Sensys™ Wireless Vehicle Detection System

Installation Guidelines for Intersection Applications

P/N 152-240-001-014 Rev E
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Contents

Document Properties

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P/N 152-240-001-014 Rev E

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This device complies with part 15 of the FCC rules. Operation is subject to the following two conditions:

(1) This device may not cause harmful interference.

(2) This device must accept any interference received, including interference that may cause undesired operation.

Any changes or modifications to this product not authorized by Sensys Networks, Inc., could void the EMC compliance and negate the authority to operate the product.

RF Exposure Statement

This device has been tested and meets the FCC RF exposure guidelines. It should be installed and operated with a minimum distance of 20 cm between the radiator of RF energy and the body of users, operators or others.

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Warnings

No Safety Switching

Sensys Networks, Inc. does not allow its equipment to be used for safety applications such as controlling a mechanical gate or switching a train to avoid a collision.

Lithium Thionyl Chloride Batteries

Sensys Networks uses Lithium Thionyl Chloride batteries in the following products:

- Sensors (VSN240-F, VSN240-T, VSN240-S)
- Repeaters (RP240-B, and RP240-B-LL)

Lithium batteries are widely used in electronic products because they contain more energy per unit - weight than conventional batteries. However, the same properties that deliver high energy density also contribute to potential hazards if the batteries are damaged. Improper use or handling of the batteries may result in leakage or release of battery contents, explosion or fire.

Following are the recommendations of the battery manufacturer for proper use and handling of batteries in the Sensys devices mentioned above:

- **DO NOT** charge or attempt to recharge the batteries (batteries are NOT rechargeable)
- **DO NOT** crush or puncture batteries
- **DO NOT** short-circuit the batteries
- **DO NOT** force over-discharge of the batteries
- **DO NOT** incinerate or expose batteries to excessive heating
- **DO NOT** expose battery contents to water
- **DO** dispose of batteries and devices containing batteries in accordance with local regulations

> Sensys Networks sensors contain no serviceable parts and should never be disassembled. Installation and removal of sensors from pavement should only be done by trained personnel and care should be taken to insure that the sensor casing is not punctured or crushed.

Additional safety information is available from the battery's manufacturer:

- Sensor battery cell: http://www.able-battery.com/msds/ABLE_MSDS_ER14505.pdf
- Repeater battery cell: http://www.able-battery.com/msds/ABLE_MSDS_ER34615.pdf

Document Control

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CHAPTER 1
Introduction

This document discusses installing a Sensys™ Wireless Vehicle Detection System for use in common intersection applications.

It is primarily intended for installers, project estimators, and distributors. A working knowledge of the components of a Sensys network, the capabilities of each component, and how they work together to form a wireless vehicle detection solution is assumed.

What's Inside

This document includes the following chapters:

- Chapter One, *Introduction*, defines the purpose and scope of the document.
- Chapter Two, *Required Equipment*, reviews the components, tools, and supplies required to successfully install a Sensys network.
- Chapter Three, *Before the Installation*, describes activities that precede deployment work.
- Chapter Four, *Installation*, surveys the installation process. (Refer to the Sensys installation guides[1] for detailed step-by-step installation procedures.)
- Chapter Five, *Estimating Labor Requirements*, provides guidelines for forecasting the labor costs of a typical installation.

1 The documents are *Sensys Wireless Sensor Installation Guide*, *Sensys Access Point Installation Guide*, *Sensys Repeater Installation Guide*, and *Sensys Contact Closure Card Installation Guide.*

Other Documents

General and Reference Information

- *The Sensys Wireless Vehicle Detection System – System Overview*
- *Sensys Wireless Vehicle Detection System Reference Guide*

Freeway and Arterial Applications

- *Design Guidelines for Freeway & Arterial Applications*
- *Configuration Guidelines for Freeway & Arterial Applications*
- *Installation Guidelines for Freeway & Arterial Applications*

Intersection Applications

- *Design Guidelines for Intersection Applications*
- *Configuration Guidelines for Intersection Applications*
- *Installation Guidelines for Intersection Applications*

Installation and Maintenance Procedures

- *Sensys Wireless Sensor Installation Guide*
- *Sensys Access Point Installation Guide*
- *Sensys Repeater Installation Guide*
- *Sensys Contact Closure Card Installation Guide*
- *Sensys Wireless Sensor Removal Guide*
- *Tools Required for Installing Sensys Equipment*
- *Replacing Batteries in the RP240B Repeater*

Application Notes

- *Using Sensys Networks With Motorcycles*
- *Executing Commands on a Access Point with HTTP*

Sensys Management Server

- *SNAPS Professional 2.0 Set Up and Operating Guide*
- *Sensys System Manager Set Up and Operating Guide*

Readers of this document are encouraged to contact Sensys Networks, Inc. (www.sensysnetworks.com) for the latest information, design guides, and best practices.

Intersection Applications

The installation considerations discussed in this document assume a requirement to implement a Sensys Wireless Vehicle Detection network in conjunction with one of the following uses:

- Traffic signal control at an intersection
- Ramp metering

See the Sensys document *Installation Guidelines for Freeway & Arterial Applications* if your requirements involve freeway or arterial count stations.

Assumption Regarding Installation Teams

The installation procedures for Sensors differ markedly from the procedures required to install Access Points and Repeaters. While it is conceivable that a single installation team could handle both activities, in this document it is assumed that two discrete teams are used – a *Sensor team* that puts the wireless Sensors into the pavement and an *Access Point team* that hangs Access Points or Repeaters from utility, signal or sign poles available at the site.

Additionally, it is assumed that the Access Point team is responsible for installing Sensys Contact Closure cards into the traffic signal controller cabinet.

Configuration and field verification of the network is essential to long-term usefulness. In many cases, network components are pre-configured and field verification is performed by the Access Point team. This aspect is not directly addressed herein. See the Sensys document *Configuration Guidelines for Intersection Applications* for more information regarding configuration and verification of network performance.

CHAPTER 2
Required Equipment

This chapter reviews the equipment, accessories, tools, and supplies required to install a Sensys™ Wireless Vehicle Detection network for an intersection application.

Sensys Components

Sensys components consist of the following types:

- *Wireless Sensor*

  Sensors come in two sub-models: the **F model,** which supports operating modes for freeway/arterial uses and an array of operating modes suitable for traffic signal control, and the **T model,** which supports only traffic signal control.

  Typical intersection installations require between eight and 40 Sensors depending on the intersection geometry, number of lanes and the need for advance detection.

- *Access Point*

  A variety of models are available, differentiated by (*i*) the ability to host statistical processes on the Access Point, (*ii*) the presence of an on-board Ethernet interface, and (*iii*) the type of cellular data modem (GSM/GPRS or CDMA2ooo/1xRTT).

  A minimum of one Access Point, capable of interfacing to traffic signal controllers[2], is required per stop bar installation.

- *Repeater*

  Repeater models differ by the expected life of their batteries. Repeaters may or may not be required depending on the site layout and application.

2 Referred to as the "S" option, as in *AP240-S* or *AP240-ES*.

- *Contact Closure Card*

  Contact Closure cards interface a Sensys network to a traffic controller.

  There are two types of Contact Closure cards – the *Master* card (CC), which connects to an Access Point via a Sensys AccessBox, and *Expansion* (EX) cards, which provide additional controller channel capacity (if needed). One master card is required for each Access Point in a network. Up to 63 expansion cards may be used in a single network.

- *Sensys AccessBox*

  An AccessBox is positioned between an Access Point and Contact Closure Master card. It splits power, drawn from the controller by the Contact Closure card and supplied to the Access Point, and the detection/command data passed between the Access Point and the Contact Closure card array. It also provides a wired IP port for a field technician's laptop or enterprise IP network.

  One AccessBox is required for each Contact Closure Master card.

Sensys Accessories

The following accessories are required for installation. These parts are sold by Sensys Networks and are typically ordered and shipped with the Sensys equipment.

Access Point Accessories (one each per Access Point)

- *Mounting hardware kit*

  The kit includes a mounting bracket, double-socket arm, and universal clamp band.

- *Ethernet cable*

  Use CAT-5, CAT-5e, or CAT-6 outdoor-rated, shielded, solid core cable. Cut to length and terminate onsite with male RJ45 connectors suited to solid core cable.

Repeater Accessories (one per Repeater)

- *Mounting hardware kit*

  The kit includes a mounting bracket, double-socket arm, and universal clamp band.

Sensor Accessories (one per Sensor)

- *Two-piece molded plastic Sensor Shell*

- *One tube Fabrik Joint Seal (FJS) epoxy*

  This is a minimum; always includes several additional tubes as spares.

Contact Closure Card Accessories (one per Contact Closure Card)

- *Ethernet patch cable*

  Patch cables are used to connect the CC Master card to the Sensys AccessBox, and to daisy-chain EX Expansion cards to the Master. Use CAT-5 or CAT-5e cables of assorted lengths, typically between three and eight feet.

Tools, Supplies, and Equipment for Access Point Installers

Equip each Access Point installation team with the following:

- Bucket or ladder truck to install Access Points and Repeaters at a minimum of eight feet (2.4 meters) above the road surface
- RJ 45 crimp tool and cable stripper[3]
- Cordless 3/8" drill and grommets for drilling into traffic signal or light poles to route Ethernet cable (as needed)
- Fish tape or other wire pulling tools
- #10 AWG copper grounding wire, as needed to ground PoE injector
- Hand tools (1" wrench or crescent wrench, Phillips screwdriver, flathead screwdriver, shears or snips, Loctite, tape measure, electrical tape, shop cloth, etc.)

Tools, Supplies, and Equipment for Sensor Installers

Equip each Sensor installation team with the following:

- Dual component epoxy applicator[4]
- Core or hammer drill with 4-inch (10-cm) bit suited to the type of road surface

  Sensys Networks recommends a hammer drill with a carbide tip or a water-cooled core drill with a diamond tip. (See the section *Coring and Drilling Considerations* below for more information.)

3 Sensys recommends the EZ-RJPRO (P/N 100044) from Platinum Tools.

4 Available from Sensys Networks (P/N VSN240-EPX.)

- A portable wet/dry shop vacuum, or other means to quickly remove debris from each Sensor hole
- Standard work-zone and lane closure equipment (cones, variable message signs, etc.)

CHAPTER 3
Before the Installation

This chapter discusses activities that precede the deployment of the Sensys components.

General Preparation

Prepare for the installation by doing the following:

- Confirm that a complete system design – including a map of the intended locations for all components – is available.
- Inventory all components, accessories, and supplies. Ensure that adequate spares and extra consumables are available.
- Label all components such that their intended location and device ID is easy to see.
- Confirm the availability of detailed information about the traffic signal controller(s) involved in the project, including controller location, controller type, cabinet type, number of open input file slots, slot numbers of open slots, and cabinet door key(s).
- (*Recommended*) Simulate a network deployment in a lab to configure and test all components.

Sensors

Provide the Sensor installation team with training in regard to the procedures for coring and Sensor installation. Perform a "dummy" installation in an available surface similar to the target road to confirm task timing and technique. Be sure to kit each Sensors with a two-piece molded plastic shell.

> *Note*: Sensors ***must*** be installed at the nominal depth of 2¼" (6 cm). Doing otherwise voids the product license and warranty unless certified by Sensys Networks, Inc.

Coring and Drilling Considerations

Sensor holes can be created with either a core drill or hammer drill. When a core drill is used with a bit requiring water cooling[5], ensure the following items are available:

- Water in sufficient quantities to cool the drill
- Hand chisel or other tool to clear the hole
- Propane torch or other tool to dry the hole prior to application of the epoxy

Note: apply epoxy only to a hole that is completely dry. Moisture in any amount may impede the curing process and jeopardize the installation.

Additionally, ensure that adequate plans have been made to capture the slurry resulting from drilling into the road. Dispose of it in accordance with local environmental regulations.

When a hammer drill with carbide or other tip is used, be sure that the tip will last for the number of Sensors planned for installation. Keep a spare tip in reserve if possible.

Access Points and Repeaters

Review the Access Point and Repeater installation procedures with the team assigned to installing those components.

If the Access Point is specified to use an integrated cellular modem, ensure that an appropriate SIM chip is available or has been installed in the Access Point.

Installation Considerations

Occasionally, the poles available at a site are not suitable for installing Access Points or Repeaters. Be prepared to install mast extensions or new masts in order to meet minimum height and antenna orientation requirements.

In atypical situations, where existing infrastructure is locked down, regulated or not available, new poles, cable conduit, and trenching equipment may be required.

5 Such as the diamond tip bit available from Sensys Networks.

Contact Closure Cards

Review the Contact Closure card installation procedures with the team assigned to install them. Be sure to cover the use of Master (CC) cards, Expansion (EX) cards, and the Sensys AccessBox.

Installation Considerations

Controller Slots

A common issue when installing an intersection detection network is the availability of controller cabinet slots. It is obvious that open slots are required into which Contact Closure cards can be installed. However, beyond this, knowing the position (that is, the slot number) of the available slots is also essential. Remember that Contact Closure cards can be ordered in two-channel models that occupy a single slot, and four-channel models that occupy two adjacent slots.

Understanding the availability and positioning of the controller cabinet slots allows the predetermination of how many Contact Closure cards are needed, where the Cards will be installed, and the cabling plan to interconnect them.

Controller Type

Contact Closure cards support a variety of traffic controller types. Determine the controller type of each signal controller involved in the project and then set circuit-board switch SW1 on each Contact Closure card to the appropriate value.

By default, Sensys Contact Closure cards are configured for Type 170, Type 2070 (without status relays) and NEMA TS1 controllers. (Refer to the document *Sensys Contact Closure Card Installation Guide* for more information.)

Card Identifiers

Additionally, each Contact Closure Card must be assigned an internal identifier (known as the *Card ID*) used by the Access Point to communicate with the card. This identifier is also used by TrafficDOT to complete the card's configuration once it has been installed in the cabinet. Card IDs are manually set for Contact Closure cards via the circuit-board switches SW1 and Sw2.[6]

By convention, Card IDs are composed of concatenating the values of *shelf-number*, *slot-number*, and *channel*. For example, a value of "`02-14-01`" decodes to

- Cabinet shelf #2
- Slot #14

6 See the Sensys document *Sensys Contact Closure Card Installation Guide* for more information.

- Channel #1

With older controllers, the slot number is assigned arbitrarily by the installer. Newer controllers, however, may assign a slot number. Therefore, Contact Closure cards support a special purpose operating mode that queries the controller for an address. (Refer to the *X mode* section in the *Sensys Contact Closure Card Installation Guide* for more information about this feature.)

CHAPTER 4
Installation

This chapter surveys the installation procedures. (Refer to the documents *Sensys Wireless Sensor Installation Guide*, *Sensys Access Point Installation Guide*, *Sensys Repeater Installation Guide* and *Sensys Contact Closure Card Installation Guide* for detailed, step-by-step procedures.) Each Sensys component must be installed in the correct location to ensure proper vehicle detection and radio communications between the components.

Sensor Installation

Sensor installation begins with enclosing the Sensor in a 2-piece molded plastic shell. Place the Sensor into the shell bottom and snap the shell pieces together by pressing along the edges.

Sensor installation requires boring a 4-inch (10 cm) diameter hole approximately 2¼ inches (6 cm) deep in the road at the desired location. The objective is to bury the Sensor while leaving enough top clearance to avoid damage to the Sensor from passing vehicles. Optimal performance is attained by ensuring a minimum clearance of ¼"(0.6 cm) and a maximum clearance of ½" (1.3 cm) between the Sensor top and the road surface.

Note: Sensors must be installed at the nominal depth of 2¼" (6 cm). Doing otherwise voids the product license and warranty unless certified by Sensys Networks, Inc.

Figure 4.1 – Coring and Clearing a Sensor Hole

Ensure that the hole is dry and clear of all debris. Begin filling the hole – approximately one-quarter of the way to the top – with the fast drying epoxy. (Sensys Networks recommends the 2:1 ratio pack of Fabick Joint Seal [FJS], a two-component 100% solid silicone polyurea-based joint sealant, available from Sensys or directly from the manufacturer.)

Place the Sensor in the hole with the label face up and the arrow on the label aligned with the direction of traffic. Document the Sensor's ID number and the location.

Fill the hole, covering the Sensor and its label, with epoxy. In temperatures from 20°F to 180°F (6.6°C to 82.2°C), FJS epoxy cures in approximately five minutes. Because it dries so quickly, be sure to manage the work so that an open tube is used immediately.

Figure 4.2 – Epoxying Sensor Into Hole

Access Point and Repeater Installation

The basic installation guidelines for Access Points and Repeaters are the same. A few Repeater-specific notes are included at the end of this section.

Each device is mounted a minimum of eight feet (2.4 meters) above the road surface and oriented so that it faces the Sensors it services. Guidelines for the supported distance between an Access Point or Repeater and Sensors are given in the table below:

Height of Access Point or Repeater Relative to Road Surface	Maximum Recommended Range to Sensor
8 – 12 feet (2.4 – 3.7 meters)	75 – 100 feet (22.9 – 30.5 meters)
16 feet (4.9 meters)	100 – 125 feet (30.5 – 38.1 meters)
20 feet (6.1 meters) or more	125 – 175 feet (38.1 – 53.3 meters)

Table 1: Recommended Sensor Ranges by Access Point/Repeater Mounting Height

The actual range attained in the field is determined by site specific factors such as local terrain, mounting height, and antenna orientation. ***Always verify*** the wireless radio signal strength and link quality after an installation.[7]

Typically, an existing pole such as a traffic signal or light pole is used. Alternatively, a mast arm, retaining wall, overpass or other vertical surface may be used. The amount of setback from the roadway, the stability of the mounting point, the relative angle of the sun, and other considerations required by competing vehicle detection systems are not important.

Sensys recommends an unimpeded line-of-sight between an Access Pointer/Repeater and its Sensors, and between Access Points and Repeaters. Optimal radio performance is attained when the devices face each other, however up to a ±60° difference in both top-to-bottom and side-to-side antenna orientation (relative to the other device) is supported. Beyond this, the signal strength drops off rapidly.

Repeaters can be up to 1,000 feet (310 meters) from an Access Point, assuming ideal, face-to-face orientation. Alternatively, a Repeater can be installed on the same pole as an Access Point, separated by a few feet, but pointed in the opposite direction. In this configuration, the Access Point and Repeater can service a Sensor dispersion that includes Sensors in front of and behind the Access Point.

Because Repeaters are battery powered, ensure that they can be serviced easily to replace the battery pack.

Contact Closure Card Installation

Contact Closure cards are installed directly into the slots of the traffic controller input rack. In some situations – for example, when there are no open slots available or when the traffic controller does not accept interface cards of the form factor used by Sensys card – an auxiliary card cage can be used.

7 Refer to the Sensys document *Configuration Guidelines for Intersection Applications* for information and procedures.

Physically installing the cards is straight-forward. However, prior to installation, each card requires board-level configuration as follows:

- Set the Card ID using circuit-board switches SW1 and SW2
- Set the controller type using circuit-board switch SW1

Additionally, install the Sensys AccessBox in the vicinity of the Master (CC) card such that it can be easily cabled to the CC card, the Access Point, and a field service engineer's laptop.

Access Point Cabling and Power

Access Points receive power via a solid core, shielded CAT-5, CAT-5E, or CAT-6 Ethernet cable. The maximum run length of this cable is 328 feet (100 meters). The ideal Access Point location minimizes the cable length and any new conduit that must be installed to accommodate it.

Always thread the cable through conduit and the bulkhead connector of the Access Point before terminating it. Use the RJ45 crimp tool to wire the pins according to the TIA/EIA 568-B specification for standard, straight-through Ethernet connections.[8]

When used in an intersection application, an Access Point receives power through a Sensys AccessBox cabled to a Contact Closure (CC) Master card that draws power from the traffic signal controller backplane.

Representative cabling diagrams are provided below.[9]

Direct Access Model

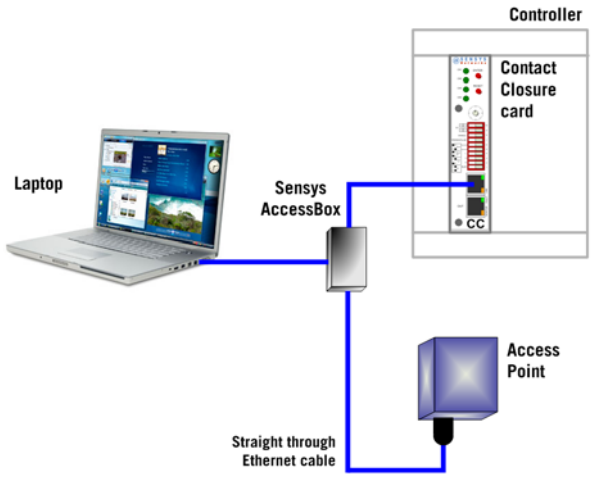


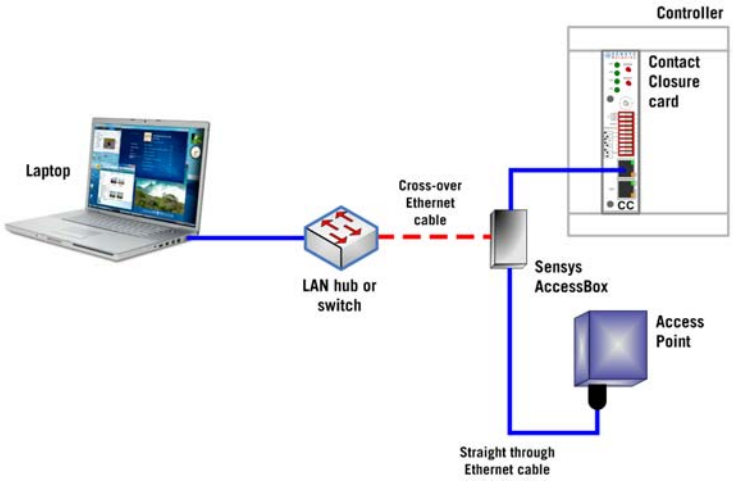
Figure 4.3 – Access Point to Contact Closure Master (CC) Card With Direct Access

8 Refer to the document *Sensys Access Point Installation Guide* for more detailed procedures including a pin-out diagram.

9 See also the document *Configuration Guidelines for Intersections* for more information.

The figure above depicts cabling an Access Point and Contact Closure Master (CC) card through the AccessBox. In the field, be sure to install the AccessBox *inside* the controller cabinet.

Access Through a Hub or Switch



A field service technician's laptop may optionally connect directly to the AccessBox using a straight-through Ethernet cable.Figure 4.4 - Access Point to Contact Closure Master (CC) Card With Switched Access

The figure above depicts an alternative cabling plan between an Access Point and Contact Closure Master (CC) card through the AccessBox. In the field, be sure to install the AccessBox *inside* the controller cabinet.

In this cabling plan, a local area network device (such as a hub or switch) connects to the AccessBox using a cross-over Ethernet cable. A laptop or other IP network connection can optionally be made to the hub/switch.

CHAPTER 5
Estimating Labor Requirements

This chapter provides guidelines for estimating the labor costs associated with installing a Sensys Wireless Vehicle Detection network.

General Notes

The labor units in this chapter are derived from the experience of Sensys Networks, Inc. and its key contractors and may not represent your environment. It is assumed that existing infrastructure is available and suitable for installation. Therefore, additional resources and costs related to installation of new mounting poles, conduit runs, solar panels, or any other equipment are not included.

Labor requirements are discussed in terms of (*i*) staffing requirements, (*ii*) vehicle requirements, and (*iii*) standard labor units.

Staffing Requirements

A typical installation is staffed with three teams:

- *Access Point and Contact Closure Card Installation Team*

  A team of two, with at least one individual a certified IMSA Level 2 traffic signal technician (or equivalent). Each team member should be able to operate a bucket/ladder truck and pull cable through conduit. One team member must be qualified to terminate an Ethernet cable using male RJ45 connectors.

- *Sensor Installation Team*

  A team of two, with each individual capable of operating a hammer or core drill and

installing Sensors as described in this document.

- *Traffic Control Team*

  A team of flagmen with traffic control equipment as dictated by standard, local practices.

Notes

1. Typically, a single Access Point team is sufficient even if Repeaters are included in the design. This team may benefit from waiting until after the Sensor team has started work.
2. For small intersections, the Sensor team may be able to take responsibility for traffic control and lane closure.
3. Large installations may benefit from rolling lane closures co-ordinated with the local law enforcement command and implemented by its officers.
4. Additional Sensor teams may be required in large installations with multiple Sensor locations.

Vehicle Requirements

A typical installation allocates the following vehicles:

- A bucket or ladder truck is assigned to the Access Point team
- A core or hammer drill truck is assigned to each Sensor team

Notes

1. Additional trucks may be required to implement traffic control and lane closures.
2. In large installations, efficiencies may be gained by mounting the drill on a truck so that it can be rapidly moved to the next Sensor location.

Labor Units

Use the labor units in the table below to compute the overall estimated labor effort.

Description of Operation	Estimated Time
Access Point Installation (includes mounting devices on poles, orienting them toward Sensors, running Ethernet cable to power source, threading cable through Access Point connector, terminating cable, connecting to power source, conducting a power-on self-test)	1 – 2 hours
Contact Closure Card Installation (includes physically configuring cards via dip switches SW1 and SW2, querying the controller for a slot address, and installing cards into the rack.)	8 – 15 minutes per card
Detection Network Configuration (includes running TrafficDOT software to configure the Sensors, Access Point, Contact Closure cards, and Repeaters [if used], verifying wireless radio performance metrics for an adequate duration, making field adjustments)	1 – 2.5 hours
Repeater Installation (includes mounting devices on poles, and orienting them toward Sensors and Access Point)	30 minutes
Sensor Installation (includes drilling setup, drilling a hole, cleaning out the hole, applying first epoxy layer, placing Sensor in hole, covering Sensor with epoxy, and an average drying time of five minutes per Sensor)	8 – 12 minutes per Sensor
Lane Closure (includes setup of a traffic configuration that meets local requirements for safety and is suited to the installation tasks)	45 – 60 minutes

Table 2: Estimated Time Requirements for Installation Activities

Example Labor Estimates

This section presents an example of calculating labor estimates for the installation of a vehicle detection network at a typical intersection as shown in the figure below.

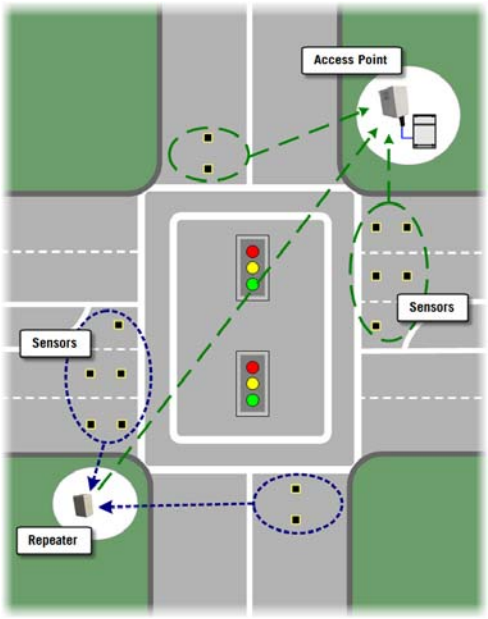


Figure 5.1 – Stop Bar Application

The installation consists of 14 Sensors, deployed in the through traffic and left-turn lanes. The Access Point services seven Sensors installed in the southbound and westbound lanes; a Repeater services seven Sensors installed in the northbound and eastbound lanes. It is assumed that each

lane requires one Contact Closure card.

Based on the estimates specified in the table above, the project labor[10] can be computed as follows:

Equipment Summary

- Number of Sensors: 14
- Number of Access Points: 1
- Number of Repeaters: 1
- Number of Contact Closure cards: 8
- Traffic lanes (including left-turn lanes): 8

Estimated Access Point/Repeater Installation Time

- 2½ hours

  Basis: (1 Access Point * 2 hours) + (1 Repeater * ½ hour)

Estimated Contact Closure Card Installation Time

- 2 hours

  Basis: (8 Contact Closure cards * 15 minutes)

Estimated Network Configuration Time

- 2½ hours

Estimated Time to Secure Work Zones

- 4 hours

  Basis: (8 lanes / 2 lanes closed at the same time) * 1 hour)

Estimated Sensor Installation Time

- 3 hours 12 minutes

  Basis: (16 Sensors * 12 minutes)

A sample work breakdown chart for the installation is shown below.

10 One Access Point team and one Sensor team are assumed; conservative values for labor units are used; all times are approximate.

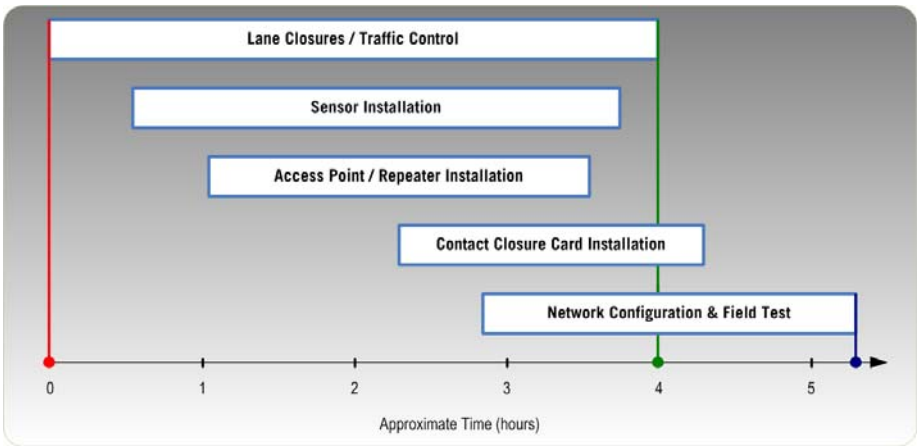


Figure 5.2 – Sample Work Plan for Example Installation

The calculations, team assignments, and work plan provided above are for purposes of illustration only. Use the examples as a basis for more detailed planning that takes into account the laws, best practices, and other particulars of your installation.