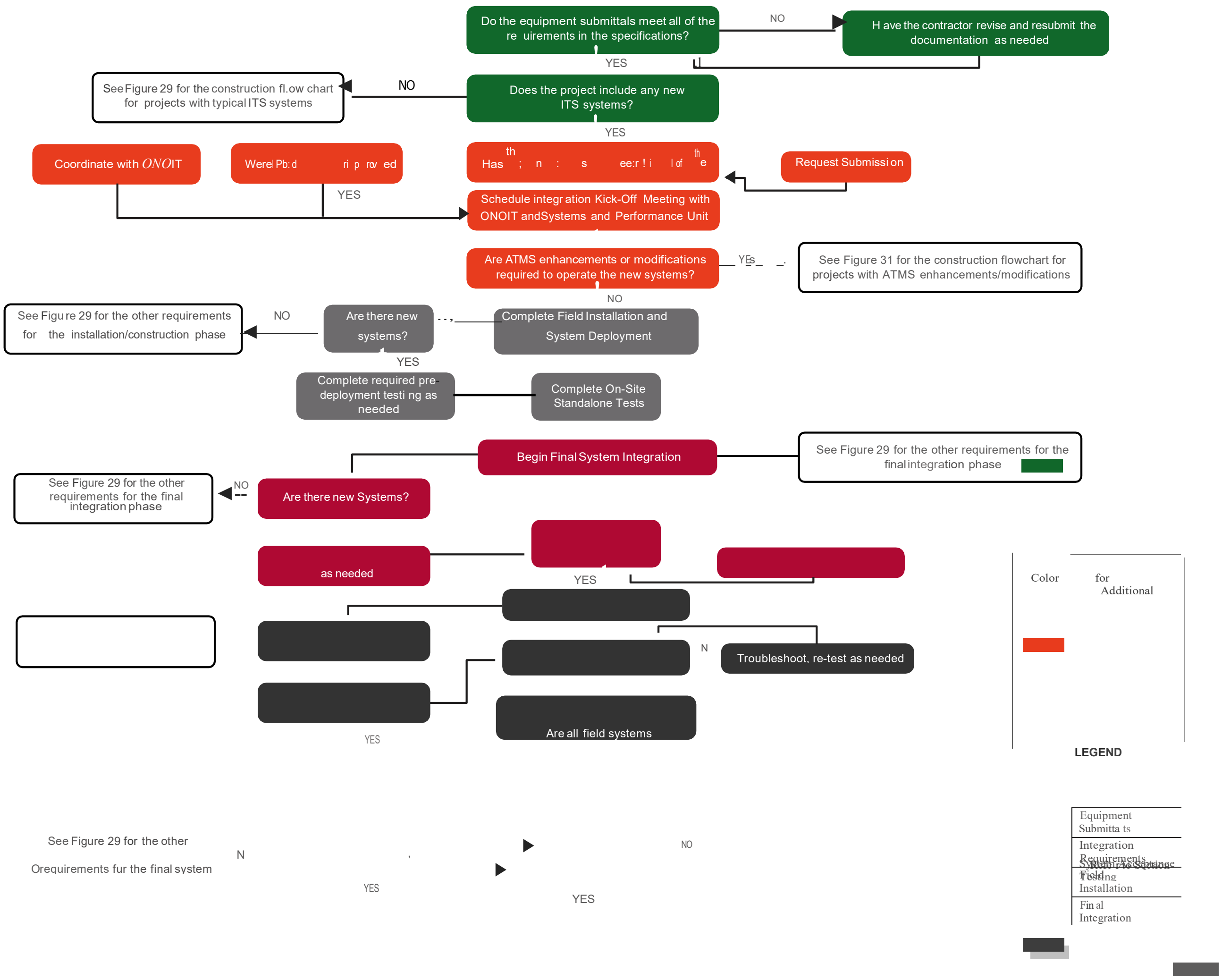
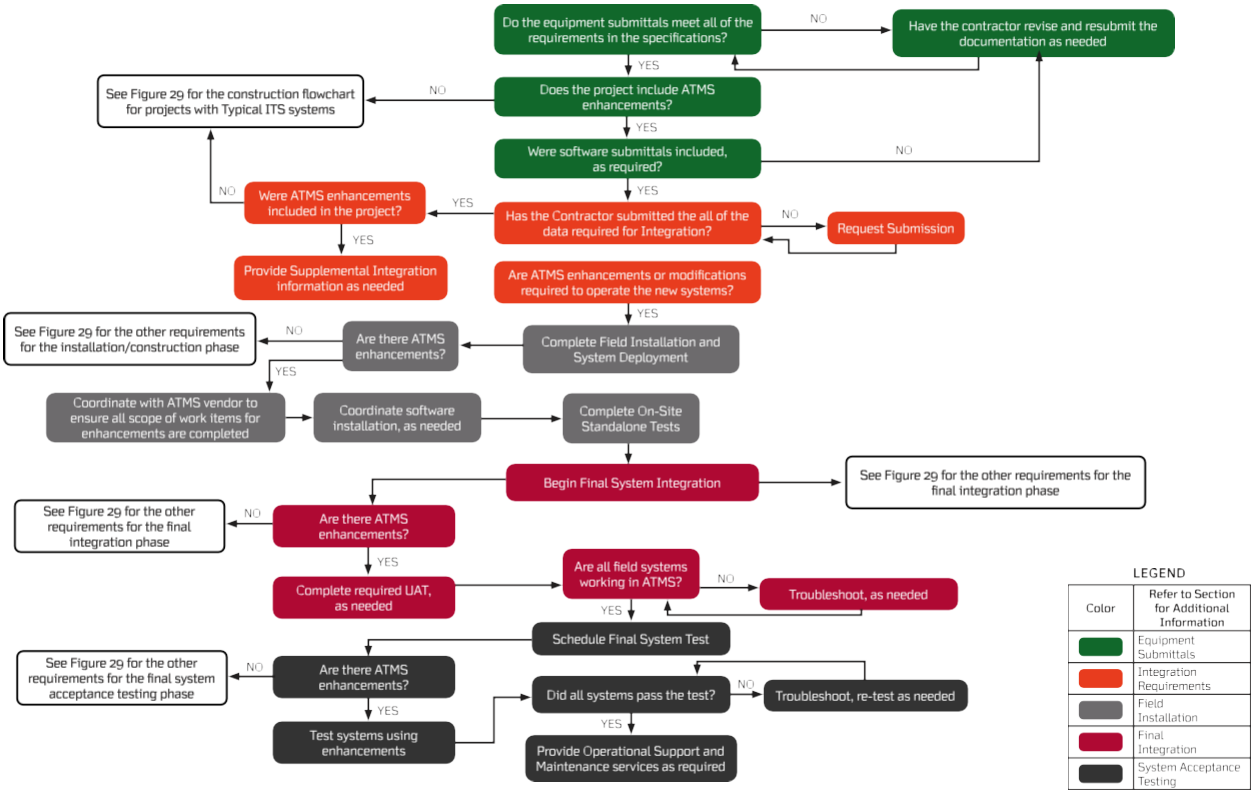


FIGURE 31: INTEGRATION PROCESS FOR A PROJECT WITH NEW ATMS MODIFICATIONS/ENHANCEMENTS



6.3 Durations

Timelines for minor, moderate, and complex ATMS modifications/enhancements are provided in Table 45. For the purposes of this guide, these categories are defined as follows:

- **Minor Project:** Enhancements limited to adding a new vendor device into an existing module.
- **Moderate Project:** Minor modification of an existing module could be required.
- **Complex Project:** Development of a new module or a substantial enhancement.

TABLE 45: ATMS MODIFICATIONS/ENHANCEMENT TIMELINE

Phase	Minor	Moderate	Complex
Submittal Review	3-5 Months	3-6 Months	6-9 Months
Detailed Software Design	N/A	0-3 Months	3-6 Months
Software Development	N/A	0-6 Months	3-12 Months
User Acceptance Testing	N/A	0-1 Months	1-2 Months
Systems Acceptance Testing	2 Months	1-2 Months	1-3 Months
Operational Testing/Support	**5 Months**	**5-12 Months**	**12-30 Months***

*Timelines are not aggregate and may overlap. Overall construction duration may be a function of field installation.

Appendix A.

Traffic Signal/ITS Device Remote Communication Scoping Form (TE-154)

Note:

The TSAMS ID will be required when completing section C- Field Devices in the TE-154. Therefore, prior to using the Traffic Signal/ITS Device Remote Communication Scoping Form (TE-154), Traffic Signals/ITS Devices must be added in TSAMS as a status of planning.

https://www.dot.state.pa.us/public/Bureaus/BOMO/Portal/Workbooks/TE-154.html

Please follow the example below for completion of the form.

TE-154 (11-22)

pennsylvania
DEPARTMENT OF TRANSPORTATION
www.penndot.pa.gov

TRAFFIC SIGNAL/ITS DEVICE REMOTE COMMUNICATION SCOPING FORM

Purpose: The purpose of this form is to identify the network requirements to support traffic signal and/or ITS field devices.

A - PROJECT INFORMATION

DISTRICT	COUNTY	PRIMARY MUNICIPALITY
11-0	Allegheny	West Mifflin Borough

PROJECT NAME
SR 51 12A (111571)

PROJECT DESCRIPTION
Roadway Betterment and Signal Upgrade

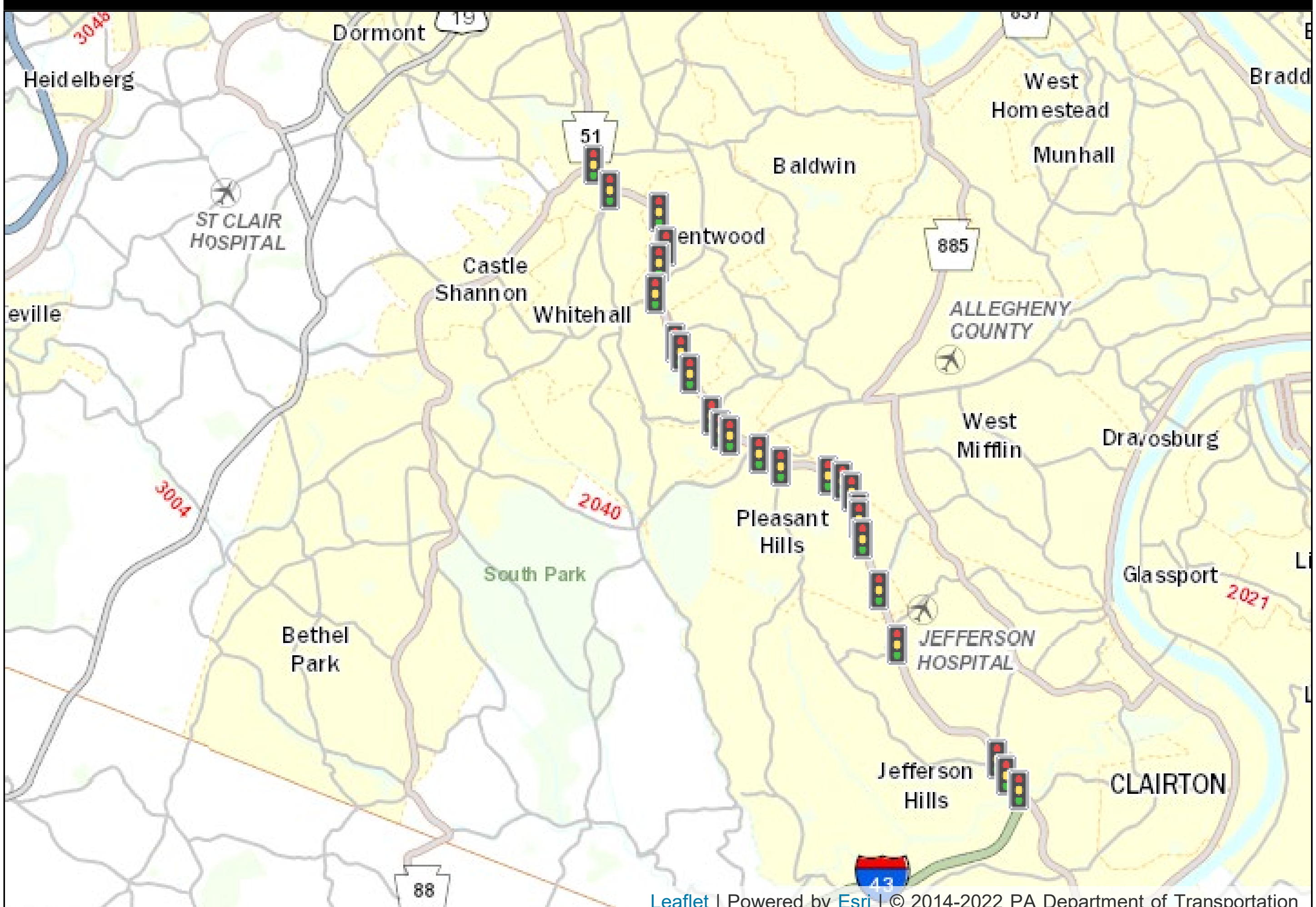
DESIGN FIRM/ORGANIZATION	DESIGN CONTACT PERSON	DESIGN CONTACT E-MAIL	DESIGN CONTACT PHONE
PennDOT	Dan Fedio	dafedio@pa.gov	412-429-4983

PROJECT COMMUNICATION SCOPE
- ○ Establish new remote network connection
- ◉ Add devices to existing remote network connection
- ○ Upgrade existing facilities

B - ATTACHMENTS LISTING

CHECK THOSE THAT APPLY AND ATTACH TO THIS FORM (*REQUIRED FOR ALL PROJECTS)
- ☑ Network Architecture Diagram*
- ☑ Field Device Listing*
- ☐ Photographs
- ☐ Concept of Operations
- ☐ Systems Engineering Documents
- ☐ Other

C - FIELD DEVICES



TRAFFIC SIGNAL DEVICES

TSAMS ID	INTERSECTION LOCATION	# OF IPS
709	Saw Mill Run Boulevard (SR 0051) @ Glenbury Street/ Hillview Street/ Library Road (SR 0088)	0

2847	Clairton Boulevard (SR 0051) @ Stewart Avenue	
868	Clairton Boulevard (SR 0051) @ Greenlee Avenue	
867	Clairton Boulevard (SR 0051) @ Delco Road/ Marylea Avenue	
99	Clairton Boulevard (SR 0051) @ Town Square Way	
98	Clairton Boulevard (SR 0051) @ Brownsville Road	
2843	Clairton Boulevard (SR 0051) @ Glen Elm Drive	
2846	Clairton Boulevard (SR 0051) @ Beall Drive	
2739	Clairton Boulevard (SR 0051) @ Borough Park Drive	
2738	Clairton Boulevard (SR 0051) @ Streets Run Road (SR 2046)	
8728	Clairton Blvd (SR 0051) @ Grace St/ Old Clairton Rd	
8726	Clairton Blvd (SR 0051) @ Irwin Dr	
2778	Clairton Boulevard (SR 0051) @ Old Clairton Road/ Old Lebanon Church Road	
2776	Clairton Boulevard (SR 0051) @ Glenburn Drive	
2775	Clairton Boulevard (SR 0051) @ Belleview Plaza Drive	
2817	Clairton Boulevard (SR 0051) @ Century Three Mall Driveway	
96	Clairton Boulevard (SR 0051) @ Century Three Mall Drive/ Fred Fiore Drive	
2773	Clairton Boulevard (SR 0051) @ Southland Shopping Center Drive North	
2772	Clairton Boulevard (SR 0051) @ Southland Shopping Center Drive South	
2771	Clairton Boulevard (SR 0051) @ East Bruceton Road	
2770	Clairton Boulevard (SR 0051) @ Lewis Run Road (SR 2032)/ Lindsay-Snyder Drive	
966	Clairton Boulevard (SR 0051) @ Coal Valley Road	
965	Clairton Boulevard (SR 0051) @ Jefferson Boulevard	
964	Clairton Boulevard (SR 0051) @ Old Clairton Road	
963	Clairton Boulevard (SR 0051) @ Dick Corporation Drive/ Peters Creek Road	

ITS DEVICES

DEVICE TYPE	STATEWIDE ID	DISTRICT ID	LOCATION DESCRIPTION	# OF IPS
CAM	THIS IS NOT CORR	CM 126	NB at E. Maple Ave. / SR 213	

D - CONCEPT OF OPERATIONS

FUNCTIONAL REQUIREMENTS (CHECK ALL THAT APPLY)

- ☑ Clock synchronization
- ☑ Remote device management (database upload/download, etc.)
- ☑ Remote configuration, monitoring of field equipment status and reporting of equipment malfunctions
- ☑ Remote device malfunction troubleshooting
- ☑ Traffic Signal Command and Control (remote selection and implementation of timing plans)
- ☑ Adaptive traffic signal control technology
- ☐ High-resolution event log for Automated Traffic Signal Performance Measures (ATSPM)
- ☐ Changeable Message Sign (CMS) Command and Control
- ☑ Traffic surveillance (CCTV): ◉ View only ○ Pan/tilt/zoom control
- ☐ Connected/Automated Vehicle Applications - Describe
- ☐ Other:

E - FIELD NETWORK

EXISTING FIELD NETWORK STATUS

○ No field network ○ Serial network ◉ IP-addressable network

FIELD NETWORK OWNERSHIP AND MAINTENANCE

○ PennDOT ○ Municipality ○ Other:

PROPOSED FIELD NETWORK COMMUNICATION METHOD (CHECK ALL THAT APPLY)

☐ Same as existing ☐ Fiber optic cable ☑ Broadband radio ☐ Copper ☐ Other:

F - BACKHAUL COMMUNICATIONS

PROPOSED BACKHAUL COMMUNICATION METHOD

○ Commonwealth-owned fiber ○ Leased fiber ◉ MPLS ○ Cellular ○ Other:

FIBER REVIEW COMMITTEE MEETING DATE

WHERE IS BACKHAUL CONNECTED TO FIELD NETWORK?

◉ PennDOT ITS cabinet ○ Traffic signal cabinet ○ Hub cabinet ○ Other field cabinet ○ Other field cabinet

DESCRIBE CONNECTION LOCATION (TSAMS SIGNAL ID, ITS STATEWIDE ID, INTERSECTION, ADDRESS, ETC.)

CCTV is at the intersection of S.R 51 and S.R 88, near TSAMS 709

BACKHAUL SECURITY (CHECK ONE)

◉ The backhaul connection uses a private, dedicated circuit which is limited to PennDOT traffic

REMOTE USERS (CHECK ALL THAT APPLY)

☑ PennDOT signal staff ☐ PennDOT TMC staff ☑ Municipal staff ☑ Municipal contractor ☐ Municipal consultant
☐ Municipal police ☐ Signal vendor ☐ Other:

HOW WILL NON-PENNDOT USERS ACCESS THE SYSTEM?

☑ Office of Administration VPN from remote computer using CWOPA credentials
☐ Other:

ESTIMATED MONTHLY RECURRING COST	RECURRING COMMUNICATION COSTS TO BE PAID BY:
	○ PennDOT ITS (10576) ◉ PennDOT GLG (11073) ○ Municipality ○ Other:

G - ADDITIONAL INFORMATION

DESCRIBE ANY ADDITIONAL INFORMATION WHICH MAY IMPACT THE SIZE, LOCATION, OR TYPE OF COMMUNICATIONS REQUIRED FOR THE PROJECT

This project will overlap with two other projects, SR 2040 A22 and SR 2040 A23. SR 2040 A22 will have an Internet drop at Lebanon Rd and SR 2040 A23 will add onto that connection. The northern half of SR 51 from Nurnberger will be able to connect back to the ITS Cameras at S.R 51 and S.R 88. The middle half of SR 51 from Streets Run to Coal Valley will be able to use the Internet drop from SR 2040 A22. The southern half of SR 51 from Jefferson Blvd to Dick Corp will need another Internet drop. See attached location map.

H - APPROVALS

PROJECT SPECIFIC REQUIREMENTS

DISTRICT TRAFFIC SIGNALS SUPERVISOR RECOMMENDATION (REQUIRED IF SIGNALS INCLUDED)	SIGNATURE	DATE
TMC MANAGER RECOMMENDATION (REQUIRED IF CONNECTION TO ITS DEVICES IS PROPOSED)	SIGNATURE	DATE
TSMO ARTERIALS & PLANNING SECTION RECOMMENDATION	SIGNATURE	DATE
TSMO OPERATIONS & PERFORMANCE SECTION RECOMMENDATION	SIGNATURE	DATE
SUBMITTED TO OA/OIT DATE	REMEDY TICKET NUMBER	

FOR OA/OIT USE ONLY

APPROVED CONNECTION METHOD

○ Direct connection to private, secure Commonwealth network via state-owned fiber

○ Direct connection to private, secure Commonwealth network via dedicated circuit

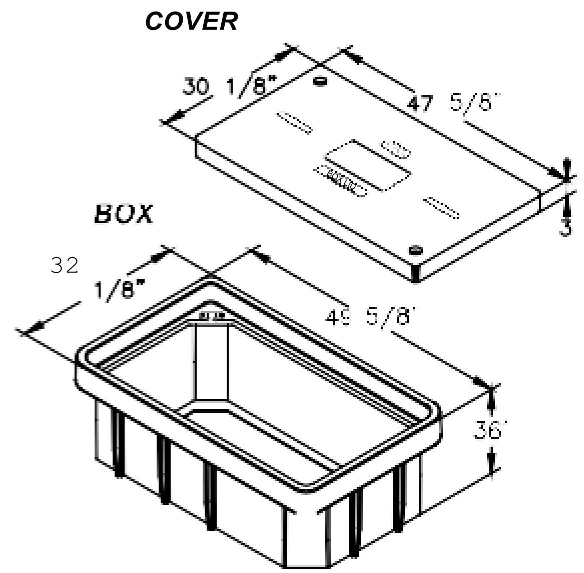
CORE NETWORK TEAM APPROVAL	SIGNATURE	DATE

Appendix B.
Sample Utility Coordination Spreadsheet

Sample Utility Coordinaton Spreadsheet

Device ID and Service Request Location	Address & City	Account	Premise	Meter	Comments	Equipment	Cost for Install	PS&E Date	Lettting Date	Start Date	Required Completion Date	Electircal Contractor	PennDOT Project Number Designer/Integ rator	Utility Compnay Designer
CMS-1003 @ SR0081 NB 800-feet south of SR0078	2150 SR 0072, Lebanon, 17656				**CMS-1003** **PPL** WILL: Remove meter for service installation Type B **CONTRACTOR** WILL: Remove Service Type B from wood pole	CMS-1003 CMS-1003 CAB INSTALL CAB SR81N-MP46.8						Company Name	ECMS # Bob Shirley	Name Phone email
CMS-1003 @ SR0081 NB 800-feet south of SR0078	2155 SR 0072, Lebanon, 17656				**CMS-1003** **PPL** WILL: Install new meter in new service enclosure **CONTRACTOR** WILL: Install service installation Type A on wood pole. Install conduit and power cables from in place wood pole to new foundation and metered service enclosure inside ROW fence	CMS-1003 CMS-1003 CAB INSTALL CAB SR81N-MP46.8						Company Name	ECMS # Bob Shirley	Name Phone email

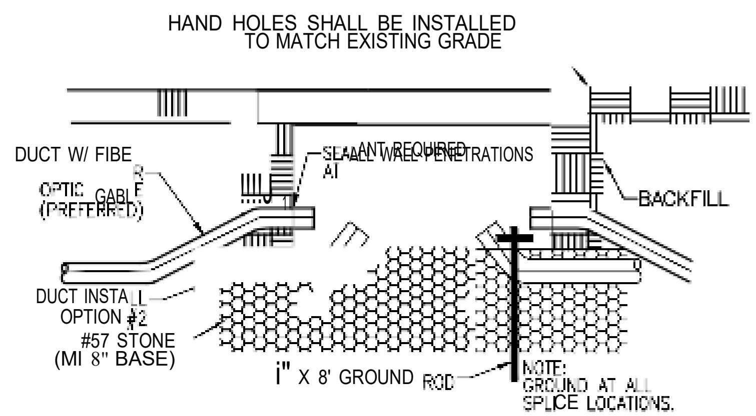
Appendix C. PennDOT Fiber Details



- TIER 22 HANDHOLES AND LIDS TO BE USED FOR BACKBONE AND PENNDOT ROW. NOT TO BE USED FOR DIRECT TRAFFIC APPL/CATIONS.

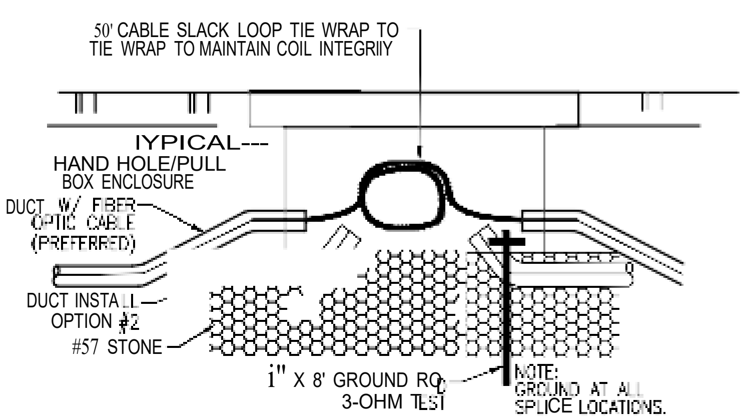
TYPICAL ANSI TIER 22 HAND HOLE/LID 30"x48"x36"

SCALE N.T.S.



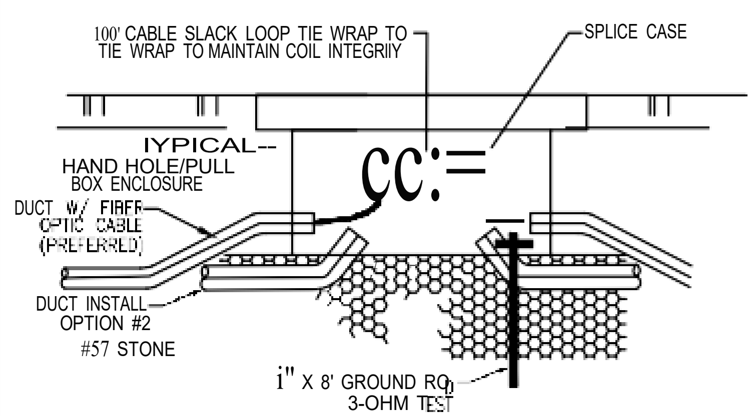
TYPICAL ANSI TIER 22 HANO HOLE INSTALL

SCALE: N.T.S.



TYPICAL HANO HOLE WITH COIL

SCALE: N.T.S.



TYPICAL HANO HOLE WITH SPLICE BOX

SCALE: N.T.S.

HAND HOLE DETA ILS:

DESCRIPTION - (30X48 X36) ALL HAND HOLES SHOULD BE ANSI TIER 22 LOAD RATED WITH OPEN BOTTOM DESIGN MEETING OR EXCEEDING THE FOLLOWING SPEC:

TIER 22 -OFF-ROADWAY APPLICATIONS SUBJECT TO OCCASIONAL NONDEL/BERATE HEAVY VEHICULAR TRAFFIC MEETING OR EXCEEDING THE FOLLOWING VERTICAL DESIGN LOAD OF 10 0.1 KN, 22,500 LBS. AND TEST LOAD OF 150 .1 KN 33,750 LBS. LATERAL DESIGN LOAD OF 38.3 KPA, 800 LBS./ SQ. FT. AND TEST LOAD OF 57.5 KPA 1,200 LBS./ SQ. FT.

TIER 22 LID- 1-PIECE, WITH 2 BOLTS, POLYMER CONCRETE FOR OFF ROADWAY APPLICATION SUBJECT TO OCCASIONAL NONDELIBERATE HEAVY VEHICULAR TRAFFIC MEETING OR EXCEEDING THE FOLLOWING WEIGHT LOAD RATING (DESIGN / TEST) 22,500/ 33,7 50 LB

INSTALLATION:

1 . HAND HOLES SPACING (SHOULD BE PLACED AT INTERVALS OF SPACING MEETING THE FOLLOWING DESIGN REQUIREMENTS)

a. FIBER OPTIC BACKBONE

i.a. SPACING BETWEEN 700FT AND I IO OFT.

ii.b. INTERSTATE AND LIMITED ACCESS ROADS A HAND HOLE MUST BE PLACED AT EVERY " CROSS ROAD " E.G. OVER PASS, UNDER PASS, ON RAM P, OFF RAMP ETC. FOR FUTURE LATERAL CONSTRUCTION

iii.c. HAND HOLES SHOULD BE PLACE AT ALL 90 ' BENDS.

iv.d . HAND HOLES SHOULD BE PLACED WITHIN 8FT OF ALL TRANSITION POINTS . (E. G. UNDERGROUND TO AERIAL , UNDERGROUND TO BRIDGE ATTACHM ENT, UNDERGROUND TO JERSEY WALL CONDUIT, UNDERGROUND TO PARAPET CONDUIT ETC.)

iw. FIBER OPTIC LATERAL

i.a. SPACING BETWEEN 250FT AND 500FT

ii.b. HAND HOLES SHOULD BE PLACE AT ALL 90 ' BENDS.

iii.c . HAND HOLES SHOULD BE PLACED WITHIN 8 FT OF ALL TRANSITION POINTS . (E. G. UNDERGROUND TO BUILDING / CABIN ET RISER, UNDERGROUND TO AERIAL , UNDERGROUND TO BRIDGE ATTACHM ENT , UNDERGROUND TO JERSEY WALL CONDUIT , UNDERGROUND TO PARAPET CONDUIT ETC.)

2. GRADING/ BACKFILL

a . HAND HOLES SHALL BE INSTALLED TO MATCH EXISTING GRADE WITH NO MORE THAN 1 -INCH PROTRUDING ON ANY SIDE.

b BACKFILL SHOULD BE MEET OR EXCEED EXISTING CONDITIONS .

i.a. IF EXISTING SPOILS ARE REASONABLY FREE OF DEBRIS (OVERSIZED STONE, ROCK , CONCRETE ETC.) THEN BACKFILL MAY BE PERFORMED WITH NATIVE SOIL IN LIFT FORMATION TO PREVENT SETTLEM ENT .

ii.b. IF NATIVE SOIL IS NOT FREE OF DEBRIS , THEN A NEW SOIL/SAND MIX MUST BE INSTALLED AROUND HAND HOLE AND COMPACTED IN LIFT FORMATION TO AVOID FUTURE SETTLEMENT

3. BASE

a EACH HAND HOLE SHOULD BE SET ON MINIMUM 8INCH BASE OF #57 STONE OR EQUI VALENT.

i.a. EXCAVATION SHALL BE EXTENDED BELOW THE BOTTOM OF THE STRUCTURE AS NECESSARY TO ACCOMMODATE THE REQUIRED BEDDING MATERIAL

4. . GROUND ROD -

a INSTALL 8FT 5/ 8 -INCH GROUND ROD WITH NO MORE THAN 24 INCHES OF EXPOSED ROD IN EACH HAND HOLE.

5 . CONDUIT INSTALLATION INTO HAND HOLES

a. PREFERRED METHOD - INSTALL THE CONDUIT INTO THE SIDE OF THE BOX THROUGH EXISTING KNOCK- OUT OR BY CUTTING CIRCULAR HOLE OF APPROPRIATE SIZE TO MATCH CONDUIT + ¼ INCH. HOLES SHOULD BE DRILLED APPROXIMATELY 10-18 INCH ABOVE THE BOTTOM OF THE BOX . ANY FIELD DRILLED HOLES MUST NOT CUT INTO STRUCTURAL REINFORCING RIB , CORNER BOX LIP, ETC. TO AVOID DAMAGING STRUCTURAL INTEGRITY.

i.a. KNOCKO UT/ HOLE MUST BE SEALED AFTER CONDUIT HAS BEEN INSTALLED TO ELIMINATE SILT RUNOFF INTO THE HAND BOX

ii.b. ALTERNATE METHOD - IF THE PITCH OF THE HOPE IS SUCH THAT ENTERING THE SIDE OF THE BOX WOULD CREATE SIGNIFICANT TENSION ON THE INSTALLATION OF THE FIBER OPTIC CABLE, AN ALTERNATE INSTALLATION METHOD WILL BE ALLOW ED. THE HOPE CONDUIT MAY BE INSTALLED INTO THE OPEN BOTTOM OF THE HAND BOX AS AN ALTERNATE TO THE PREFERRED " SIDE ENTRY" M ETHOD . THIS ALTERNATIVE METHOD WILL BE ALLOWED FOR SPECIAL CIRCUMSTANCE WHERE THE INSTALLATION DEPTH OF THE HOPE AND TERRAIN DID NOT ALLOW FOR SUFFICIENT SPACING TO " RETURN TO PLAIN " BEFORE ENTERING THE BOX WITHOUT DEGRADATION TO CONDUIT INNER DIAMETER. ALL CONDUIT ENTERING THE BOTTOM OF THE BOX MUST EXTEND A MINIMUM OF 12-16 INCHES ABOVE THE GRAVEL BASE.

SKYLINE TECHNOLOGY SOLUTIONS
6956-F AVIATION BOULEVARD
GLEN BURNIE, MD 21061
410-553-2600
WWW.SKYLINENET.NET

DESIGNED BY: S CRAWFORD
CHECKED BY: S CRAWFORD
DRAWN BY: N CALEO

REVISIONS

REV	DESCRIPTION	DATE	BY
	REVISED LID SPECS	09/29/20	NC
2	UPDATE TEXT ON SH.4 & SH.6	12/09/22	NC

KEY SHEET

PENNDOT FIBER DETAILS

HAND HOLE INSTALL DETAILS

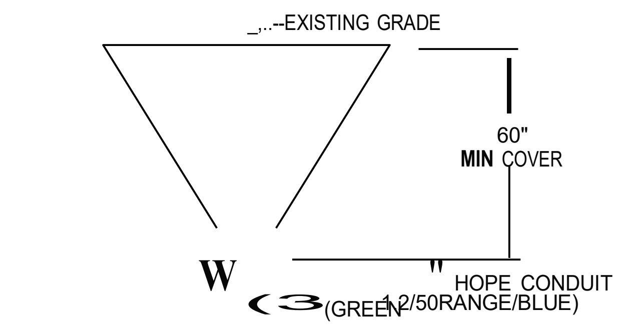
Pennsylvania Department of Transportation
1101 South Front Street
Harrisburg, PA 17104

SCALE: N.T.S.

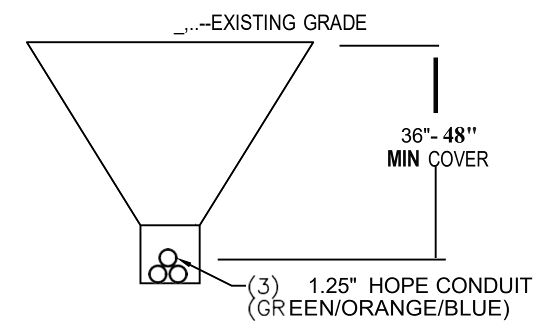
0 12.5 25 50

Date: 06/05/19 | SHEET 1 OF 8

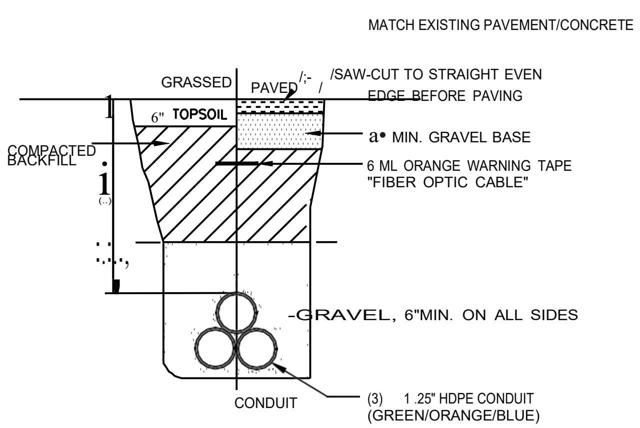
Filename:PENNDOT FIBER DETAILS_V6_REV2



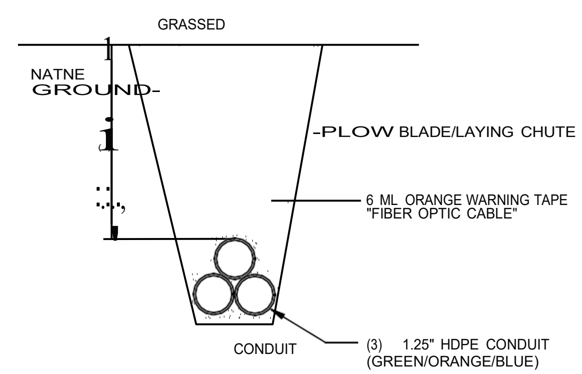
TYPICAL ROAD BORE/COMMERCIAL
SCALE:N.T.S.



TYPICAL DRIVEWAY BORE/RESIDENTIAL
SCALE: N.T.S.



TYPICAL TRENCH DETAIL
SCALE: N.T.S.



TYPICAL PLOW DETAIL
SCALE: N.T.S.

HOPE SDRII X 3 DETAILS:

DESCRIPTION - FURNISH AND INSTALLATION OFA SUBSURF ACE3 WAY HOPE SDRII 1.25" CONDUIT BY M EANS OF HORIZONTAL DIRECTIONAL DRILL, VIBRATORY PLOW OR OPEN TRENCH.

MATERIAL- HOPE SDRII 1 ¼ (1.25} INCH ID. REELS CAN BE SEPARATE OR COMBINED ONTO A SINGLE REEL

COLOR - COLORS OF THE HOPE SHOULD BE GREEN, ORANGE AND BLUE.

DESIGN AND INSTALLATION GUIDELINES:

1. APPROVED SUBSURFACE METHODS OF INSTALLATION ARE HORIZONTAL DIRECTIONAL DRILL, VIBRATORY PLOW OR OPEN TRENCH.
   a. FIBER OPTIC BACKBONE CONDUIT
      i.a. CONDUIT WILL BE CONTINUOUS IN INTERVALS RANGING FROM 700FT TO 1,IOOFT BETWEEN PULL POINTS (HAND HOLE).
      ii.b. INTERSTATE AND LIMITED ACCESS ROADS CONDUIT PLACEMENT
      - PREFERRED PLACEMENT WILL BE ALONG THE SHOULDER ROW TO LIMIT INTERFERENCE OF VEHICULAR TRAFFIC.
      - SECONDARY/ ALTERNATIVE PLACEMENT WILL BE IN THE MEDIAN PROVIDED ENOUGH ROW (GRASS AREA) EXISTS AS TO NOT INTERFERE WITH OPPOSING VEHICULAR TRAFFIC IN A MULTILANE DIVIDED HIGHWAY SCENARIO WITHOUT SPECIAL TRAFFIC CONTROL PROVISIONS.

      iii. a. PULL POINTS / SLACK STORAGE / PLACEMENT
      - HAND HOLES MUST BE PLACED AT EVERY " CROSS ROAD" E.G. OVER PASS, UNDER PASS, ON RAM P, OFF RAMP ETC. FOR FUTURE LATERAL CONSTRUCTION
      - HAND HOLES SHOULD BE PLACE AT ALL 90 ° HORIZONTAL BENDS.

      iv.a. CONDUIT TRANSITIONS
      - HAND HOLES SHOULD BE PLACED WITHIN 8 FT OF ALL TRANSITION POINTS. (E.G . UNDERGROUND TO AERIAL, UNDERGROUND TO BRIDGE ATTACHMENT, UNDERGROUND TO JERSEY WALL CONDUIT , UNDERGROUND TO PARAPET CONDUIT ETC.}

   b. FIBER OPTIC LATERAL CONDUIT
      i.a. SPACING BETWEEN 250FT AND 500FT
      ii.b. HAND HOLES SHOULD BE PLACE AT ALL 90 ° BENDS.
      iii. c. HAND HOLES SHOULD BE PLACED WITHIN 8 FT OF ALL TRANSITION POINTS. (E.G. UNDERGROUND TO BUILDING / CABIN ET RISER , UNDERGROUND TO AERI AL, UNDERGROUND TO BRIDGE ATTACHM EN T, UNDERGROUND TO JERSEY WALL CONDUIT, UNDERGROUND TO PARAPET CONDUIT ETC.}
2. INSTALLAT/ON DEPTH OF CONDUIT AND SEPARATION OF UTILITIES
   a. ALL "PARALLEL TO ROAD" CONDUIT SHOULD BE INSTALLED AT A DEPTH BETWEEN 36 AND 48 INCHES OF COVER.
   b. ALL HIGHWAY OR COMMERCIAL ROAD CROSSINGS SHOULD BE AT A MINIMUM DEPTH OF 60 INCHES OF COVER
   c. ALL RESIDENTIAL ROAD CROSSINGS (E.G. DRIVEWAYS} SHOULD BE MADE AT 36-48 INCHES OF COVER
   d. ALL PERPENDICULAR CROSSINGS TO OTHER UTILITIES (WATER, SEW ER, STORM , PHONE ETC.} MUST BE AT A MINIMUM OF 12 -18 INCHES OR MUST MEET UTILITY OWNER DESIGNATIONS
   e. PARALLEL INSTALLATION WITH EXISTING UTILITIES MUST MAINTAIN A MINIMUM OF 18 INCHES OF SEPARATION IN ALL DIRECTI ONS.
3. CONDUIT BEND RADIUS
   a. DO NOT EXCEED THE MAXIMUM BEND RADIUS OF THE CONDUIT OR CABLE INSTALLED IN THE CONDUIT
      i.a. CONDUIT BEND RADIUS IS CALCULATED AT 20X THE DIAMETER OF CONDUIT
4. HOPE PULL STRENGTH
   a. PULL STRENGTH IS CALCULATED AT 80% OF TENSILE OR BREAKING STRENGTH WHICH FOR THE HOPE SDRII 1.25" IS APPROX. 1 7 00
5. PULL STRING INSTALLATION IN CONDUIT
   a. EACH CONDUIT WILL HAVE "PULL LINE" INSTALLED AND WILL HAVE THE FOLLOWING CHARACTER /ST/CS:
      i.a. 1250 LB. PULL STRENGTH (MINIMUM)
      ii.b. FLAT DESIGN WITH ½ INCH WIDTH
      iii .c. SEQUENTIAL FOOTAGE MARKINGS
      iv.d. POLYESTER MATERIAL OR SIMILAR
6. ACCEPTANCE / PROOFING TEST
   a. MANDREL TEST
      i.a. ALL HOPE DUCT WILL BE PROOFED BY PULLING WITH A MANDREL NO SMALLER THAN 1 1/8" OD AND 2 7/8" LENGTH TO ENSURE THAT A MINIMUM OF 80% OF THE PUBLISHED ID IS MAINTAINED AFTER SUBSURFACE INSTALLATION IS COM PLETE.
      ii.b. MANDREL INSTALLATION WILL BE FROM PULL POINT TO PULL POINT AS WELL AS THROUGH ALL TRANSITIONS
      iii.e. THIS ACCEPTANCE TEST MUST BE PERFORMED PRIOR, NOT DURI NG, THE FIBER CABLE INSTALLATION.

SKYLINE TECHNOLOGY SOLUTIONS
6956-F AVIATION BOULEVARD
GLEN BURNIE, MD 21061
410-553-2600
WWW.SKYLINENET.NET

DESIGNED BY: S CRAWFORD
CHECKED BY: S CRAWFORD
DRAWN BY: N CALEO

REVISIONS

REV	DESCRIPTION	DATE	BY
	REVISED LID SPECS	09/29/20	NC
2	UPDATE TEXT ON SH.4 & SH.6	12/09/22	NC

KEY SHEET

PENNDOT FIBER DETAILS

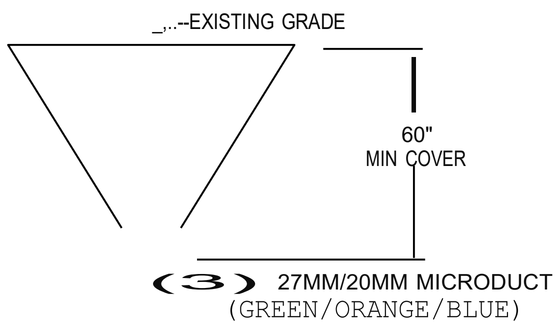
3-WAY 1.25 " HOPE INSTALL DETAILS

Pennsylvania Department of Transportation
1101 South Front Street
Harrisburg, PA 17104

SCALE: illtl sc,.Qt
0 12.5 25 50

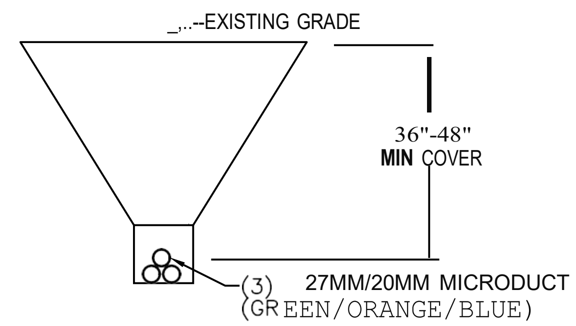
Date: 06/05/19 | SHEET 2 OF 8

Filename: PENNDOT FIBER DETAILS_V6_REV2



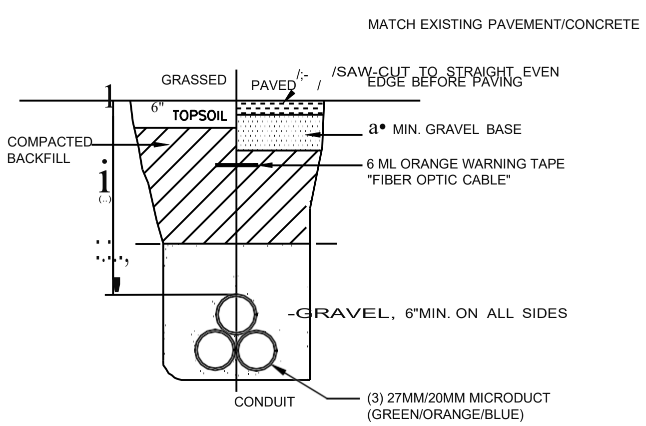
TYPICAL ROAD BORE/COMMERCIAL

SCALE:N. T.S.



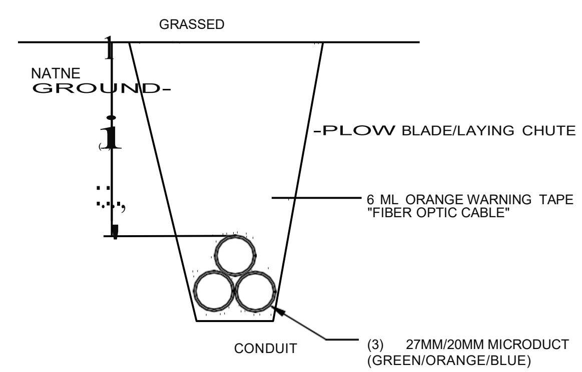
TYPICAL DRIVEWAY BORE/RESIDENTIAL

SCALE: N. T.S.



TYPICAL TRENCH DETAIL

SCALE: N.T.S.



TYPICAL PLOW DETAIL

SCALE: N.T.S.

MICRODUCT CONDUIT 3-WAY {CITY ENVIRONMENT WITH LIMITED ACCESS TO ROW}

DESCRIPTION *- FURNISH AND INSTALLATION OF A SUBSURFACE 3 WAY MICRODUCT CONDUIT BY MEANS OF HORIZONTAL DIRECTIONAL DRILL, VIBRATORY PLOW OR OPEN TRENCH.*

MATERIAL *- HOPE 3-WAY FACTORY BUNDLED MICRODUCT WITH A POLYETHYLENE OVERSHEATH. EACH MICRODUCT ARE TO BE SMOOTH ON THE OUTSIDE, MICRO-RIBBED ON THE INSIDE AND HAVE A CO-EXTRUDED PERMANENT LUBRICATION LAYER.*

COLOR *- THE MICRODUCT OVERSHEATH SHOULD BE ORANGE IN COLOR. INNER MICRODUCT COLORS SHOULD BE GREEN, ORANGE AND BLUE.*

MICRODUCT SIZE *- MICRODUCT SIZES ARE REFERENCED USING AN {OD / ID} MEASUREMENT. THE 3-WAY MICRODUCT SHOULD MEET OR EXCEED THE FOLLOWING OD/ IDMEASUREMENT: 27MM/20MM*

DESIGN AND INSTALLATION GUIDELINES:

1. *APPROVED SUBSURFACE METHODS OF INSTALLATION ARE HORIZONTAL DIRECTIONAL DRILL, VIBRATOR PLOW OR OPEN TRENCH.*
   - i. *FIBER OPTIC BACKBONE MICRO CONDUIT /CITY TYPE ENVIRONMENT WITH LIMITED / NO ROW)*
     - *CONDUIT WILL BE CONTINUOUS IN INTERVALS RANGING FROM 700FT TO 1,IOOFT BETWEEN PULL POINTS {HAND HOLE).*
     - *INTERSTATE AND LIMITED ACCESS ROADS CONDUIT PLACEMENT*
       - *PREFERRED PLACEMENT WILL BE ALONG THE SHOULDER ROW TO LIMIT INTERFERENCE OF VEHICULAR TRAFFIC.*
       - *SECONDARY/ ALTERNA TIVE PLACEMENT WILL BE IN THE MEDIAN PROVIDED ENOUGH ROW {GRASSAREA) EXISTS AS TO NOT INTERFERE WITH OPPOSING VEHICULAR TRAFFIC IN A MULTILANE DIVIDED HIGHWAY SCENARIO WITHOUT SPECIAL TRAFFIC CONTROL PROVISIONS.*
     - *PULL POINTS/ SLACK STORAGE/ PLACEMENT*
       - *HAND HOLES MUST BE PLACED AT EVERY "CROSS ROAD" E.G. OVER PASS, UNDER PASS, ON RAMP, OFF RAMP ETC. FOR FUTURELATERAL CONSTRUCT/ON*
       - *HAND HOLES SHOULD BE PLACE AT ALL 90' HORIZONTAL BENDS.*
     - *CONDUIT TRANSITIONS*
       - *HAND HOLES SHOULD BE PLACED WITHIN 8FT OF ALL TRANSITION POINTS. /E.G. UNDERGROUND TO AERIAL, UNDERGROUND TO BRIDGE ATTACHMENT, UNDERGROUND TO JERSEY WALL CONDUIT, UNDERGROUND TO PARAPET CONDUIT ETC.)*
   - ii. *FIBER OPTIC LATERAL CONDUIT //CITY TYPE ENVIRONMENT WITH LIMITED/NO ROW)*
     - *SPACING BETWEEN 250FT AND 500FT*
     - *HAND HOLES SHOULD BE PLACE AT ALL 90' BENDS.*
     - *HAND HOLES SHOULD BE PLACED WITHIN 8FT OF ALL TRANSITION PO INTS. (E.G. UNDERGROUND TO BUILDING/ CABINETRISER, UNDERGROUND TO AERIAL, UNDERGROUND TO BRIDGE ATTACHMENT, UNDERGROUND TOJERSEY WALL CONDUIT, UNDERGROUND TO PARAPET CONDUIT ETC.}*
2. *INSTALLATION DEPTH OF CONDUIT AND SEPARATION OF UTILITIES*
   - i. *ALL "PARALLEL TO ROAD" CONDUIT SHOULD BE INSTALLED AT A DEPTH BETWEEN 36 AND 48 INCHES OF COVER.*
   - ii. *ALL HIGHWAY OR COMMERCIAL ROAD CROSSINGS SHOULD BE AT A MINIMUM DEPTH OF 60 INCHES OF COVER*
   - iii. *ALL RESIDENTIAL ROAD CROSSINGS (E.G. DRIVEWAYS) SHOULD BE MADE AT 36-48 INCHES OF COVER*
   - iv. *ALL PERPENDICULAR CROSSINGS TO OTHER UTILITIES {WA TER, SEWER, STORM, PHONE ETC.} MUST BE AT A MINIMUM OF 12-18 INCHES OR MUST MEET UTILITY OWNER DESIGNATIONS*
   - v. *PARALLEL INSTALLATION WITH EXISTING UTILITIES MUST MAINTAIN A MINIMUM OF 18 INCHES OF SEPARATION IN ALL DIRECTIONS.*
3. *CONDUIT BEND RADIUS*
   - i. *DO NOT EXCEED THE MAXIMUM BEND RADIUS OF THE CONDUIT OR CABLE INSTALLED IN THE CONDUIT*
     - *CONDUIT BEND RADIUS IS CALCULATED AT 20X THE DIAMETER OF CONDUIT*
4. *MICRO CONDUIT PULL STRENGTH*
   - i. *PULL STRENGTH IS CALCULATED AT 80% OF TENSILE OR BREAKING STRENGTH WHICH FOR THE HOPE SDRII 1.25" IS APPROX. 1700*
5. *COUPLINGS*
   - i. *NO COUPLING OF THE MICRODUCTS SHALL BE INSTALLED BETWEEN PULL POINTS {HAND HOLES) WITHOUT THE INSTALLATION OF A PULL BOX OVER SUCH COUPLINGS.*
   - ii. *PULL BOX (HAND HOLE) COUPLING DIMENSIONS WILL BE 17X24X36 MINIMUM MEETING THE ANSI TIER 22 RATING*
6. *ACCEPTANCE/ PROOFING TEST*
   - i. *PRESSURE TEST*
     - *PERFORM SEPARATE PRESSURE TESTING ON EACH INDIVIDUAL MICRODUCT /ORANGE, GREEN, BLUE)*
     - *TESTING MUST BE PERFORMED BETWEEN PULL POINTS OR AT ANY TRANSITION POINT*
     - *EACH MICRODUCT MUST MAINTAIN IOOPSI FOR A PERIOD OF 1 MINUTE WITH A MINIMUM OF 5% PRESSURE DROP ALLOWED*
     - *EACH TEST WILL BE RECORDED AND DELIVERED UPON COMPLETION BEFORE FIBER CAN BE INSTALLED.*
   - ii. *BB PROOFING TEST*
     - *USING APPROVED PLASTIC 88 {PROOFING BALL) BLOW THROUGH EACH INDIVIDUAL MICRODUCT {ORANGE, GREEN, BLUE} FROM PULL POINT TO PULL POINT TO ENSURE ID OF MICRODUCT WAS NOT COMPROMISED DURING INSTALLATION.*
     - *EACH DUCT MUST BE "PROOFED" WITH APPROPRIATE BB SIZE TO ENSURE THAT A MINIMUM OF 80% OF THE PUBLISHED ID IS MAINTAINED.*

SKYLINE TECHNOLOGY SOLUTIONS
6950-F AVIATION BOULEVARD
GLEN BURNIE, MD 21061
410-553-2600
WWW.SKYLINENET.NET

DESIGNED BY: S CRAWFORD
CHECKED BY: S CRAWFORD
DRAWN BY: N CALEO

REVISIONS

REV	DESCRIPTION	DATE	BY
	REVISED LID SPECS	09/29/20	NC
2	UPDATE TEXT ON SH.4 & SH.6	12/09/22	NC

KEY SHEET

PENNDOT FIBER DETAILS

3-WAY MICRODUCT INSTALL DETAILS

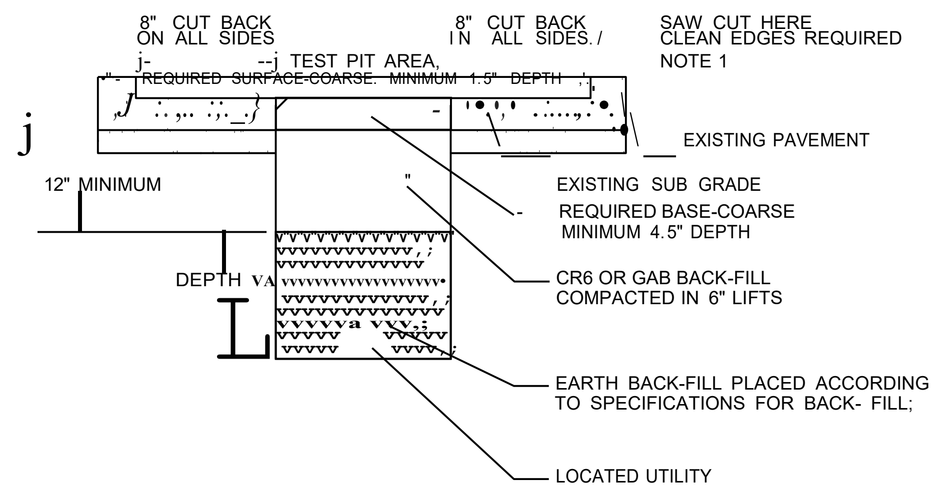
Pennsylvania Department of Transportation
1101 South Front Street
Harrisburg, PA 17104

SCALE: 0 12.5 25 50

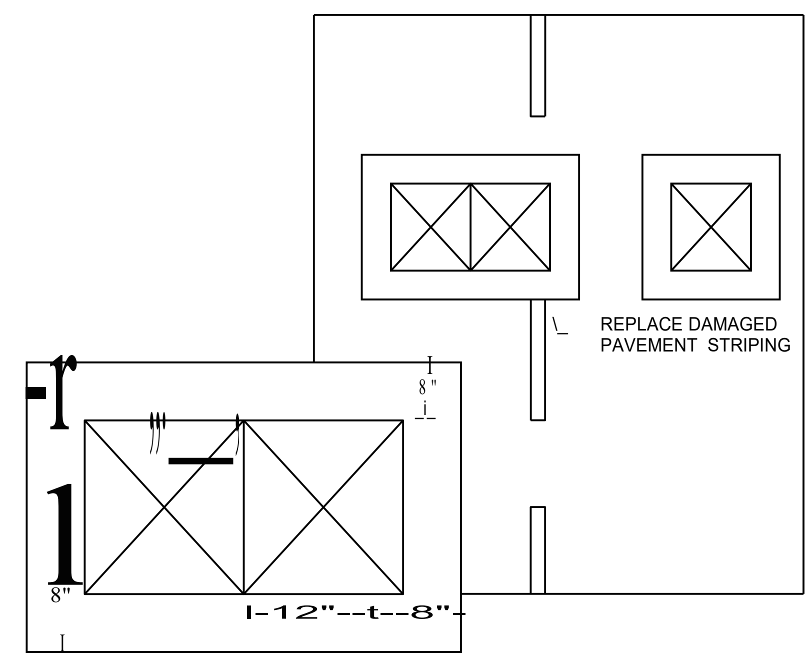
Date: 06/05/19 SHEET 3 OF 8

Filename: PENNDOT_FIBER_DETAILS_V6_REV2

PERMANENT REPAIR OF FLEXIBLE PAVEMENT ROADWAY TEST PIT DETAIL FOR 1'X1' OR 1'X2' OPENINGS CROSS-SECTION VIEW



FLEXIBLE PAVEMENT ROADWAY TEST PIT REPAIR DETAIL FOR 1'X1' OR 1'X2' OPENINGS TOP-SECTION VIEW



NOTES

1. MEASURE 8 INCHES FROM THE EXISTING PERIMETER OF THE ORIGINAL (UP TO 1'X2' OPENING FOR TEST PITS LARGER THAN 1'X2'; REFER TO XXX PENNDOT STANDARDS) AND SAW CUT TO A MINIMUM DEPTH OF 1.5 INCHES; MAKING SURE THAT THE EDGES ARE CLEAN AND FREE OF DEBRIS. REMOVE ANY EXISTING CRACKED, LOOSE, OR BROKEN ASPHALT.
2. HMA REPAIRS SHALL BE A MINIMUM DEPTH OF 6 INCHES, OR MATCH THE EXISTING PAVEMENT SECTION; WHICHEVER IS GREATER, UNLESS OTHERWISE DIRECTED BY ROADWAY ENGINEER.
3. PLACE 12" MINIMUM OF PROPERLY COMPACTED CR6 OR GAB BETWEEN THE TOP OF THE COMPACTED EARTH BACK-FILL AT THE BOTTOM OF THE TEST PIT. DEPTHS OF EARTH BACK -FILL WILL VARY BASED ON THE TOTAL DEPTH OF THE TEST PIT.
4. CLEAN ALL EXPOSED VERTICAL AND HORIZONTAL SURFACES OF THE EXISTING ASPHALT PAVEMENT AND APPLY AN APPROVED TACK COAT (PRIMER BINDER E.G. EM50) TO ALL EXISTING EXPOSED ASPHALT SURFACES ONCETHE BASE COARSE HAVE BEEN PROPERLY COMPACTED, TACK COAT SHALL BE APPLIED TO THE BASE COARSE PRIOR TO THE APPLICATION AND COMPACTION OF THE SURFACE COARSE. PRIME COAT MUST BE APPLIED TO TO DRY SURFACE WHEN AMBIENT TEMPERATURE IS GREATER THAN 50 DEGREES F. PRIME COAT WILL BE ASTM D-2O28, GRADE RC-70 CUTBACK ASPHALT. ASTM D-977, TYPE RS-1 OR ASTM D-2397, TYPE CRS-1 EMULSIFIED ASPHALTAS APPROPRIATE.
5. A BASE-COARSE SHALL BE COMPACTED IN LAYERS NOT TO EXCEED 3". A SURFACE-COARSE SHALL BE COMPACTED IN LAYERS NOT TO EXCEED 1.5". USE 12.5 **MM** HMA FOR ALL LAYERS.
6. EACH COARSE OF HMA MUST BE COMPACTED WITH APPROPRIATE COMPACTING EQUIPMENT TO ACHIEVE 92% - 97% COMPACTION PER XXX PENNDOT STANDARDS.
7. THE FINAL ASPHALT PATCH MUST BE COMPACTED FLUSH WITH THE EXISTING PAVEMENT.
8. PAVEMENT MARKINGS MUST BE REPLACED, IN KIND, WITH SIMILAR MATERIALS.

SKYLINE TECHNOLOGY SOLUTIONS
6956-F AVIATION BOULEVARD
GLEN BURNIE, MD 21061
410-553-2600
WWW.SKYLINENET.NET

DESIGNED BY: S CRAWFORD
CHECKED BY: S CRAWFORD
DRAWN BY: N CALEO

REVISIONS

REV	DESCRIPTION	DATE	BY
	REVISED LID SPECS	09/29/20	NC
2	UPDATE TEXT ON SH.4 & SH.6	12/09/22	NC

KEY SHEET

PENNDOT FIBER DETAILS

ROADWAY TEST PIT DETAILS

Pennsylvania Department of Transportation
1101 South Front Street
Harrisburg, PA 17104

SCALE: 0 12.5 25 50

Date: 06/05/19 SHEET 4 OF 8

Filename: PENNDOT FIBER DETAILS_V6_REV2

SITE CONDITIONS

THE ACTUAL LOCATION OF EXISTING CONDUIT AND CABLE:S MAY VARY FROM THE LOCATION SHO'MI. REPAIR OF ANY DAMAGE:D CONDUIT CONTAINING CABLE: SHALL BE MADE BY US£ OF PVC SPUT DUCT. THE CONTRACTOR SHALL ENCLOSE THE EXISTING CABLE:S IN PVC.

THE LOCATIONS OF EXISTING UTIUTIES SHO'MI IN THIS PLAN ARE APPROX/MA TE:. WHEN WORK IS TO BE CONDUCTE:D IN THE VICINITY OF KNO'MI UTIUTIES, THEIR ACTUAL LOCATION MUST BE FIELD VE:RIFIED TO AVOID CONFLICTS OR DAMAGE: TO THOSE UTIUTIE:S. VAR/ATION IN LOCATION BETWE:EN "RECORDED POSITIONS" AND ACTUAL POSITIONS SHOULD BE ANTIC/PATE:D.

IT SHALL BE THE CONTRACTOR'S RESPONSIBILITY TO VE:RIFY THE LOCATION OF ALL UNDERGROUND UTIUTIES. BURIED UTILIT'1ES MAY EXIST IN THE AREA IN ADDIT10N TO THOSE: SHO'MI ON THE PLAN. THE CONTRACTOR SHALL CONTACT PROPERTY O'MIERS WHEN WORKING WITHIN PR/VATE: EASEMENTS FOR LOCATION OF UNDERGROUND TANKS, PIP£LJNES, DRAIN TILE:S, OR OTHER BURIED IMPROVEMENTS. THE CONTRACTOR SHALL ALSO NOTIFY THE UTILITY NOTIFICATION CE:NTE:R PRIOR TO COMMENCING ANY CONSTRUCTION ACTIVITIES.

THE CONTRACTOR MUST ASSUME ALL BURIED UTIUTIES ENCOUNTE:RED ARE ALIVE: AND ACTIVE: UNLE:SS SPECIF/CALLY INSTRUCTE:D OTHE:RWISE: BY THE O'MIE:RS OR OPERATORS OF SAID UTILITIES.

DAMAGE TO SUB-SURFACE STRUCTURES IS THE SOL£ RESPONSIBIUTY OF THE PLACING CONTRACTOR.

THE CONTRACTOR SHALL PROTE:CT THE EXISTING TRAmc CONTROL LOOPS. IF EXISTING TRAmc CONTROL LOOPS ARE DAMAGED DURING CONSTRUCTION, THE ENTIRE LOOP/t'fRE FROM FROM TE:RMINAL TO TE:RMINAL SHALL BE REPLACED IN ACCORDANCE l'tfTH GOVE:RNING AGENCY STANDARDS AND REGULATIONS AT CONTRACTOR'S EXPENSE.

REMOVAL OF EXISTING ASPHALT PAVE:MENT, CONCRETE: CURBS, AND CONCRETE: SIDEWALKS l'tfLL BE "NEAT UN£" l'tfTH SAW OR PAVE:MENT CUTTE:R, PE:R REQUIRE:MENTS AND SPECIFICATIONS OF THE AGE:NCY OR DE:PARTMENT RESPONSIBLE FOR EACH LOCATION. IF CONCRETE: PAVE:MENT IS ENCOUNTE:RED WHILE: EXCAVATING CONDUIT TRENCHES, THE CONCRETE: REMOVAL WILL BE "NEAT UN£" l'tfTH A PAVE:MENT SAW.

IF CONCRETE: CURB RETURNS AND/OR SIDEWALKS ARE REPLACED DUE TO CONDUIT OR MANHOLE: INSTALLATION, THE CONTRACTOR SHALL INSTALL APPROVE:D HANDICAPPED SIDEWALK AND CURB ACCE:SS RAMPS IN CONFORMANCE: WITH STATE: STATUTE:S.

ALL MATE:RIALS NECESSARY FOR THE RE:PAIR OF STRffTS, CURBS, SIDEWALKS, SANITARY SEWERS, STORM SEWERS, AND PUBLIC SE:RVICE: UTILITIES, AND THE INSTALLATION OF SUCH MATE:RIALS SHALL BE IN CONFORMANCE: WITH THE REQUIRE:MENTS AND SPECIF/CATIONS OF THE AGENCY OR DEPARTMENT RESPONSIBLE: FOR THE OPE:RATION AND MAINTE:NANCE: OF THE REPAIRED FACILITY.

ALL WORK SHALL CONFORM TO THE SPECIF/CATIONS OF THE JURISDICTIONAL PERMIT AGENCY.

ALL OPEN TRENCH l'tfLL BE CLEARLY MARKED WITH BARRICADES OR CONE:S. STE:EL PLATE:S OR OTHE:R TYPES OF BRIDGING SHALL BE PROVIDED TO COVE:R OPEN TRENCH IN THE TRAV£L PORTION OF THE STRffTS. THE:5£ PLATE:S OR BRIDGING SHALL BE ADEQUATE: TO SUPPORT THE NORMAL VE:HICLE: LOADS ANTIC/PATE:D IN THIS AREA AND SHALL BE IN PLACE DURING ALL NON-WORKING HOURS.

ALL SURFACES TO BE RESTORED TO ORIGINAL CONDIT10N, AND BACKFILL TO BE COMPACTE:D AS SPECIFIED. TRENCH EXCAVATION IN SURFACE:S WHICH INCLUDE CONCRETE: TREATE:D BAS£ SHALL FOLLOW LOCAL AREA SPECIF/CATIONS.

TRAFFIC CONTROL

THIS PROJECT l',fLL INVOLVE: WORKING ALONG A MAJOR ARTE:RIAL ROAD AND HEAVY TRAmc VOLUME SHOULD BE ANTIC/PATE:D.

UNIFORM TRAmc FLOW SHALL BE MAINTAINED AT ALL TIMES. ONLY EQUIPMENT AND MATE:RIALS NECESSARY FOR IMMEDIATE:LY SCHEDULE:D OR IN PROGRESS WORK l'tfLL BE MAINTAINED IN THE WORK AREA. ALL OTHER EQUIPMENT AND MATE:RIALS l'tfLL BE "STORED OR STOCKPILED" IN SUCH A MANNE:R AS TO EUMINATE: HAZARDOUS CONDIT10NS FOR TRAmc OR PEDESTRIANS DURING NON-WORKING OR SHUT DO'MI PERIODS.

TRAmc WARNING DEVICE:S AND SIGNS SHALL CONFORM TO THE MANUAL ON UNIFORM TRAmc CONTROL DEVICES FOR STRffTS AND HIGHWAYS (U.S. GOVE:RNMENT PRINTING OFFICE) AND TO THE PENNSYLVANIA STATE: HIGHWAY DIVISION STANDARD SPECIFICATIONS FOR HIGHWAY CONSTRUCTION. HIGH LE:VE:L WARNING TYPE DEVICES ARE TO BE USE:D AT ALL TIMES AND SPECIAL WARNING DEVICE:S MAY BE STIPULATE:D BY THE JURISDICTIONAL PERMIT AGENCY AT ANY TIME THE US£ WILL ADD TO THE SAFE:TY AND PROTE:CTION OF TRAmc OR PEDESTRIANS IN THE CONSTRUCTION AREA.

ALL CONDUIT TRENCHING IN PAVE:D AREAS SHALL BE BACKFILLE:D WITH CRUSHED GRAVE:L OR COMPLE:TE:LY COVE:RED AT THE COMPLETION OF EACH WORKING DAY. ANY BACKFILLE:D TRENCH SHALL BE CAPPED WITH A MINIMUM LAYE:R OF ASPHALT1C CONCRETE: COLD PATCH AT THE END OF EACH WORKING DAY.

THE CONTRACTOR SHALL MARK THE CONDUIT TRENCH AND Dff/NE HIS CONSTRUCTION AREA CLE:ARLY WITH BARRICADES, CONES, AND/OR OTHER VISIBLE: METHODS THAT ALE:RT THE PUBLIC OF THE CONSTRUCTION ACTIVITY.

A TRAmc CONTROL PLAN SHALL BE PRE:PARED BY THE CONTRACTOR AS REQUIRED AND SUBMITTE:D TO EACH PERMImNG AGENCY REQUESTING SUCH PLAN FOR REVIEW AND APPROVAL OR REVISION PRIOR TO COMMENCING ANY CONSTRUCTION ACTIVITY FOR THIS PROJE:CT. THE APPROVE:D PLAN SHALL BE SUBMITTE:D TO THE AGE:NCY AND A COPY OF THE PLAN SHALL BE KEPT AT THE CONSTRUCTION SITE: AND MUST BE READILY AVAILABLE: FOR REVIEW BY AGE:NCY REPRESE:NTA TIVE:S.

AERIAL NOTES

- AE:RIAL CONSTRUCTION AND FIBE:R PLACE:MENT TO BE PERFORMED TO ACCE:PTABLE INDUSTRY STANDARDS.
- ALL HEIGHTS OF INSTALLE:D CABLE: WILL BE RECORDED IN THE AS- BUILDS.
- 1/4-INCH 6.6M EHS GALVANIZED STRAND l'tfLL BE USED l'tfTH THE APPROPRIATE: HARDWARE, UNLE:SS OTHERWISE SPECIFIED
- J-INCH FIANGE:D GALVAN/ZED RISE:R GUARD WILL BE USE:D WITH THE APPROPRIATE: HARDWARE.
- ALL FIBER OPTIC CABLE:S WILL BE DOUBLE: LASHED.
- STAINLESS STE:EL LASHING WIRE, 0.045-INCH DIAMETE:R WILL BE USE:D WITH THE APPROPRIATE: HARDWARE.

PERMITS - FRANCHISES - EASEMENTS

PHYSICAL WORK SHALL NOT BE STARTE:D UNTIL THE GOVE:RNING AGE:NCY INSPECTOR AND THE CONTRACTOR ARE IN POSSE:SSION OF AND HAVE: CARffULLY REVIEWE:D AND FULLY UNDERSTAND ALL CONDIT10NS AND SPECIFICATIONS SE:T FORTH IN THE REQUIRED PE:RMITS, FRANCHISES, AND/OR EASEMENTS.

PLACING FOREMAN TO HAVE: A COPY OF THE PERMITS,/£AS£MENTS ON SITE: AT ALL TIMES.

ANY CONFLICT BETWE:EN WORK PRINT SPECIF/CATIONS AND SPECIF/CATIONS SE:T FORTH UNDER RELATE:D PERMITS, FRANCHISE:S, AND/OR EASE:MENTS MUST BE CLE:ARED BY PROPER COMPANY AUTHORITY BffORE PROGRESSING WITH WORK INVOLVE:D.

CONDUITS

CONDUIT l'tfLL BE HDPE SDR11 DIRECTIONAL BORE UNLE:SS OTHERl'tfSE: SPECIF/£0.

CONTRACTOR SUPPLIED MATE:RIALS SHALL CONFORM TO THE JURISDICTIONAL PERMIT AGENCY AND O'MIER SPECIF/CATIONS.

ALL CONTRACTOR SUPPLIED MATE:RIALS SHALL INCLUDE A CERTIFIED TE:ST REPORT CLE:ARLY STATING THAT THOSE: SUPPLIED MATE:RIALS COMPLY l'tfTH ANY SUCH SPECFI/CATION.

CONDUIT IN LOCATION SHO'MI ON PRINTS WITH MINIMUM COVE:R OF 60" ON SHA ROAD CROSSINGS AND A MINIMUM OF J6" ON SHA & COUNTY RIGHT-OF-WAYS, UNLE:SS OTHERWISE SPECIFIED.

TOTAL LE:NGTH OF TRENCH OPEN AT ANY ONE TIME TO BE KEPT TO A MINIMUM.

THE CONTRACTOR l'tfLL PROOF ALL CONDUITS UTIUZING A 1.75 INCH DIAMETE:R AND 4" LONG MANDREL

THE CONTRACTOR SHALL FURNISH AND INSTALL (1) 14 GAUGE:TRACER l'tfRE, AND FURNISH AND INSTALL (1) 1250LB. MULE: TAPE IN THE CONDUIT.

PRE-CONSffiUCTTON MEETTNG

THE CONTRACTOR SHALL BE RESPONSIBLE: FOR SCHEDUUNG A PRE-CONSTRUCTION MffTING WITH XXX INSPECTOR PRIOR TO CONSTRUCTION COMMENCING

AS-BUILT REDLINES AND SEQUENTTALS

THE CONTRACTOR SHALL BE RESPONSIBLE: FOR SUPPLYING XXX WITH A HARD COPY OF THE AS-BUILT REDUNES DRAl'tfNG AND/OR A SOFT COPY OF THE AS-BUILT DRAWING IN A PDF FORMAT.

AS-BUILT REDUNE DRAWING FOR UNDERGROUND CONSTRUCTION SHALL INCLUDE OFFSETS AND DEPTHS OF ALL CONDUIT EVE:RY 50 FE:E:T INCLUDING BUT NOT UMITE:D TO THE DEPTHS AT ROADWAY CROSSINGS.

AS-BUILT REDUNE DRAWING FOR UNDERGROUND CONSTRUCTION SHALL INCLUDE FIBER SEQUENTIAL NUMBE:RS IN AND OUT AT EACH HAND HOLE LOCATION AND END NUMBE:R AT TE:RM PANE:L.

AS-BUILT REDUNE DRAWING FOR AERIAL CONSTRUCTION SHALL INCLUDE FIBE:R SEQUENTIAL NUMBE:RS AT EACH UTIUTY POL£ AND IN AND OUT AT EACH AERIAL SLACK LOOP

DELJVE:RY DATE: OF AS-BUILT REDUNES DRAl'tfNGS SHALL BE NO LATE:R THAN ONE WE:EK AFTE:R CONSTRUCTION IS COMPLE:TE:D.

IF HH PLACEMENT LOCATIONS ALTE:R FROM ORIGINAL DESIGN ON DRAl'tfNG THEN REDUNES MUST REF1£CT NEW STATION NUMBE:R AND LOCATION.

UTILITY SERVICES

LANDSCAPE AREAS SE:RVE:D BY IRRIGATION SYSTEMS SHALL BE MAINTAINED AT ALL TIMES DURING CONSTRUCTION BY THE UTIUZATION OF TEMPORARY SOURCE:S OF /RR/GATION WATE:R OR BY MAKING TE:MPORARY REPAIRS TO THE DAMAGED SYSTE:M TO ALLOW ITS SATISFACTORY OPERATION.

ANY UTIUTY DAMAGE:D BY CONSTRUCTION ACTIVITY SHALL BE RETURNED TO FULL SE:RVICE: IMMEDIATE:LY AND ANY COST OR EXPENSE: CONSIDERED TO BE LOST BY THE UTIUTY USER SHALL BE THE CONTRACTOR'S RESPONSIBIUTY.

LANDSCAPING

TRffS AND SHRUBS TO BE TRIMMED OR RE:MOVE:D SHALL BE IDENTIFIED PRIOR TO ALL SUCH ACTIVITY TO VE:RIFY THE NECESSITY OF SAID ACTION AND THE METHOD OF DEALING l'tfTH THE:M.

TR££ AND SHRUB TRIMMING SHALL BE DONE BY A UCE:NSED LANDSCAPER AND SHALL CONFORM TO THE STANDARDS OF THE AMERICAN NURSERYMAN'S ASSOCIATION.

TRffS AND SHRUBS USE:D AS SIGHT SCRffNING, OR RE:PLACED DUE TO CONSTRUCTION, SHALL MffT THE AMERICAN NURSE:RYMAN'S ASSOCIATION STANDARDS FOR QUALITY AND SIZE:. REMNANT TRffS AND SHRUBS SHALL SATISFY THE PROPERTY O'MIER AS TO SIZE AND QUALITY.

EXCAVATION IN LA'MI AREAS SHALL BE "NEAT LINED" l'tfTH A SOD CUTTE:R TO ENSURE A SMOOTH MATCH LINE FOR REPAIR WITH APPROVE:D SOD.

ALL LA'MI RESTORATION SHALL BE DONE BY USING SOD TO THE GROWE:R/SUPPUERS SPECIF/CATIONS AND ADJACENT PROPERTY O'MIER'S SPECIF/CATIONS.

SOD USE:D TO REPAIR EXISTING LA'MI AREA SHALL BE OF A BLE:ND THAT WILL MATCH THE ADJACENT UNDISTURBED LA'MI AREA FOR BOTH COLOR AND TE:XTURE.

PRIVATE: IRRIGATION SYSTE:MS ARE OCCASIONALLY LOCATE:D WITHIN THE PUBLIC RIGHT-OF-WAY OF ADJACENT STRffT AREAS THE CONTRACTOR SHALL BE RESPONSIBLE: FOR THE:IR OPERATION AND REPAIR IF DAMAGE: OCCURS DURING HIS CONSTRUCTION ACTIVITY. PR/VATE: /RR/GATION SYSTE:MS LOCATE:D ON PR/VATE: PROPERTY DAMAGED BY CONSTRUCTION ACTIVITY SHALL BE REPAIRED IMMEDIATEIY TO THE O'MIE:R'S SATISFACTION AT NO COST TO THE O'MIE:R.

IN DEVE:LOPED (PROFE:SSIONALLY) LANDSCAPED AREAS, NO WORK SHALL BE DONE WITHOUT THE O'MIER'S l'tf?ITTE:N PE:RMISSION OR AUTHORIZATION.

TEMPORARY BACKFILL

THE CONTRACTOR SHALL BE REQUIRED TO MAINTAIN NORMAL TRAmc MOVE:MENT DURING NON-WORK PERIODS FOR ALL CONSTRUCTION ACTIVITY l'tfTHIN THE UM/TS OF CITY STRffTS BY THE US£ OF STE:E:L PLATE:S (DESIGNED FOR H-20 LOADING) OR BACKFIWNG THE TRENCH. IF THE CONTRACTOR ELE:CTS TO BACKFILL THE TRENCH HE SHALL "CAP" THE TRENCH l'tfTH A 2: (COMPACTE:D MINIMUM) DEPTH OF CLASS "C" ASPHALTIC CONCRETE: COLD MIX. IF THE CONTRACTOR E:LE:CTS TO PLATE: THE TRENCH THE PLATE:S SHALL BE PINNED AT EACH CORNER AND THE EDGES SHALL BE "RAMPE:D" l'tfTH CLASS "C" ASPHALT1C CONCRETE: COLD MIX TO PREVE:NT "WHffL SHOCK" ON IMPACT. COLD MIX SHALL BE COMPACTE:D AND SMOOTH IN EITHER TYPE OF INSTALLATION. TO PREVE:NT SKIDDING, TRAmc PLATE:S SHALL BE TREATE:D l',fTH WE:LD BEADS TO PROVIDE TRACTION. WELD BEADS SHALL BE LOCATE:D 4• ON CENTE:R AND EXTE:ND THROUGH THE TRAVE:L PORTIONS OF THE PLATE:S.

BACKFILL

BACKFILL OF CONDUIT TRENCH OR MANHOLE: EXCAVATION SHALL BE J/4" - O CRUSHED ROCK IN 6" UFTS AND COMPACTE:D l'tfTH MECHANICAL VIBRATING TYPE COMPACTION EQUIPMENT TO 95" OF MAXJMUM DRY DENSITY (ASTM D-1550 OR AASHTO T-180) UNDE:R ALL PAVE:D SURFACES UNLE:SS OTHERl'tfSE: SPECIFIED.

BACKFILL OF CONDUIT TRENCH OR MANHOLE: EXCAVATION IN NON-PAVE:D AREAS SHALL BE CLE:AN SAND OR SILTY LOAM SOILS PLACED IN 1•-0• UFTS COMPACTE:D BY MECHANICAL VIBRATING TYPE COMPACTION EQUIPMENT TO 95" OF MAXJMUM DRY DENSITY (ASTM D698 OR AASHTO T-99) UNLE:SS OTHERl'tfSE: SPECIFIED.

SAND MAY BE WATER SE:TTLED IF THAT TYPE OF COMPACTION IS ALLOWED BY THE PERMImNG AGE:NCY IN EITHER PAVE:D OR NON-PAVE:D SITUATIONS. THE CONTRACTOR SHALL VE:RIFY THE TYPE OF COMPACTION ALLOWED PRIOR TO BEGINNING ANY BACKFILL ACTIVITY.

BACKFILL SHALL BE PLACED IN ACCORDANCE l'tfTH THE SPECIF/CATIONS AND REGULATIONS OF THE JURISDICTIONAL PERMIT AGENCY

SKYLINE TECHNOLOGY SOLUTIONS
6956-F AVIATION BOULEVARD
GLEN BURNIE, MD 21061
410-553-2600
WWW.SKYLINENET.NET

DESIGNED BY: S CRAWFORD
CHECKED BY: S CRAWFORD
DRAWN BY: N CAL£0

REVISIONS			
REV	DESCRIPTION	DATE	BY
	REVISED LID SPECS	09/29/20	NC
2	UPDATE TEXT ON SH.4 & SH.6	12/09/22	NC

KEY SHEET

PENNDOT FIBER DETAILS

GENERAL CONSTRUCTION NOTES TO CONSIDER

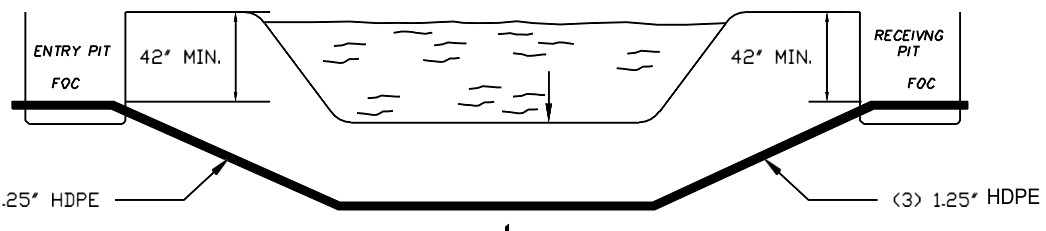
Pennsylvania Department of Transportation
1101 South Front Street
Harrisburg, PA 17104

SCALE: 12.5 25 50

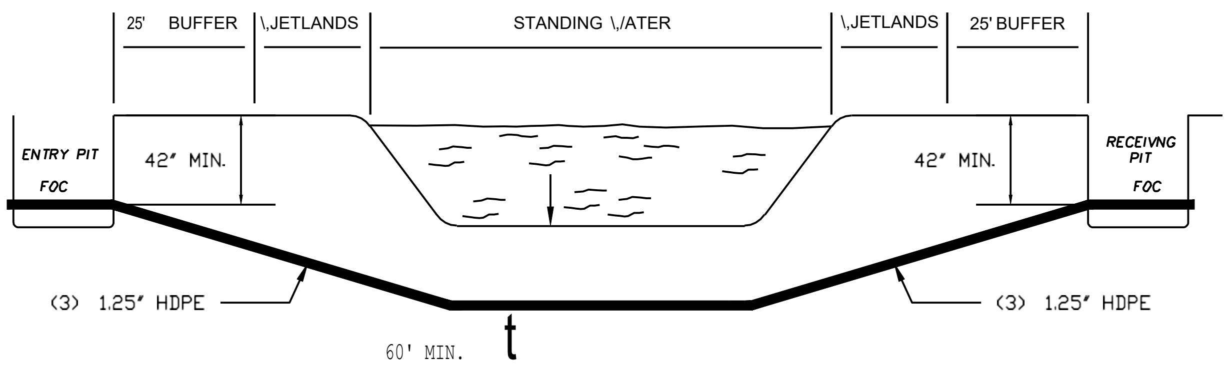
Date: 06/05/19 | SHEET 5 OF 8

Filename: PENNDOT FIBER DETAIL.S_V6_REV2

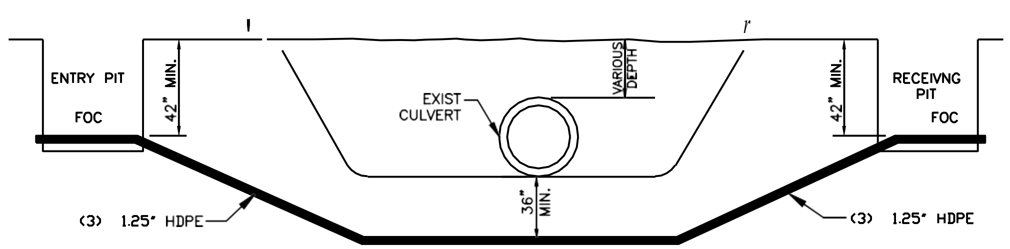
DETAIL D
TYPICAL DIRECTIONAL BORE



BORE ACROSS STREAM
SCALE: N.T.S.



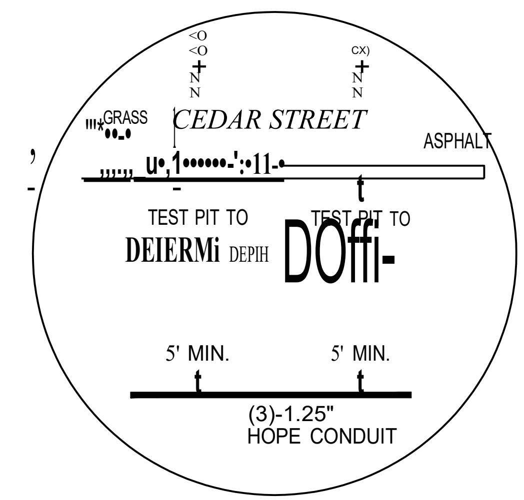
STREAM CROSSING DETAIL
SCALE: N.T.S.



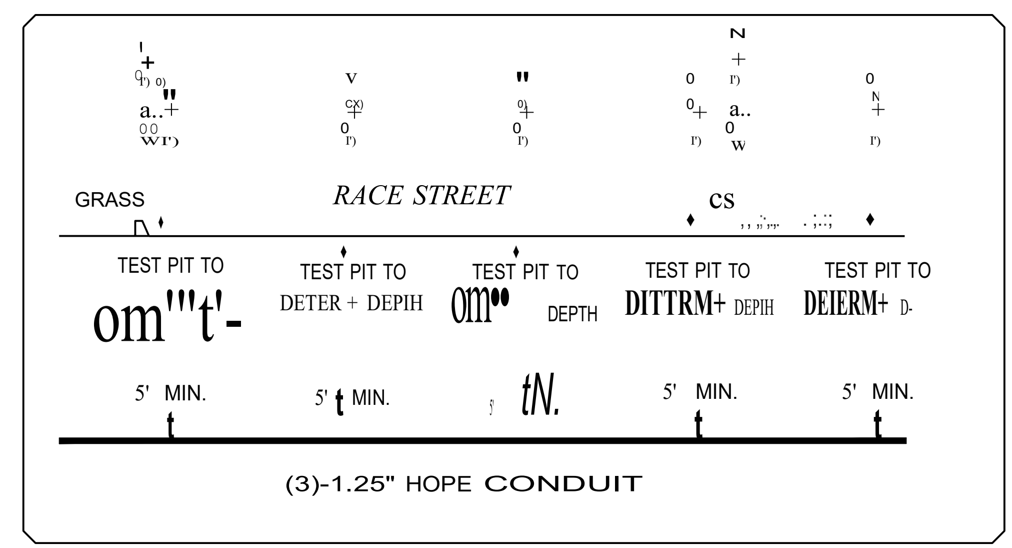
DETAIL E
TYPICAL DIRECTIONAL BORE CULVERT CROSSING

DI: Ac;1 : L BORE CULVERT CROSSING

DETAIL "J"



DETAIL "K"



SKYLINE TECHNOLOGY SOLUTIONS
6956-F AVIATION BOULEVARD
GLEN BURNIE, MD 21061
410-553-2600
WWW.SKYLINENET.NET

DESIGNED BY: S CRAWFORD
CHECKED BY: S CRAWFORD
DRAWN BY: N CALEO

REVISIONS

REV	DESCRIPTION	DATE	BY
	REVISED LID SPECS	09/29/20	NC
2	UPDATE TEXT ON SH.4 & SH.6	12/09/22	NC

KEY SHEET

PENNDOT FIBER DETAILS

DIRECTIONAL BORE & UTILITY CROSSING DETAILS

Pennsylvania Department of Transportation
1101 South Front Street
Harrisburg, PA 17104

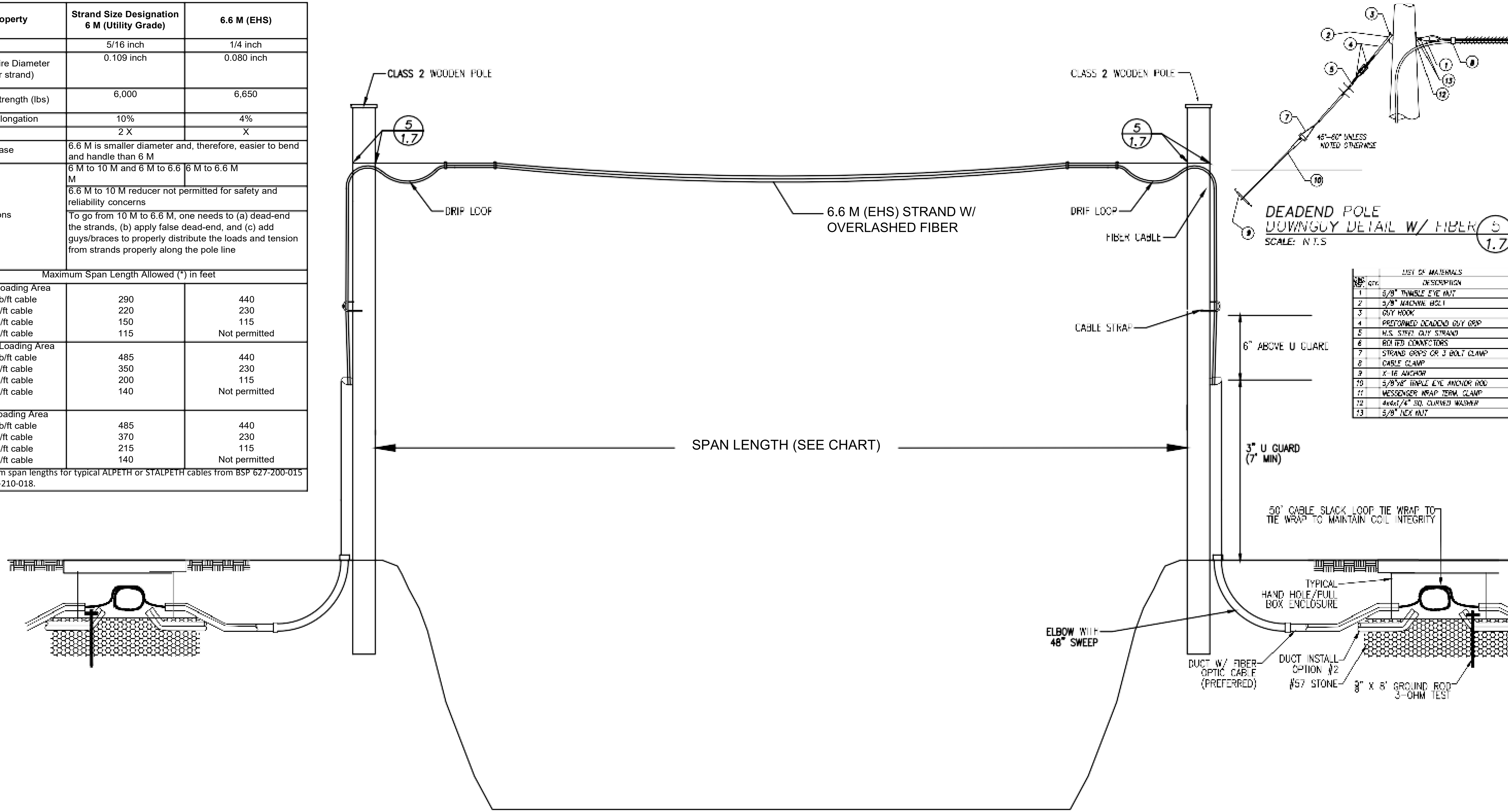
SCALE: 0 12.5 25 50

Date: 06/05/19
SHEET 6 OF 8

Filename: PENNDOT FIBER DETAILS_V6_REV2

Property	Strand Size Designation 6 M (Utility Grade)	6.6 M (EHS)
Size	5/16 inch	1/4 inch
Nominal Wire Diameter (7 wires per strand)	0.109 inch	0.080 inch
Breaking Strength (lbs)	6,000	6,650
Minimum Elongation	10%	4%
Cost ($)	2 X	X
Handling Ease	6.6 M is smaller diameter and, therefore, easier to bend and handle than 6 M	
Reducer configurations practices	6 M to 10 M and 6 M to 6.6 M	6 M to 6.6 M
	6.6 M to 10 M reducer not permitted for safety and reliability concerns	
	To go from 10 M to 6.6 M, one needs to (a) dead-end the strands, (b) apply false dead-end, and (c) add guys/braces to properly distribute the loads and tension from strands properly along the pole line	
Maximum Span Length Allowed (*) in feet		
Heavy Loading Area		
0.5 lb/ft cable	290	440
1 lb/ft cable	220	230
2 lb/ft cable	150	115
3 lb/ft cable	115	Not permitted
Medium Loading Area		
0.5 lb/ft cable	485	440
1 lb/ft cable	350	230
2 lb/ft cable	200	115
3 lb/ft cable	140	Not permitted
Light Loading Area		
0.5 lb/ft cable	485	440
1 lb/ft cable	370	230
2 lb/ft cable	215	115
3 lb/ft cable	140	Not permitted

(*) Maximum span lengths for typical ALPETH or STALPETH cables from BSP 627-200-015 and BR-627-210-018.



DEADEND POLE
DOWNGUY DETAIL W/ FIBER (5/1.7)
SCALE: N.T.S

LIST OF MATERIALS

NO.	QTY.	DESCRIPTION
1		5/8" THIMBLE EYE NUT
2		5/8" MACHINE BOLT
3		GUY HOOK
4		PREFORMED DEADEND GUY GRIP
5		H.S. STEEL GUY STRAND
6		BOLTED CONNECTORS
7		STRAND GRIPS OR 3 BOLT CLAMP
8		CABLE CLAMP
9		X-16 ANCHOR
10		5/8"x8' TRIPLE EYE ANCHOR ROD
11		MESSENGER WRAP TERM. CLAMP
12		4x4x1/4" SQ. CURVED WASHER
13		5/8" HEX NUT

SKYLINE TECHNOLOGY SOLUTIONS
6956-F AVIATION BOULEVARD
GLEN BURNIE, MD 21061
410-553-2600
WWW.SKYLINENET.NET

DESIGNED BY: S. CRAWFORD
CHECKED BY: S. CRAWFORD
DRAWN BY: N. CALEO

REVISIONS

REV	DESCRIPTION	DATE	BY
1	REVISED ID SPECS	09/29/20	NC
2	UPDATE TEXT ON SH.4 & SH.6	12/09/22	NC

PENNDOT FIBER DETAILS

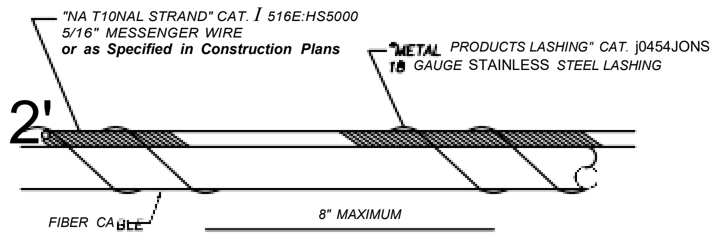
AERIAL DETAILS

PREPARED FOR:
Pennsylvania Department of Transportation
1101 South Front Street
Harrisburg, PA 17104

Skyline Technology Solutions
SCALE: NO SCALE

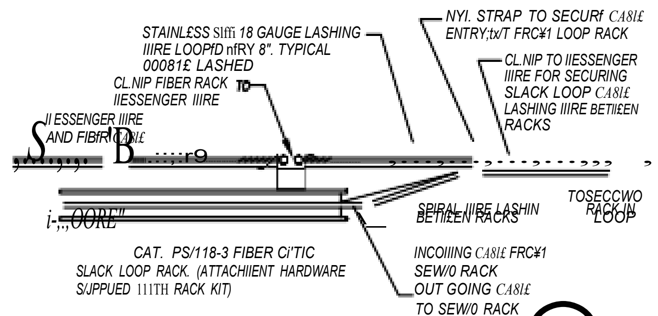
Date: 08/05/19 | SHEET 7 OF 8

Filename: PENNDOT FIBER DETAILS_V6_REV2

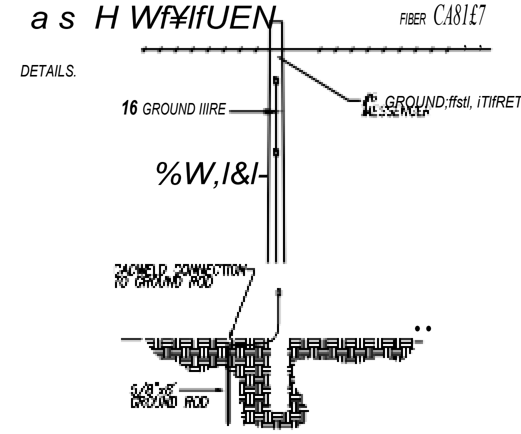


NOit: ALL FIBfR IS TO BE 00081£ LASHED, NOT S/NGl.E LASHED

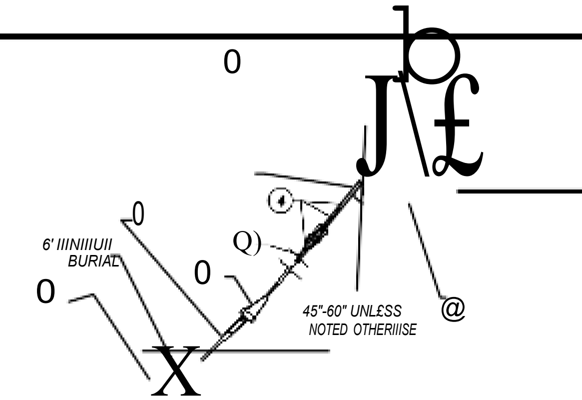
TYPICAL LASHING DETAIL
SCALE: N.T.S.



; . r ACK LOOP DETAIL

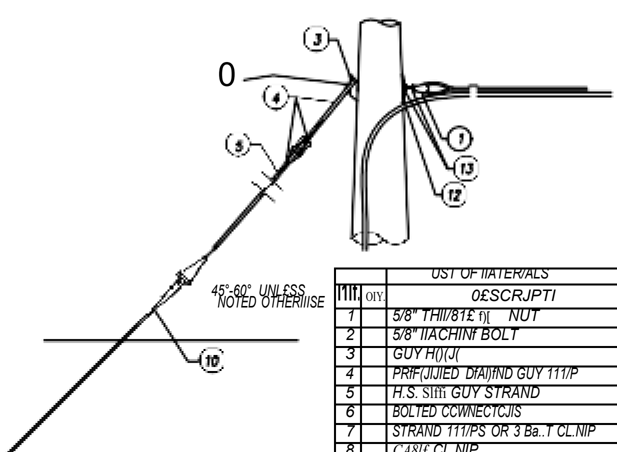


POLE GROUNDING DETAIL
SCALE N.T.S.



DEAD END POLE
W / MESSENGER ONLY
SCALE N.T.S.

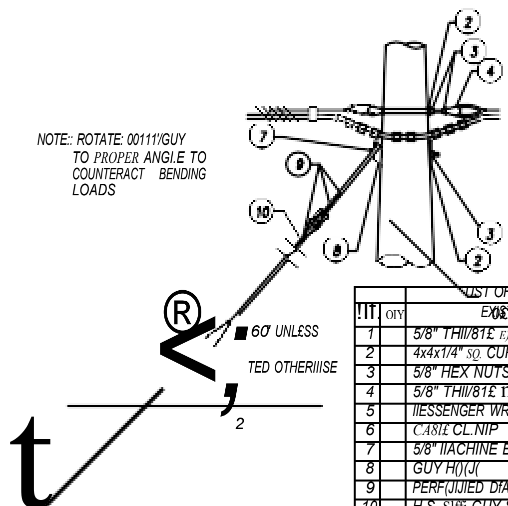
!If.	OIY	UST OF IIATER!ALS
		0£SCRJPTI
1		5/8" THII/81£ EY[NUT
2		5/8" IIACHINE B0LT
3		GUY H()(J(
4		PREFORIIED DfAl)fNO GUY GRIP
5		E.H.S. Slffi GUY STRAND
6		BotTED CCWNECTCJIS
7		STRANO 111/PS OR 3 BOLT CL.NIP
8		X-16 ANCHOR
9		5/B"x8' TRIPLE EY[ANCHOR R<XJ
10		4x4x1/4" SQ. CURVED WASHER
11		5/8" HEX NUT



!If.	OIY.	UST OF IIATER/ALS
		0£SCRJPTI
1		5/8" THII/81£ f)[NUT
2		5/8" IIACHINf BOLT
3		GUY H()(J(
4		PRfF(JIJIED DfAl)fND GUY 111/P
5		H.S. Slffi GUY STRAND
6		BOLTED CCWNECTCJIS
7		STRAND 111/PS OR 3 Ba..T CL.NIP
8		CA8l£ CL.NIP
9		X-16 ANCHOR
10		5/B"x8' TRIP!£ f)[ANCHOR R<XJ
11		IIESSENGER WRAP TtRM. CL.NIP
12		4x4x1/4" SQ. CURVED WASHER
13		5/8" HEX NUT

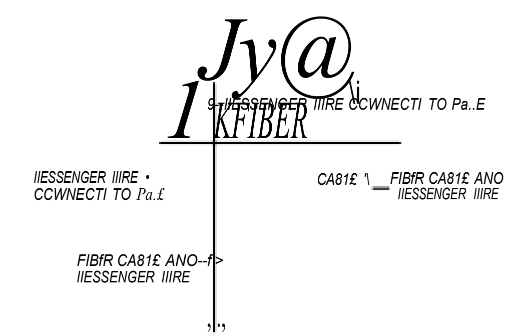
DEADEND POLE
fc y DETAIL W/ FIBER®

NOTE:: ROTATE: 00111/GUY
TO PROPER ANGl.E TO
COUNTERACT BENDING
LOADS



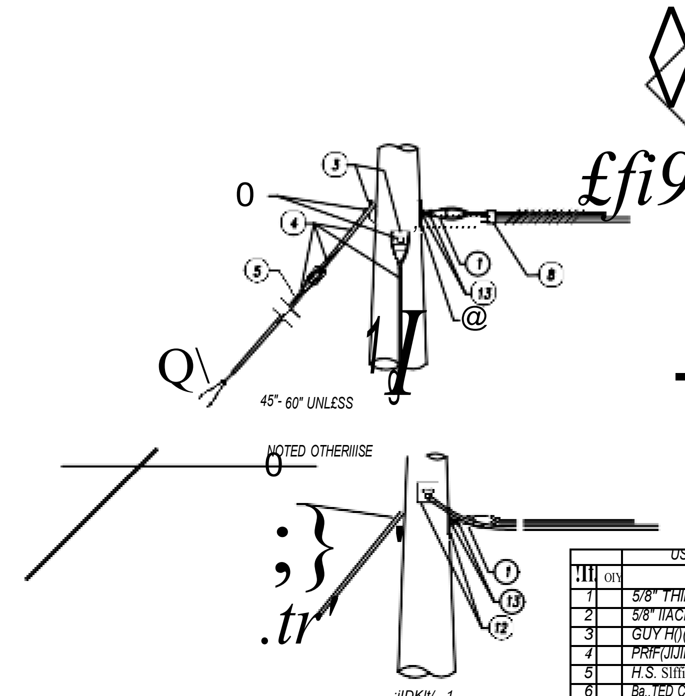
!If.	OIY	UST OF IIATER!ALS
		EXISTING Pa..E GROUND 0£SCRJPTI
1		5/8" THII/81£ E)[B0LT
2		4x4x1/4" SQ. CURVED WASHER
3		5/8" HEX NUTS
4		5/8" THII/81£ m NUT
5		IIESSENGER WRAP TERI/. CL.NIP
6		CA8l£ CL.NIP
7		5/8" IIACHINE BOLT
8		GUY H()(J(
9		PERF(JIJIED DfAl)fNO GUY 111/P
10		H.S. Slffi GUY STRANO
11		STRANO GRIPS OR 3 BOCT CL.NIP
12		5/B"x8' TRIP!£ m ANCHOR R<XJ
13		X-16 ANCHOR

FALSE DEADEND POLE
fc - y DETAIL W/ FIBER®



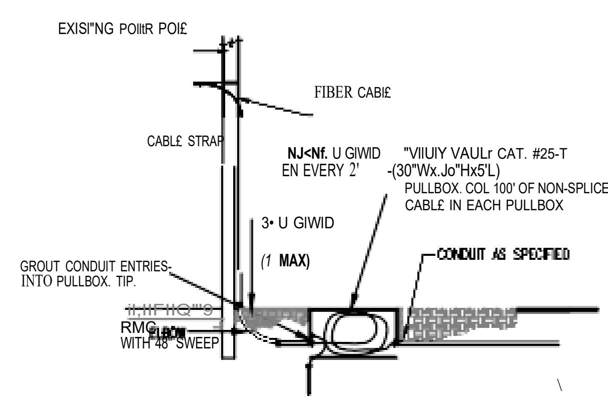
CORNER/ DEAD END POLE(t;)-

DOWNGUY DETAIL
SCALE: N.T.S.



!If.	OIY	UST OF IIATER!ALS
		0£SCRJPTIOO
1		5/8" THII/81£ EY[NUT
2		5/8" IIACHINE BOCT
3		GUY H()(J(
4		PRfF(JIJIED DfAl)fNO GUY 111/P
5		H.S. Slffi GUY STRANO
6		Ba..TED CCWNECTORS
7		STRANO 111/PS OR 3 BOLT CL.NIP
8		CABl£ CL.NIP
9		X-16 ANCHOR
10		5/8"x8' TRIPLE EY[ANCHOR ROO
11		IIESSENGER WRAP TERI/. CL.NIP
12		4x4x1/4" SQ. CURVED WASHER
13		5/8" HEX NUT

COMMON CORNER
DOWNGUY DETAIL
SCALE: N.T.S.



TYPICAL AERIAL / UNDERGROUND

;: ; ON DETAIL

SKYLINE TECHNOLOGY SOLUTIONS
6956-F AVIATION BOULEVARD
GLEN BURNIE, MD 21061
410-553-2600
WWW.SKYLINENET.NET

DESIGNED BY: S CRAWFORD
CHECKED BY: S CRAWFORD
DRAWN BY: N CALEO

REVISIONS			
REV	DESCRIPTION	DATE	BY
	REVISED LID SPECS	09/29/20	NC
2	UPDATE TEXT ON SH.4 & SH.6	12/09/22	NC

KEY SHEET

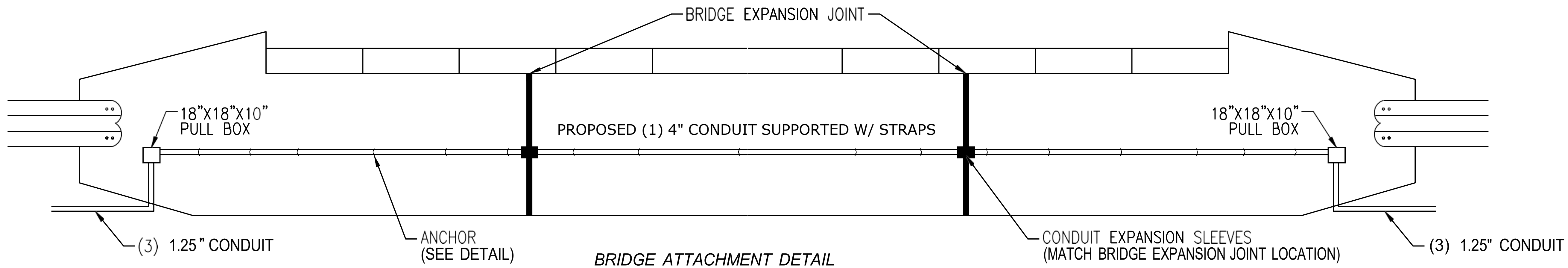
PENNDOT FIBER DETAILS

AERIAL DETAILS (CONTINUED)

Pennsylvania Department
of Transportation
1101 South Front Street
Harrisburg, PA 17104

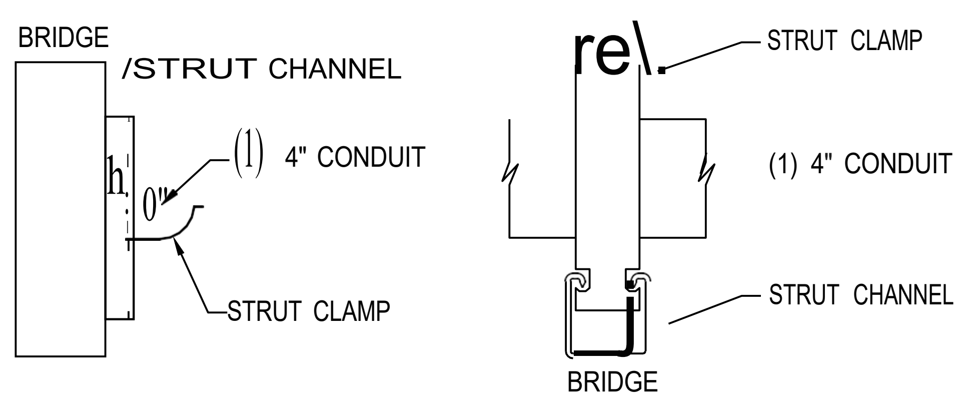
SCALE: illtl ,sc,,Qt
0 12.5 25 50

Date: 06/05/19
SHEET 8 OF 8
Filename: PENNDOT FIBER DETAIL.S_V6_REV2



BRIDGE ATTACHMENT DETAIL

SCALE: N.T.S.



ANCHOR DETAIL (TBD)

SCALE: N.T.S.

SKYLINE TECHNOLOGY SOLUTIONS
6956-F AVIATION BOULEVARD
GLEN BURNIE, MD 21061
410-553-2600
WWW.SKYLINENET.NET

DESIGNED BY: S CRAWFORD
CHECKED BY: S CRAWFORD
DRAWN BY: N CALEO

REVISIONS

REV	DESCRIPTION	DATE	BY
	REVISED LID SPECS	09/29/20	NC
2	UPDATE TEXT ON SH.4 & SH.6	12/09/22	NC

KEY SHEET

PENNDOT FIBER DETAILS

BRIDGE ATTACHMENT DETAILS

Pennsylvania Department of Transportation
1101 South Front Street
Harrisburg, PA 17104

SCALE:

Date: 06/05/19
SHEET 7 OF 8

Filename: PENNDOT FIBER DETAILS_V6_REV2

Appendix D.
Sample Plan Sheets

D - 1 Sample Index Map with Summary of Devices Table

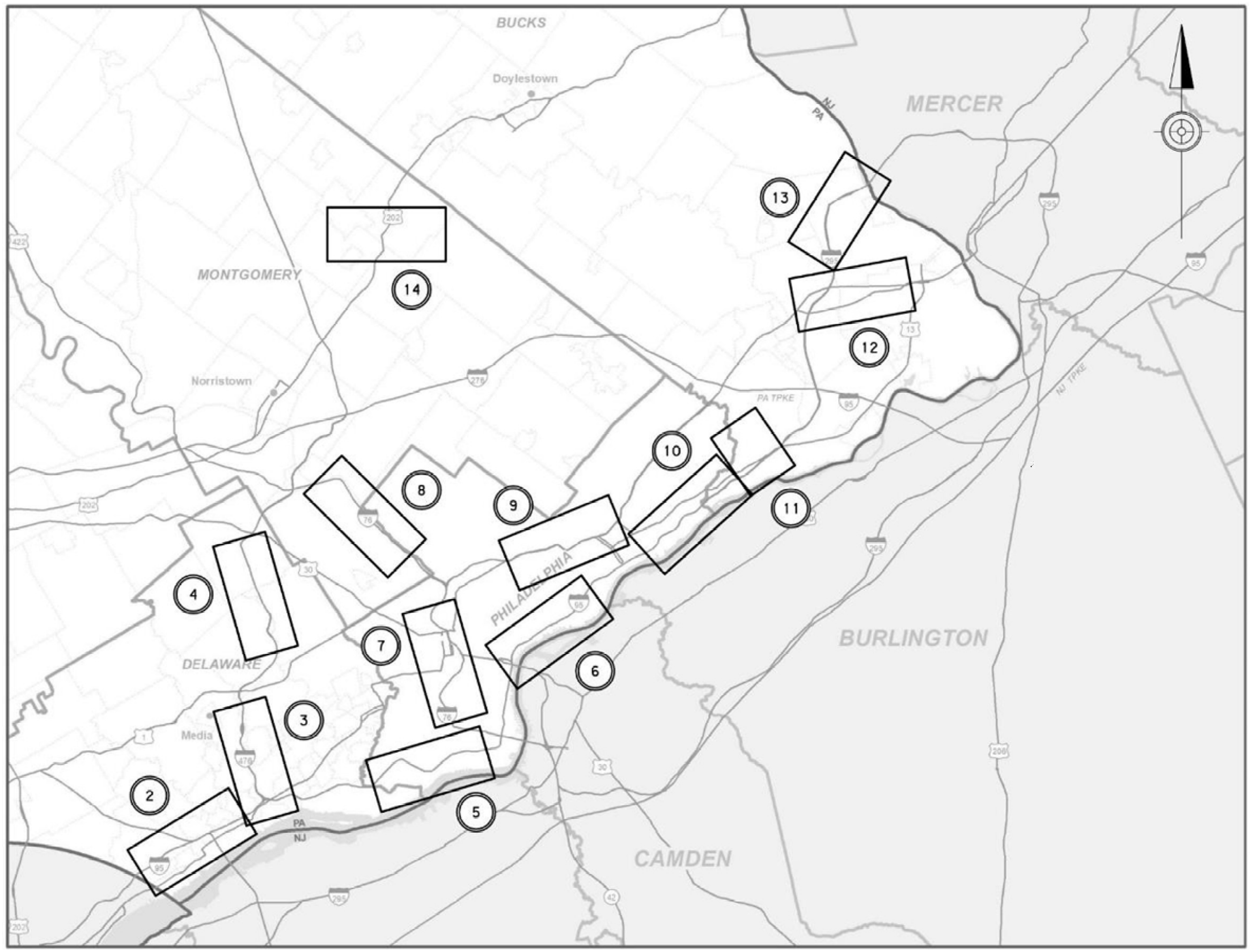
DISTRICT	COUNTY	ROUTE	SECTION	SHEET
6-0	PHILADELPHIA	0095	GR8	I OF 122

CITY OF PHILADELPHIA

REVISION NUMBER	REVISIONS	DATE	BY	APPO

DEVICE NUMBER	INDEX MAP SHEET NO.	ITS PLAN SHEET NO.	ASSOCIATED STRUCTURE NO.
BOS-I	11	86	NIA
BOS-2	11	86	NIA
CM-242	14	61	NIA
CM-950	2	34	NIA
CM-9513-A	5	39	NIA
CM-9519	5	40	NIA
CM-9519-A2	5	41	NIA
CM-9546-A	10	47	NIA
CM-9550B	11	**86**	**NIA**
CM-9562	12	51	NIA
0001s 51	9	62	S-39622
0001S 67	12	63	S-39627
0001$ 70	12	64	S-39626
D063E 47	11	**58**	S-39631
D076E 04	**8**	56	S-39629
0076E.08	7	57	S-3962
0095N.16	10	48	S-39620
0095N.31	3	36	S-39630
D095N 32	5	42	S-39619
00 95.PNR.0	11	65	S-39618
0095S 10	6	45	NIA
0095S.14	10	46	S-39628
D095S 17	10	49	S-39615
0095S.19	11	50	S-39632
0095S29	6	44	**NIA**
0202S.IO	14	60	S-39633
029E.01	**S**	59	S-39625
D295E 28	13	53	S-39613
D295W 26	13	52	**NIA**
D476N.03	3	54	S-39624
0476N.07	4	55	S-39623
D476N 15	3	35	**NIA**
0476S.04	3	54	S-39624
D476S o8	4	55	S-39623
TV0-1	11	89	NIA
TV0-2	11	89	NIA
TVD-3	11	9(),	*NI f*
TVD-4	11	90	NIA

IN ADDITION TO THE **WORK** ON THE SHEETS L ISTED ABOVE, THERE ARE OTHER PROPOSED CCTV REPLACEM ENT LOCATIONS. THESE ARE L ISTED ON SHEETS 75 TO 85. THERE ARE NO LAYOUT PLAN SHEETS PROVIDED I N THIS PLAN SET FOR MOST OF THOSE LOCATIONS.



NOT TO SCALE

SHEET INDEX

DESCRIPTION	SHEETC S1
INDEX MAPS	1 TO 14
GENERAL NOTES	15
MISCELLANEOUS DETAIL S	16 TO 26
TABULATION OF QUANTITIES	27 TO 32
CONSTRUCTION NOTES ANO SCHEDULES	33
LOCATION PLANS	**34** TO 65
SITE DETAILS	66 TO 74
CCTV CAMERA REPLACEMEN T	75 TO 85
AUTOMATED TRUCK ROLLOVER **WARNING** SYSTEM	86 TO BB
SMART PARKING MANAGEMENT SYSTEM	89 TO 90
DMS/ADMS AND STATIC SIGN LOCATIONS **OVERV I EW**	91 TO 95
COMMUNICATI ONS SCHEMATICS	96 TO 105
ELEC7RICAL DETAILS	106 TO 120
ITS STRUCTURE DETAILS	12 1 TO 122

LEGEND

D INDEX MAP SHEET LIMITS

0 INDEX SHEE T NUMBER

ITS PLAN

INDEX MAP

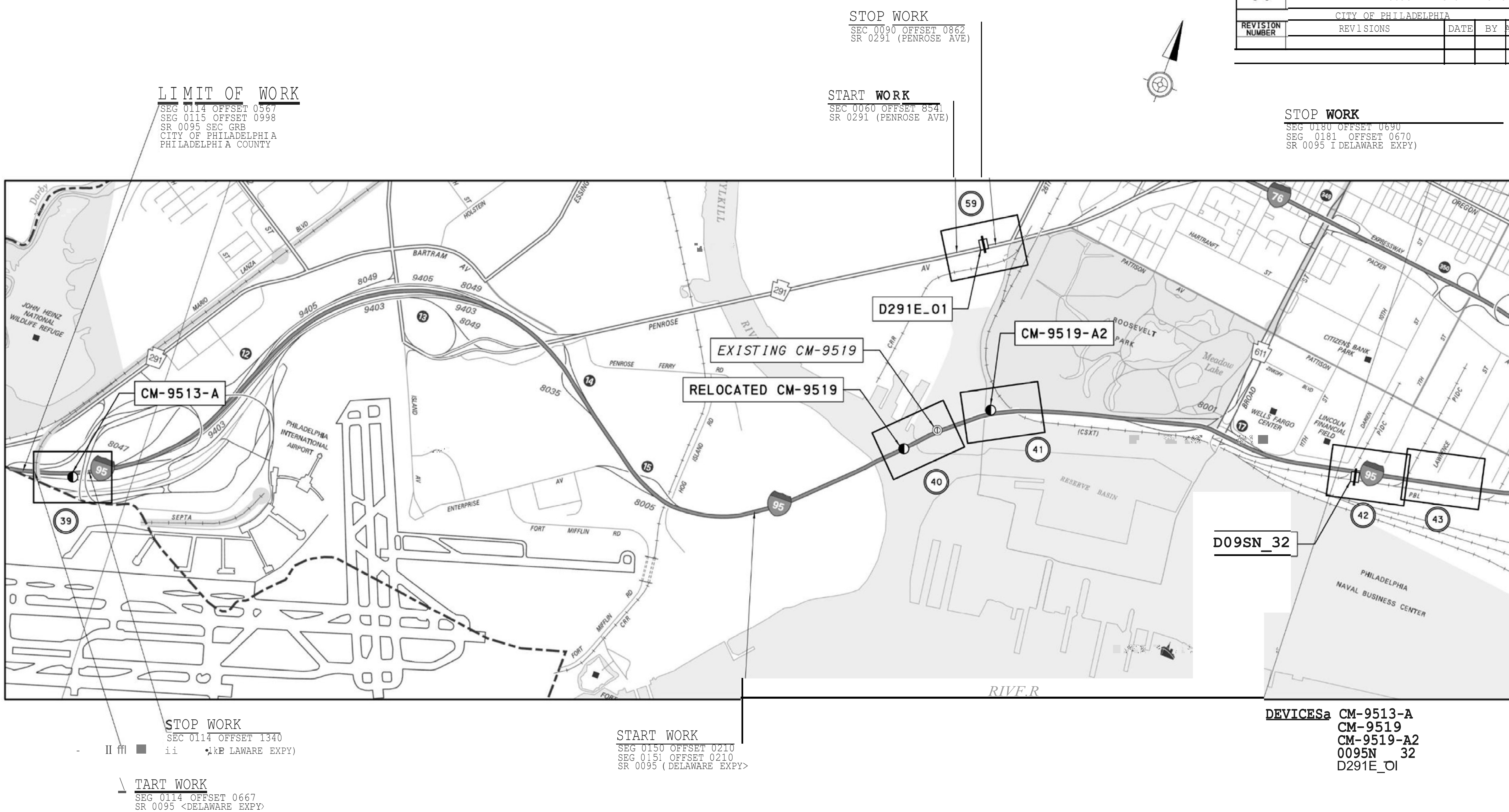
(SHEET 1 OF 14)

D - 2 Sample Index Map with Existing and Proposed Device Labels

DISTRICT	COUNTY	ROUTE	SECTIOtl	SHEET
6-0	PHILADELPHIA	0095	GR8	5 OF 122

CITY OF PHILADELPHIA

REVISION NUMBER	REVISIONS	DATE	BY	APPD



LEGEND

SHEET LIMITS

PLAN SHEET

BACK-TO-BACK DYNAMIC MESSAGE SIGNS (DMS)

DYNAMIC MESSAGE SIGN (DMS/ADMS)

CLOSED CIRCUIT TELEVISION CAMERA (CCTV/THERMAL VEHICLE DETECTOR)

BLANK OUT SIGNS

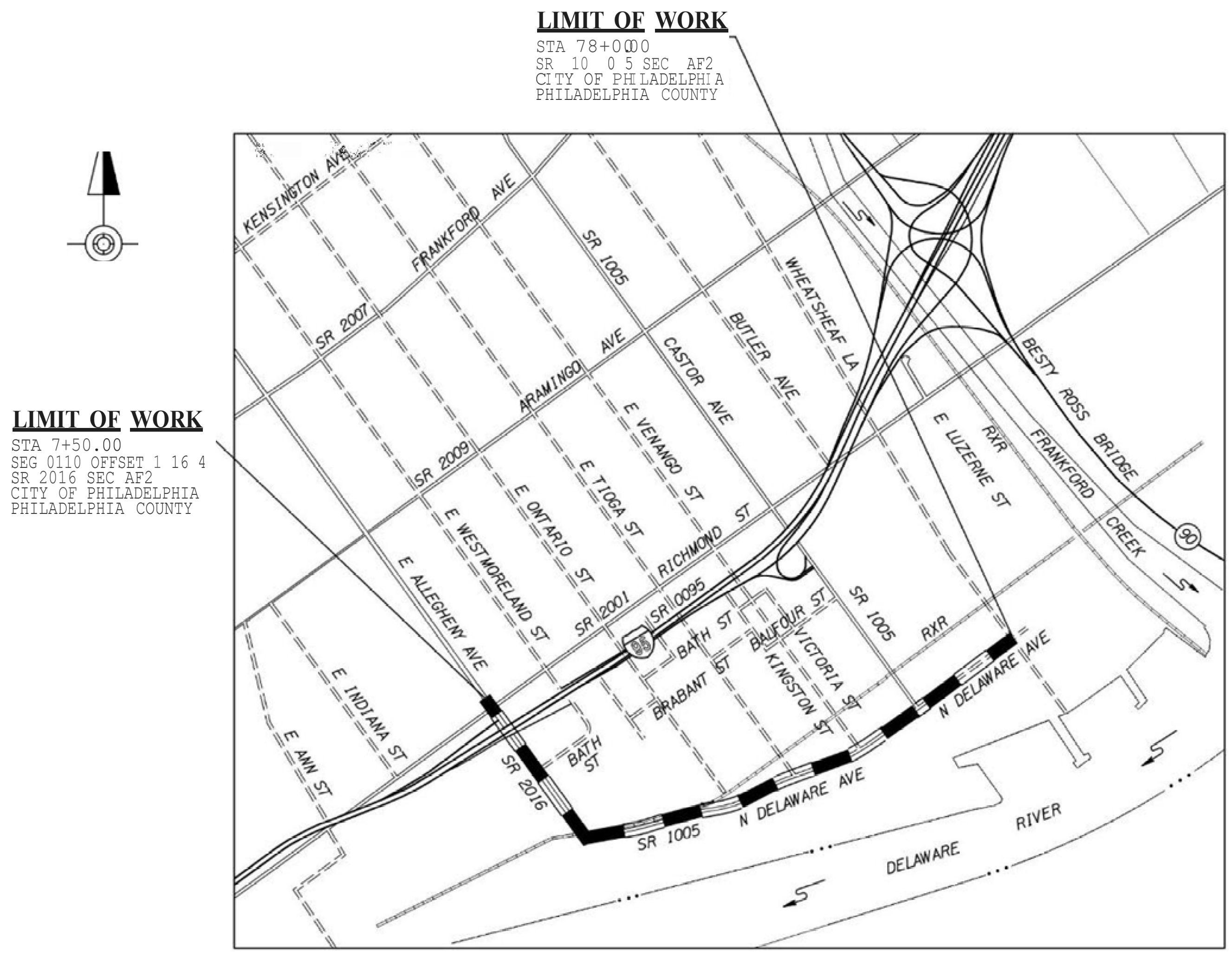
0 1000 2000 FEET

ITS PLAN
INDEX MAP
(SHEET 5 OF 14)

SAMPLE

Location Map

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
6-0	PHILADELPHIA	0095	AF2	2 OF 37
		1005	AF2	
		2016	AF2	
	CITY OF PHILADELPHIA			
	REVISIONS		DUE	BY

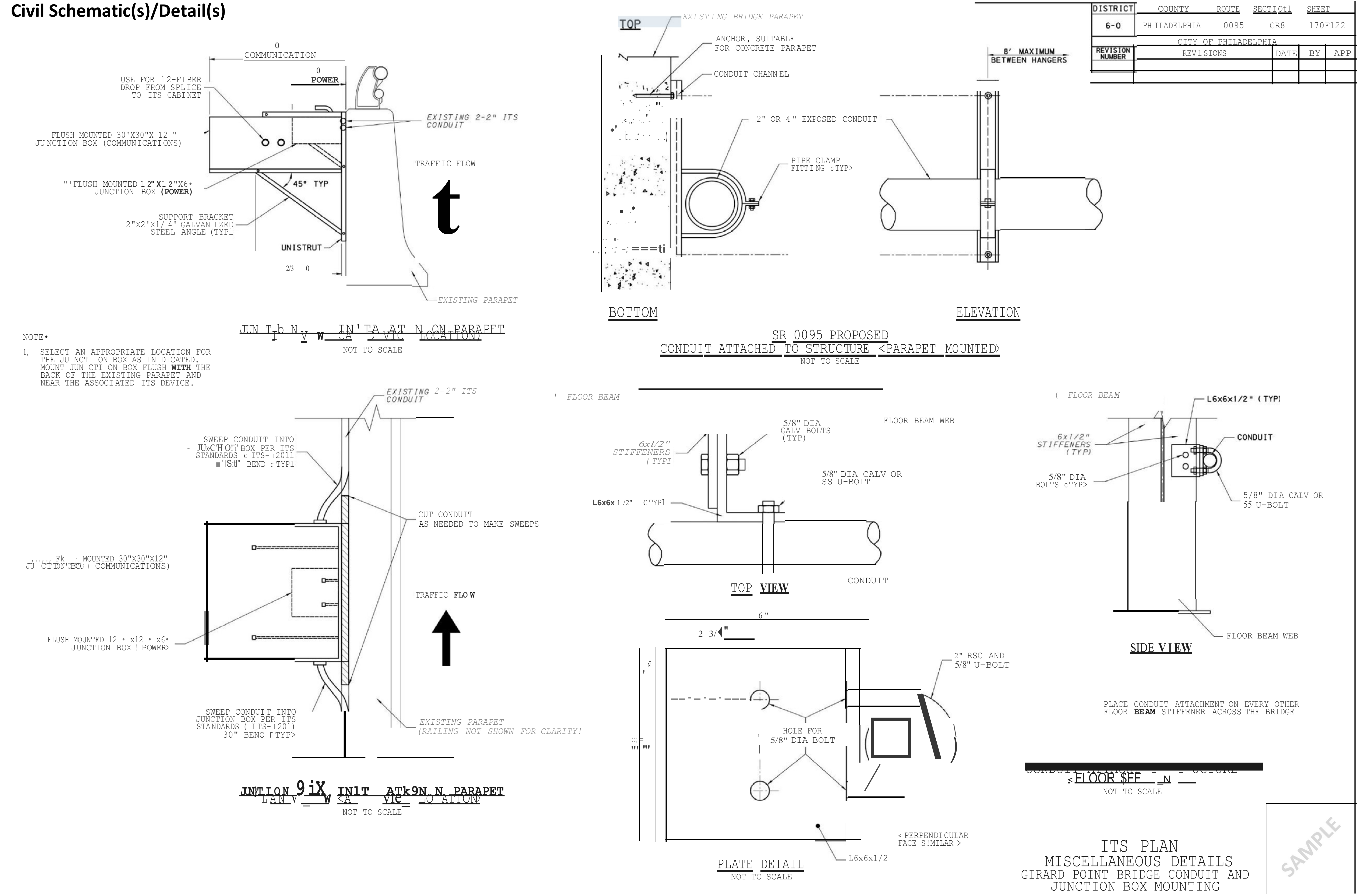


PROJECT
STATE HIGHWAY
CITY STREET

SCALE
0 1 000 2 000 FEET

ITS PLAN
LOCATION MAP

D - 4 Civil Schematic(s)/Detail(s)

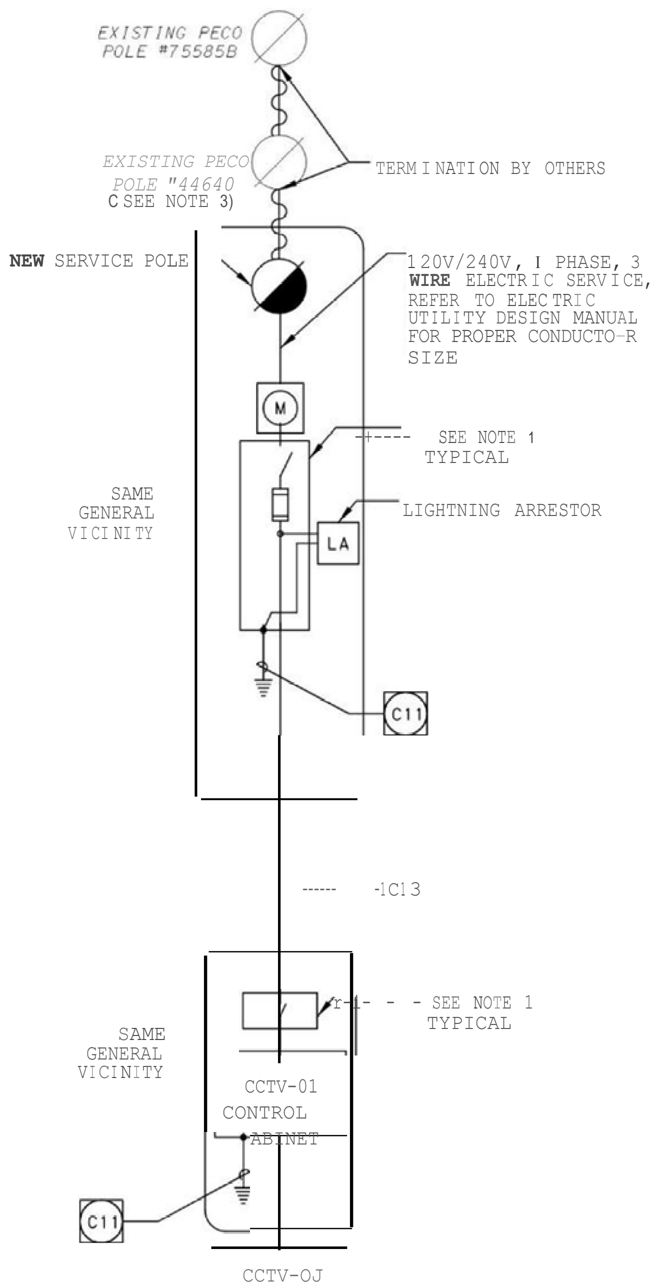


D - 5 **Electrical Schematics(s)/Detail(s) - Device**

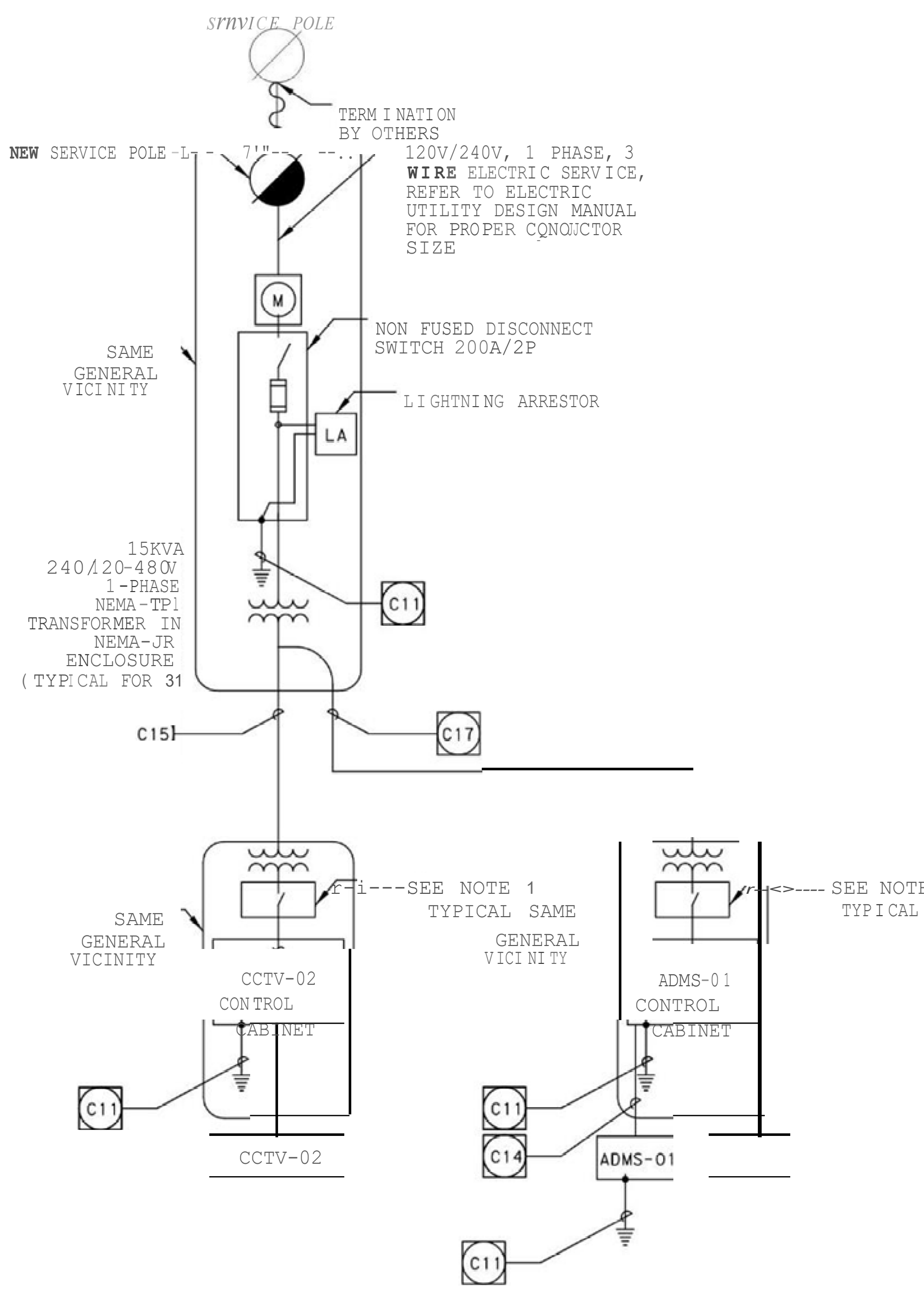
DISTRICT	COUNTY	ROUTE	SECTION	SHEET
6-0	PHILADELPHIA	0095 / 2016	AF2 / AF2	28 OF 37

CITY OF PHILADELPHIA

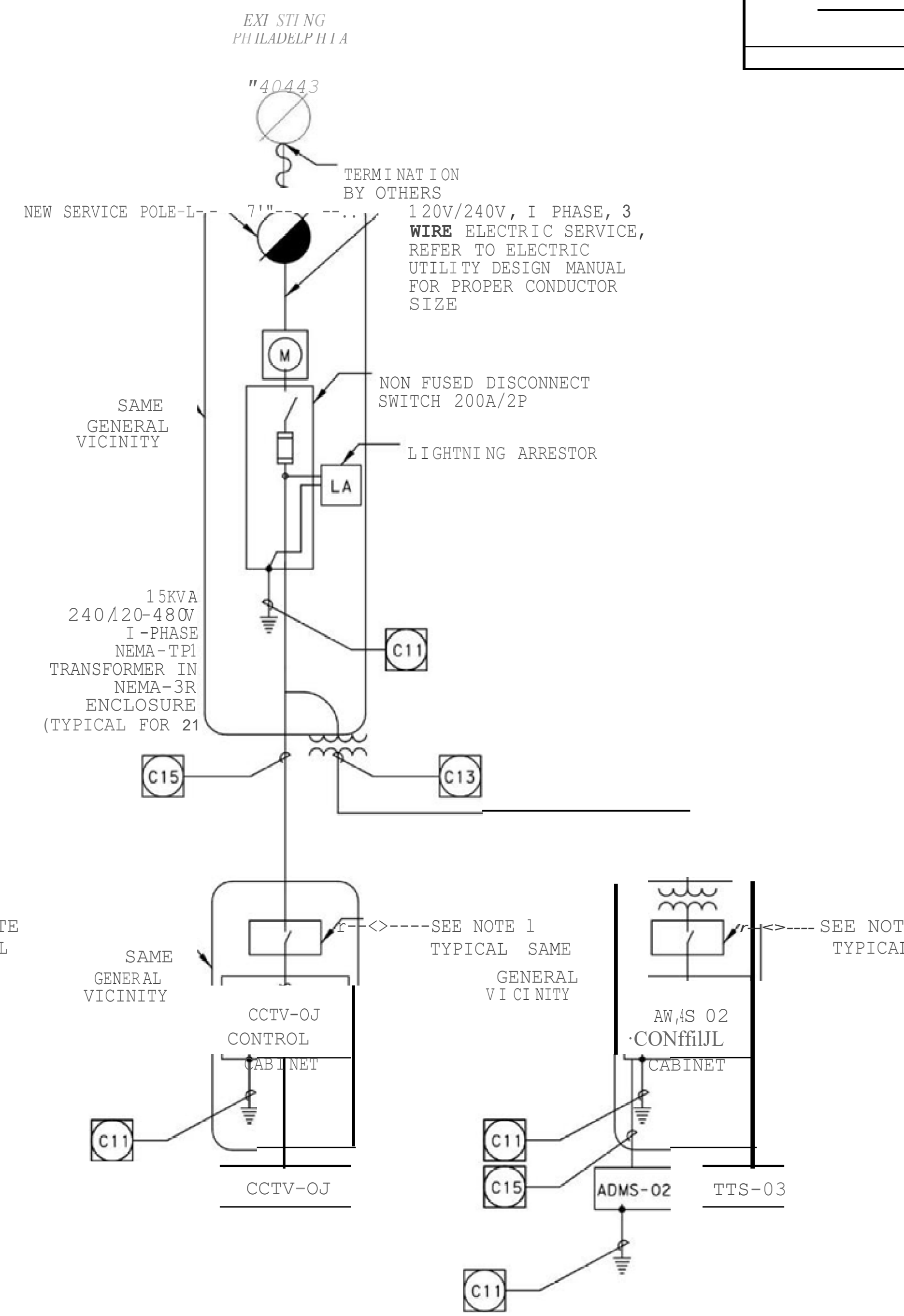
REVISIONS	DATE	BY



ELECTRIC 1-LINE DIAGRAM
CCTV-01



ELECTRIC 1-LINE DIAGRAM
CCTV-02, ADMS-01 & TTS-02



ELECTRIC 1-LINE DIAGRAM
CCTV-03, ADMS-02, & TTS-03

ABBREVIATIONS

ADMS	ARTERIAL DYNAMIC MESSAGE SIGN
AWG	AMERICAN WIRE GAGE
TTS	TRAVEL TIME SENSOR
CCTV	CLOSED CIRCUIT TV

CABLE LEGEND:

- B — IC 4AWG, BARE COPPER WIRE
- 8 — 3C 1AWG, +IC 8AWG (Grd), RHW/RHH/USE, 600-VOLT
- 8 — JC 2AWG, +IC 8AWG (Grd), RHW/RHH/USE, 600-VOLT
- 8 — 3C 4AWG, +IC 8AWG (Grd), RHW/RHH/USE, 600-VOLT
- 3C 6AWG, +IC 8AWG (Grd), RHW/RHH/USE, 600-VOLT
- B — JC 8AWG, +1C 8AWG (Grd), RHW/RHH/USE, 600-VOLT
- a — JC 8AWG, +1C 8AWG (Grd), RHW/RHH/USE, 600-VOLT
- 8 — JC 12AWG, +1C 8AWG (Grd), RHW/RHH/USE, 600-VOLT
- B — 3C 1/0AWG, +1C 8AWG (Grd), RHW/RHH/USE, 600-VOLT
- 2 — 50-OHM COAXIAL

1. 100A/2P DISCONNECT SWITCH EXCEPT AS NOTED.

SWITCH/BREAKER,

3. EXISTING PECO POLE •44640 CURRENTLY DOES NOT HAVE ANY ELECTRICAL CABLES INSTALLED.
4. GROUND CABLES SHOWN IN CABLE LEGEND THAT ARE INSTALLED WITHIN UNDERGROUND CONDUIT MAY BE TYPE THHN/THWN, 600-VOLT CABLE.

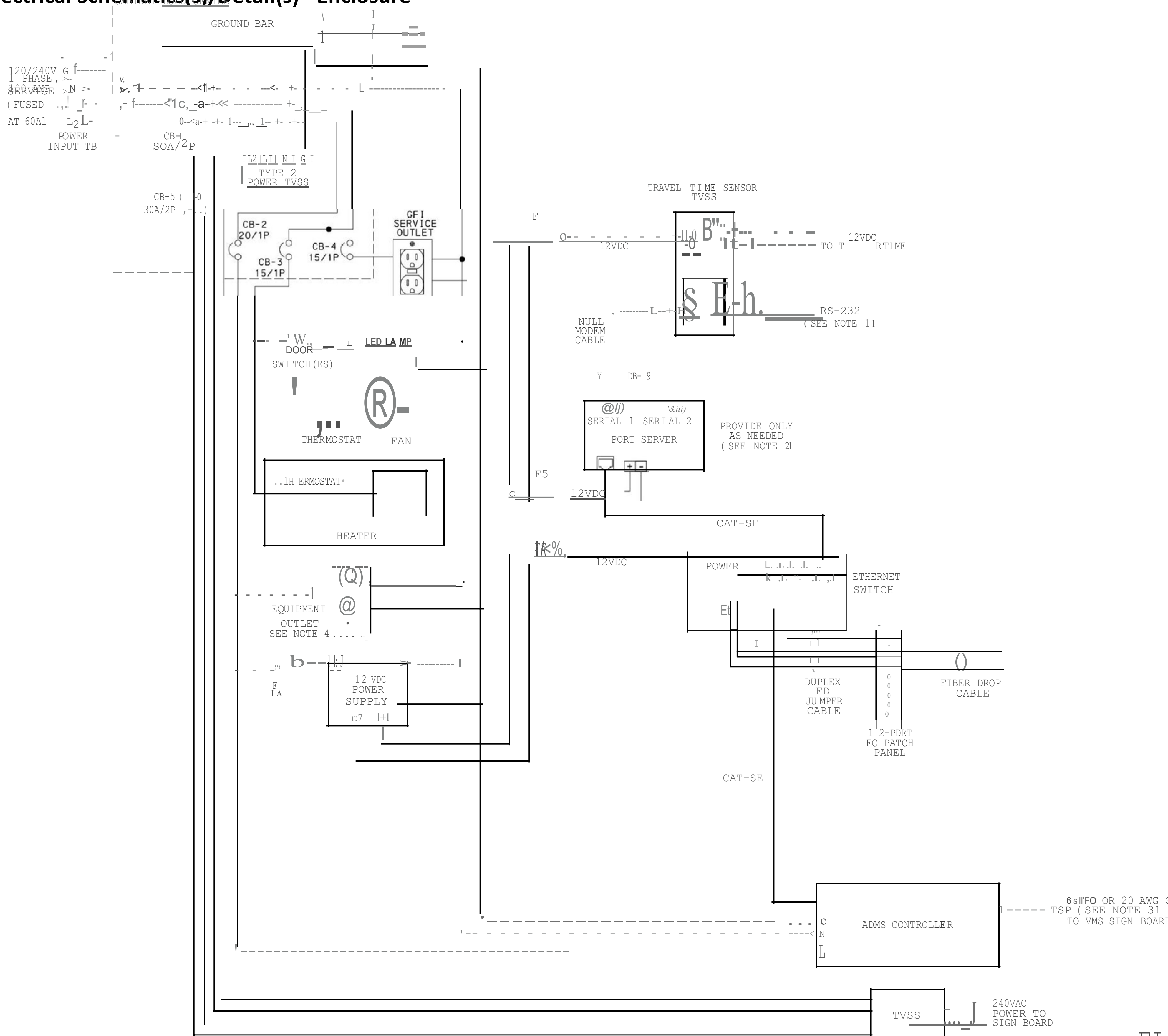
ITS PLAN

ELECTRICAL DETAILS
(SHEET 1 OF 4)

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
6-0	PHILADELPHIA	0095	AF2	30 OF 37
		2016	AF2	

CITY OF PHILADELPHIA

REVISIONS | DATE | BY



CABINET WIRING DIAGRAM (ADMS & TRAVEL TIME SENSOR)

NOTES:

1. CAT-5E TO BE USED IF ETHERNET IS SUPPORTED BY PROPOSED PRODUCT. IF ETHERNET IS USED, PORT SERVER WILL NOT BE NEEDED.
2. TERMINAL PORT SERVER FOR TRAVEL TIME SENSOR, IF REQUIRED, IS INCIDENTAL TO THE TRAVEL TIME SENSOR.
3. LISTED CABLE TYPE IS INDICATIVE FOR USE AS CONTROL CABLE FOR DMS SIGN BOARD. REFER TO MS MANUFACTURER FOR ACTUAL REQUIRED CABLE TYPE. FOR NON-FIBER CONTROL CABLE, PROVIDE APPROPRIATE TVSS ON ALL COPPER CONDUCTORS.
4. RECEPTACLE FOR EQUIPMENT OUTLET SHALL NOT BE GFI TYPE.

LEGEND

-0 0-	CIRCUIT BREAKER
-o'o-	SWITCH
-<%>-	FUSE
	TERMINAL BLOCK
___	EARTH GROUND

ABBREVIATIONS

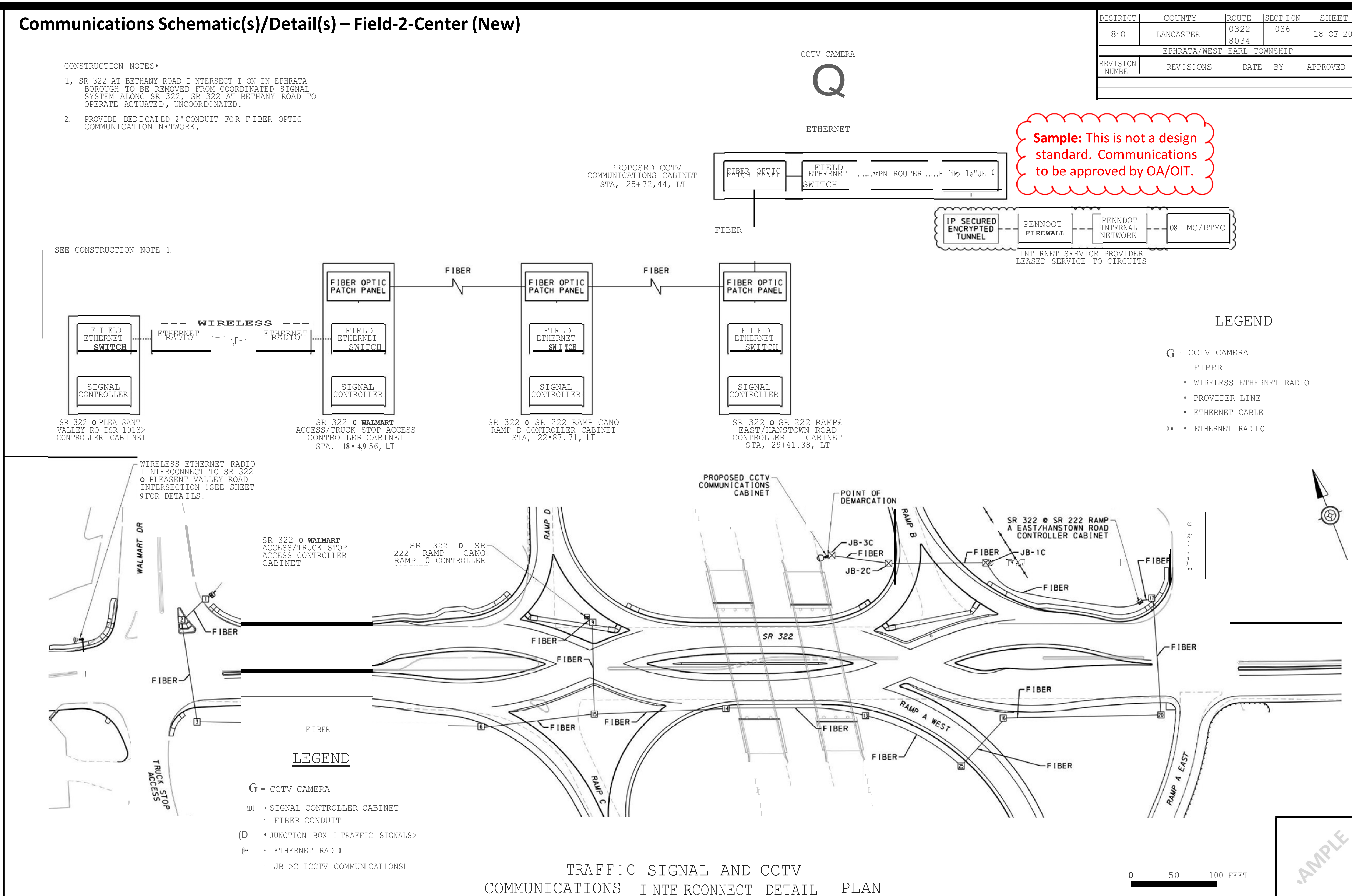
CB	CIRCUIT BREAKER
ADMS	ARTERIAL DYNAMIC MESSAGE SIGN
F	FUSE
FD	FIBER OPTIC
G	GROUND
GFI	GROUND FAULT INTERRUPT
L	LINE (HOT)
N	NEUTRAL
TVSS	TRANSIENT VOLTAGE SURGE SUPPRESSOR
TB	TERMINAL BLOCK

ITS PLAN

ELECTRICAL DETAILS

(SHEET 3 OF 4)

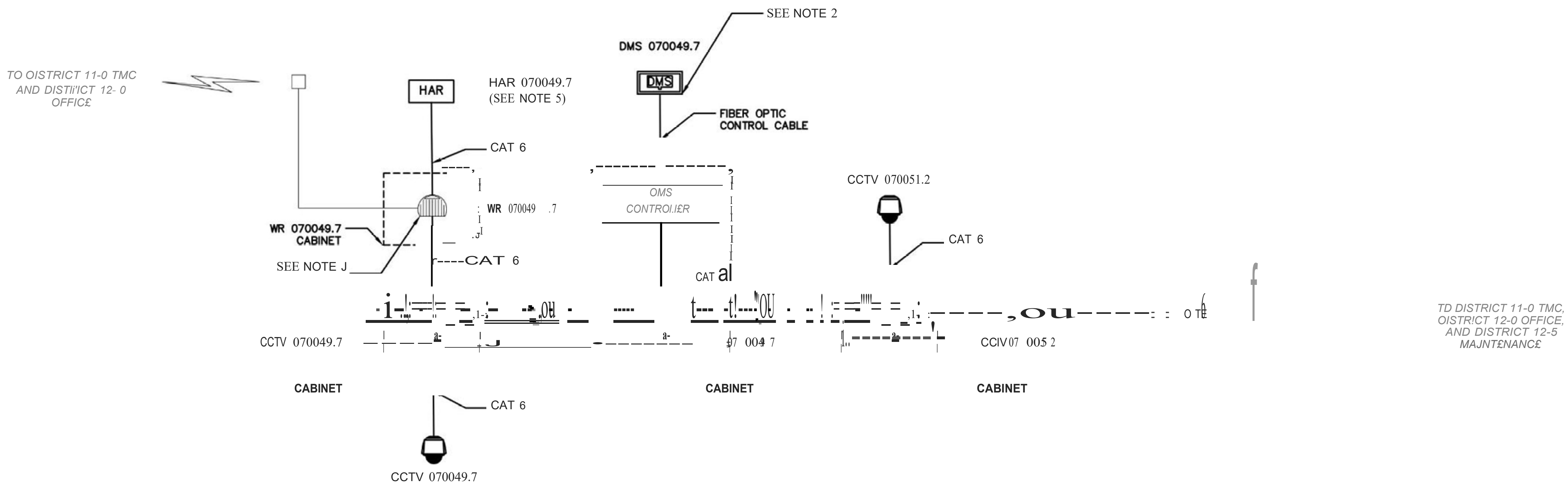
D - 7 Communications Schematic(s)/Detail(s) – Field-2-Center (New)



Communications Schematic(s)/Detail(s) – Field-to-Center (Existing)

DISTRICT	COUNTY	SECTION	SHEET
12–0	WESTMORELAND 0070	K10	8 OF 23
	SOUTH HUNTINGDON TOWNSHIP		

REVISION NUMBER	REVISIONS	DATE	BY	APPROVED



1. REFER TO SR 0070 SECTION 189 - 70/79 ITS DESIGN/INSTALLATION FOR **ADDITIONAL** COt.41.IUNICATIONS DETAILS OUTSIDE IHE AREA COVERED BY IHIS PRO.ECT.
2. **OMS** 070049.7 **BOARD WIU. BE** REMO'vm FROM EXISTING STRUCIIJRE. AND INSTALLED **ON NEW** SIRUCIURE AND FOUNDATION. SEE SHEET 11 OF 23 FOR PROPOSED DEVICE LOCATION.
J. **WR** 070049.7 'MLL BE REMOVED FROM EXISTING POLE AND INSTALLED ON NEW POLE. SEE SHEET 10 OF 23 FOR PROPOSED DEVICE LOCATION
4. REFER TO SIGNING AND PAVING t.4ARKING PLAN FOR LOCATION OF RELOCATED HIGHWAY ADVISORY RADIO SIGN.
5. SEE SIGNING AND PAVEMENT MARKING PLAN FOR RELOCATION OF HAR SIGN. ITS PLAN SHEET 10 SHOWS ETHERNET CA6!.E TO EIE INSTAU.£0 B N WR 0700 49.7 AND RELOCATED HAR. ONCE IHE WR 070049.7 LOCATION HAS BEEN APPROVED; CONIRACTOR SHAU SUBMIT PI.AN DETAILING THE PROPOSED COMMUNICATION BE"TVIEEN WR 070049.7 AND IHE RELOCATED HAR. SEE ITEM 9000-0106 FOR MORE DETAILS.
6. INSTAII. CONDUIT SI\JB AS INDICATED IN IHE PLANS AND SPECIAL PROVISIONS. CONDUIT TO BE USED FOR PROPOSED FIBER OPTIC CABLE INSTALLED UNDER SR 0070 SECTION LiO PRO..ECT.

LEGEND

a	PROPOSED/RELOCATED WIRELESS DEVICE	0	PROPOSED/RELOCATED CCTV CAt.4ERA
-rou-	*£X!ST1N(J 36 STRANO FIBER BACKBCWE*	-FOU-	PROPOSED 36 STRAND FIBER BACKBONE
[;!)]	PROPOSED DYNAMIC MESSAGE SIGN		PROPOSED ETHERNET SWITCH
□	*£XIST1N(J OISH ANTENNA*	E3	PROPOSED GROUND MOUNTED SPLICE CABINET
	RELOCATED HIGHWAY ADVISORY RADIO SIGN	-----------	DEVICE CABINET

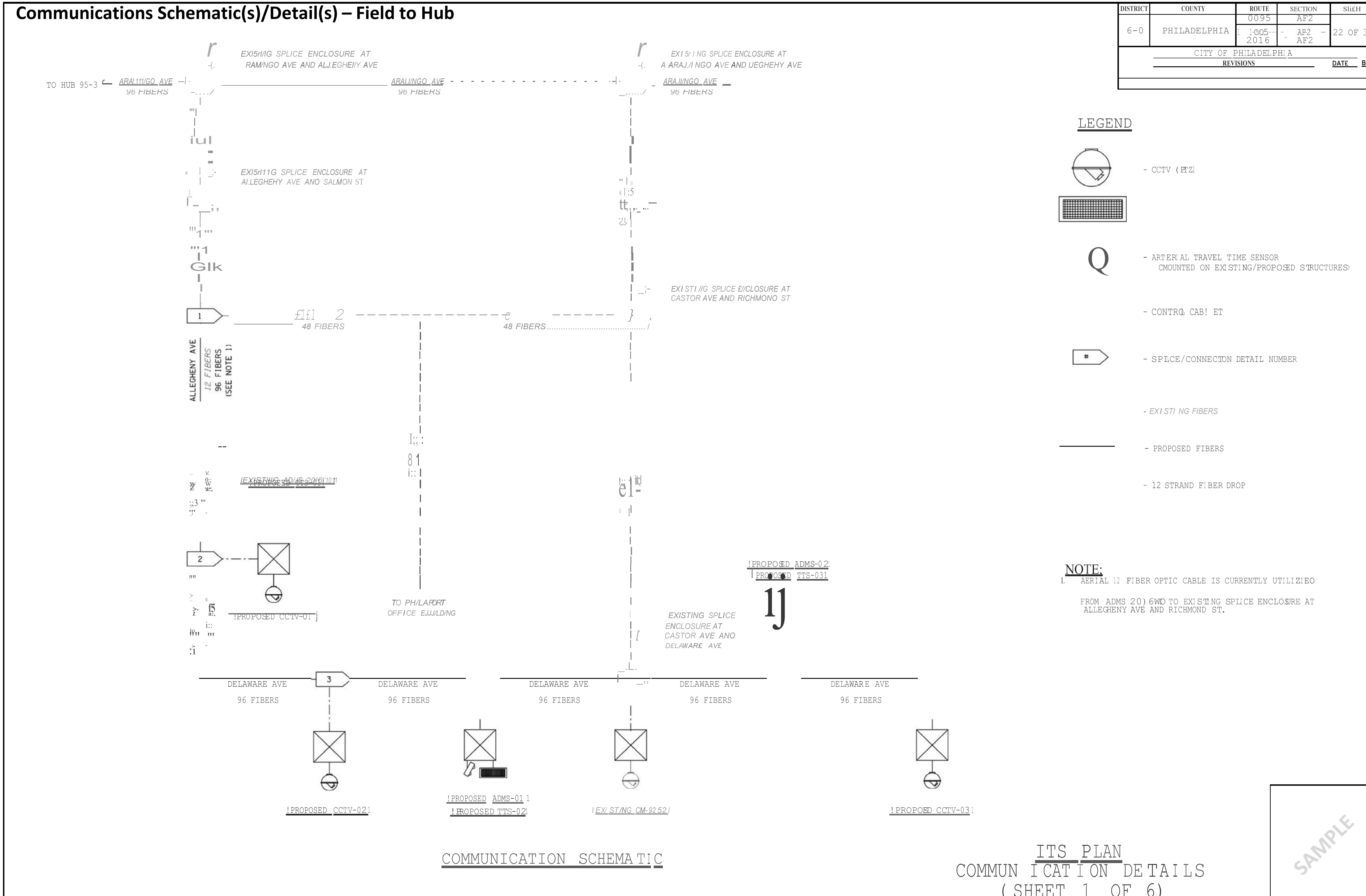
ITS COMMUNICATIONS SUMMARY

NOT TO SCALE

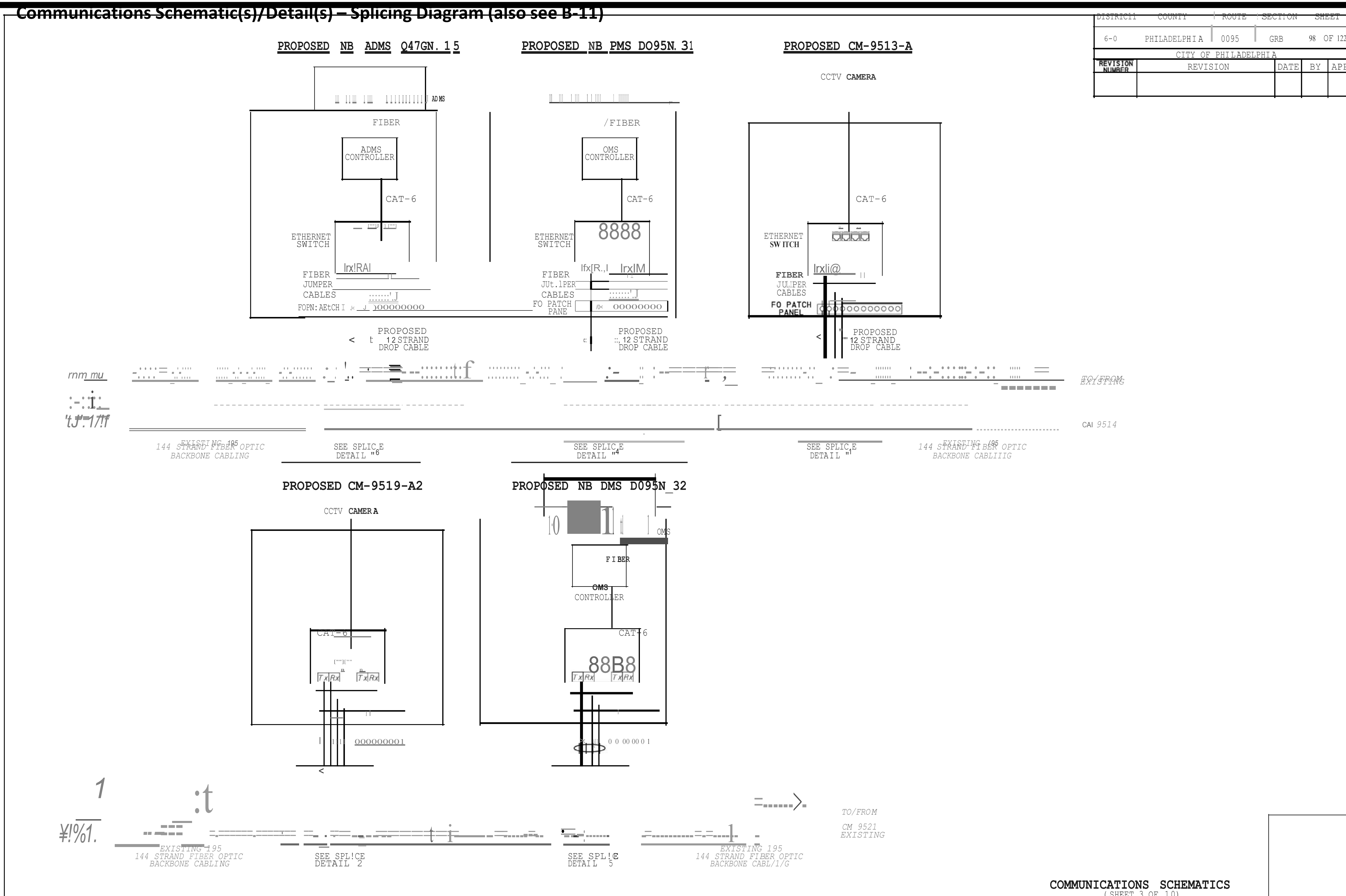
COMMUNICATION DETAILS

(SHEET 2 OF 3)

D - 9 Communications Schematic(s)/Detail(s) – Field to Hub



D - 10 Communications Schematic(s)/Detail(s) – Splicing Diagram (also see B-11)



ITS PLAN

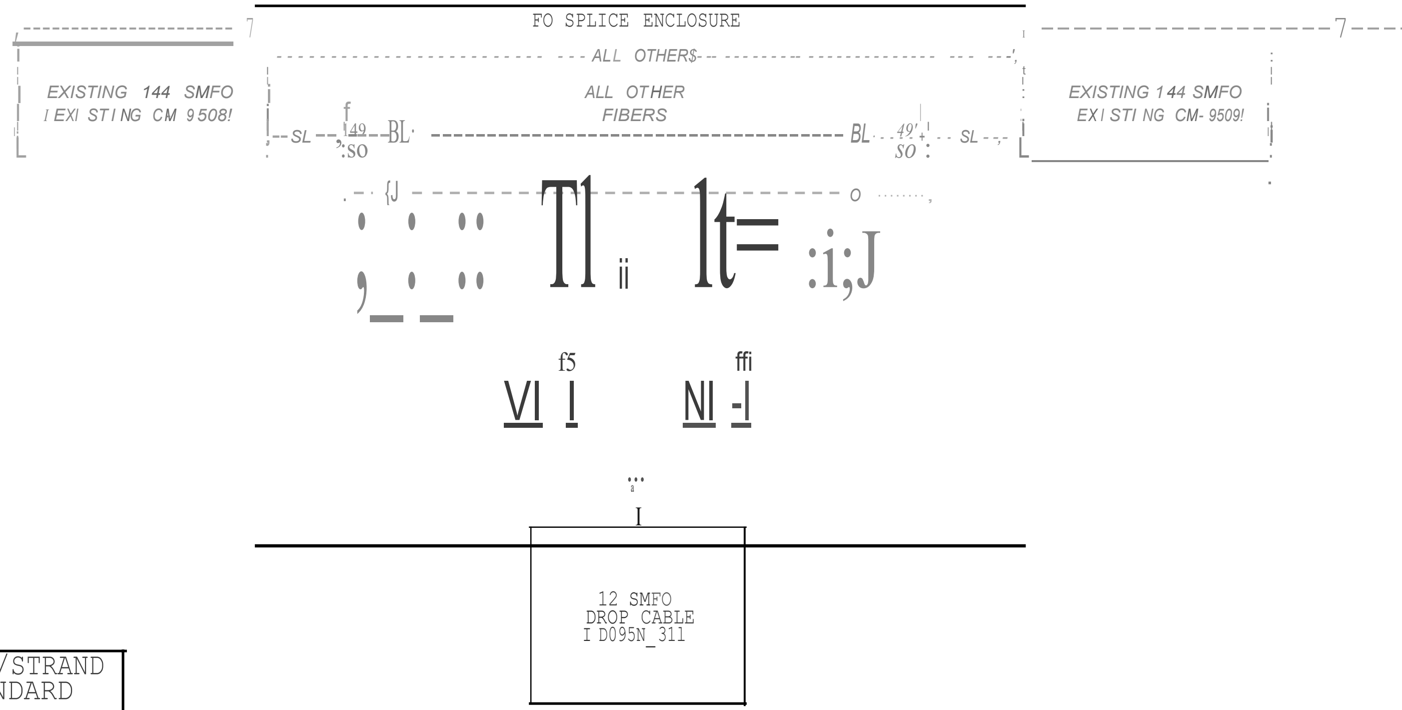
SPLICING DETAILS DIAGRAM

D - 11 Communications Schematic(s)/Detail(s) – Splicing Details (also see B-10)

DISTRIC11	COUNTY	ROUTE	SECTION	SHEET
6-0	PHILADELPHIA	0095	GRB	101 OF 122

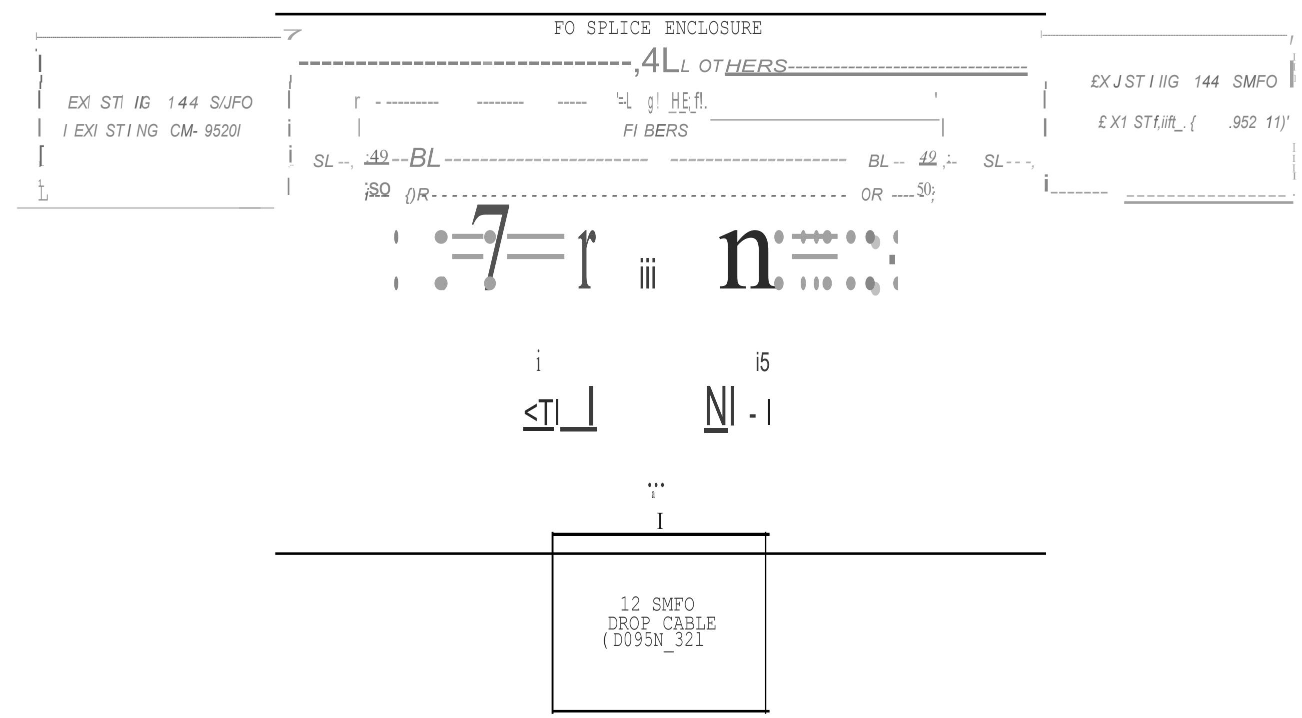
CITY OF PHILADELPHIA

MimN	REv1s10N	DATE	aY	APPD



DETAIL #

FIBER BUFFER/STRAND COLOR STANDARD			
AQ	**AQUA**	RD	RED
BK	**BLACK**	RS	ROSE
BL	BLUE	SL	SLATE
BR	**BROWN**	VI	VIOLET
GR	GREEN	**WH**	**WHITE**
OR	ORANGE	YL	YELLOW



DETAIL •S

LEGEND

D FO ENCLOSURE
• DETAIL NUMBER

FO BUFFER

FO FIBER

• FUSION SPLICE

EXI STI NG FU SI ON SPLICE

0 UNTERMINATED FIBER< Sl OR BUFFER< S>

D PATCH FI BERS

NOTES:

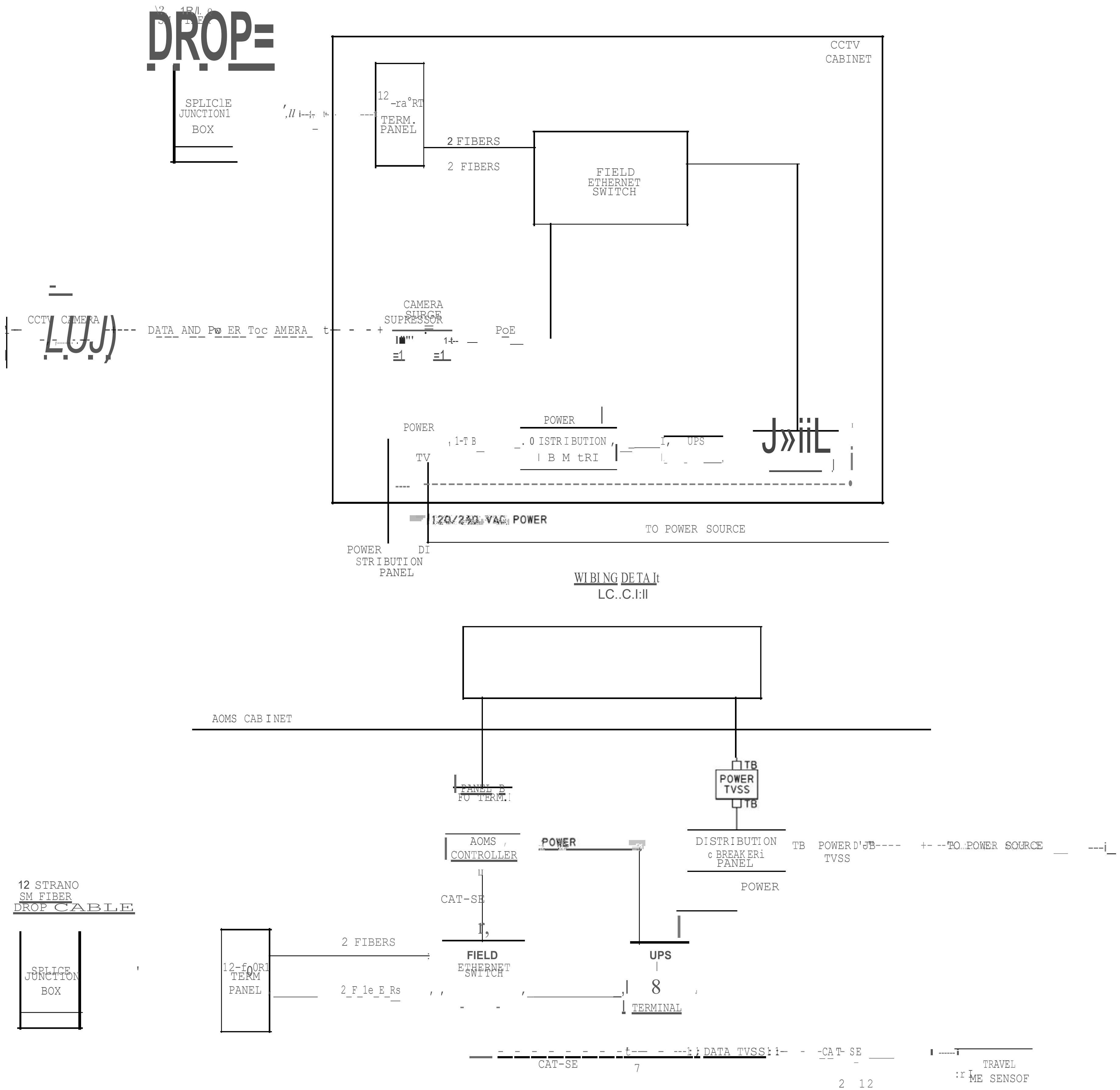
1. FIBER STRANDS OR BUFFERS NOT **SHOWN** ARE TO BE LEFT UNTERM I NATED, CAPPED AND NEATLY COILED INSIDE OF SPICE ENCLOSURES.
2. COORDINATE **FIBER** OPTIC FUSION SPLICES **WI TH** THE REPRESENTATIVE.
3. DASHED ELEMENTS REPRESENT EXISTING INFRASTRUCTURE.

ITS **PLAN**

TYPICAL SPLICE DETAILS
COMMUNICATIONS SCHEMATICS
(SHEET 6 OF 10)

D - 12 Communications Schematic(s)/Detail(s) – Enclosure Details

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
6-0	PHILADELPHIA	0095 / 1005 / 2016	AF2 / AF2 / AF2	27 OF 37
	CITY OF PHILADELPHIA			
	REVISIONS		DATE	BY



WIRING DETAIL

NOTE
1. WHERE POE <POE OVER ETHERNET> OF TTS IS USED, PROVIDE THE RELATED POWER INJECTOR AND APPURTENANCES AS APPLICABLE.

WIRING DETAIL (ADMS AND TTS)

ITS PLAN
COMMUNICATION DETAILS
(SHEET 6 OF 6)

D - 13 Summary of Quantities Sheet

SUMMARY

REVISION NO	REVISIO	DAU	DY	DISTRICT	COUNTY	ROUTE	SECTION	SHEET
				11	W-'SHINGTOIi	79	III,..S	G OF 16

♦ - SEESPECIIIL PROVISIO!',S

QUANTITY	ITEM NO / UNIT	DESCRIPTION	DESIGN NO	FOR TABS SEE SHEET	QUANTITY	ITEM NO / UNIT	DESCRIPTION	DESIGN NO	FOR TAB SEE SHEET
	060 0001 LS	MOEIIL!ZATIO		NOIAB	80	11910 5115 LF	2" EXPOSED C|ONDUIT		7
	0509 0003 LS	INSPECTOR'S FIELD OFFICE AND INSPECTION FACIUTIES, TYPE B		ND,AD	SO	111117 0106 EACH	GUIDE RA:IL.MOU TED DEUNEATOR TYPE B. (WIB)		II. II
	060111 0000 LS	EQUIPMEI'fI" PACKAGE ♦		NOtAB	50	0'9 7 0113 EACH	GutDE RAIL MOU D DELINEATOR TYPE D. (Wi8)		10.11
	11619	PERMANEN:r IMP ACT ATTENUATING DEVICE. TYPE 11,		10, 11		-49 7	FLEXIBLE DEUNEATOR IPOS.T. GROUND-MOUNT TYPE		7, 8, 9
11 13	11459 EACH 0G2:0 11400 EACH	TEST:. 3, TANGI;NI (MAS TERMINAL ec11!>N, SIIIIGIE		10, 11	12 1i s	EACH .49:.1 0012 LF	GM EC TRIGHT POST WIIH WHIT!,III,LANK Stt(,E TING, 2 INCH COIIiDUIT, III G!DGA VAN'2:ED S1 E!. ♦		T, !r
	0620 0402 E LCH	TERMINAL SECTION BRIDGE CO NECTION		10	1445	4954 0015 LF	S IN'CH CON'DUIT, HDPE ♦		II, 9
IIM	11620 0500 LF	REMOVE E JSIiING GUIDE RAii.. (CONTRACf OR:S PROPER'f 'II)		10, 11	8195	.egs-4 01 LF	TR1ENCH AND BACKFILL, TYPE I, OETEC ABLE MA!mNC TAPE		7, 8, 9
13	(1!i 0362 EACH	TVP,E 2-S POST ANCHORAGE		10. 11	!!	095'! D4D t EACH	ELECm!CAL SERVICE, TYPE A		7. 9. 9
U$	0610 1050 LF	TYP,E 2,w c GUIDERA!		11		095'4 0500 LF	DIRECTIONAL IBORING		II,,
u:;	06211 1400 LF	TYP,E 2-'IVCC GU!DE RAJL		11	6	1201 10 00 EACH	ITS DIEVIOE FIELD ENCLOSURE', GROU D !!!O\IHT		T, i
3500	0620 1600 LF	TYP,E 31-S GIIDE RAIL		II, 11	S	1201 1300 EACH	ITS DEVIOE FIELD E CLOSURE, POLE MOUNT		ti,
	11689 0000 LS	CPM SCHEDULE		N01iAB	24245	52o.I OODI LF	MICRO-FIBEROPTIC CABLE, JG-STRAND		7, 8, 9
1 000	(1(:90 0001 00 L UI	INTER L FACIUf ATION		tf0 '11A8	5	1210 00()1 EACH	ITS CLOSED CIRCUIIT TEUEVISION, CAMERA SU!I SYSTEM. POLE MOUNT		8,
5000	oa.5 0001 00 L1 A	UN'FOR£SE N WATER. POLLUIION CONTROL		N0 1iAD	2	,210 0100 EACH	ITS CLOSEJO CIRCUIT TeLE VISION, CAio! RA SUBSYSTEM, STRIICT RE MOU T		9
	0901 11001	MAINTENANCE AND PROTIECT10N OF TAAFFIC Dli/RING CONSfRUCTION		HO; AB	S	1210 8400 EACH	ITS CLOSEeD CIRCUIT M II!VISIOH, POLE, 50-FOOT		a, i;
	0901	SPE.£0 DISPLAY SIGN		TCP		12 10	ITS CL.OSSO CIRCUIT mLIEViS 0 11, POLE		e,')
2 10	EACH 0901 0231 DAY	ADDIII ONA WARNING LIGHTS, TYPE 8		TCP	t	EACH 5230 e!G00 EACH	FOUNDA'!!0 N, CAISSON. Jl .f OCT I'.O 50-FOOT f OIJE		
	(19(11	AOOnIONAL TRAFFIC CONTROI SIGNS.		TCP			ITS OY MI(.MESSAGI;31(,N. 1c" TEXT, FRONT ACCESS, 30-0EG. MOUIII! 1NG HARDWARE / FLEXIBLE DELI EATOR POST, GROtJN 0-MOIJNT TYPE		7, 8, 9
1000	0.240 SF				11/5,	0001 EACH	GM-.' OI'b\ GE POST WIIH WHIIBIBLA'NK SHEETING, COMMUNICAIi ION		
2	0901 04S1 EACH	3-LINE CHANGEABLE ESS AG E SIGN WITHOUT TELECOMMUNICAf IOIIIS		'!ICF'	7	!!!!00 0002 EACH	TAP INTO EXISTING POWER SUPPLY		T,
18	10 0001 EACH	JUNCTION BOXES J.B. 1, ELECTRICAL ♦		t, e.11	13	900(1 0003 EACH	U STRAND, F 18 6 R OPTIC CABLE SPLICE ENCLOSURE ♦		t, e, ,
44	4010 0002 EA CH	JUIIICTIO'I'I BOXES J.8.-2, COMMU ICATIONS		7, 8,1)	10 2115	0000 0004 LF	THREE WAY MICR ODUCTCO DUIT		e, 9
2	910 0005 EACH	CTION BOXES J.B.-12 COMMUNICATIONS		8	9950	9000 0005 Lf	IN-LINE FOUR DUCT ♦		8
331:5	0910 !!!! LF	AWG UNDERGROUND CA:SL COP PER 1 CONDUCTOR		7, 9	9800	9000 0006 lf	MICRO TRENCH		8
41"	0910 55 UF	2 DIRECT BURIAL CONDUIT		7, 8, 9	11	!!!IOO OOOII EACH	FN..E PORT MANAGED SWITCH		7, 8, 9

QUANTITY	ITEM NO / UNIT	DESCRIPTION	DESIGN NO	FOR TAB SEE SHEET	QUANTITY	ITEM NO / UNIT	DESCRIPTION	DESIGN NO	FOR TAB SEE SHEET
36	9000 00 H) LF	THREE WAY MICRODIJCT CONDUIT, CO CRETIE BNCASBO		II					
316	9000 0011 L	IN!!NE FOUR DUCT. CONCR.ETE ENCASED ♦		e					
1	,000 0012 EACH	II-1• x| 1o· COPPER CIA D STEel:. GROUliID ROD		I					
	91)00	GROUN D MOUrfl'EO SRI.ICE CAB IN ET		7, 8, 9					
13	EACH								

9.'v

SHEET 1 OF 1

P
OJ
EC
T
IC>
3
614 MPMS: 112a 2 ECMS U :2:292 8/il/20Z0 8:12:Mi AM

D - 14 Tabulation of Quantities Sheet

ITEM NUMBER	UNIT	DESCRIPTION
4810 0024	LS	TREE TRIMMING TO AN UNLIMITED HEIGHT MODIFIED
4810 0052	EACH	SELECTIVE TREE REMOVAL MODIFIE,D
4910 0001	EACH	JUNCTION BOXES J.B.-1 MODIFIED
4910 000.2	EACH	JUNCTION BOXES J.B.-2 MODIFIED
4910 0004	EACH	JUNCTION BOXES J.B.-11 MODIFIED
4910 0005	EACH	JUNCTION BOXES J.B.-12 MODIFIED
4910 4111	LF	AWG 1!0 UNDERGROUND CABLE , COPPER , 1 CONDUCTOR MODIAED
4910 4113	LF	AWG 2 UNDERGROUND CABLE , COPPER , 1 CONDUCTOR MODIAED
4910 4"117	LF	AWG 10 UNDERGROUND CABLE, COPPER, I CONDUCTOR MODIAED
4910 5400	LF	~~CONDUIT SLEEVE MODIFIED~~
4937 0339	EACH	FLEXIBLE DELINEATOR POST, GROUND-MOUNT TYPE GM-2, RED POST WITH WHITE/BLANK SHEETING MODIAED
~~0954~~ 0012	LF	~~2 INCH CONDUIT~~
4954 001 2	LF	2 INCH CONDUIT MODIFIED
~~0954~~ 0151	LF	TRENCH AND BACKA LL , TYPE I
4954 0151	LF	TRENCH ANO BACKA LL, TYPE I MODIFIED
4954 0152	LF	TRENCH AND BACKA LL , TYPE II MOOIAED
0954 0301	EACH	JUNCTION BOX, JB-26
0954 0500	LF	DIRECTIONAL BORING
0956 0001	LF	DETECTOR LEAD IN CABLE
0956 0101	LF	LOOP SENSOR
0970 0001	EACH	REMOVE POST MOUNTED SIGNS, TYPE A
5201 1300	EACH	ITS DEVICE A ELD ENCLOSURE, POLE MOUNT MODIFIED
5201 3100	LS	ITS DEVICE TESTING, COMPLETE, NO FACTORY DEMONSTRATION TEST MODIFIED
1202 0001	LS	ATMS ITS DEVICE INTEGRATION
5210 0001	EACH	116 CLOSED CIRCUIT TELEVISION, CAMERA SUBSYSTEM, POLE MOUNT MODIAED
5210 0100	EACH	ns CLOSED CIRCUIT TELEVISION, CAMERA §.1.JBS YSTEM , STRUCTURE MOUNT MODIFIED
1210 5000	EACH	ns CLOSED CIRCUIT TELEVISION, CAMERA 'tIOWERING DEVICE, INTEGRAL

Construction Note Master Sheet

GENERAL NOTES

1. TOPOGRAPHY AND HORI ZONTAL CONTROL IS DERIVED FROM EXISTING ROADWAY AND SIGNAL PLANS FOR THE FOLLOWING DEVICES: CM-4[illegible] 3 AND 020006E 02. THE TOPOGRAPHY HAS NOT BEEN VERIFIED BY SURVEY.
2. LOCATIONS OF EXISTING AND PROPOSED ITS DEVICES, CONDUITS AND JUNCTION BOXES (FOR COMMUNICATIONS AND POWER) SHOWN ON THE PLANS ARE APPROXIMATE AND NOT TO SCALE. INSTALL NEW ITS DEVICES, CONDUITS AND JUNCTION BOXES BASED ON FIELD CONDITIONS. LOCATIONS ARE TO BE APPROVED BY THE REPRESENTATIVE.
3. DO NOT INTERFERE WITH THE OPERATIONS OF ANY FIRE HYDRANT, FIRE CALL BOX OR POLICE CALL BOX.
4. PROVIDE MATERIALS AND WORKMANSHIP IN ACCORDANCE WITH PUBLICATION 408/2020-< LATEST EDITION), CONTRACT SPECIAL PROVISIONS, AND AASHTO/AWS D1. SM/D1. 5 2020 BRIDGE WELDING CODE. USE AASHTO/AWS D1. 1/D1. 1f.1 2020 FOR WELDING NOT COVERED IN AASHTO/AWS D1. SM/D1. 5:2020.
5. THE CONTRACTOR IS RESPONSIBLE FOR ENSURING THAT ALL COORDINATION NECESSARY IS PERFORMED TO IDENTIFY AND LOCATE UTILITIES WITHIN THE PROJECT LIMITS BEFORE BEGINNING WORK. PRIOR TO ANY EXCAVATION OR DEMOLITION WORK IN THE VICINITY OF UNDERGROUND UTILITIES, THE CONTRACTOR MUST CONTACT THE PA "ONE CALL SYSTEM" AND COMPLY WITH THE PROVISIONS OF ACT 187 (ONE CALL 1-800 242-1776).
6. COMPLY WITH THE REQUIREMENTS OF PENNA. ACT 38 (19911 ENTITLED UNDERGROUND UTILITY LINE PROTECTION LAW. CALL BEFORE YOU DIG PENNSYLVANIA REQUIRES THREE (3) WORKING DAYS NOTICE FOR CONSTRUCTION PHASE AND TEN (10) WORKING DAYS IN DESIGN STAGE -STOP CALL. PENNSYLVANIA ONE CALL SYSTEMS, INC. 1-800-242-1776.
7. THE CONTRACTOR MUST ADEQUATELY SUPPORT AND BE RESPONSIBLE FOR ALL UTILITY LINE(S) EXPOSED AS A RESULT OF CONTRACTOR CONSTRUCTION ACTIVITIES. ANY DAMAGE TO TO UNDERGROUND INFRASTRUCTURE IS THE CONTRACTOR'S RESPONSIBILITY AND REPAIRS **WILL** BE MADE AT THE CONTRACTOR'S EXPENSE.
8. TYPE AND LOCATION OF UNDERGROUND UTILITIES AND APPURTENANCES SHOWN ON THE PLANS WERE DERIVED FROM INFORMATION SUPPLIED BY THE PENNSYLVANIA ONE CALL, THE DEPARTMENT OF TRANSPORTATION DOES NOT GUARANTEE THE ACCURACY OF THE LOCATIONS OF THE EXISTING UTILITY STRUCTURES SHOWN ON THE PLANS, NOR DOES THE DEPARTMENT GUARANTEE THAT SUBSURFACE STRUCTURES ARE SHOWN.
9. ALL NEW UNDERGROUND CONDUIT MUST BE SLOPED TO DRAIN TO JUNCTION BOXES. IF THIS CONDITION CANNOT BE ACCOMPLISHED, THE CONDUIT MUST BE PROVIDED WITH "TEES" AT LOW POINTS OF CONDUIT RUNS.
10. TRENCH, LAY CONDUIT(S), AND BACKFILL ALL CONDUIT TRENCHES AT THE END OF THE DAY. SEED TO STABILIZE DISTURBED AREA IMMEDIATELY. DO NOT TRENCH MORE THAN THE LENGTH THAT CAN BE BACKFILLED AT THE END OF THE DAY.
11. FILTER ALL DEWATERING OF EXCAVATIONS. USE A SUITABLE FILTER AT THE END OF THE PUMP OUTLET.
12. COMPLETE ALL WORK PERTAINING TO NEW POWER SUPPLIES AND ELECTRICAL SERVICES IN ACCORDANCE **WITH** ALL NATIONAL AND LOCAL ELECTRICAL CODES. COORDINATE WITH PECO FOR ALL ELECTRICAL SERVICE HOOK UPS.
13. GROUND WIRE. NOT SHOWN IN THE WIRE CALLOUTS. THE tot,JrMtDR" IS TO INCLUDE GROUND WIRE WITH ALL CABLE RUNS WHERE REQUIRED. THE QUANTITY AND COST OF GROUND WIRE IS INCLUDED IN ITEM 9000-0106 ITS COMPLETE POWER SUPPLY.
14. ALL ELECTRICAL MATERIALS AND EQUIPMENT FOR WHICH THERE ARE ESTABLISHED UNDERWRITER'S LABORATORIES INC. (UL) STANDARDS SHALL BEAR THE "UL" LABEL.
15. ANY DAMAGE TO THE ROADWAY, STRUCTURES AND/OR EXISTING ITS EQUIPMENT CAUSED BY THE CONTRACTOR'S PERFORMANCE OF WORK SHALL BE CORRECTED AT THE CONTRACTOR'S EXPENSE.
16. THE CONTRACTOR SHALL LOCATE AND INSTALL JUNCTION BOXES AS REQUIRED TO PREVENT DAMAGE TO CABLE DURING INSTALLATION.
17. THE CONTRACTOR WILL BE REQUIRED TO SUBMIT SHOP DRAWINGS, CONSTRUCTION METHODOLOGIES AND PRODUCT MANUFACTURER SPECIFICATIONS BEFORE INSTALLING ANY WORK AS A PART OF THIS CONTRACT. ALL PROPOSED WORK **WILL** BE REVIEWED AND APPROVED BY THE REPRESENTATIVE.
18. EQUIPMENT LOCATION PLANS ARE DIAGRAMMATIC AND ARE INTENDED TO CONVEY THE SCOPE AND GENERAL ARRANGEMENT OF EQUIPMENT AND CONDUIT. THE LOCATIONS OF ITEMS NOT DIMENSIONED ARE APPROXIMATIONS ONLY. THE FINAL LOCATIONS SHALL BE DETERMINED AT THE PROJECT SITE AND SHALL HAVE THE APPROVAL OF THE REPRESENTATIVE.
19. CONTRACTOR WILL INSTALL COMMUNICATIONS CABLE(S) AND 1E i : t N B R[illegible] AEE A 3M 3 1fto 15ff D SHALL BE SPACED A MINIMUM OF 12" APART FROM OTHER 7 e t8clF 5JU R Ag Lt v 6 : E kE f tiEM'S.
20. ENSURE JUNCTION BOXES ARE LOCATED OUTSIDE OF UTILITY EASEMENTS. INSTALL ALL JUNCTION BOXES IN A CONDITION THAT ENSURES PROPER MAINTENANCE ACCESS.
21. CONSTRUCTION NOTES REPRESENT HOW ITS DEVICES AND ITS INFRASTRUCTURE SHALL BE BUILT. REFER TO PROJECT TAB SHEETS AND SPECIAL PROVISIONS FOR HOW ITEMS ARE TO BE PAID.
22. COORDINATE ALL INSTALLATION, SPLICING, TESTING, AND TERMINATION OF FIBER OPTIC CABLES FOR THE DEVICE LOCATIONS WITH PENNDOT DISTRICT 6-0 TRAFFIC UNIT.

CONTACT: JOHN LYNCH
PENNDOT DISTRICT 6-0
TEL: 215-205-6577

23. ALL ITS DEVICES AND ITS INFRASTRUCTURE ARE TO BE LOCATED WITHIN THE DEPARTMENTS LIMITED ACCESS AND LEGAL RIGHT-OF-WAY. ALL ITS CONDUITS OUTSIDE THE DEPARTMENT'S LIMITED ACCESS RIGHT-OF-WAY ARE TO BE ENCASED IN CONCRETE.
24. DETAILS OTHER THAN THOSE INDICATED ARE ON THE FOLLOWING STANDARD DRAWINGS:

BC-736M	JANUARY 31, 2019
BC-741M	AUGUST 4, 2017
RC-1 OM	JUNE 1, 2010
RC-1 IM	JUNE 1, 2010
RC-SIM	FEBRUARY 19, 2021
RC-SIM	JUNE 1, 2010
RC-82M	JUNE 1, 2010
RC-8 M	JUNE 1, 2010
TC-8604	DECEMBER 12, 2011
ITS-1201	MARCH 1, 2013
ITS-1210	MARCH 1, 2013
ITS-1230	MARCH 1, 2013

PA ONE CALL SYSTEM INC., PHONE 1-800-242-1776
THE PA ONE CALL NOTIFICATIONS PERFORMED DURING PROJECT DEVELOPMENT ARE AS FOLLOWS:

PRELIMINARY DESIGN
SERIAL NO. 2011 1992770 - 6/18/2011 - RIDLEY TOWNSHIP

FINAL DESIGN
SERIAL NO. 20200142353 - 1/14/2020 - RIDLEY TOWNSHIP

CONSTRUCTION NOTES

- [1] INSTALL FIBER OPTIC CABLE IN NEW CONDUIT(S)
- [2] INSTALL ELECTRICAL CABLE IN NEW CONDUIT(S)
- [3] INSTALL AERIAL FIBER OPTIC CABLE(S)
- [4] INSTALL 2" CONDUIT RISER(S)
- [5] INSTALL CCTV CAMERA ASSEMBLY ON EXISTING SIGNAL POLE, PENDANT INSTALLATION
- [6] INSTALL CCTV CAMERA ASSEMBLY ON EXISTING SIGNAL POLE, MOUNTING BRACKET INSTALLATION
- [7] INSTALL DYNAMIC MESSAGE SIGN ASSEMBLY, STRUCTURE AND FOUNDATION
- [8] INSTALL JB-2 (COMMUNICATIONS)
- [9] INSTALL JB-1 (POWER)
- [10] INSTALL SERVICE DISCONNECT AND METER ON SERVICE POLE
- [11] INSTALL CONTROL CABLE(S) AS REQUIRED
- [12] INSTALL POLE MOUNTED CCTV FIELD ENCLOSURE
- [13] INSTALL FIBER OPTIC COMMUNICATIONS EQUIPMENT
- [14] REMOVE AND/OR TRIM TREES AS REQUIRED TO PROVIDE LINE OF SIGHT, REFER TO PUB 646 TABLE 3-4.
- [15] POWER SERVICE (BY OTHERS)
- [16] INSTALL POLE MOUNTED DYNAMIC MESSAGE SIGN FIELD ENCLOSURE
- [17] INSTALL 35' WOOD POLE
- [18] INSTALL CONDUIT(S) IN EARTH USING TRENCHING METHOD, TYPE I MODIFIED (CONCRETE ENCASED)
- [19] INSTALL CONDUIT(S) IN SIDEWALK/PAVED SHOULDER USING TRENCHING METHOD, TYPE II MODIFIED (CONCRETE ENCASED)
- [20] COORDINATE WITH PECO ENERGY FOR POWER CABLE(S) INSTALLATION
- [21] COORDINATE WITH THE REPRESENTATIVE PRIOR TO FIBER OPTIC DROP CABLE(S) INSTALLATION
- [22] INSTALL TYPE 2-S GUIDE RAIL. WORK IS QUANTIFIED AND PAID FOR IN ROADWAY PLANS.
- [23] INSTALL SERVICE DISCONNECT ON SERVICE POLE

CONSTRUCTION NOTES CONT.

- [24] INSTALL CONDUIT(S) IN EARTH USING TRENCHING METHOD, TYPE I
- [25] INSTALL SERVICE METER AND DISCONNECT ON TRAFFIC SIGNAL POLE
- [26] INSTALL CONDUIT(S)/RISER(S) ON TRAFFIC SIGNAL POLE/MAST ARM
- [27] INSTALL NEW CCTV CAMERA ASSEMBLY AND LOWERING DEVICE ON 50' CCTV POLE
- [28] INSTALL NEW 50' CCTV POLE AND POLE FOUNDATION
- [29] RETROFIT EXISTING CONDUIT(S) INTO NEW JUNCTION BOX
- [30] POWER SERVICE TO METER (BY OTHERS)
- [31] RETROFIT CONDUIT(S) INTO EXISTING JUNCTION BOX
- [32] REMOVE EXISTING CCTV CAMERA, CABINET, POLE, AND FOUNDATION (SEE ITEM 9000-01031. COORDINATE EQUIPMENT DELIVERY WITH THE REPRESENTATIVE.
- [33] REMOVE GUIDE RAIL. WORK IS QUANTIFIED AND PAID FOR IN ROADWAY PLAN AS PART OF ITEM 0620-0502
- [34] RETROFIT CM-4701 COMMUNICATIONS AND ELECTRICAL SERVICE (SEE ITEM 9000-01031
- [35] INSTALL FIBER OPTIC SPLICE ENCLOSURE
- [36] INSTALL CONDUIT(S) IN BORING SLEEVE
- [37] SPLICE FIBER OPTIC DROP CABLE(S) TO SR 2006 BACKBONE
- [38] RESET TYPE A POST MOUNTED RAMP METER SIGN ON TYPE E POSTS (SEE ITEM 8940-00011
- [39] INSTALL TYPE A POST MOUNTED **RAMP** METER SIGN
- [40] INSTALL TYPE II 6'x6' LOOP DETECTOR IN PAVEMENT
- [41] INSTALL DETECTOR LEAD IN CABLE(S) IN NEW CONDUIT
- [42] INSTALL FLUSH MOUNTED JUNCTION BOX ON STRUCTURE
- [43] ATTACH CONDUIT(S) ON STRUCTURE
- [44] INSTALL CONDUIT SLEEVE UNDER ROADWAY USING DIRECTIONAL BORING METHOD
- [45] ABANDON EXISTING LOOP DETECTOR(S) AND CABLE(S)
- [46] RETROFIT POWER SERVICE FOR TR 47601 (SEE ITEM 9000-01181
- [47] INSTALL ELECTRICAL CABLE(S) IN EXISTING CONDUIT
- [48] INSTALL FIBER OPTIC CABLE(S) IN EXISTING CONDUIT
- [49] CONNECT NEW ELECTRICAL CABLES IN EXISTING ITS CABINET
- [50] DISCONNECT EXISTING DETECTOR LEAD IN CABLES AND FLASHER CABLE. COORDINATE TEMPORARY DEVICE OUTAGE WITH THE REPRESENTATIVE (SEE ITEM 9000[illegible]
- [51] SPLICE FIBER OPTIC DROP CABLES IN JUNCTION BOX
- [52] INSTALL JB-11 (COMMUNICATIONS)
- [53] INSTALL TERMINAL END SECTION, SINGLE. WORK IS QUANTIFIED AND PAID FOR IN ROADWAY PLANS
- [54] [illegible] METER CABLE(S) AT JUNCTION BOX. CONNECT PROPOSED RAMP METER CABLE(S) TO EXISTING RAMP METER CABLE(S) (SEE ITEM 9000-01211
- [55] REMOVE EXISTING JUNCTION BOX
- [56] REMOVE E-ZPASS READERS AND RETURN TO PENNDOT
- [57] REMOVE TEMPORARY TYPE E POST MOUNTED RAMP METER SIGN
- [58] INSTALL EXISTING ELECTRICAL CABLE IN NEW CONDUIT(S)
- [59] INSTALL ALL PROPOSED DETECTOR LEAD IN CABLES AND FLASHER CABLES IN EXISTING RAMP METER CABINET (SEE ITEM 9000-01021

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
6-0	DELAWARE	2006	476	2 OF 29

RIDLEY TOWNSHIP

REVISION NUMBER	REVISIONS	DATE	BY

CONSTRUCTION NOTES CONT.

- [60] INSTALL SERVICE DISCONNECT
- [61] INSTALL JB-26
- [62] INSTALL JB-12 (POWER)
- [63] DISCONNECT EXISTING ELECTRICAL CABLES FROM EXISTING TR CABINET (SEE ITEM 9000-01181
- [64] INSTALL DMS NUMBERING SIGN PANEL(S)
- [65] PATCH FIBER OPTIC CABLE AT TERMINATION CABINET
- [66] RETROFIT CONDUIT INTO EXISTING CABINET

CONDUIT SCHEDULE

- (A) 1 - 2" GALV. RIGID STEEL CONDUIT
- (B) 2 - 2" GALV. RIGID STEEL CONDUIT
- (C) 1 - 2" PVC CONDUIT
- (D) 2 - 2" PVC CONDUIT
- (E) CONDUIT SLEEVE, 4" HDPE

CABLE SCHEDULE

- 1 — 12 STRAND FIBER OPTIC CABLE(S)
- 2 — 3 - #2, 1 - #4 AWG COPPER ELECTRICAL CABLES
- 3 — ELECTRICAL SERVICE CABLE (INCIDENTAL TO ITEM 9000 01061
- 4 — EXISTING #2 AWG COPPER ELECTRICAL CABLE(S)
- 5 — CATEGORY 6, OUTDOOR RATED CONTROL CABLE(S)
- 6 — DETECTOR LEAD IN CABLE(S)
- 7 — 3 CONDUCTOR, #10 AWG FLASHER CABLE(S)
- 8 — ITS DEVICE CONTROL CABLE
- 9 — 3 - #0, 1 - #4 AWG COPPER ELECTRICAL CABLES
- 10 — 3 - #10, 1 - #4 AWG COPPER ELECTRICAL CABLES

ITS PLAN - GENERAL NOTES AND CONSTRUCTION NOTES
(SHEET 1 OF 11)

D - 16 **Construction Note Plan Sheet (also see B-17)**

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
12- 0	WASHINGTON	0079	OMS	18 OF 36
VARIOUS				

REV NO	REVISIONS	DATE	BY	APPD

NOTE:
SEE SHEET 16 OF 35 FOR
CONNECTION TO POWER SOURCE.

-E- ELECTRIC AERIAL
-EU- ELECTRIC UNDERGROUND
-FOU- UNDERGROUND FIBER OPTIC CABLE IN CONDUIT
- FOU - EXISTING UNDERGROUND FIBER OPTIC CABLE IN CONDUIT
IZI JB-1
JB-2
BASE MOUNTED CABINET
cgJ POLE MOUNTED CABINET
D§) CCTV CAMERA INSTALLATION
6 *EXISTING UTILITY POLE*
·e 9'0ND MOUNTED SPLICE CABINET

CONSTRUCTION NOTES

OJ INSTALL 2" DIRECT BURIAL CONDUIT
m DIRECTIONAL BORE
[II INSTALL MICRO FIBER OPTIC CABLE
[I] INTERCEPT EXISTING FIBER OPTIC CABLE.
m PLACE CABLE AT LEAST 5' FROM GUIDE RAIL ANO BRIDGE PIER
[iQ] INSTALL CCTV CAMERA
[jJJ INSTALL CCTV CAMERA, POLE, FOUNDATION AND CONTROLLER CABINET
[Ill INSTALL JB-1
I!] TRENCH AND BACKFILL
fill INSTALL JB-2

20 **INSTALL 50' OF MICRO FIBER OPTIC CABLE IN CABINET**
INSTALL FIBER OPTIC OELINEATORS
INSTALL MICRO DUCT CONDUIT
INSTALL 50' OF MICRO FIBER OPTIC CABLE IN JB-2
INSTALL 5 PORT MANAGED SWITCH
INSTALL GROUND MOUNTED CABINET
[I] INSTALL FIBER OPTIC DELINEATOR, EVERY 500'
[EI INSTALL FIBER OPTIC SPLICE TRAY
@] TAP INTO POWER SOURCE
INSTALL 31-S GUIDE RAIL & ET
INSTALL 5" HOPE

CABLE SCHEDULE

0 3 - "8 AWG
(!) 1 - 36 MICRO FIBER OPTIC CABLE

0 50' 100'

CONDUIT SCHEDULE

@ 1 - 2" DIRECT BURIAL CONDUIT
® 1 - CONDUIT SLEEVE, 5" HOPE
© 1 - MICRO DUCT CONDUIT

Construction Note Plan Sheet (also see B-16)

DISTRICT	COUNTY	ROUTE	SECTION	SHEET
12-0	ALLEGHENY	0079	OMS	19 OF 36
		VARIOUS		

REV ND	REVISIONS	DATE	BY	APPD

CONDUIT SCHEDULE

0 I-2" PVC CONOUIT

CABLE SCHEDULE

[!) 3 - •a **AWG** ELECTRICAL CABLE

0 3G STRANO MICRO FIBER OPTIC CABLE

CONSTRUCTION NOTES

OJ INSTALL JB-2

[I) INSTALL 50' OF 36 STRAND MICRO FIBER OPTIC CABLE IN JB2

[I) INSTALL 2" PVC DIRECT BURIAL CONDUIT

[I) TAP INTO EXISTING CCTV POLE CABINET'S FIBER OTIC CABLE NETORK

[I) INSTALL MICRO FIBER OPTIC OEL!NEATOR

[I) INSTALL MICRO FIBER OPTIC SPLICE TRAY

[I) INSTALL 5 PORT MANAGED SWITCH

[I) INSTALL FULL COLOR TYPE A OMS BOARD (GROUND MOUNTED ITS CABINET INCLUDED)

[I) INSTALL JB-1

[QI INSTALL 3 - **•S AWG WIRE**

[DJ TAP INTO EXISTING TYPE A POWER POLE

INSTALL 36 STRAND MICRO FIBER OPTIC CABLE

TYPE 1 TRENCHING

[8j INSTALL ITS GROUND MOUNTED CABINET

[ill INSTALL PVC CONDUIT ON EXISTING UTILITY POLE

- FO - FIBER OPTIC CABLE, AERIAL
- FOU - UNDERGROUND FIBER OPTIC CABLE IN CONDUIT
- FOU- *EXISTING UNDERGROUND FIBER OPTIC CABLE IN CONOOIT*

l:iiil JB-1

JB-2

1ZJ BASE MOUNTED CABINET

l:iiil *EXIST/ING JB-1*

I!] *EXISTING JB-2*

[8] *EXISTING POLE MOUNTED CABINET*

1,f)'l» *EXISTING ANTENNA POLE WITH WIRELESS DEVICE, SINGLE PANEL*

9 *EXISTING POWER SUPPLY*

e *EXISTING UTILITY POLE*

—EU— ELECTRIC UNDERGROUND

] TYPE A FULL COLOR OMS BOARD

0 50' 100'

D - 1 Typical Plan Sheet

DISTRICT	COUNTY		SECTION	SHEET
12-0	WESTMORELAND	0070	K10	11 OF 23
	SOUTH HUNTINGDON TOWNSHIP			
REVISION NUMBER	REVISIONS		DATE	BY / APPROVED

CABLE SCHEDULE

G) 1-36 STRAND MICRO- FIBER OPTIC CABLE
(I] 2-J6 STRAND MICRO-FIBER OPTIC CABLE
G) OMS CONTROL CABLES
G)J - #0 AWG

[i] SERVICE FROM UTILITY COMPANY
OUIDOOR RATED EnIERNET CABLE
L:JOPTIC CAB.£

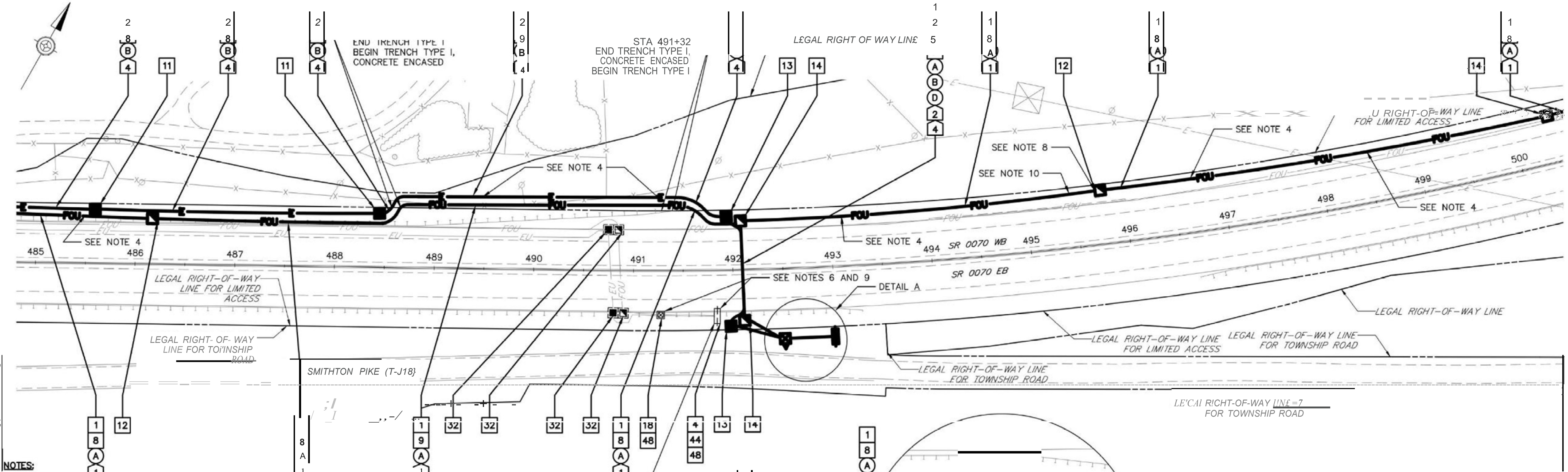
CONDUIT SCHEDULE

@ MICROOUCT CONDUIT JACKET
® 1 - 2" HOPE CONDUIT (ITEM 0910-5055)
© 2 - 2" HOPE CONDUIT (ITEM 0910-5055)
® CONDUIT SIEEVE, 6" HOPE

© 1 - 2" RGS CONDUIT
® (ITEM 4954-0012)
2 - 2" RGS CONDUIT
(ITEM 4954-0012)

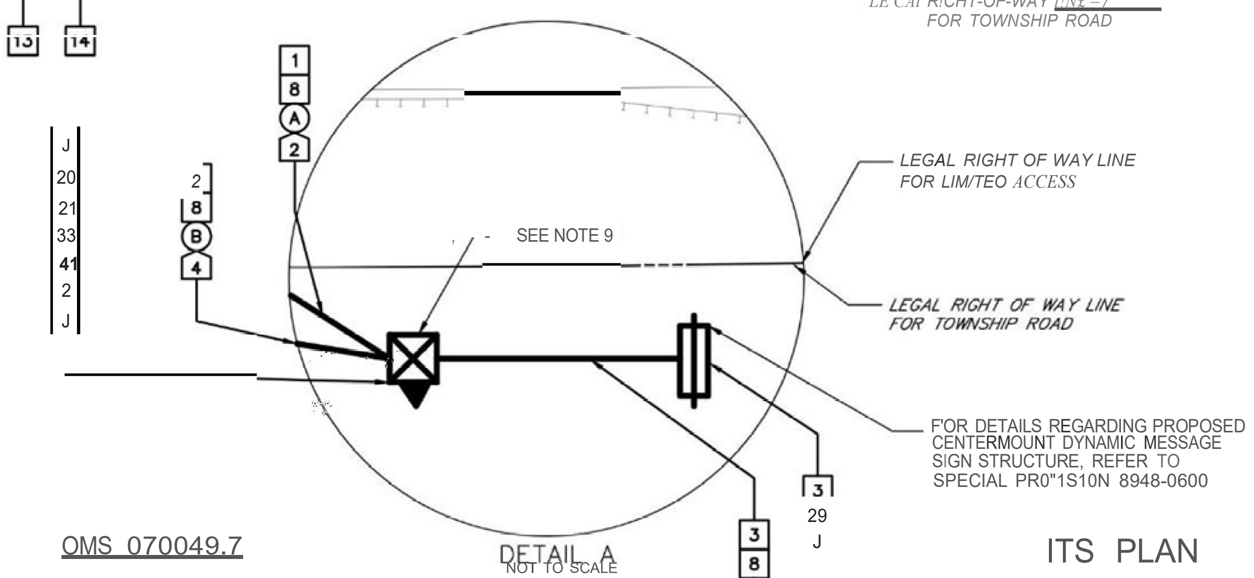
CONSTRUCTION NOTES

[!] INSTALL FIBER OPTIC CABLE(S) IN NEW CONDUIT
[!) INSTALL ELECTRICAL SERVICE/POWER CABLE(S) IN NEW CONDUIT(S)
Q REMOVE EXISTING DYNAMIC MESSAGE SIGN STRUCTURE AND
L.:..J FOUNDATION (INCIDENTAL TO ITEM 9000-0109)



NOTES:

1. LOCATION OF EXISTING SR 0070 FIBER, JUNCTION BOXES, AND CONDUIT IS APPROXIMATE AND SHOWN FOR INFORMATION PURPOSES ONLY.
2. INSTALL ALL PROPOSED COMMUNICATIONS CABLE (S) BEFORE DISCONNECTING EXISTING COMMUNICATION CABLE(S) AT AN EXISTING DEVICE. COORDINATE ALL DOWNTIME AND/OR OUTAGES WITH THE DISTRICT ENGINEER AND THE RTMC TO OBTAIN APPROVAL FOR LENGTH OF DOWNTIME.
3. POWER AND FIBER SHOWN SEPARATELY FOR PLAN CLARITY. CONDUITS CAN BE INSTALLED IN THE SAME TRENCH.
4. COORDINATE INSTALLATION OF ALL ITS UNDERGROUND INFRASTRUCTURE TO AVOID CONFLICTS WITH UNDERGROUND DRAINAGE AND UTILITIES. REFER TO ROADWAY PLANS FOR PROPOSED DRAINAGE AND UTILITY LOCATIONS. WHEN ITS CONDUIT MUST CROSS DRAINAGE OR UTILITIES, INSTALL IN ACCORDANCE WITH PUBLICATION 647 ITS- 1201 SHEET 11 OF 2J.
5. PLAN SHOWS TOPOGRAPHY AS THE FINAL ROADWAY ALIGNMENT AND LAYOUT.
6. COORDINATE WITH THE REPRESENTATIVE TO DETERMINE THAT EQUIPMENT FROM THE EXISTING OMS SYSTEM IS TO BE RETURNED. SEE ITEM 9000- 0109.
7. VERIFY FINAL DEVICE LOCATIONS WITH THE REPRESENTATIVE BEFORE INSTALLATION.
8. JUNCTION BOXES TO BE INSTALLED OUTSIDE THE LIMITS OF PROPOSED R-J ROCK.
9. RELOCATE AND REUSE EXISTING DAKTRONICS OMS CONTROLLER FROM EXISTING DMS
10. CABINET TO PROPOSED OMS CABINET. SEE ITEM 9000-0109. COORDINATE TRENCHING WITH THE REPRESENTATIVE WHERE ITS CONSTRUCTION COULD CONFLICT WITH INSTALLATION OF R-J ROCK BEHIND CONCRETE BARRIER.



OMS 070049.7

DETAIL A
NOT TO SCALE

ITS PLAN LOCATION PLAN
(SHEET 2 OF 12)

CONSTRUCTION NOTES (CONT)

INSTALL CONDUIT SLEEVE UNDER ROADWAY USING DIRECTIONAL BORING METHOD
INSTALL SERVICE METER ON WOOD POLE
INSTALL CONDUIT(S) IN BORING SLEEVE
INSTALL CONDUIT(S) IN TRENCH TYPE I
INSTALL CONDUIT(S) IN TRENCH TYPE I, CONCRETE ENCASED (ITEM 4954-0151)
REMOVE EXISTING (INCIDENTAL TO ITEM 9000-0109)
INSTALL .E-1 (ELECTRICAL)
INSTALL .E-2 (COMMUNICATIONS)
INSTALL .E-12 (ELECTRICAL)
INSTALL .E-11 (COMMUNICATIONS)
INSTALL POLE MOUNTED FIELD ENCLOSURE
ALL CCTV CAMERA ASSEMBLY ON
REMOVE EXISTING GROUND MOUNTED FIELD ENCLOSURE AND FOUNDATION
REMOVE EXISTING POLE/STRUCTURE MOUNTED FIELD ENCLOSURE
SPLICE FIBERS AS SHOWN ON SPLICE DETAILS
INSTALL FIBER OPTIC NETWORK SWITCH
22 REMOVE EXISTING WOOD POLE
REMOVE EXISTING 50' POLE, CCTV
23 ASSEMBLY, AND FOUNDATION
24 INSTALL OUTDOOR RADIO AND DISH ANTENNA ON NEW WOOD POLE
25 TERMINATE FIBER OPTIC CABLE(S) IN TERMINATION PANEL
26 INSTALL FIBER OPTIC CABLE IN EXISTING CONDUIT
INSTALL ELECTRICAL CABLE(S) IN NEW RISER(S)
SPLICE FIBER OPTIC CABLES IN GROUND MOUNTED SPLICE CABINET
29 INSTALL EXISTING DYNAMIC MESSAGE SIGN ON NEW STRUCTURE AND FOUNDATION
VERIFY LINE OF SIGHT PRIOR TO INSTALLATION OF DEVICE (INCIDENTAL TO ITEM 9000-0106)
RETROFIT NEW CONDUIT INTO EXISTING JUNCTION BOX
REMOVE EXISTING JUNCTION BOX
INSTALL GROUND MOUNTED FIELD ENCLOSURE
REMOVE EXISTING WIRELESS REPEATER SYSTEM (ITEM 9000-0106)
INSTALL CONDUIT RISER
INSTALL 50 FT WOOD POLE
REMOVE EXISTING CCTV SYSTEM (ITEM 9000-0108)
TO BE INSTALLED BY UTILITY COMPANY. COORDINATE WITH UTILITY COMPANY FOR CABLE INSTALLATION
INSTALL GROUND MOUNTED SPLICE CABINET
INSTALL 45 FT WOOD POLE (INCIDENTAL TO ITEM 9000-0102)
41 INSTALL SERVICE DISCONNECT
INSTALL TYPE A POWER SERVICE
INSTALL OUTDOOR RATED ETHERNET CABLE IN NEW CONDUIT/RISER
RELOCATE EXISTING DYNAMIC MESSAGE SIGN BOARD
INSTALL EXISTING FIBER OPTIC CABLE IN NEW CONDUIT
INSTALL TYPE C POWER SERVICE
INSTALL UTILITY SERVICE PEDESTAL
REMOVE EXISTING OMS SYSTEM (ITEM 9000-0109

9.

Appendix E.
Sample Special Provisions

E - 1 Sample Modified Standard Specification

SPECIAL PROVISION

Project: 79912 Standard / Federal Oversight Construction

Short Description: Reconstruction of Allegheny, Delaware, and Castor Avenues. Design Build Limited to ADA Ramps **Org Code:** 0800

County: Philadelphia **SR:** 95 **Section:** AF2

District: 06 **Group ID:** 0095-AFC **Municipality:** PHILADELPHIA

General

Type: Project Specific **Addendum:** 0

Detail

Index or Category: **District:**

Sequence ID: 0

Version: 0

Provision Name: ITEM 5210-6400 - ITS CLOSED CIRCUIT TELEVISION, POLE, 50-FOOT, PAINTED

Completed: Yes

Associated Items

Item Number	Unit of Measure	Item Description
5210-6400	EACH	ITS CLOSED CIRCUIT TELEVISION, POLE, 50-FOOT , PAINTED

Header

ITEM 5210-6400 - ITS CLOSED CIRCUIT TELEVISION, POLE, 50-FOOT, PAINTED

Provision Body

DESCRIPTION – This work is the furnishing and installing of a ground-mounted, 50-foot, steel CCTV camera support pole

MATERIAL – Section 1210.2 and as follows:

Provide poles that have a finish color of National Park Service Brown (Fed #20040). Submit a color sample to the Representative for approval prior to coating.

CONSTRUCTION – Section 1210.3.

MEASUREMENT AND PAYMENT – Each

Audit Information

Created By	Created On	Modified By	Modified On
Paul Linahan/PennDOT BP-000064	08/21/2020 07:29:04 AM	Paul Linahan/PennDOT BP-000064	10/01/2020 10:01:08 AM

pennsylvania DEPARTMENT OF TRANSPORTATION ECMS home site map help pennsylvania PA Stephen McGinley

SPECIAL PROVISION

Project: 112282 Standard / PENNDOT Oversight NHS Construction

Short Description: D12 Interstate 70/79 DMS Boards **Org Code:** 1240
County: Washington **SR:** 79 **Section:** DMS
District: 12 **Group ID:** D12 Interstate 70/79 DMS Board **Municipality:** SOUTH STRABANE

General

Type: Project Specific **Addendum:** 0

Detail

Index or Category: **District:**
Sequence ID: 0
Version: 0

Provision Name: Item 5230-4600 - ITS Dynamic Message Sign, 18" Text, Front-Access, 30-Deg
Completed: Yes

Associated Items

Item Number	Unit of Measure	Item Description
5230-4600	EACH	ITS DYNAMIC MESSAGE SIGN, 18" TEXT, FRONT-ACCESS, 30-DEG , MOUNTING HRDWARE

Header

ITEM 5230-4600 ITS DYNAMIC MESSAGE SIGN, 18" TEXT, FRONT-ACCESS, 30-DEG , MOUNTING HRDWARE

Provision Body

In accordance with Section 1230 and as follows:

Section 1230.2(d) Display Modules. Revise by adding the following:

Provide a color full matrix sign which is three lines high. The DMS is to contain a full display matrix measuring a minimum of 96 rows high by 208 pixel columns wide. Sign shall use a 20 mm Pixel Pitch. Maximum DMS size is 8' high by 16' wide by 2' deep.

Section 1230.2(f)1. Display Subsystem Hardware. Revise by adding the following:

Provide one spare Ethernet cable between the DMS controller and the display modules.

Section 1230.3 Installation and Mounting. Revise by adding the following: Install DMS on Type A sign structure as shown in Publication 647, ITS-1230.

Audit Information

Created By	Created On	Modified By	Modified On
Ron E Murray/PennDOT	07/27/2020 12:35:43 PM	Candace H Compton Stansak/PennDOT	07/31/2020 11:14:47 AM

You are currently logged in as **Stephen McGinley**

Release: 89.0
Session size: 0.1k

PennDOT | Home | Site Map | Help | Pennsylvania

PennDOT Privacy Policy

Thu May 19 15:58:02 EDT 2022
Official ECMS Date/Time

E - 3 Sample Standard Special Provision

pennsylvania DEPARTMENT OF TRANSPORTATION home site map help ECMS pennsylvania PA STEPHEN MCGINLEY

STANDARD SPECIAL PROVISION

Detail

Index or Category: General Provisions Related
Status: Active
Sequence ID: 60000
District: 06
Version: A
Provision Name: a60000 PENNDOT TRAFFIC UNIT AND FIBER OPTIC CONTRACTOR COORDINATION

Usage Information

Measurement: Dual
Edit Body: Yes
Include on all projects: No
Edit Header: Yes
Include on all federally funded projects: No
Edit Project Specific Details: Yes
Include on all 100% State funded projects: No
Instructions for Usage: For use on projects where coordination with District 6 traffic unit and their fiber optic contractor is needed.
408 Section:
Effective From: 03/06/2018
To: 01/01/2199

Associated Items

Item Number	Description
No records found.	

Header

PENNDOT TRAFFIC UNIT AND FIBER OPTIC CONTRACTOR COORDINATION

Provision Body

Coordinate with the PennDOT Traffic Unit and fiber optic contractor to ensure completion of work and testing on schedule. Communicate throughout the project duration with the PennDOT Traffic Unit and fiber optic contractor to keep them informed of project schedule milestones. Coordinate and communicate with the District fiber optic contractor to ensure their presence at all progress meetings and to inform them of all circumstances that would affect their work.

Coordinate with the PennDOT Traffic Unit a minimum of three weeks prior to the need for fiber optic communications within the traffic signal or ITS device cabinets for each of the tail locations. This will ensure that the District's fiber optic contractor will have the cable terminated and tested prior to the device's standalone test so the project schedule is not adversely impacted. Request that the PennDOT Traffic Unit schedule the pulling, termination, labeling, and testing of the fiber optic cable between each termination location. The request can go directly to the District's fiber optic contractor. Make the request by email and copy the PennDOT Traffic Unit on the email so they can follow up on the progress.

PennDOT Traffic Unit Contact: John Lynch; 610-205-6577; jjlynch@pa.gov

PennDOT Fiber Optics Contractor Contact: Chris Mumber, Blair Park; 267-388-2611; cmumber@blairpark.com

Project Specific Details

Audit Information

Created By	Created On	Modified By	Modified On
Matthew DeCola/PennDOT	03/06/2018 08:41:40 AM	Tim R Culbertson/PennDOT	03/12/2018 01:08:26 PM

You are currently logged in as **Stephen McGinley**.

Release: 89.0
Session size: 0.1k

PennDOT | Home | Site Map | Help | Pennsylvania

PennDOT Privacy Policy

Thu May 19 15:51:38 EDT 2022
Official ECMS Date/Time

pennsylvania DEPARTMENT OF TRANSPORTATION home site map help ECMS pennsylvania Anonymous

SPECIAL PROVISION

Project: 103555 Standard / Federal Oversight Construction

Short Description: I-95 Corridor ITS
County: Philadelphia
District: 06
SR: 95
Group ID: 0095-GIR
Org Code: 0600
Section: GR8
Municipality: PHILADELPHIA

General

Type: Project Specific **Addendum:** 0

Detail

Index or Category:
Sequence ID: 0
Version: 0
District:

Provision Name: ITEM 9000-0095 - ATMS NEW MODULE DEVELOPMENT
Completed: Yes

Associated Items

Item Number	Unit of Measure	Item Description
9000-0095	DOLLA	ATMS NEW MODULE DEVELOPMENT

Header

ITEM 9000-0095 - ATMS NEW MODULE DEVELOPMENT

Provision Body

DESCRIPTION - This work is the development, testing, implementation, integration, and maintenance of new and modified software modules into the OpenTMS platform by PennDOT's ATMS Vendor.

CONSTRUCTION -

Provide the following new and enhanced modules in OpenTMS for the noted Section GR8 systems:

A. AUTOMATED TRUCK ROLLOVER WARNING SYSTEM:

1. Reporting Module
   - Develop new report detailing truck roll over warning system activations
2. Archiving Module
   - Implement truck roll over warning system protocol
   - Archive activation details for subsequent reports

B. SMART PARKING MANAGEMENT SYSTEM:

1. Traffic Sensors Module
   - Implement FLIR TrafiSense protocol
2. Travel Times Module
   - Implement SEPTA API
   - Implement/integrate travel time algorithm accounting for drive time, train schedule, and train trip time
3. DMS Module
   - Expose messages to 511PA
4. Parking Module (NEW)
   - Consume lot traffic sensor data
     - Calculate lot counts from configured lot details and raw traffic sensor data
   - Consume train travel times
   - Post messages to configured signs indicating trip times and lot availability

Perform the following enhancements to OpenTMS for the noted Section GR8 systems:

SMART PARKING MANAGEMENT SYSTEM:

- ActiveITS Core Functionality

E - 4 Sample Special Provision

- Perform initial backend integration in order to use any ActiveITS modules within OpenTMS.
- Coordinate this work with the WZDx work effort.

- Traffic Sensors
  - Enhance the existing OpenTMS traffic sensor module to support consumption of the FLIR TrafiSense protocol.
- Travel Times
  - Enhance the existing OpenTMS travel times module to support consumption of the SEPTA Application Programming Interface (API) providing train departure and arrival times.
  - Combine these departure/arrival times with the drive times from area DMS to the parking lot, and the walk time from the parking lot to the train platform, to provide multi-model travel times.
- DMS
  - Make the OpenTMS DMS status available to the 511PA System for display purposes.
- Parking (NEW)
  - Integrate the ActiveITS parking module into OpenTMS.
  - Adapt the parking module to consume necessary FLIR traffic sensor data from OpenTMS traffic sensor module.
  - Adapt the parking module to consume necessary travel times from the OpenTMS travel times module.
  - Ensure that the parking module reports lot space availability based on configured total available spots and vehicle counts reported by the FLIR devices.
  - Ensure that the parking module reports available parking spots, train travel time, and drive travel time on the configured DMS.
- Licensing
  - Utilize the ActiveITS ATMS software which is based on state-owned software from the Texas Department of Transportation and Florida Department of Transportation.
  - Provide the ATMS Vendor's ActiveITS Software Licensing Agreement to PennDOT for their review, approval, and signature.

AUTOMATED TRUCK ROLLOVER WARNING SYSTEM:

- Device Comms
  - Update OpenTMS to implement the truck rollover warning system protocol and receive notifications.
- Archival
  - Update the existing OpenTMS archival module to archive times for activations of the truck rollover warning system.
- Reporting
  - Update the existing OpenTMS reporting module to provide a new report detailing activations of the truck rollover warning system.

DOCUMENTATION AND TRAINING

- Submit user documentation and training materials, for the Section GR8 modules, to the RTMC for review and approval. Coordinate with the RTMC on the format of the material. Provide all material in advance of user training.
- Provide training sessions to each of the RTMC shifts at a time and location of the RTMC's choosing. Provide one (1) refresher course during the contract period.

BURN IN PERIOD

- Provide continuous support for a six (6) month burn-in period.
  - Assume one (1) restart of the six (6) month burn-in period during this period.

WARRANTY

- Warrant that the ATMS Vendor will perform the services under this project with the degree of high professional skill and sound practices and judgment which is normally exercised by recognized professional firms with respect to services of a similar nature.
- Provide a twenty-four (24) month warranty on the software enhancements made for this project.
- Correct deficiencies (bug fixes) found in the OpenTMS and ActiveITS software for this project pertaining to mutually agreed upon and accepted requirements.

MEASUREMENT AND PAYMENT – Dollar

Includes all required labor, materials, and equipment to develop, test, implement, integrate, and maintain new and modified ATMS Modules into Open TMS providing a fully functional system.

Audit Information

Created By	Created On	Modified By	Modified On
Antoinette MacIntyre/PennDOT BP-000324	07/07/2020 04:34:44 AM	Antoinette MacIntyre/PennDOT BP-000324	07/02/2021 09:25:13 AM

You are currently logged in as **Anonymous**.

SPECIAL PROVISION

Project: 103555 Standard / Federal Oversight Construction

Short Description:	I-95 Corridor ITS			Org Code:	0600
County:	Philadelphia	SR:	95	Section:	GR8
District:	06	Group ID:	0095-GIR	Municipality:	PHILADELPHIA

General

Type: Project Specific **Addendum:** 0

Detail

Index or Category: **District:**

Sequence ID: 0

Version: 0

Provision Name: ITEM 9000-0097 - SMART PARKING MANAGEMENT SYSTEM (SPMS)

Completed: Yes

Associated Items

Item Number	Unit of Measure	Item Description
9000-0097	LS	SMART PARKING MANAGEMENT SYSTEM (SPMS)

Header

ITEM 9000-0097 - SMART PARKING MANAGEMENT SYSTEM (SPMS)

Provision Body

DESCRIPTION -

This work is the installation, commissioning, integrating into OpenTMS, and testing of a Smart Parking Management System (SPMS) at the Cornwells Heights Park'n'Ride Lot.

MATERIAL –

Sections 956.2, 1202.2, 1104.07 (b) 2-4, and as follows:
Materials to perform this work, as required or needed, will be paid for and specified under the following item numbers. Refer to these items for detailed description of the material requirements.
ITEM 4910-0001 – JUNCTION BOXES J.B.-1, ELECTRICAL
ITEM 4910-0004 – JUNCTION BOXES J.B.-11, COMMUNICATIONS
ITEM 4910-0005 – JUNCTION BOXES J.B.-12, ELECTRICAL
ITEM 4954-0012 – 2-INCH CONDUIT (PVC)
ITEM 4954-0151 – TRENCH AND BACKFILL, TYPE I, MARKING TAPE
ITEM 5201-1300 – ITS DEVICE FIELD ENCLOSURE, POLE MOUNT, SIZES
ITEM 5201-3000 -- ITS DEVICE TESTING, COMPLETE (ADVANCE NOTICE)
ITEM 5204-0100 – STANDARD FIBER OPTIC CABLE, 12 STRAND
ITEM 5210-6400 – ITS CCTV, POLE, 50-FOOT (SPMS)
ITEM 5210-7100 – ITS CCTV, POLE FOUNDATION, CAISSON, 31-FOOT TO 50-FOOT POLE (SPMS)
ITEM 9000-0039 – WOODEN UTILITY POLE ASSEMBLY, 35 FOOT
ITEM 9201-3000 – ITS DEVICE TESTING, 2 YEAR OPERATIONAL SUPPORT PERIOD
ITEM 9991-0170 – FIELD ETHERNET SWITCH
ITEM 9991-0196 – HORIZONTAL DIRECTIONAL DRILLING
ITEM 9991-0204 – FIBER OPTIC PATCH CABLE
ITEM 9991-0206 – FIBER OPTIC TERMINATION PANEL
ITEM 9991-0207 – FIBER OPTIC SPLICE ENCLOSURE
ITEM 9991-0211 – ITS SYSTEM, COMPLETE POWER SUPPLY
ITEM 9991-0212 – TESTING OF COMPLETE POWER SUPPLY
ITEM 9991-0214 – PECO ELECTRICAL SERVICES AND COORDINATION

Thermal Vehicle Detector:

Provide four (4) FLIR TrafiSense thermal vehicle detectors as manufactured by FLIR Systems, Inc, 27700 SW Parkway Ave, Wilsonville, Oregon 97070 as the detector assemblies.

Thermal Vehicle Detector Cabling:

Provide cabling, per manufacturer recommendation, from each thermal vehicle detector to the ITS node cabinet

Software:

Coordinate with PennDOT's ATMS Vendor in providing software to be installed on PennDOT's central server with the capability of utilizing FLIR's public API to access data from each of the four (4) TrafiSense thermal vehicle detectors.

Provide software with the following capabilities:
- Pull data in near real time from each detector using FLIR's public API.
- Combine data from each detector to calculate one combined value.
- Provide combined value updates in near real time for data exportation.
- Provide near real time data export capability from software to Open TMS DMS messaging system.
- Provide automatic updates, in real time, the display of next train arrival time on local DMS.
- Provide for the monitoring and storing of parking availability data.
- Provide for the sharing of data between SEPTA's server and PennDOT's central server.

Incorporate into the overall SEPTA Train travel times, the individual travel times from the local DMS to the Cornwells Height's train platform.
- Provide for the removal of handicap spaces from the overall available space count.
- Provide for a parking availability buffer number.

CONSTRUCTION –

Sections 956.2-4, 1202.3 (b) 5.a and as follows:

Thermal Vehicle Detector assembly:

Have a manufacturer's representative on site to assist during installation, set-up, and testing.

Install thermal vehicle detector system elements as indicated and as recommended by the manufacturer, providing a fully functional detector system.

Provide all necessary hardware and or/software to enable PennDOT to collect data and change thermal vehicle detector set-up parameters as needed.

Install, setup, and pre-test all elements of the thermal vehicle detector assembly prior to field installation.

Work with the manufacturer's representative for recommended lens configuration and thermal vehicle detector mounting height. Mount thermal vehicle detectors using manufacturer recommended mounting hardware.

Establish proposed detection zone, for each thermal vehicle detector, in accordance with the requirements as determined by the manufacturer and as indicated. Submit a list of proposed preset detection zones to the Representative for review and approval. Work from the approved list to set up the preset detection zones for each detector as directed by the Representative.

Provide moisture-proof cable entry points.

Display subtitles with the associated video image. Include the entrance/exit location the detector is detecting, the detector number, and any other information as directed by the Representative and RTMC.

Cables and Surge Protection:

Install cables between the ITS node cabinet and thermal vehicle detector assemblies as indicated and as recommended by the manufacturer.

Install all cables inside conduits or hollow poles with no exposed portions, unless otherwise approved by the Representative.

For installation of coaxial cables through hollow poles, make provisions to keep some slack in the vertical cable run within the pole.

Provide a strain-relief mechanism for the cable in vertical runs exceeding fifty (50) feet.

Submit connectors and method of connectorization to the Representative for review and approval.

Properly install all connectors as recommended by the manufacturer and approved by the Representative.

Detector Surge Protection System:

Provide surge protection devices meeting the requirements in ITEM 5201-1300 ITS FIELD DEVICE ENCLOSURE, POLE MOUNT.

Provide re-settable surge protection devices, incidental to the cable installation, for all copper cables between the ITS node cabinet and detector assemblies.

IP Detector Surge Protection:

Provide IP Detector Surge Protection per manufacturers recommendation.

Detector ITS Node Cabinet:

Provide an ITS node cabinet at each new detector site, as shown on the plans, and in accordance with ITEM 5201-1300 ITS DEVICE ENCLOSURE, POLE MOUNT, SIZES.

Software:

Begin all coordination efforts as early as possible to avoid any project delays.
Coordinate with PennDOT's ATMS Vendor to integrate the SPMS into the RTMC OpenTMS software.
Coordinate with PennDOT IT, and PennDOT's ATMS Vendor so as not to not interfere with firewall protection protocol

Testing:

E -5 Sample Special Provision

As specified and in accordance with ITEM 5201-3000 ITS DEVICE TESTING, COMPLETE (ADVANCE NOTICE), and ITEM 9201-3000 ITS DEVICE TESTING, 2 YEAR OPERATIONAL SUPPORT PERIOD and as follows

Provide a test plan to the Representative for review and approval.

Ensure a detection rate of ≥98% for the detection of vehicle presence at the entrances/exits sites comprising the SPMS.

Ensure a detection rate of ≥99% for vehicle counting for all lanes at the entrances/exits comprising the SPMS.

Provide a written report to the Representative, for review and approval, detailing the testing and detection rates achieved over a specified period of time as recommended by the manufacturer. Include in the report detailed information on the integration with OpenTMS and the field display of the resulting DMS/ADMS messages.

MEASUREMENT AND PAYMENT – Lump Sum

Includes all required labor, miscellaneous wire, cable, conduit, fittings, attachments, mounting, equipment, software updates, integration, testing, and coordination efforts to provide a complete and fully functional SPMS.

Audit Information

Created By	Created On	Modified By	Modified On
Antoinette MacIntyre/PennDOT BP-000324	07/07/2020 04:17:02 AM	Antoinette MacIntyre/PennDOT BP-000324	07/02/2021 09:39:03 AM

pennsylvania DEPARTMENT OF TRANSPORTATION ECMS

home site map help

pennsylvania Anonymous

SPECIAL PROVISION

Project: 103555 Standard / Federal Oversight Construction

Short Description:	I-95 Corridor ITS			**Org Code:**	0600
County:	Philadelphia	**SR:**	95	**Section:**	GR8
District:	06	**Group ID:**	0095-GIR	**Municipality:**	PHILADELPHIA

General

Type: Project Specific **Addendum:** 0

Detail

Index or Category: **District:**

Sequence ID: 0

Version: 0

Provision Name: ITEM 9000-0098 - AUTOMATED TRUCK ROLLOVER WARNING SYSTEM

Completed: Yes

Associated Items

Item Number	Unit of Measure	Item Description
9000-0098	LS	AUTOMATED TRUCK ROLLOVER WARNING SYSTEM

Header

ITEM 9000-0098 - AUTOMATED TRUCK ROLLOVER WARNING SYSTEM

Provision Body

DESCRIPTION - This work is the installation, testing, and commissioning of a complete and operational Automated Truck Rollover Warning System (ATRWS) on the I-95 NB off-ramp to PA-63/Woodhaven Road.

MATERIAL-

Sections 930.2 (a) (c), 951, 956, 1201, 1230, the standard drawings and as follows:
Materials to perform this work, as required or needed, will be paid for and specified under the following item numbers. Refer to these items for detailed description of the material requirements.
ITEM 0936-0010 – STRUCTURE MOUNTED FLAT SHEET ALUMINUM SIGNS WITH STIFFENERS
ITEM 0951-0135 – TRAFFIC SIGNAL SUPPORT, 35' MAST ARM
ITEM 0955-3206 – VEHICULAR SIGNAL HEAD, ONE 12" SECTION
ITEM 4910-0005 – JUNCTION BOXES JB-12 ELECTRICAL
ITEM 4954-0012 – 2-INCH CONDUIT (PVC)
ITEM 4954-0151 – TRENCH AND BACKFILL, TYPE I, MARKING TAPE
ITEM 5201-1000 – ITS DEVICE FIELD ENCLOSURE, GROUND MOUNT, SIZES
ITEM 5201-3000 – ITS DEVICE TESTING, COMPLETE (ADVANCE NOTICE)
ITEM 5204-0100 – STANDARD FIBER OPTIC CABLE, 12 STRAND
ITEM 9201-3000 – ITS DEVICE TESTING, 2 YEAR OPERATIONAL SUPPORT PERIOD
ITEM 9991-0170 – FIELD ETHERNET SWITCH
ITEM 9991-0197 – BORING
ITEM 9991-0204 – FIBER OPTIC PATCH CABLE
ITEM 9991-0206 – FIBER OPTIC TERMINATION PANEL
ITEM 9991-0207 – FIBER OPTIC SPLICE ENCLOSURE
ITEM 9991-0211 – ITS SYSTEM - COMPLETE POWER SUPPLY
ITEM 9991-0212 – TESTING OF COMPLETE POWER SUPPLY
ITEM 9991-0214 – PECO ELECTRICAL SERVICES AND COORDINATION

1) Microwave Detector Assembly:

Provide FLIR TrafiRadar Detectors as manufactured by FLIR Systems, Inc, 27700 SW Parkway Ave, Wilsonville, Oregon 97070 as the detector assemblies. These detectors shall provide real-time advance vehicle classification and speed detection.

2) Mast Arm Pole Assembly:

Provide one (1) Traffic Signal Support, 35' Mast Arm with pole and foundation, sized accordingly, to support (2) twelve (12) inch flashing yellow LED signal heads and a 60" x 60" overhead warning sign (W1-13L (MOD)).

3) Cabinet Assembly:

Provide and utilize a separate ITS node cabinet (Ground Mounted Type D see 0521-1000) for housing the ATRWS controller. Modify this cabinet as necessary to accept the necessary detector inputs, Model 2070 controller, outputs to the ATRWS flashing beacons and blank out signs, and all other components necessary for ATRWS operations as described.

4) Controller:

The system will be based on a Model 2070 controller with custom firmware to operates the local ATRWS. Provide the required interfaces to accept inputs from the FLIR TRAFFIRADAR Detectors and outputs to actuate the flashing yellow LED beacons and the blank out signs. Include a test switch panel to operate the flashing beacons and the blank out signs independently of the model 2070 outputs.

5) Blank Out Message Sign Assembly:

This Assembly includes the blank out sign, housing, sign controller (if required by manufacturer), supports, breakaway systems, concrete foundation, ground rod, and miscellaneous hardware, wire and cable. Submit for review and approval, complete details for the sign, sign control (if any), housing, and supports, including design calculations, power requirements, and heat load.

a) Blank Out Signs

Provide two (2) 120 VAC switched signs, for intermittent or continuous duty. Provide LED Roadside Message Signs meeting or exceeding the following requirements:

a. Create a sign display matrix utilizing high intensity, high efficiency AMBER AlInGaP Light Emitting Diodes (LED). Characters must be legible from a distance of 500 feet under all lighting conditions. Letter size to be 11 inches with the text as indicated.

b. Arrange LED bundles to form pixels, and arranged to form the required letters. Legend shall be "ROLLOVER WARNING REDUCE SPEED" or other legend as directed by the Representative. Fabricate the legend to have the pixels form the fixed message. Electronics to be all solid state, no moving parts with louvers over the pixels to block sun loading.

c. Provide redundant LED bundles forming pixels, so that the message remains legible with 25 percent of the LED's inoperable.

d. Provide illuminated characters that show a uniform display across the sign, with no difference in luminous intensity from pixel to pixel. Provide sign with the capability to operate without any decrease in performance over an ambient temperature range of -30 degrees C to +60 degrees C.

b) Sign Housing:

a. Provide a weatherproof housing that is constructed of 0.125 inch high quality, aluminum alloy sheet.
b. Provide a complete sign housing made of natural maintenance free aluminum to minimize heat buildup.
c. Provide a sign housing that can withstand wind pressure of 74 psf (AASHTO 120 mph) without permanent deformation.
d. Provide all front face panel surfaces, not directly in front of a light emitting pixel, masked with a flat black non-painted aluminum to reduce glare and increase the contrast ratio.
e. Protect all interior parts and components completely from the elements.
f. Ensure the ability to read the displayed message by eliminating any light intrusion into the housing.
g. Seal all openings to prevent moisture and dirt from entering the housing interior.
h. Provide screened ventilation louvers and filtered drains to eliminate moisture buildup due to condensation.
i. Provide access to the interior of the housing for routine maintenance or inspection by an access door mounted on the rear of the sign.
j. Provide a rubber seal or other approved seal material around the door to ensure a watertight enclosure.
k. Provide doors that include locks with "Best" 7-pin interchangeable core to keep unauthorized persons from accessing the interior of the sign.
l. Provide a GFCI service outlet for service personnel use.
m. Provide a separate photo sensor control located in the cabinet to reduce the brightness level at night. Provide a photosensor for detecting ambient lighting conditions to set the sign brightness levels. Provide a photosensor with a minimum range from 2 to 2000 lux to be used for day/night selection.

6) Complete Power Supply:

Provide a complete AC power supply for the ATRWS as specified and in accordance with ITEM 9991-0211 – ITS SYSTEM - COMPLETE POWER SUPPLY

7) Communication Cable:

Provide manufacturer recommended cables from the ATRWS controller to the microwave detection devices.

8) Signal Cable:

Provide manufacturer recommended signal cables from the controller assembly to the LED signal heads and LED Blank Out signs.

9) Miscellaneous:

Furnish all miscellaneous wire, cable, conduit, mounting, hardware, and fittings that are necessary for a complete ATRWS.

CONSTRUCTION-

Section 910.3 (q), 930.3, and as follows:

Have a manufacturer's representative on site to assist during installation, set-up, and testing.
Construct and install the ATRWS in accordance with the requirements of the Plans, the manufacturer, applicable codes, regulations, and applicable standards to provide a fully functional ATRWS.
The ATRWS includes the microwave detector assemblies, mast arm pole assembly, cabinet assembly, and Blank Out Message Sign Assembly, as well as conduit and cable for communication and for power.
Position the two (2) upstream facing detection devices for the classification of trucks and speed detection, with each device detecting one (1) of the two (2) lanes of the ramp. Ensure that these devices activate the two (2) flashing yellow LED signal heads.

Position the two (2) downstream facing detection devices for the classification of trucks and speed detection, with each device detecting one (1) lane of the ramp Ensure that these devices activate the messaging on the two (2) amber blank out signs.

Microwave Detector Assembly:

Install four (4) microwave detection devices on a 35' mast arm as recommended by the manufacturer using appropriate mounting hardware. For each detector, work with the manufacturer representative to establish and program the proposed detection- zones for each lane on the ramp. Refer to manufacturer's user manual for proper setup and testing of the devices.

Mast Arm Pole Assembly:

Mount two (2) twelve (12) inch yellow LED flashing signal heads on the 35' mast arm using the manufacturer's recommended mounting hardware.

Mount the 60" x 60" overhead warning sign (W1-13L (MOD)) between the LED flashing signal heads using appropriate mounting hardware.

Controller Assembly:

Install and perform initial testing of the Model 2070 Controller firmware. Program the parameters and controller logic required to activate the warning devices. The parameters of the ATRWS include:

- The upstream facing detectors will classify trucks and detect speed. Upon detection of a truck going over 25 mph, a signal is sent to the ATRWS controller to activate the flashing yellow LED signal heads. The LED signal heads will remain flashing for 9 seconds.
- The downstream facing detectors will also classify trucks and detect speed. Upon detection of a truck going over 25 mph, it will send a signal to the controller to activate the blank out signs. The blank out signs will shut off 20 seconds after they are actuated.

Blank Out Sign Foundations, Signposts and Grounding:

Construct foundations and place ground rods. Erect posts with breakaway supports. Attach rigid steel conduit with breakaway coupling for power cable. Attach signs to posts as indicated.

Testing:

As specified and in accordance with ITEM 5201-3000 ITS DEVICE TESTING, COMPLETE (ADVANCE NOTICE), and ITEM 9201-3000 ITS DEVICE TESTING, 2 YEAR OPERATIONAL SUPPORT PERIOD and as follows:

Provide a test plan to the Representative for review and approval.

Ensure a detection accuracy rate of ≥99% for detection of vehicle classification

Ensure a detection accuracy rate of ≥99% for vehicle speeds

MEASUREMENT AND PAYMENT – Lump Sum

Includes all required labor, materials, equipment, software, integration, and testing for a fully functioning ATRWS.

Audit Information

Created By	Created On	Modified By	Modified On
Antoinette MacIntyre/PennDOT BP-000324	07/07/2020 04:27:17 AM	Antoinette MacIntyre/PennDOT BP-000324	07/02/2021 09:41:38 AM

E -7 Sample Special Provision

SPECIAL PROVISION

Project: 103555 Standard / Federal Oversight Construction

Short Description:	I-95 Corridor ITS			**Org Code:**	0600
County:	Philadelphia	**SR:**	95	**Section:**	GR8
District:	06	**Group ID:**	0095-GIR	**Municipality:**	PHILADELPHIA

General

Type: Project Specific **Addendum:** 0

Detail

Index or Category: **District:**
Sequence ID: 0
Version: 0

Provision Name: ITEM 9000-0100 - 511PA ENHANCEMENTS
Completed: Yes

Associated Items

Item Number	Unit of Measure	Item Description
9000-0100	DOLLA	511PA ENHANCEMENTS

Header

ITEM 9000-0100 - 511PA ENHANCEMENTS

Provision Body

DESCRIPTION - This work is the development, implementation, integration, and testing, of enhancements to the 511PA Traveler Information System.

CONSTRUCTION -

Coordinate with Information Logistics, Inc., (215-262-4709) to provide the following system enhancements:

1. Real-time parking data for Cornwells Heights Park & Ride Lot
2. Travel times for pre-selected trips
3. SEPTA station icons added to 511PA
4. DMS message information
5. Links
6. Project and Inter-Agency Meeting Support

Enhancement Details:

1. Real-time parking data for Cornwells Heights Park & Ride Lot:
   - Website – Add this information to the 511PA website with an icon located at the position of the facility on the map. Ensure that by clicking on the icon the number of spaces available, and total spaces, are shown.
   - Create up to three (3) design options for the custom icon for the Cornwells Heights Park & Ride Lot.
   - IVR – Add information about available parking spaces to the traffic report, or as an additional option, for the Greater Philadelphia region.
   - Mobile app – Ensure that parking data information is read to users in Drive Mode when they come within a pre-defined radius of the park & ride location. This information may be added as a separate option that can be turned on/off by users.
2. Travel times for pre-selected trips that pass by the Cornwells Heights Park & Ride Lot:
   - Base the travel times on INRIX data, with beginning and ending points selected by the PennDOT team. Include up to five (5) trips (both directions) calculated from INRIX data.
   - Website – Design a portion of the existing 511PA website, or a special events website (e.g. Marysville or the LLWS) to compare travel times on different sections of the project area. Ensure that train travel times are not precluded.
   - IVR – Set up a dedicated option on the IVR to read the comparisons to users. This would be contained within the Greater Philadelphia region.
   - Mobile app – Ensure that this information is read to users in Drive Mode when they come within a pre-defined radius of the trip. This information may be added as a separate option that can be turned on/off by users.
3. SEPTA station icons added to 511PA with real-time train information:
   - Website – Add icons for the fifteen (15) stations on the Trenton Regional Rail line to the 511PA webmap. Ensure that by clicking on an icon that the latest train status(es) are provided. Also include all the stations that are part of the pre-selected trips.
   - Mobile app – Ensure that this information is read to users in Drive Mode. Have it be read when the app is first turned on, within a radius of a SEPTA station, or a combination of both. Make this an option for users to turn on/off.

4. DMS message information:

    - Website – Add a new layer to the website to show DMS information. Ensure that by clicking on an icon the full message of the DMS is shown. Display this as text or an image, if the image is provided by the data feed. Display different icons for active and inactive DMS.
    - Mobile app – Read the DMS messages as Drive Mode announcements, when users come within a pre-defined radius of the sign. This information may be added as a separate option that can be turned on/off by users.

5. Links:

    - Add links to the 511PA webmap for the SEPTA website, the I95Revive.com website, and other regional transportation partners.

6. Meetings:

    - Include three (3) meetings (virtual and/or in-person) per task.

Coordinate with PennDOT for the following:

1. Real-time parking data for Cornwells Heights Park & Ride:

    - Provide the data feed for the real-time parking information.

2. Travel times for pre-selected trips in the vicinity of the project:

    - Identify the appropriate beginning and ending points for trips, as well as any comparisons that will be made.
    - Decide which format they prefer for presentation of the travel times.

3. SEPTA station icons added to 511PA with real-time train information:

    - Secure permission to use the SEPTA logo on the 511PA website.
    - Confirm that https://www.opendataphilly.org/organization/septa is the correct location for SEPTA real-time data.
    - Decide how much information to display when an icon is clicked

4. DMS message information:

    - Provide the data feed for the DMS information.

5. Links:

    - Determine the website links, titles for navigation, and preference for location on the webmap.

Schedule:

- Submit a task-based schedule to the Representative for review and approval prior to commencing any work.

MEASUREMENT AND PAYMENT – Dollar

Includes all required coordination, labor, materials, and equipment to develop, test, implement, and integrate the enhancements into the PA511 system.

Audit Information

Created By	Created On	Modified By	Modified On
Antoinette MacIntyre/PennDOT BP-000324	09/21/2020 01:41:41 PM	Antoinette MacIntyre/PennDOT BP-000324	07/02/2021 09:45:36 AM

Appendix F.
Sample Integration Spreadsheet

The spreadsheet provided in this appendix serves as an example of the information that the ATMS vendor would need to integrate various types of systems into the ATMS platform. This is simply an example spreadsheet, and the specific project integration information should be in accordance with PennDOT Publication 408, Section 1202 and the project special provisions.

Project Name	Project POC - PennDOT	Contractor	District	Device Type	Device Count	Device Vendor	Model	Device Protocol	Device ID	Statewide ID	District ID	IP Address

Continue on next page

IP Address Port	Subnet Mask	Gateway	Descriptive Location	Road	Direction	Mile Marker	Latitude	Longitude	County	Community String (if applicable)	Manufacture

Continue on next page

Model	Protocol	Dimensions (if applicable)	Detector information (if applicable)	Joystick information (if applicable)	Notes

Appendix G.
Sample Test Plans

Sample Stand-alone Test

Changeable Message Sign

CMS Stand–Alone Test Procedures

Project #:________________________ **Sign Contract #:**________________________

Date:__________________________ **RTMC #:**_____________________________

Location:________________________ **Sign Model #:**_________________________

________________________ **Pixel Spacing:** ________ **Color / Monochrome**

Participants: (Name/Company/Agency)

______________________________ ______________________________

______________________________ ______________________________

______________________________ ______________________________

______________________________ ______________________________

Functional Testing Procedures

1.0 COMMUNICATIONS

1.1 A qualified technician shall connect a laptop, with the manufacturer's software system loaded onto it, to the controller to initially demonstrate communications with the CMS.

Communications established:________Yes ______No

Software on Laptop:_______Yes________No Version_____________________

Additional Notes: ____

2.0 DISPLAYING MESSAGES

2.1 Display a SINGLE PHASE message containing the sequential alphabet across each line.

Verify the correct layout and definition of each letter:_______Yes ______No

Display the SINGLE PHASE message using:

Single stroke (5x7)_______Yes ______No; _________# of characters per line

Double stroke (7x6)_______Yes ______No; _________ # of characters per line

Smallest font sign is capable of displaying_______Yes ______No

Font selected:________________;_____________# of characters per line

Note any issues: ____

2.2 Blank each SINGLE PHASE message.

Note any issues: ____

2.3 Display a TWO PHASE message containing the sequential alphabet across each line on the FIRST PHASE and sequential numbers across each line on the SECOND PHASE.

Verify the correct layout and definition of each letter/number:_______Yes_________No

Display the TWO PHASE message using:

Single stroke (5x7)_______Yes_________No;___________# of characters per line

Double stroke (7x6)_______Yes_________No;__________# of characters per line

Smallest font type sign is capable of displaying_______Yes_________No

Font selected:________________ ; # of characters per line: ___________

Note any issues: ____

2.4 Blank each TWO PHASE message.

Note any issues: ____

2.5 Display a TIMED MESSAGE.

Display a test message for one (1) minute.

Verify with a stop watch that the message displays for one (1) minute.
______Yes ______No

Verify that the message automatically blanks after one (1) minute +/- three (3) seconds.
______Yes ______No

3.0 COLOR & GRAPHICS CAPABILITIES

3.1 Color Text

Display varying combinations of text and background color combinations on the sign to demonstrate the full capabilities of the sign.

Note any issues: ____

3.2 Graphics

Display various graphics including highway shields to demonstrate the full capabilities of the sign.

Note any issues: ____

4.0 BRIGHTNESS TESTING

4.1 Manual Brightness Setting

Display a SINGLE PHASE message on the sign.

*Select/display the following brightness levels (**1, 25, 50, 75, and 100**) through the appropriate command on the laptop.________Yes _______No*

Note any issues: ____

4.2 Automatic Brightness Setting

Set the sign to Automatic brightness mode using the laptop.

Verify that the sign reports that it is in Automatic brightness mode.

Display a SINGLE PHASE message on the sign.

Verify and record the sign's brightness level. ______________________

Manually change the light on the photocells to induce different brightness levels.

Verify that the sign adjusts and changes the brightness levels.________Yes _______No
Record the "adjusted" brightness level. ________________________

Note any issues: ____

5.0 POWER RECOVERY

5.1 Short Power Recovery

Display a message for five (5) minutes.

Switch the Main Power Supply OFF and wait less than one (1) minute.

Then switch the Main Power Supply ON and verify that the message re-appears.
______*Yes* ______*No*

Verify that the sign blanks at the end of the selected message duration.
______*Yes* ______*No*

Note any issues: ____

Notes:

1) *The message will have to be sent to the controller 15 minutes prior to displaying the message or send the message and soft reset the controller before displaying the message.*

2) *The* ***CMS-Short-Power-Recovery-Message*** *needs to be set to Current Message and The* ***End-Duration-Message*** *needs to be set to blank.*

5.2 Long Power Recovery

Display a message for five (5) minutes.

***With the Controller ON**, switch the Main Power Supply OFF and wait longer than the maximum power loss time (usually 90 seconds).*

Switch the Main Power Supply ON and verify that the sign is blank.
_______Yes _______No

Note any issues: ____

<u>Notes:</u>

1) *If **<u>CMS-Short-Power-Loss-Time</u>** is set to less than 5 minutes,*

   ***<u>CMS-Long-Power-Recovery-Message</u>** needs to be set to **BLANK**.*

2) *If **<u>CMS-Short-Power-Loss-Time</u>** is set to 5 minutes or greater,*

   ***<u>CMS-Long-Power-Recovery-Message</u>** can be set to **BLANK** or **Current Message**.*

6.1 Verify the configured communication loss maximum time value. If necessary, reconfigure the time to a shorter period for this test. (usually 1 minute) Configured Time = _______________

Display a SINGLE PHASE message.

Disconnect the communications cable (Ethernet cord from laptop).

Wait for the communications loss configured time to elapse.

Verify, with a stop watch, that the sign blanked after the configured time.
_______Yes _______No

Verify the correct reporting using the communications software.________Yes _______No

******* VERIFY THAT THE ORIGINAL SETTINGS HAVE BEEN RE-ENTERED__________YES***

7.0 PHYSICAL FEATURES

*Check the operation of the cabinet Fan.*________*Yes* _______*No*

*Check the operation of the cabinet Heater.*________*Yes* _______*No*

Check the physical internal / external condition of the cabinet.

________*Ok* _______*Needs Work*

Check the condition of the internal wiring / overall workmanship / cleanliness of cabinet.

________*Ok*_________*Needs Work*

*Check the condition of the cabinet filter.*________*Ok*_________*Replace*

Note any issues: ____

____

____

____

8.0 PUNCH LIST ITEMS

____

____

____

____

____

9.0 SIGNATURES

Contractor: ____

Qualified CMS Technician: ____

PennDOT / PennDOT Representative: ____

Sample System Acceptance Test

Changeable Message Sign & Communications

CMS SYSTEM ACCEPTANCE TESTING

1. TRODUCTION

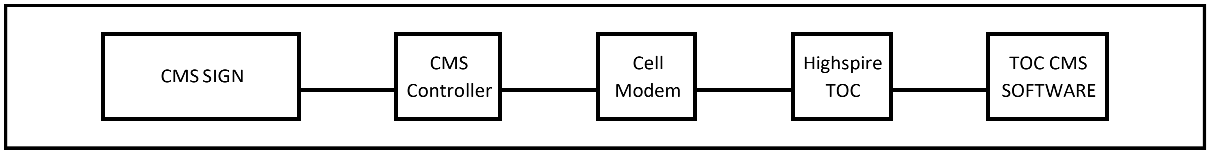
System Acceptance Testing (SAT) verifies that the installed Changeable Message Sign (CMS) locations are fully operational as part of the entire system from the Highspire PA Traffic Operations Center (TOC) / PennDOT D-5 TMC. This document provides the procedures for the CMS SAT.

2. OCEDURES

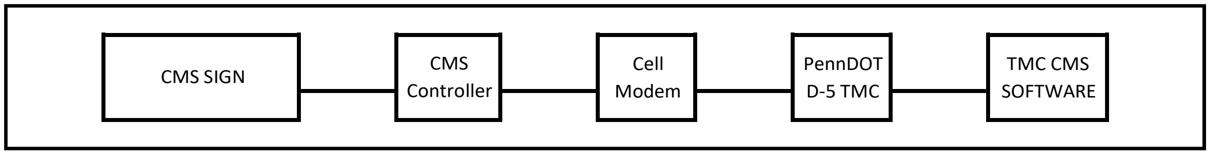
From the TOC / TMC using the ATMS Software, select the CMS. Verify that the CMS is operational and that the CMS can be controlled from the ATMS.

PA Turnpike CMS Locations:
- A56-2
- A56-4
- A74-1
- A74-2
- A87-1
- A87-2
- A95-1
- A95-2
- A31-3

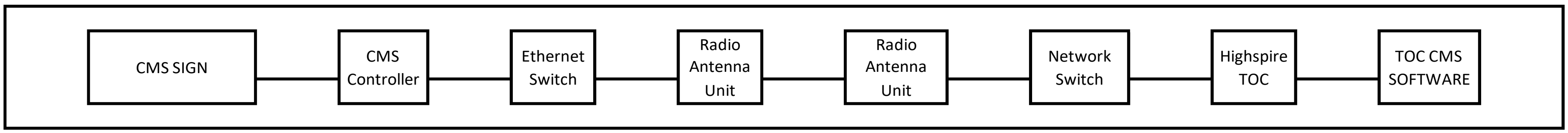
PennDOT CMS Locations:
- D078.E050.5
- D078.W050.6
- D_D5_309S-US-22
- D022.W318.2



Typical Cell Modem Communications (PA Turnpike)



Typical Cell Modem Communications (PennDOT)



Typical Wireless Radio Communications (PA Turnpike)

CMS SAT PROCEDURES

	DESCRIPTION	Procedure	RESULTS	CMS A31-3	CMS A56-2	CMS A56-4	CMS A74-1	CMS A74-2	CMS A87-1	CMS A87-2	CMS A95-1	CMS A95-2	CMS D022. W318.2	CMS D078. E050.5	CMS D078. W050.6	CMS D_D5_ 309S-US-22
SECTION 1 - COMMUNICATIONS TESTS																
1.1	VERIFY COMMUNICATIONS TO THE SIGN (PING)	Send Ping Test to Sign IP	Response received *(Ping test is successful)* No Response, Ping times out *(Ping test is unsuccessful)*													
1.2	SIGN STATUS	VERIFY THE CMS APPEARS AS ACTIVE IN ATMS Software	Active and ready for operation													
1.3	COMMUNICATION RETURNED	SIGN STATUS IN CMS CONTROL SOFTWARE WILL APPEAR BLACK AND CMS WILL REMAIN BLANK	SIGN STATUS IN CMS CONTROL SOFTWARE WILL APPEAR BLACK AND CMS WILL REMAIN BLANK													
1.4	POWER FAILURE	POWER IS DISCONNECTED IN THE FIELD FOR 2 MINUTES THEN RESTORED	VERIFY THAT CMS CONTROL SOFTWARE REGAINS COMMUNICATIONS TO THE SIGN AFTER POWER HAS BEEN RESTORED. VERIFY THE CMS APPEARS BLANK AFTER POWER IS RESTORED.													
1.5	RESET CONTROLLER FROM CMS CONTROL SOFTWARE	UTILIZE CMS SOFTWARE TO RESET CONTROLLER.	VERIFY (IN THE FIELD) THE CONTROLLER SHUTS DOWN AND COMES BACK ON LINE. VERIFY THE CMS APPEARS BLACK AFTER COMMUNICATIONS IS RE-ESTABLISHED.													
TESTING WITNESS INTIALS & DATE																

Ping Test

Equipment: Cellular Gateway / Wireless Antenna
Model: Cisco C809 / Radwin RW-5525-0C50
Description: Ping test Cellular Gateway / Wireless Antenna and CMS Controller to verify accessibility.
Observe ping test to verify no data (packets) lost. Document **PASS** or **FAIL**.

Location	IP Address	Pass/Fail	Technician	Date	Witness & Acceptance Name	Company	Date
CMS A31-3	4.9 GHZ Subscriber ___.___.___.___				1.		
					2.		
	CMS Controller ___.___.___.___				3.		
					4.		
CMS A56-2	Cellular Gateway ___.___.___.___				1.		
					2.		
	CMS Controller ___.___.___.___				3.		
					4.		
CMS A56-4	Cellular Gateway ___.___.___.___				1.		
					2.		
	CMS Controller ___.___.___.___				3.		
					4.		
CMS A74-1	Cellular Gateway ___.___.___.___				1.		
					2.		
	CMS Controller ___.___.___.___				3.		
					4.		
CMS A74-2	Cellular Gateway ___.___.___.___				1.		
					2.		
	CMS Controller ___.___.___.___				3.		
					4.		
CMS A87-1	Cellular Gateway ___.___.___.___				1.		
					2.		
	CMS Controller ___.___.___.___				3.		
					4.		

Ping Test

Equipment: Cellular Gateway / Wireless Antenna
Model: Cisco C809 / Radwin RW-5525-0C50
Description: Ping test Cellular Gateway / Wireless Antenna and CMS Controller to verify accessibility.
Observe ping test to verify no data (packets) lost. Document **PASS** or **FAIL**.

Location	IP Address	Pass/Fail	Technician	Date	Witness & Acceptance Name	Company	Date
CMS A87-2	Cellular Gateway . . .				1.		
					2.		
	CMS Controller . . .				3.		
					4.		
CMS A95-1	Cellular Gateway . . .				1.		
					2.		
	CMS Controller . . .				3.		
					4.		
CMS A95-2	Cellular Gateway . . .				1.		
					2.		
	CMS Controller . . .				3.		
					4.		
CMS D022. W318.2	Cellular Gateway . . .				1.		
					2.		
	CMS Controller . . .				3.		
					4.		
CMS D078. E050.5	Cellular Gateway . . .				1.		
					2.		
	CMS Controller . . .				3.		
					4.		
CMS D078. W050.6	Cellular Gateway . . .				1.		
					2.		
	CMS Controller . . .				3.		
					4.		

Ping Test

Equipment: Cellular Gateway / Wireless Antenna
Model: Cisco C809 / Radwin RW-5525-0C50
Description: Ping test Cellular Gateway / Wireless Antenna and CMS Controller to verify accessibility.
Observe ping test to verify no data (packets) lost. Document **PASS** or **FAIL**.

Location	IP Address	Pass/Fail	Technician	Date	Witness & Acceptance Name	Company	Date
CMS D_D5_ 309S-US-22	Cellular Gateway ___.___.___.___				1.		
					2.		
	CMS Controller ___.___.___.___				3.		
					4.		

CMS SAT PROCEDURE

CMS NUMBER/LOCATION: ______________________________

ADDITIONAL COMMENTS: ______________________________

____

____

____

____

____

____

TEST CONDUCTED BY: ______________________________

DATE: ______________________________

WITNESS: ______________________________

ORGANIZATION:

WITNESS:

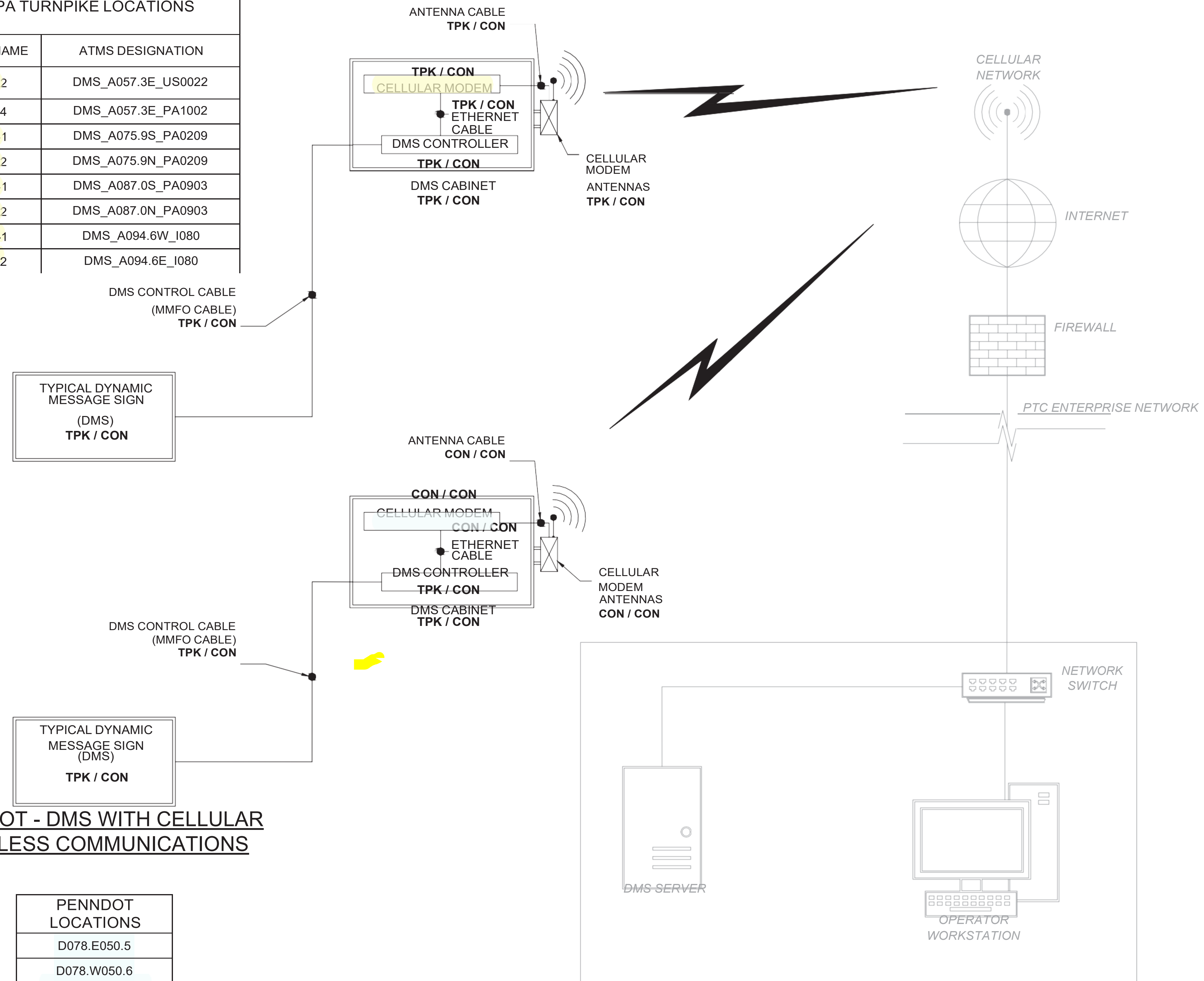
ORGANIZATION:

WITNESS:

ORGANIZATION: ______________________________

PTC - DMS WITH CELLULAR WIRELESS COMMUNICATIONS

PA TURNPIKE LOCATIONS	
SITE NAME	ATMS DESIGNATION
56-2	DMS_A057.3E_US0022
56-4	DMS_A057.3E_PA1002
74-1	DMS_A075.9S_PA0209
74-2	DMS_A075.9N_PA0209
87-1	DMS_A087.0S_PA0903
87-2	DMS_A087.0N_PA0903
95-1	DMS_A094.6W_I080
95-2	DMS_A094.6E_I080

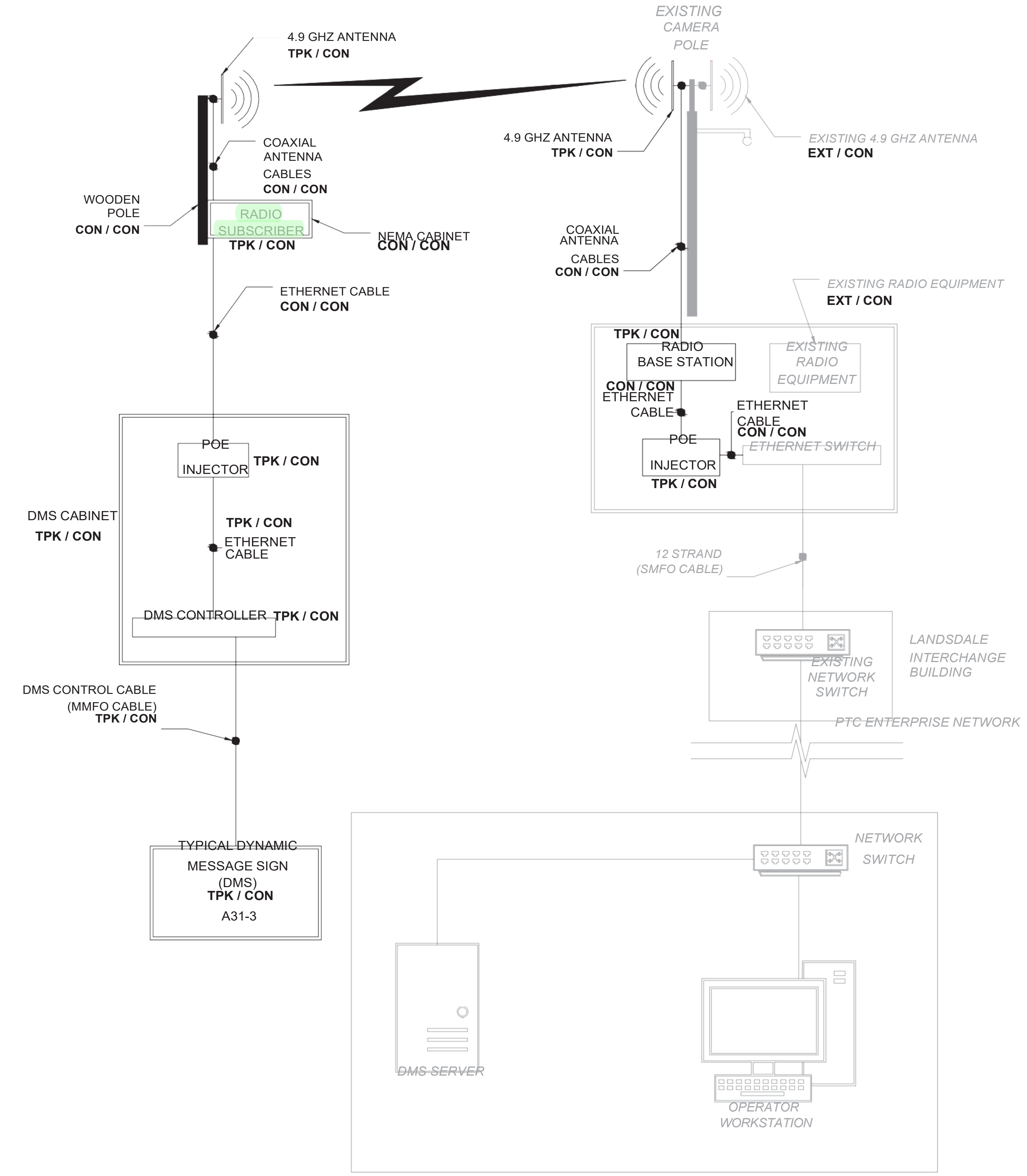


PENNDOT - DMS WITH CELLULAR WIRELESS COMMUNICATIONS

PENNDOT LOCATIONS
D078.E050.5
D078.W050.6
D_D5_309S-US-22
D022.W318.2

LEGEND

CON / CON	SUPPLIED BY CONTRACTOR / INSTALLED BY CONTRACTOR
TPK / CON	SUPPLIED BY TURNPIKE / INSTALLED BY CONTRACTOR
TPK / TPK	SUPPLIED BY TURNPIKE / INSTALLED BY TURNPIKE
EXT / CON	EXISTING EQUIPMENT / RELOCATED BY CONTRACTOR



DMS WITH 4.9 GHZ WIRELESS INFRASTRUCTURE

PA TURNPIKE LOCATION	
SITE NAME	ATMS DESIGNATION
A31-3	DMS_A030.1S_PA0063

PREPARED BY:
MCMAHON ASSOCIATES
415 FALLOWFIELD ROAD, SUITE 301
CAMP HILL, PA 17011

PREPARED FOR:
THE PENNSYLVANIA TURNPIKE COMMISSION

PENNA TURNPIKE

NO.	REVISIONS	DATE	APPR.

WBS NO.
A-056.00M001-3-02
NETWORK NUMBER: 7007720
FILE NAME: 6383ITSbd01
DRAWING TYPE: 1A
STRUCTURE NUMBER: NA
SCALE: NA

INSTALLATION OF PRE-ENTRY INTELLIGENT TRANSPORATION SYSTEMS BETWEEN MILEPOST A30.13 & MILEPOST A94.59

SYSTEM BLOCK DIAGRAM

DISTRICT: 4,5 | COUNTY: CARBON, LEHIGH, MONTGOMERY | DRAWING: 1 OF 1
TOWNSHIP / BOROUGH: VARIES | SHEET: 21 OF 117

Sample Stand-alone Test

CCTV Camera

This document details the On-Site Stand-Alone Test procedure required to verify that the new CCTVs are installed and configured according to specifications.

2 Procedure

1. Attach a laptop computer to an available port on the Ethernet switch or Power Over Ethernet injector in the camera equipment cabinet. Open a browser and point it to the IP address of the camera.
2. Click on LivePage to view the video image.
3. Use the controls on the View Control tab to control the camera pan, tilt, zoom, focus, iris and presets.
4. Use the controls on the Aux Control tab to turn the day/night mode on and off.

3 Legend

Test:	Desired Result:
Image	All available video streams received on On-Site Monitor
Pan Right	The camera pans to the right
Pan Left	The camera pans to the left
Tilt Up	The camera tilts up
Tilt Down	The camera tilts down.
Zoom In	The camera zooms in
Zoom Wide	The camera zooms out
Variable Speed	Moving the cursor farther from neutral causes the camera to move faster
Auto Focus	The camera automatically adjusts focus
Iris Override	Pressing IRIS OPEN and CLOSE buttons manually overrides auto-iris
Preposition Pan	Calling up a preset shot pans the camera to the correct position
Preposition Tilt	Calling up a preset shot tilts the camera to the correct position
Preposition Zoom	Calling up a preset shot zooms the lens to the correct position
Day/Night Shift	Pressing ON/OFF 57 turns on/off Night Mode
Cabinet	Cabinet wiring is acceptable
Heater & Fan	Ensure enclosure Heater/Fan are operational and thermostatically controllable

4.1 CM-8718 Standalone Test

Location: Structure S-2; (39.9102492, -75.1579595) **IP Address:** 10.3.4.96

Camera Manufacturer: Bosch **Camera Model:** NDP-5512-Z30

Function	Pass:	Fail:	Comments:
Image	❑	❑	
Pan Right	❑	❑	
Pan Left	❑	❑	
Tilt Up	❑	❑	
Tilt Down	❑	❑	
Zoom In	❑	❑	
Zoom Wide	❑	❑	
Variable Speed	❑	❑	
Auto Focus	❑	❑	
Iris Override	❑	❑	
Preposition Pan	❑	❑	
Preposition Tilt	❑	❑	
Preposition Zoom	❑	❑	
Day/Night Shift	❑	❑	
Cabinet	❑	❑	
Heater & Fan	❑	❑	

Additional Comments: ____

____

Test Conducted By:______________________________Date: ____________________

Witness:____________________Witness:____________________Witness: ____________________