PIA INSTALLATION AND USER GUIDE: 2009 UPDATE

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ACKNOWLEDGMENTS

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1. INTRODUCTION

BACKGROUND

A significant number of TxDOT's signalized intersections operate under isolated control. At many of these signals, it is not uncommon for an approaching platoon of vehicles to face a red signal when it arrives at the stopbar. Often, these platoons are forced to stop because of a single vehicle on one of the side-street approaches. This condition results in driver aggravation, excessive stops, higher delay and fuel consumption, and excessive pavement wear and tear.

The objective of enhanced platoon identification and accommodation (PIA) system developed and field-tested by TTI in this research project is to remedy this situation without unnecessarily taxing traffic on minor approaches. This document describes the PIA system and presents guidelines for installing and operating this system.

SYSTEM APPLICATIONS

The PIA system is useful for signals that face the following traffic conditions during significant parts of a normal day:

- Platoons of vehicles arrive at one or both of the main-street approaches.
- There is light demand for movements being serviced by phases conflicting with the main-street phases.
- The traffic signal faces varying and unpredictable demand levels.

A candidate approach for providing priority treatment to platoons of through vehicles may belong to one of the following two categories:

- The signal approach receives traffic from an upstream signal, but it is not interconnected to the upstream signal to provide coordinated operation.
- There is no signal upstream of the signal approach, but platoons form naturally due to vehicles slowing down as they approach the intersection.

In Texas, signals meeting these criteria are generally located on highways near small towns or on suburban arterials.

HOW THE PIA SYSTEM WORKS

The PIA system consists of hardware and software that perform the following functions:

- uses advance sensors to detect individual vehicles and estimates their speeds, lengths, and projected arrival times at the stopbar;
- uses the above information to identify the presence of platoons approaching the intersection;

- monitors real-time status of signal phases and stopbar detectors and uses this information to collect real-time performance measures;
- uses real-time phase and detector-status information to estimate intersection performance measures;
- when permitted by user-specified constraints, overrides normal controller operation to progress identified platoons; and
- provides dilemma-zone protection to vehicles at the back end of the platoon.

PURPOSE OF THIS DOCUMENT

This document describes the PIA system and provides guidelines for installing, configuring, and operating the system. Its intended audience includes traffic signal engineers and technicians who wish to install and operate the system within their respective jurisdictions.
- Chapter 1 provides a brief description about the PIA system and its suggested applications.
- Chapter 2 provides detailed information about the system, including its architecture and various components, especially system hardware. This chapter also provides contact information for vendors and approximate prices of off-the-shelf hardware components.
- Chapter 3 describes how to install and configure software components needed for operating the PIA system. Information provided in the latter part of this chapter is also useful for fine-tuning of the system operation when needed.
- Appendices provide additional details.
    - Appendix A provides the recommended wiring map for system installation in a TS-1 cabinet located at a four-legged intersection with eight signal phases. This appendix also provides an example of site-specific customization.
    - Appendix B provides input-output mapping of communication using enhanced bus interface units (BIUs) in TS-2 cabinets.

2. SYSTEM ARCHITECTURE AND REQUIREMENTS

As mentioned in the previous section, the PIA system consists of software and hardware components that work together to provide platoon progression to vehicles on one or both main-street approaches of an intersection. This chapter describes the PIA system architecture and its components. Furthermore, it provides information about hardware and software requirements.

ARCHITECTURE OF THE PIA SYSTEM

The PIA system software is the brain of this real-time traffic control system.

Figure 1 provides an overview of the PIA system architecture from this perspective. This software   consists of four main modules:
- the Software Classifier (SC) module,
- the Platoon Detection (PD) module,
- the Platoon Scheduling and Progression (PSP) module, and
- the (TS-1 or TS-2) Controller Cabinet Interface (CCI) module.

The PIA system software runs on a field-hardened industrial personal computer (PC) that resides in the traffic controller cabinet or an auxiliary cabinet if the traffic controller cabinet does not have room to house additional equipment.   The following sections provide a brief description of each one of the PIA software modules.
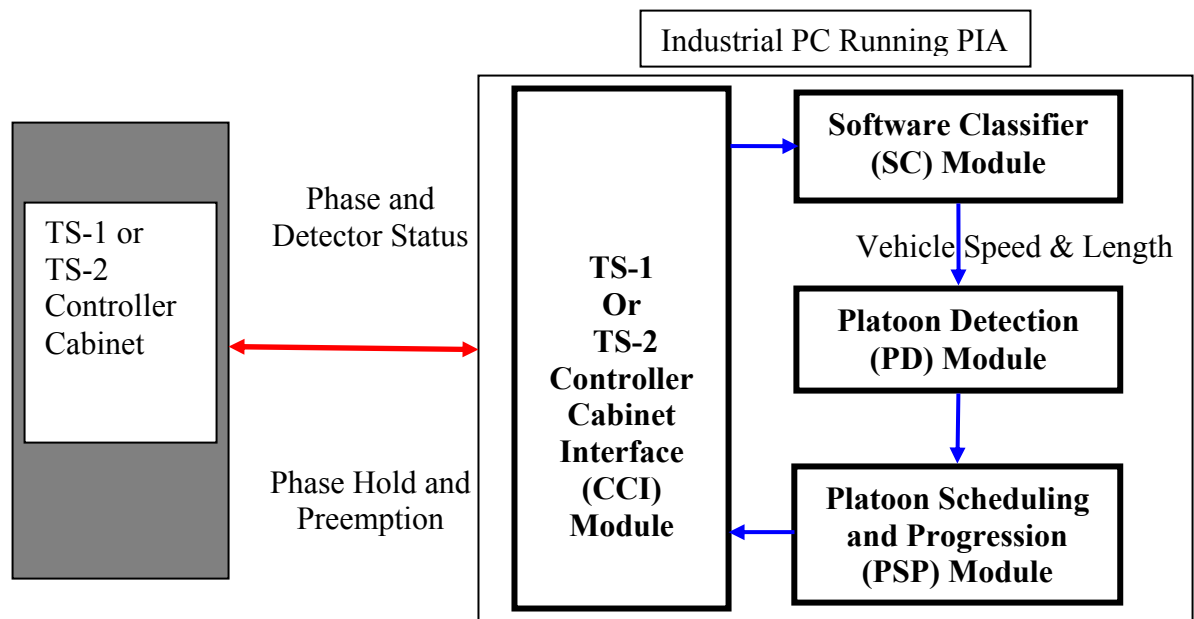
Figure 1. PIA System Architecture.

Software Classifier Module

The purpose of the SC module is to provide advance detection of individual vehicles on a per lane basis for one or both main-street approaches. For each vehicle, it obtains or calculates speed and length. Then, it passes this information to the PD module along with lane number of lane in which the vehicle was detected. The SC module requires the following components to be installed at each PIA site:

- one speed trap (inductive loops or video camera-based) per lane or a radar-based detection system capable of detecting individual vehicles and providing per-vehicle speed, length, and lane number information;
- appropriate detection unit(s) (loop amplifier or video processor) to provide contact closure information from the trap (both loops) or a serial message that contains the per-vehicle information required by the PIA system; and
- communication links between the trap detectors and detection unit(s) or radar sensor and the PIA system (hardwired or wireless).

The SC module receives individual actuations (contact closure information) from traditional advance detectors (i.e., inductive loop speed traps) through the CCI module and processes the actuations to calculate the speed and length of the detected vehicles upstream of the intersection. If the sensor provides detection information through serial messages, the SC module can decipher these messages and extract information required by the system. In the latter case, the SC module needs proprietary communications protocol specifications from the sensor manufacturer. Currently, this module supports communications protocol for Wavetronics® SmartSensor. However, it can be easily modified to accommodate other protocols.

Controller Cabinet Interface Module

The CCI module provides the interface between the PIA system and the traffic controller cabinet. The PIA system requires several inputs from the controller cabinet including green/yellow status of each signal phase at the intersection and on/off status of each stopbar detector at the intersection. The PIA system also sends appropriate signals to the controller cabinet any time it decides to activate preempts or holds to progress detected platoons on the main-street. The PIA system also receives data from advance sensors. These data consist of detector actuations if advance detection uses a pair of inductive loops (a trap) in each lane and detection messages if a smart sensor was used for advance detection.

The CCI subsystem consists of a software module and a number of hardware components depending on the type of controller cabinet (TS-1 or TS-2) used at the intersection.

TS-1 Cabinets

In TS-1 controller cabinets, the CCI subsystem requires the National Instruments Data Acquisition PCI-6527 digital input-output (NI-DAQ) card, which is installed in the industrial PC running the PIA software. The NI-DAQ card has 24 inputs and 24 outputs. The digital I/O inputs are used to obtain real-time status (green/yellow) of each active phase and the on/off status of each stopbar detector at the intersection. The input channels are also used to get contact-closure signals from advance detection in cases where detection is provided using inductive loop detectors or video vehicle detection system. The PIA system installation at a standard eight-phase intersection requires two NI-DAQ cards. However, depending on the number of phases, number of stopbar detectors, and the number of advance detection traps, the PIA system may need only one NI-DAQ card. The PIA system uses a maximum of five output channels on the NI-DAQ card (up to two holds and three preempts) to override normal controller operation to progress detected platoons. The red status of signal phases is deduced from the green and yellow contact closure signals that are received from the back panel. If an enabled phase is not green or yellow, then its status is assumed to be red.

In TS-1 cabinets the CCI module checks the status of the phases and stopbar detectors every 15-20 milliseconds. The CCI module uses the contact closure information it gets through the NI-DAQ card to determine the status of each phase (green/yellow/red) and stopbar detector status (on/off) and makes the information available to the rest of the PIA system software modules. The CCI module also checks the status of each detector in the advance detector traps and passes the information to the SC module that calculates speed and length of each detected vehicle once it clears the trailing detector of a trap. In this configuration, timer relays can be used to provide fail-safe operation. When installed, such a timer relay terminates a hold or preempt signal passing through it any time it continues beyond a user-specified maximum time.

TS-2 Cabinets

There are two options for installing the PIA system in TS-2 cabinets.
- Option 1 is similar to the one described in the previous subsection and requires the installation of a TS-2 to TS-1 conversion panel. This option requires NI-DAQ card(s) to obtain phase and detector status information via contact closure connections.
- Option 2 uses enhanced BIUs that provide the PIA system with an RS-232 serial interface to obtain information it needs from the traffic controller cabinet. In this option, information is sent and received from the controller cabinet via messages through the RS-232 serial interface provided by the enhanced BIUs. However, it requires replacement of the existing BIUs with up to five enhanced BIUs (BIUs 1, 2, 3, 4, and the detector BIU 9). In case the existing BIU rack in the cabinet has only two slots (for BIUs 1 and 2), an additional auxiliary BIU rack will be needed to install BIUs 3 and 4.

Figure 2 provides an illustration of an enhanced BIU. Notice the additional RS-232 serial port on the front.

The CCI module communicates with the controller through the enhanced BIUs via serial messages every 100 milliseconds. The CCI module deciphers the serial messages to determine the status of phases and detectors. This module also sends any controller override commands through such messages. The phase status information is retrieved from BIU 1, the stopbar detector status is retrieved from BIU 9 (detector BIU), the phase hold commands are sent to the controller through BIU 3, and the preempt activations are sent through BIU 2. BIU 4 is needed in cases where the phase check input is required for phases instead of the stopbar detector status.

Figure 2. TS-2 Cabinet Enhanced BIU.

The user does not need to know any additional details about BIUs for installing and operating the PIA system. However, such detailed information can be obtained from Tables 5-5 through 5-12 (pages 9-17) in Section 5 of NEMA Standard Publication TS-2, 1997.

Platoon Detection Module

The PD module receives per-vehicle speed, length, and lane identification information from the advance detector through the SC module. The module uses this information to calculate projected arrival times of vehicles at the stopbar. In the absence of a detected platoon at the subject approach, the module evaluates projected arrival times of groups of consecutive vehicles against two user-specified parameters. The parameters are: the least number (n) of vehicles in an acceptable platoon, and the cumulative headway between the

first and the *n*th vehicles in any group of *n* consecutive vehicles. Once a platoon is detected on an approach, the PD module creates a platoon progression schedule for that approach and switches to a platoon extension mode. In platoon extension mode, the PD module uses two additional parameters (namely: average headway threshold and extension threshold) specified by the user to determine if newly detected vehicles at advance sensors are part of the currently detected platoon, either being progressed or scheduled to be progressed. Figure 26 in the next chapter illustrates the user-specified criteria used by the PD module.

Platoon Scheduling and Progression Module

The PSP module uses real-time phase status, stopbar detector status, and platoon detection information for each main-street phase to make platoon progression decisions. Depending on different cases, PSP uses combinations of phase holds and high-priority preempts to progress platoons. We recommend preempts 4 and 5 for individually controlling phases 2 and 6, and preempt 3 when both main-street phases (2 and 6) need to be controlled simultaneously. The following list identifies different cases assuming that preempt 4 activates phase 2 only, preempt 5 activates phase 6 only, and preempt 3 activates both phases 2 and 6:

- If a platoon is to be progressed on phase 2 (6) only, and this phase is red, PSP activates preempt 4 (5). Once phase 2 (6) changes to green, PSP places a hold on this phase and drops the preempt.
- If a platoon is to be progressed on phase 2 (6) only, and this phase is green, PSP places a hold on this phase.
- If platoon progression is needed on both phases and both phases are green, PSP places holds on both phases.
- If platoon progression is needed on both main-street phases and at least one main-street phase is red, PSP activates preempt 3. Once both main-street phases are green, PSP places preempts with holds on both phases.

Note that the user has flexibility to specify which preempts call which phases. For instance, the software allows 4 and 8 to be the main-street phases. The only requirement is the common preempt that activates both main-street phases be a lower number than the individual preempts.

HARDWARE AND SOFTWARE REQUIREMENTS

This section provides information about hardware and software components needed to install the PIA system at an intersection. An additional cabinet may be required if the existing cabinet does not have sufficient room to install system components.

Industrial PC

An industrial PC is needed to run the PIA software and any additional software needed for monitoring and maintaining the system from a remote location.

Advance Detection

Advance detection may use any technology that can provide accurate lane-by-lane detection of vehicles to directly or indirectly obtain per-vehicle detection time, speed, length, and lane number where a vehicle is detected. In addition, detector-to-cabinet connections can be hardwired or wireless. Depending on the detection technology used (loops, video, or a smart sensor), the following additional items may be needed:
- loop detector amplifiers,
- video detection unit, or
- a smart sensor message interpreter.

NI-DAQ Card(s)

One or two NI-DAQ cards, each with 24 input and 24 output channels, are used to access the phase and detector status contact-closure connections on the controller cabinet's back panel and receive actuations from the advance detector traps in case a TS-1 cabinet is used at the intersection or a TS-2 cabinet with a TS-2 conversion panel.

Timer Relays

Timer relays are recommended to provide a fail-safe operation. The purpose of a timer relay is to terminate a controller override (preemption or hold) signal going through that relay, if the signal continues beyond a user-specified maximum limit. The timer relay provides protection against any possibility of a PIA system malfunction before normally terminating its override signal. Such a situation may occur due to power failure or unknown bugs in the software. The timer relays can be used only in TS-1 cabinets or TS-2 cabinets with a TS-2 breakout panel. They cannot be used in TS-2 cabinets with enhanced BIUs.

TS-2 Conversion Panel

A TS-2 conversion panel is used in a TS-2 cabinet only when approach one (described above) is implemented. An additional auxiliary BIU rack is also needed to enable BIUs 3 and 4. The breakout panel is connected to BIUs 3 and 4 to communicate the status of the A, B, and C bits from both rings in the controller, the phase on status, and stopbar detector status to the PIA system. The conversion panel is also used to deliver hold output activations from the PIA system to the controller. Another possible solution for TS-2 cabinets is to replace the standard BIUs with enhanced BIUs and add an additional BIU rack to enable BIUs 3 and 4 without the need to install a TS-2 conversion panel in the cabinet and NI-DAQ card(s) in the industrial PC.

Connector Panel

The connector panel is a resistor input interface circuit for the NI-DAQ card(s). The interface circuit consists of a double layer terminal strip with 24 individual terminals. A

bus connecting all 24 bottom level terminals supplies all 24 16 kilo-ohm resistors with 24 volt direct current (VDC). The supply to the bus is fused by a 0.2 amp fuse to protect the output of the traffic signal controller. The current flowing through each resistor is approximately 1 milli-ampere (mA) when the output from the traffic signal controller is "active low" on a particular output. Each input of the NI-DAQ card requires 1mA for its optical isolator's light-emitting diode (LED) to work reliably. The current from the 24 VDC supply flows through the fuse, through the resistor into the NI-DAQ card's optical isolator, and into the output of the traffic signal controller. Current sinks into the output only when the output of the traffic signal controller is active low.

PIA Software

The PIA software developed by TTI runs on the industrial PC described earlier. It communicates with the traffic controller cabinet to obtain needed information to detect the existence of platoons and to override the normal controller operation to progress the detected platoon of vehicles.

The PIA software works with either TS-1 or TS-2 traffic controller cabinets. In TS-1 cabinets the PIA system utilizes NI-DAQ card(s) to acquire the inputs it needs from the cabinet. The National Instruments' "NI-DAQ Software for Windows/NT/XP/9x" version 6.9.2 needs to be installed on the industrial PC where the PIA system resides and runs before the PIA system is run for the first time.

SPECIFICATIONS OF THE PIA SYSTEM COMPONENTS

Advance Detection

Advance detection is required for each arterial approach for which platoon progression is desired. The system requires speed, length, and the lane number where the vehicle was detected upstream of the stopbar to detect platoons arriving on main-street approaches. The current PIA system design uses an inductive loop detector (ILD) based speed-trap (a pair of detectors) in each main-street approach lane to obtain these data. However, other sensor technology (i.e., a video imaging or a radar-based system) may be used as long as it has the ability to provide accurate vehicle-by-vehicle information. The following subsections describe the advance detection requirements of PIA, especially traditional ILD speed traps that are currently used in PIA installations.

ILD Speed Traps

In the present PIA system design, the two ILD detectors forming the speed trap in a lane are called the A detector advance (ADA) and B detector advance (BDA) detectors. ADA is the leading detector, and BDA is the trailing detector of the speed trap. Both detectors operate in the presence mode of detection. Both ILD detectors shall be 6-ft × 6-ft inductive loop detectors, and each loop installed on the approach *must* have an independent home run (lead-in wire) back to the cabinet. For a single-lane approach, two advance detectors and two lead-in wires will be installed. For a two-lane approach, four advance detectors and four lead-in wires will be installed. Figure 3 illustrates the

configuration of the pair of loops in each lane where ADA and BDA are the names of the two loops.
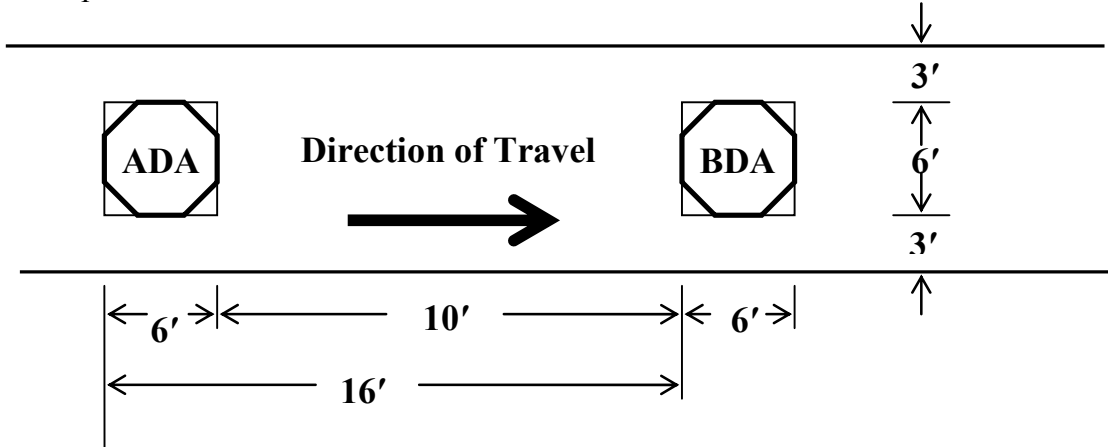

Figure 3. Standard ILD-Based Speed Trap Configuration.

Two advance detectors per main-street approach lane are added to existing signal control systems to calculate the speed, length, and arrival time of each and every vehicle to the stopbar. The distance between the trailing edge of ADA and the leading edge of BDA should be at least 10 ft. If the distance between the trailing edge of ADA detector and leading edge of the BDA detector is increased to 24 ft, the advance detector trap can also be used to estimate (classify) the type of vehicle into car or truck categories.

The design, location, and construction of the advance speed-trap detectors are critical to the successful operation of PIA. Legacy ILD designs are currently recommended for PIA applications based on field experience with their operational measurement precision, dependability, and technology requirements. Wire line communication is also recommended due to its dependability, although wireless technology has been successfully used by TTI researchers in similar projects.

Location of Advance Detection

The advance detector should be placed such that the trailing edge (illustrated in Figure 4) of the second detector meets the following criteria:

- For an approach with operating speeds of more than 40 mph, the detector should be placed approximately 1000 ft from the stopbar.
- For an approach with operating speeds of 40 mph or lower, the detector should be placed 600 to 700 ft from the stopbar.
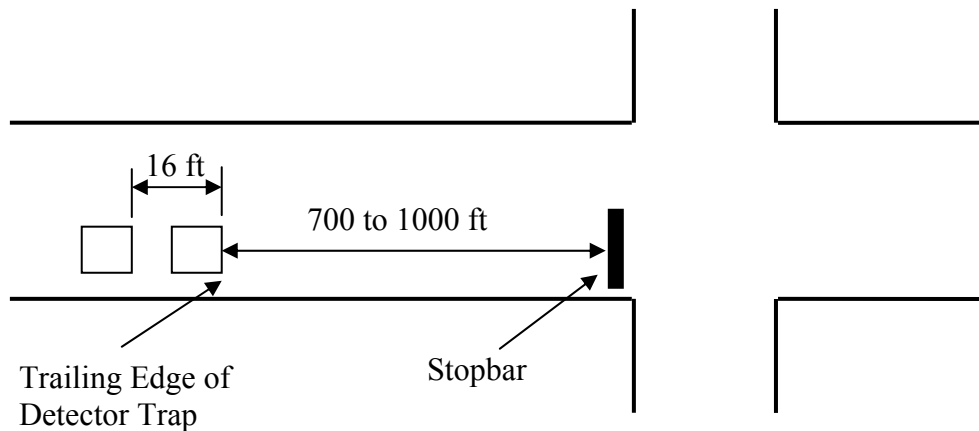
16 ft

700 to 1000 ft

Trailing Edge of
Detector Trap

Stopbar

Figure 4. Placement of Detector Trap.

Video Imaging Vehicle Detection Systems

In an earlier TxDOT project, TTI researchers evaluated the use of two Iteris systems for advance detection at a PIA installation in George West, Texas. This evaluation of these video imaging vehicle detection systems (VIVDS) revealed that inductive loops were more reliable and more accurate than these systems for detecting speeds of individual vehicles. Because of this finding, researchers recommend ILDs for advance detection; however, in case video-based detection is selected, the system should be installed using the guidelines provided here.

Video-based speed detection can be of the following two types:
- using two detectors as shown in Figure 5 (i.e., Iteris Intersection Model), or
- using one detector to emulate a trap (i.e., Iteris Freeway Model).

In either one of the above cases, one camera can be used to provide detection in one or two lanes of an approach. Project 0-4304 recommended that the camera be installed on the near side at angles as shown in Figure 5. These angles ensure that the top plus side of each vehicle is captured as it approaches the camera. This type of camera placement results in better detection of trucks.
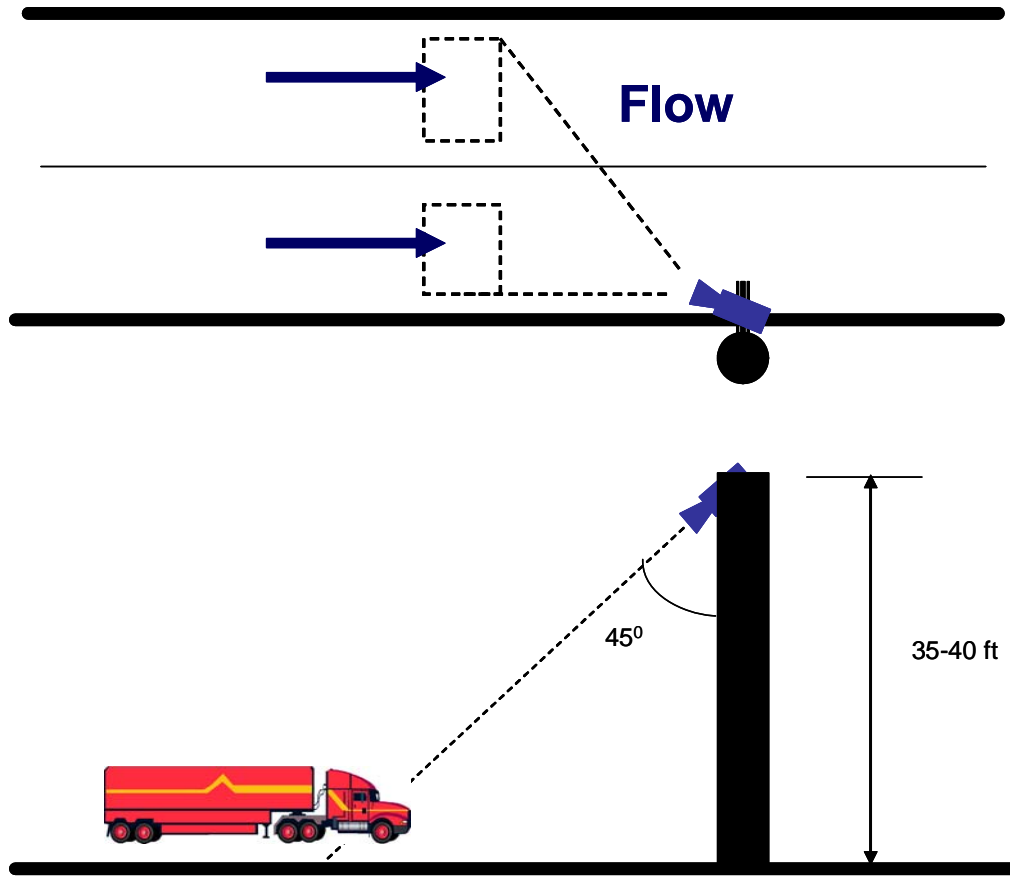
Figure 5. Camera Installation Guidelines.

In addition, for systems that emulate a trap using a single detector, the detector should be placed on a section of roadway over which the vehicles are moving at a constant speed because accelerating or decelerating vehicles may introduce errors in speed measurement.

Other Sensors

Other types of sensors that can satisfy PIA requirements for per-vehicle speed, length, and lane number information in an accurate manner have emerged on the market in the last couple of years. Of these, Wavetronix High Definition (HD) radar sensor installed in a side-fire mode is the best choice because it is accurate and the easiest to install and configure. As opposed to traditional sensors, which provide vehicle detections via contact closure signals, the HD provides per vehicle information (speed, length, and lane information) in an ASCII message over an RS-232 serial connection. Communication with the sensor can be established either through a serial cable from the sensor to the cabinet or through a radio transmitter at the sensor location and a receiver at the cabinet. TTI researchers had previously used Encom radios to communicate with an HD sensor installed at the George Bush Drive and FM 2818 intersection in College Station. In this implementation project, researchers modified the existing SC module in PIA to receive and process messages from HD, while retaining the previous capability of the software to receive and process contact closure information to derive vehicle speeds and lengths.

Industrial PC and Cabinet

An industrial PC is currently used to operate the PIA system. The industrial PC used is manufactured by Kontron America and includes an Intel 850 MHz single-board computer, 40 gigabyte hard disk, and two NI-DAQ cards with 24 inputs and 24 outputs each. The industrial PC requires Microsoft Windows 2000 for PIA installation in TS-1 cabinets because this is the only version of Microsoft Windows operating system that guarantees the required refresh rate of 15 to 20 milliseconds. However, Windows XP can be used in TS-2 cabinet installations. This is because the refresh rate of 100 milliseconds permitted by an enhanced BIU is significantly slower than the fastest refresh rate guaranteed by Windows XP. The NI-DAQ card(s) are used to monitor the actuations of the advance speed-trap detectors. These cards are also used to monitor the:
- green and yellow status of the intersection phases,
- status of stopbar detectors, and
- send hold and preempt signals to the controller through contact closure connections on the signal cabinet's back panel.

The large hard disk is necessary to store event data in log files. The PIA software provides options to save several different types of data for offline processing. Such processing can be used to evaluate system performance.

The cabinet should have enough space to install the digital input/output connector blocks or enhanced BIUs, the advance detectors, and the industrial PC. The cabinet should have a loop input panel to monitor all the intersection detectors. These detectors include the stopbar detectors as well as the dilemma zone detectors. In some cases, the stopbar detectors may consist of video detectors. Provision should be made for providing access to the actuations even from these video detectors. It may be desirable to have a large detector rack with all the slots enabled. This setup would call for the use of rack-mounted amplifiers for advance detectors instead of shelf-mounted amplifiers. This setup saves space and maintenance becomes easier.

Enhanced BIUs

The enhanced BIUs are used in TS-2 cabinet installations to enable the PIA system to monitor the phase green, yellow, and red status, stopbar detector status, and advance detector actuations in case ILD speed traps were used. The enhanced BIU has an extra RS-232 serial port (Figure 2) on the front that the PIA system uses to monitor the controller inputs it needs and send outputs to the controller. The enhanced BIU sends a status message via the serial port every 100 milliseconds. In TS-2 cabinets, BIU 1 is replaced with an enhanced BIU, the detector BIU is replaced with an enhanced BIU, an auxiliary BIU rack is installed to house BIUs 3 and 4 that are usually not present in standard traffic signal installations, and two enhanced BIUs are installed in the auxiliary BIU rack for BIUs 3 and 4. The phase hold and preempt signals can be sent through the enhanced BIUs. However, for fail-safety reasons, users might still want to send the phase hold and preempt signals using the NI-DAQ card(s) with timer relays monitoring the signal being sent by the PIA system to the traffic controller.

NI-DAQ Card Terminals

The NI-DAQ card(s) mentioned above is used in TS-1 cabinet installations of PIA. The card consists of six ports. The ports are numbered 0, 1, 2, 3, 4, and 5. Ports 0, 1, and 2 are input ports, and ports 3, 4, and 5 are output ports. Each port consists of eight channels. The card provides a total of 24 input and 24 output channels. The 24 input channels are used to get the actuations of the advance detectors, intersection detectors, and phase green and yellow status from the cabinet's back panel. Five output channels send a signal to hold the two main-street phases and the three preempts to terminate minor phases. Detailed assignment of the channels for all six ports is illustrated in Appendix A. Depending on the number of phases available at the intersection and number of lanes per each main-street approach, two NI-DAQ cards might be needed by PIA to monitor all the inputs.

A bus connecting all 24 bottom-level terminals supplies all 24 16 kilo-ohm resistors with 24 VDC. The supply to the bus is fused by a 0.2 amp fuse to protect the output of the traffic signal controller. The current flowing through each resistor is approximately 1 mA when the output from the traffic signal controller is active low on a particular output. Each input of the NI-DAQ card requires 1 mA for the NI-DAQ card's optical isolator's LED to work reliably. The path the current flows is from the 24 VDC supply through the fuse, through the resistor and into the NI-DAQ card's optical isolator, and then out of the NI-DAQ card and into the output of the traffic signal controller. Current sinks into the output only when the output of the traffic signal controller is active low.

Loop Amplifier Specifications

TTI researchers have used and have recommended the use of Reno Model S series two-channel loop amplifiers. If a large fully wired detector rack is available, rack-mounted amplifiers should be used. Otherwise, shelf-mounted amplifiers should be used with two cable harnesses per unit.

Timer Relay for Phase Holds and Preempts

Five electronic timer relays (IDEC GT3D-4AD24) are used to monitor the two main-street phase holds and the three preempt signals from PIA in case of a malfunction in the system. The timer relay is set to mode 3C on the operation mode selector and 70 seconds of delay on the time setting digital switch. In this mode, the relay starts counting down when a phase hold or preempt signal is applied. The phase hold or preempt signal passes through closed contacts in the timer relay. If the phase hold or preempt signal continues longer than 70 seconds, the timer relay times down from 70 seconds to zero and opens the contacts, dropping the phase hold or preempt. If the phase hold or preempt signal does not last for more than 70 seconds, then nothing happens. The relay resets back to 70 seconds whenever PIA drops the phase hold or preempt signal. There are two timer relays that work independently for each phase hold and three timer relays for the 3 preempts that could be used by PIA. The PIA Belton installation uses only two preempt signals. Figure 6 illustrates the layout of the timer relay for phase holds.
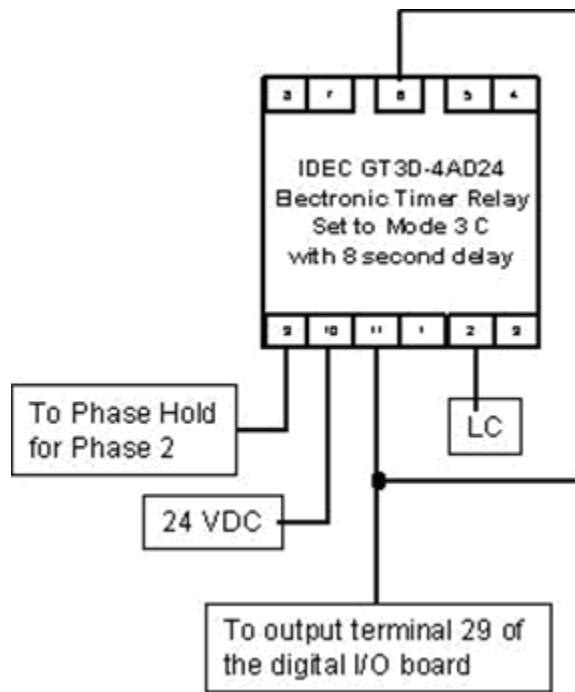
Figure 6. Timer Relay for Phase Hold.

3. PIA SOFTWARE INSTALLATION AND CONFIGURATION

PIA SOFTWARE INSTALLATION

The PIA software version 2.1 requires the National Instruments "NI-DAQ Software for Windows/NT/XP/9x" version 6.9.2 to be installed on the machine where the PIA system will be running for PIA to work properly. The order of installation is not important as long as the NI-DAQ software is installed on the industrial PC where PIA will be running before starting the PIA software. Otherwise, the PIA software will display an error message. The following sections and steps explain how to install the PIA software version 2.1 and the NI-DAQ software.

Installing the NI-DAQ Software

To install the National Instruments "NI-DAQ Software for Windows/NT/XP/9x" version 6.9.2, insert the NI-DAQ software CD provided with the PIA installation CD into the CD-ROM drive and follow the installation directions provided with the NI-DAQ installer once it finishes initialization as shown in Figure 7. The NI-DAQ software installer takes a few minutes to initialize. Please wait until the "Next" button becomes enabled as shown in Figure 8 and then click the "Next" button to proceed to the next step.

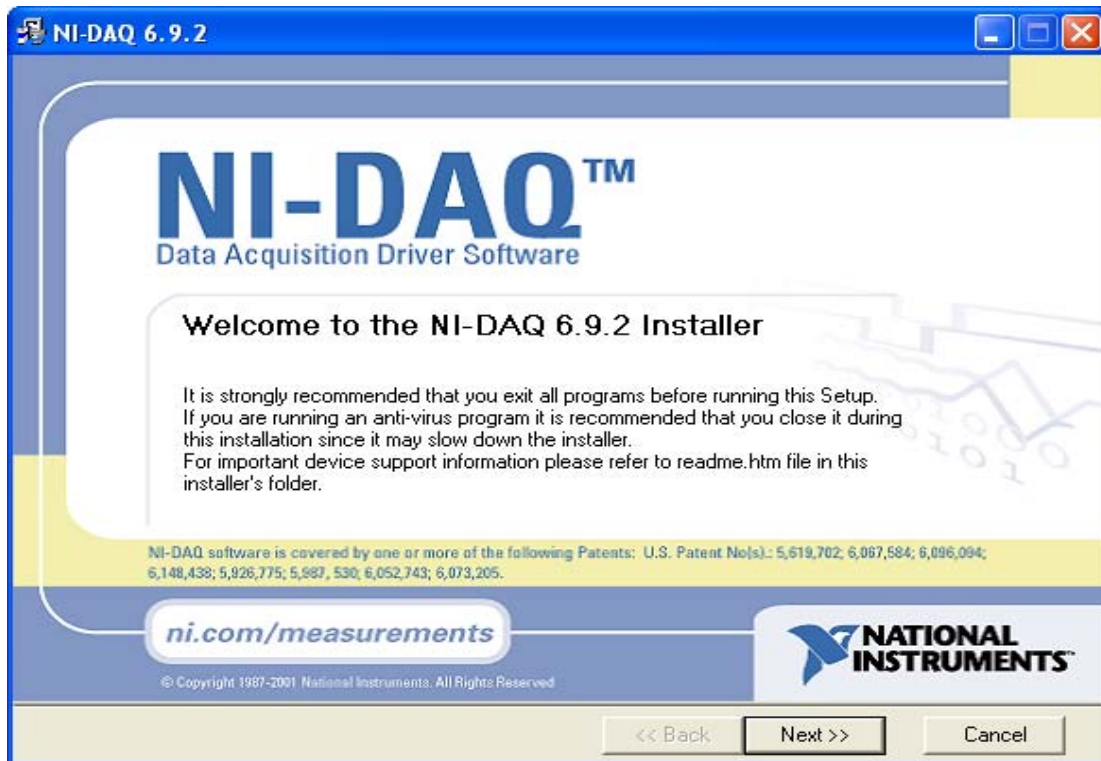**Figure 7. NI-DAQ Software Installer Initialization Screen.**

Figure 8. NI-DAQ Installation Welcome Screen.

Accept the National Instruments Software License Agreement illustrated in Figure 9 by selecting the "I accept the License Agreement" option button and then click the "Next" button.
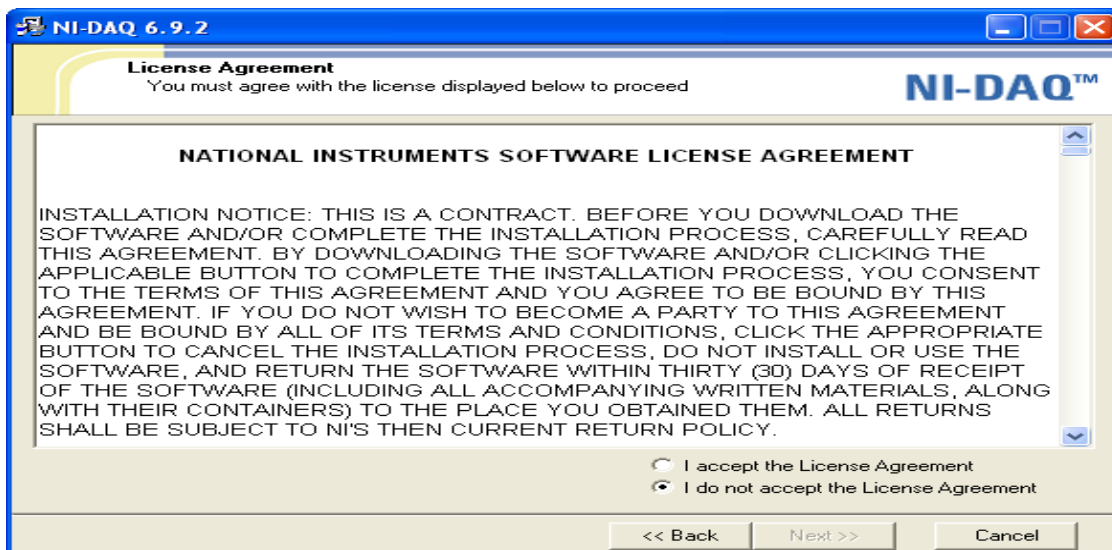

Figure 9. NI-DAQ Software License Agreement Screen.

The NI-DAQ software "Feature Tree" that enables the user to select the features he wants to install will be displayed next. Again click on the "Next" button as shown in Figure 10 without changing any of the selected features to continue the installation process.
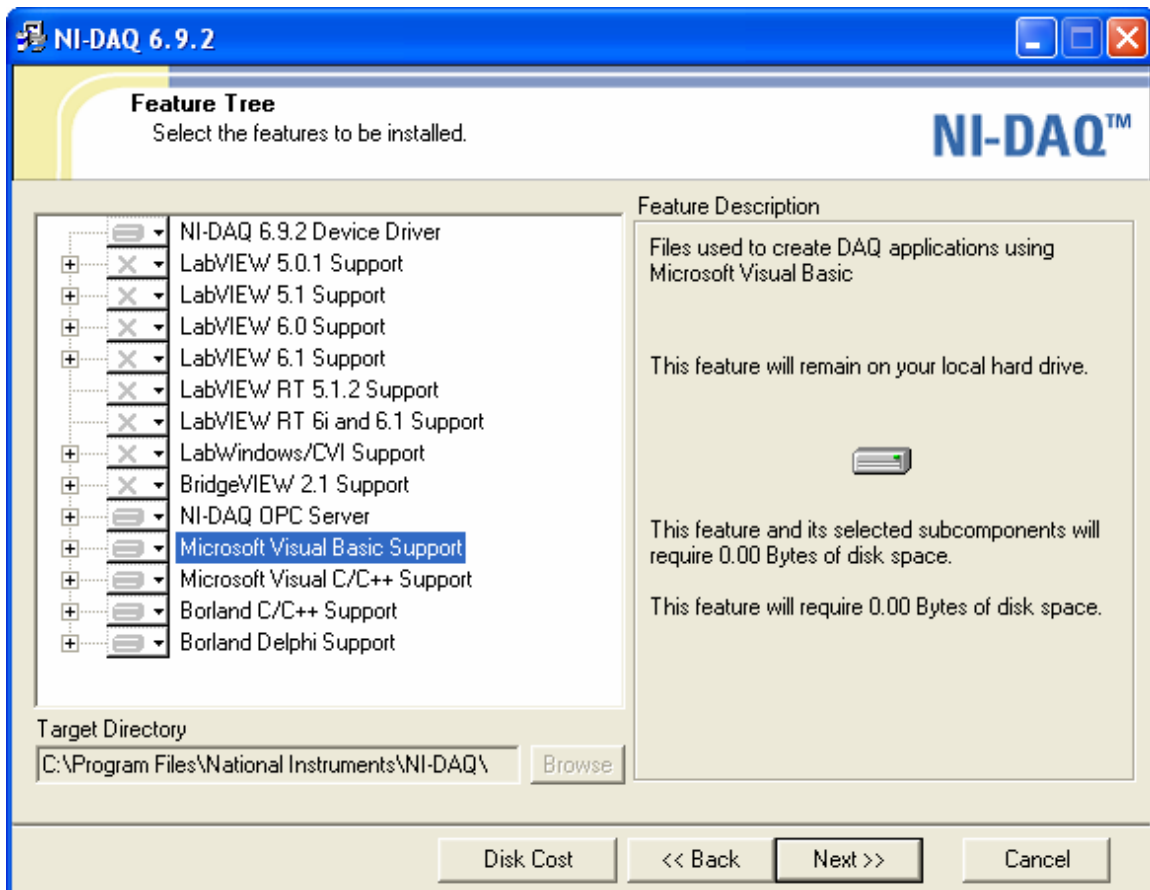

Figure 10. NI-DAQ Software Installation Feature Tree Screen.

A new screen will be displayed showing the options that were selected for installation if any changes were made to the standard set of features. Click the "Next" button again, and the NI-DAQ software will start installing the selected features on the machine. Once the NI-DAQ software finishes installation, it requires the machine to be shut down and the NI-DAQ card(s) be installed in the machine before rebooting the machine. When, the machine is started again, the NI-DAQ software will complete the software installation process and detect the NI-DAQ card(s). To verify that the NI-DAQ card(s) was detected properly, double click on the "Measurement & Automation" icon that was placed by the NI-DAQ software on the industrial PC's desktop. Click "OK" on the "User Preferences" screen that is displayed to enable the "Measurement & Automation Explorer" screen shown in Figure 11. In the "Measurement & Automation Explorer" screen, double click on the "Devices and Interfaces" option under the "Configuration" tab and a list of the card(s) that were detected by the NI-DAQ software will be displayed under the "Devices and Interfaces" option. Once, the NI-DAQ card(s) are installed and detected, this

completes the NI-DAQ software installation. The PIA software is ready to start if already installed on the machine.
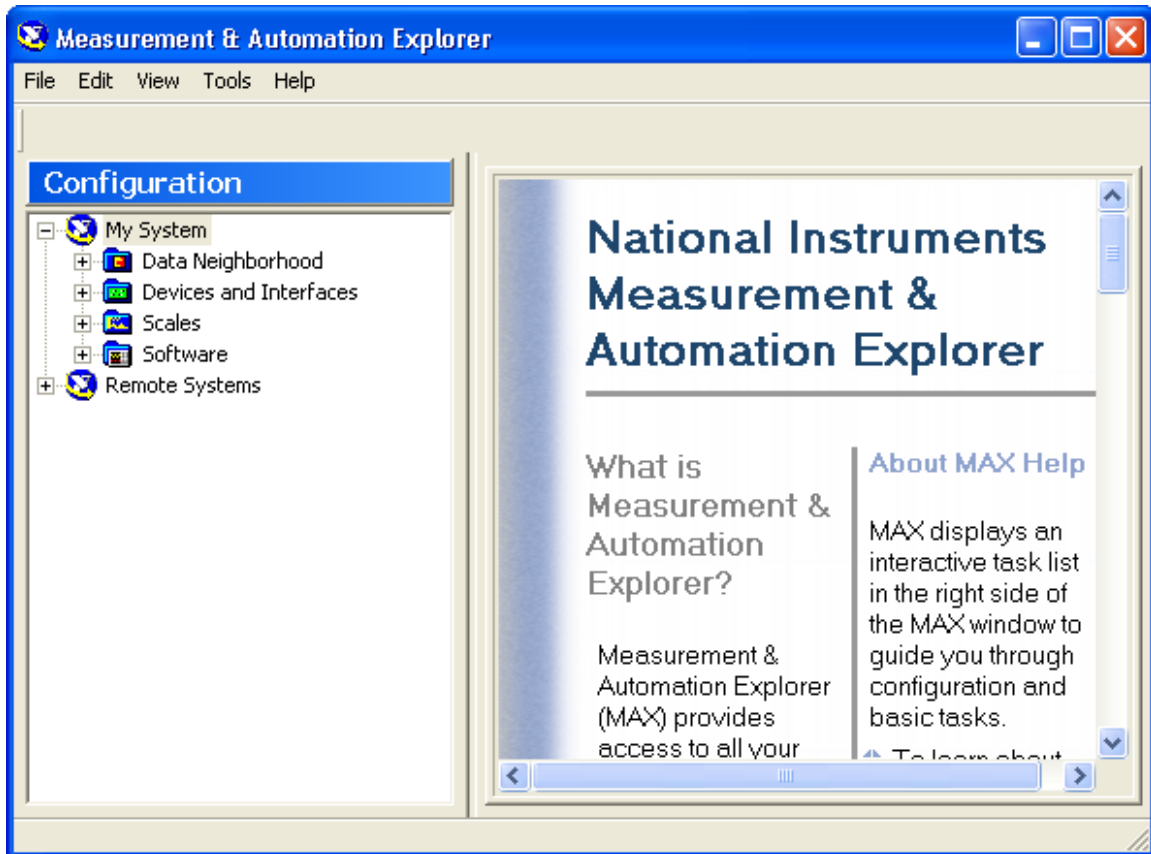

Figure 11. NI-DAQ Measurement and Automation Explorer.

Installing the PIA Software

The PIA software version 2.0 installation includes two steps:
- PIA software installation, and
- PIA software configuration.

The following sections explain the steps for installing and configuring the PIA system.

To proceed with the PIA software installation, insert the PIA software installation CD into the CD-ROM drive. The Install Shield Wizard will initialize the installation process and the installation welcome screen (Figure 12) will be displayed. Click the "Next" button to proceed with the PIA software installation process.

On the next screen (Figure 13) optionally enter the "User Name" and the "Organization" information and click the "Next" button to proceed.
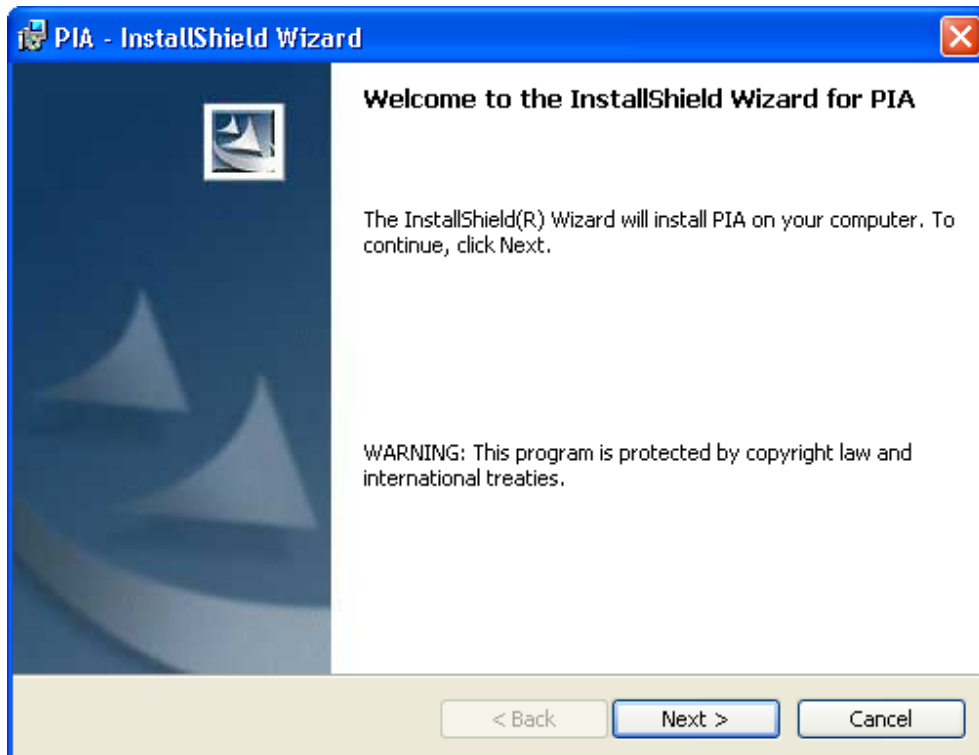
Figure 12. Install Shield Wizard for PIA Installation Welcome Screen.
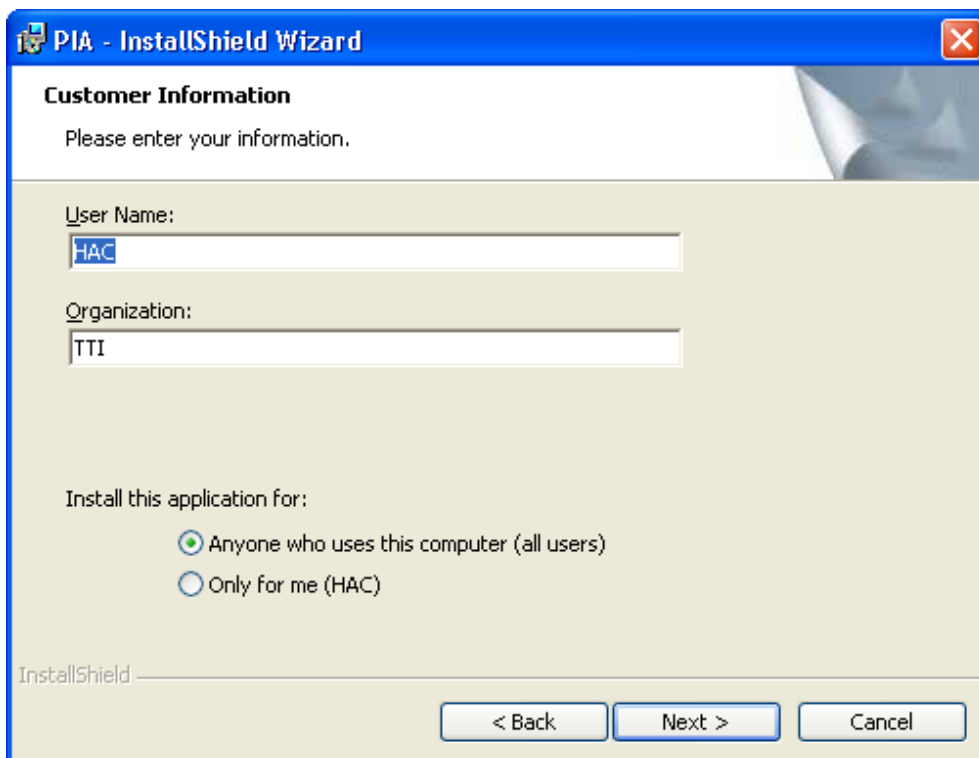
Figure 13. User Name and Organization Data Entry Screen.

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On the following screen (Figure 14), click "Next" to proceed with installation of the software in the default directory.
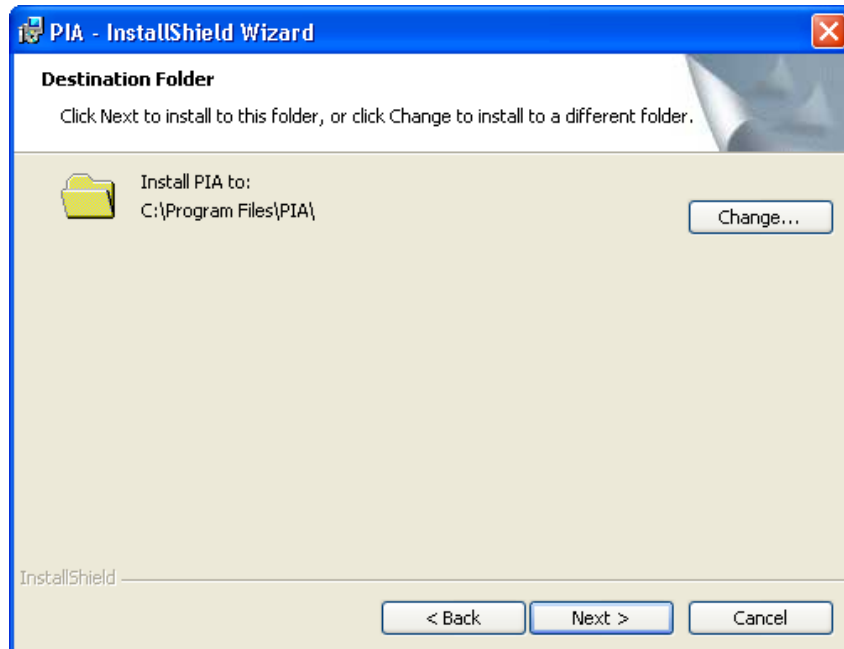

Figure 14. PIA Software Default Installation Directory Screen.

The next screen (Figure 15) displays a summary of installation options selected. Click the "Next" button to proceed with the installation.
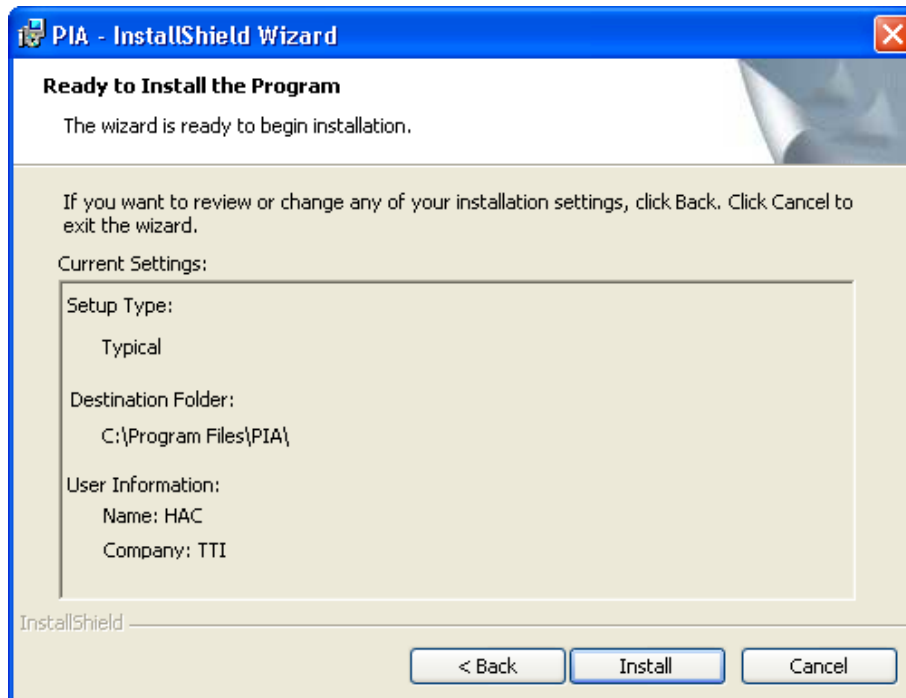

Figure 15. PIA Software Installation Summary Screen.

Once the PIA software finishes installation, a screen will be displayed that informs the user that the installation is finished. Click the "Finished" button to complete the PIA software installation process.

To verify the PIA software installation, double click on the PIA icon on the desktop. If the program installation is successful, the main window of the PIA software (Figure 16) will be displayed along with two other screens (not illustrated here).
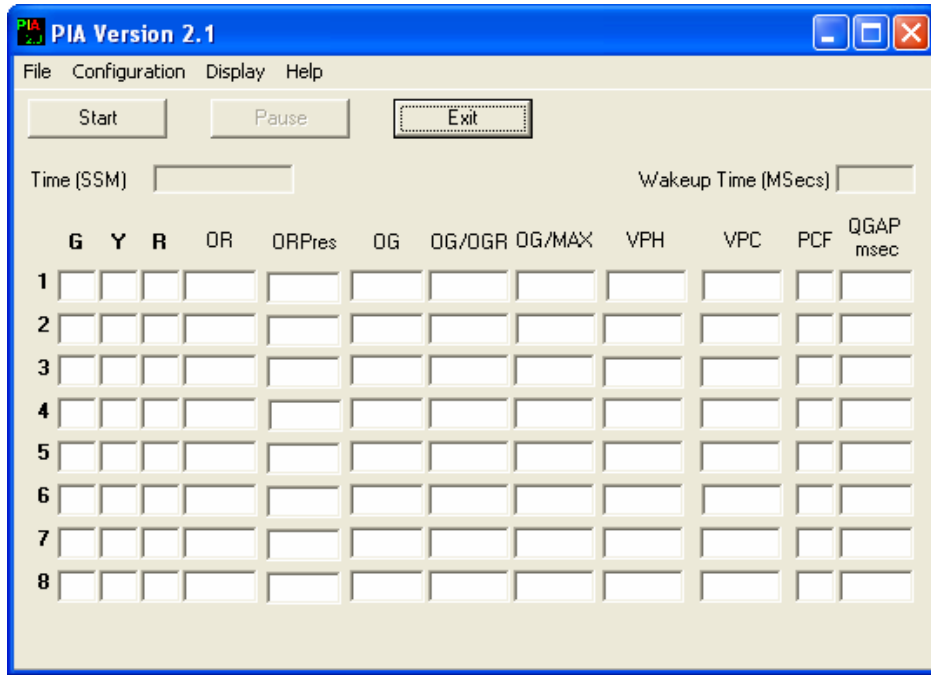
Figure 16. Main Screen of PIA Software.

The top portion of this window has four menu options. Below these options, there are three buttons: Start, Pause (disabled in Figure 16 illustration), and Exit. When the program is running, the Start button converts to a Stop button and the Pause button becomes enabled. The data field labeled "Time (SSM)" displays the industrial PC's system time in seconds since midnight. The remaining part of this window is for displaying real-time measures of effectiveness (MOEs) obtained/calculated by the program. The next section provides more detailed information about this window.

PIA SOFTWARE CONFIGURATION

This step includes information about the customization of PIA software configuration for the local site by entering appropriate data into various data entry and configuration screens. The PIA software has four drop down menus:
- File,
- Configuration,
- Display, and
- Help.

The first three items provide the user access to all data entry screens. The third item allows the user to select which status/output screens to display. The following sections provide detailed information about these screens.

File Menu

As illustrated in Figure 17, the File menu has two items.
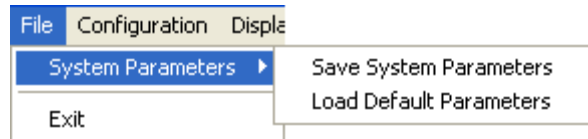
Figure 17. Options in File Menu.

System Parameters

This option has a submenu that contains two items described below.

Save System Parameters
Selecting this option saves any changes made to the PIA configuration into a file named PIA.XML. As implied by the name extension, the contents of this configuration file are saved in extensible markup language (XML). Any time the user makes changes to the PIA system configuration; this option must be used to save the changes. Otherwise, all changes are lost when the program is stopped.

Load Default Parameters
This option allows the user to load default parameters. Because most sites will have some unique characteristics, most users will never use this option.

Exit

Selecting this option terminates the program.

Configuration Menu

The configuration menu includes several items shown in Figure 18.

Figure 18. Configuration Menu.

Auto Start

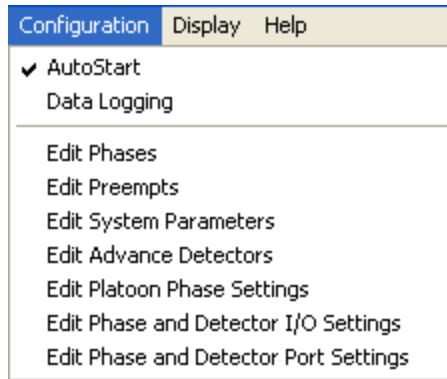Selecting this option enables the PIA system software to start automatically as soon as the program is started. Otherwise, the user will need to click the "Start" button from the PIA system's main window. This option must be selected when the system is running in the field so that the PIA system will start automatically any time the industrial PC is rebooted manually or due to power failure. The check-mark before the "Auto Start" option in the menu indicates that the auto start option is enabled. This option can be enabled or disabled by repeatedly clicking on the option.

Data Logging

As illustrated in Figure 19, selecting this option opens a new window, which provides for logging of different event-based (raw) and derived data while the PIA system is running in the field during real-time operation. The user can request the program to log data under various categories by checking the appropriate box. The logging options provided by the PIA system are described below.
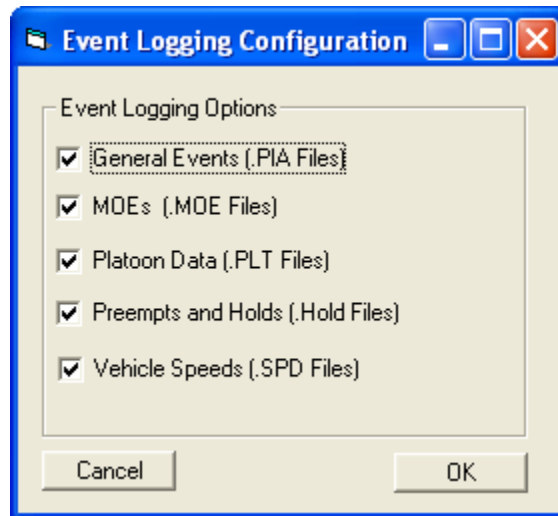

Figure 19. **Event Logging Options Screen**.

General Events (.PIA Files)

Selecting this option creates a daily log file, with a ".PIA" extension. This file contains all events that are monitored or generated by the PIA system during its operation. These events include:
- advance detector actuations,
- stopbar detector actuations,
- traffic signal events,
- platoon detection events,
- controller override (preemption and/or phase hold) events, and
- platoon progression events.

All logged events include the event time (hour, minute, second, and millisecond).

MOEs (.MOE Files)

Checking this option enables the program to log into a daily file all real-time MOEs calculated by the PIA system program. These MOEs include:
- occupancy during green and red for each phase and
- per cycle and hourly estimates of vehicles served during each green phase.

Platoon Data (.PLT Files)

The .PLT file logs all the events, decisions, and calculations made by the PIA system in detecting, progressing, extending, and ending platoons on main-street approaches.

Preempts and Holds (.Hold Files)

The .Hold file logs all the phase hold and preempt activation and ending decisions made by the PIA system.

Vehicle Speeds (.SPD Files)

The .SPD file logs all the per-vehicle information that the PIA system calculates for every vehicle detected by the upstream detector traps on main-street approaches. Data logged include vehicle speed, vehicle length, and lane number where the vehicle was detected.

Edit Phases

Selecting this option opens a new window labeled "Phase Settings" (Figure 20) where the user can enter the phase information required by the PIA system. Some of this information is critical for the performance of the PIA system. The critical information includes:
- "Min Grn" (i.e., phase minimum green) in seconds,
- "Max1" in seconds,

- "Max Delay" (i.e., maximum delay allowed before accommodating detector call on a non-priority phase) in seconds,
- "Min Delay" (i.e., minimum delay allowed before accommodating non priority phases) in seconds, and
- "Delay Incr" (i.e., delay increment/decrement value used by the PIA system to select the actual real-time value of delay in accommodating calls.

Other critical information includes selection of priority phases (by checking under "Platoon Phase"). The rest of the information on this screen is optional. Optional information is presently not needed for correct program operation. However, these optional data will impact MOE estimates. The "Sat Flow Rate" (i.e., saturation flow rate for a phase) is entered in vehicles per hour and used in estimating the demand per hour and per cycle MOEs. The "Queue Gap" is in milliseconds. It specifies the length of the gap that needs to be detected on a stopbar detector after a phase turns green before considering the queue on that phase has cleared.

The user must specify at least one phase as a platoon phase; otherwise an error message will be displayed if the user clicks on the "Update Phase Settings" button before doing that. Checking the check box that corresponds to a phase in the "Ph Chk Display" or the "Ph On Display" rows would enable the display of the stopbar detector status and the status of the phase (green, yellow, and red) that the check box corresponds to on the "Intersection" display screen. Once the user finishes entering the required information in the "Phase Settings" window, the "Update Phase Settings" button must be clicked to save the entered information into system memory. However, this memory will only last as long as the program is running. If the user wants the system to remember the entered information for future runs, the "System Parameters/Save System Parameters" option under the "File" menu must be used to save these data into the PIA.XML configuration file.

Figure 20. Phase Settings Screen

Edit Preempts

This option (Figure 21) provides data entry fields where the user specifies the digital I/O channel settings for each preempt used by the PIA system to provide progression to identified platoons. The PIA system requires three preempts for a traditional intersection

with eight phases. However, depending on the number of phases available at an intersection (like in a T intersection) and the number of platoon phases specified (1 or 2), it might need configuration of only one or two preempts. To update a preempt setting, first select the preempt number from the "Select Preempt" drop down combo box in the "Preempt I/O Settings" frame. Then, click on the I/O channel it is connected to in the "I/O Channels" option group. Finally, click on the "Update Preempt" button to save the information temporarily into the PIA system memory. The drop down combo boxes in the "Platoon Phase Preempt Selection" frame enables the user to map preempts to corresponding platoon phases. The "Common Preempt" is used to bring both platoon phases at an intersection to green, in case they were both red. The common preempt should have a higher priority than preempts used for individual directions. Preempts 1 and 2 should always be left for the rail and/or fire preemption applications. Again, if the user wants the PIA system to remember the entered information for future runs after it is stopped, the "System Parameters/Save System Parameters" option from the "File" menu must be used.
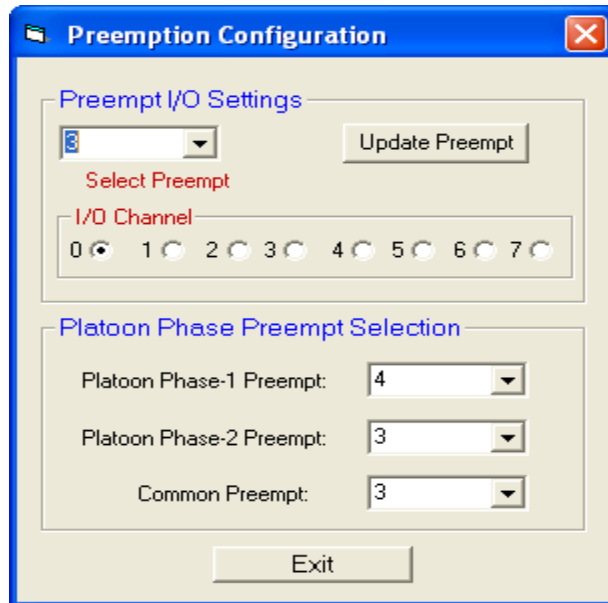
Figure 21. Preemption Configuration Screen.

Edit System Parameters

This option provides the user with a new window called "System Parameters" (Figure 22) that enables entry or editing of general data elements that are particular to a PIA system installation site. These data elements include optional information (such as city name and location) and information used to determine the type of system operation. Fields labeled DZP and AWEG are for future use. This screen allows the user to specify type of advance detection. The illustration in Figure 22 shows Wavetronix HD Sensor as the selected sensor type. Loop is the other option for this field. This latter selection applies to all sensors that provide detection information via contact closure signals. The following subsections provide further information about key data items.
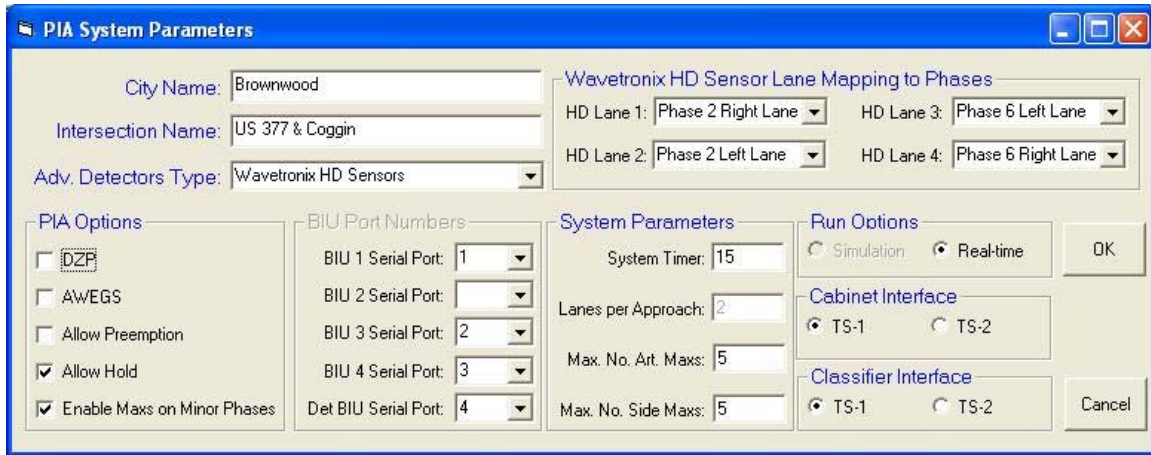
Figure 22. System Parameters Screen.

Allow Preemption

Selection of this option allows the program to use signal preemption to progress a detected platoon in cases when the priority approach has a red phase. Note that the user specifies the maximum duration of a preemption signal issued by the PIA software.

Allow Hold

This option enables the PIA system to use phase holds to progress detected platoons. This option can work by itself or in conjunction with "Allow Preemption." In the first case, the phase hold function is to prevent a priority green phase from terminating in the presence of a detected platoon. In the second case, the program applies phase hold immediately after preemption signal has forced the subject phase to turn green.

Enable Maxs on Minor Phases

Selection of this option permits the program to activate a feature that eliminates delay in taking action on detector calls when a minor phase maxes out in a row for a user-specified number of maximum times. The user specifies this constraint by entering desired data for "Max No. Art. Maxs" and "Max No. Side Maxs." In the labels, "Art" refers to left turn phases on the arterial, and "Side" refers to side-street phases.

Wavetronix HD Sensor Lane Mapping to Phases

These fields, applicable only for advance detection using HD sensor, allow the user to specify mappings of lane detections to phases.

BIU Port Numbers

These data, only applicable when a TS-2 interface is selected, specify the BIU number from which specific data are to be obtained.

Cabinet and Classifier Interface Selections

Cabinet interface selection specifies how the PIA system will communicate with the controller cabinet in the field. Communications with TS-1 and TS-2 cabinets are via back panel and BIUs, respectively. Classifier interface data specify the communication mechanism for obtaining data from advance detectors. Select TS-1 if contact closure data are received from the detectors and TS-2 if detector feeds are received through detector BIU.

Edit Advance Detectors

This option provides access to a series of windows that enable the user to enter the information required by the PIA system about the advanced detectors and any dilemma zone detectors. The detectors are organized by the main-street phase they belong to. Figure 23 illustrates the first window named "Advance Detector Selection." This screen enables the user to select a main-street phase and then one of the detectors for that phase. To enter data, first select a phase (phase 2 in the illustration) from the drop down list and then click on the desired detector. Detectors are identified by buttons in the middle section of this screen. The illustration in Figure 23 shows five detectors (one pair of advance detector per lane for this two-lane approach and a dilemma zone detector for the phase).
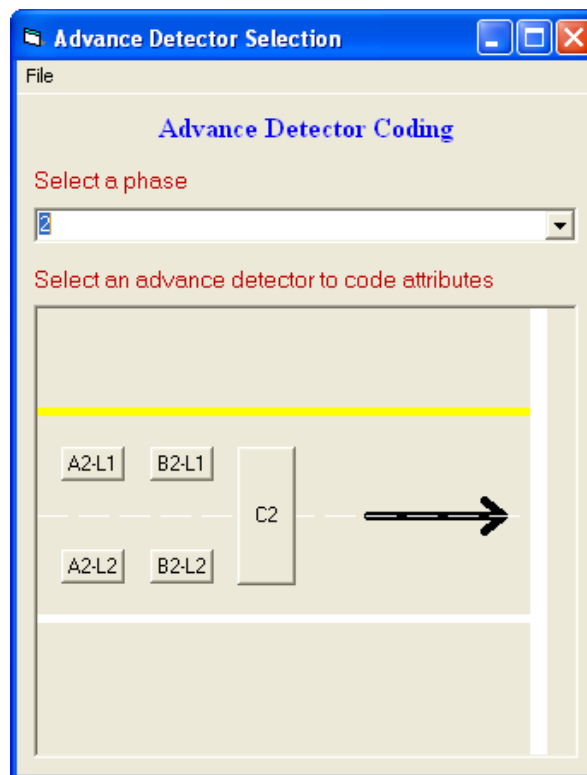
Figure 23. Advance Detector Selection Screen.

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In the detector labels, L1 and L2 refer to Lane 1 (inside lane) and Lane 2 (the curb lane) while A and B (followed by phase number) refer to ADA and BDA detectors described in the previous chapter. Clicking on any one of these buttons will take the user to the screen illustrated in Figure 24. This screen is used to specify detector size, the distance from the leading edge of the detector to the stopbar, and the distance from the leading edge of this detector to the leading edge of the first dilemma zone detector downstream (but farthest from the stopbar). In the case of the Wavetronix HD sensor, detector width and length data are not needed. In the case of a TS-1 cabinet installation, the user must also specify the digital input channel the advance detector actuation is feeding into through the digital I/O connector block.
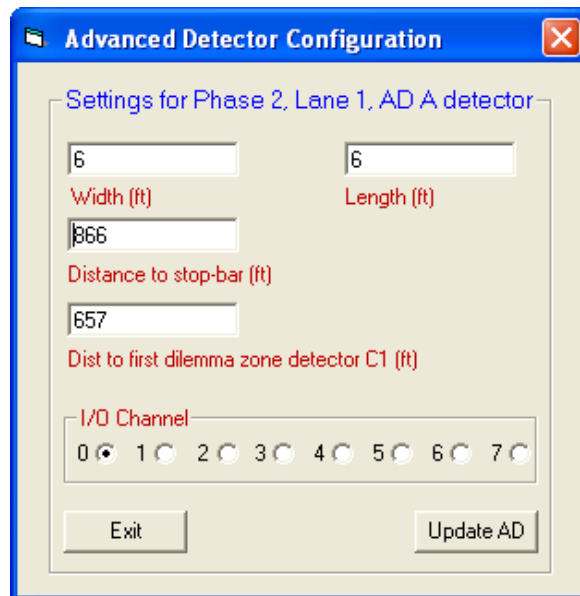
Figure 24. Advance Detector ADA/BDA Configuration Screen.

Figure 25 illustrates the data elements for a dilemma zone detector (identified as C2 for phase 2 in Figure 23) when present. These data refer to the dilemma zone detector farthest from the stopbar. Like advance detectors, the size and digital I/O information is also needed for these detectors.

Edit Platoon Phase Settings

Figure 26 illustrates the screen used to provide data by which the program detects platoons. The field labeled "Select Platoon Phase" is used to select the subject main-street priority phase. After making any changes, click update to save the changes to memory. Keep in mind that any changes will become permanent only after saving the data to the configuration file. An earlier section described this process. The following subsections describe the data items on this screen. With the exception noted below, all data are in seconds.
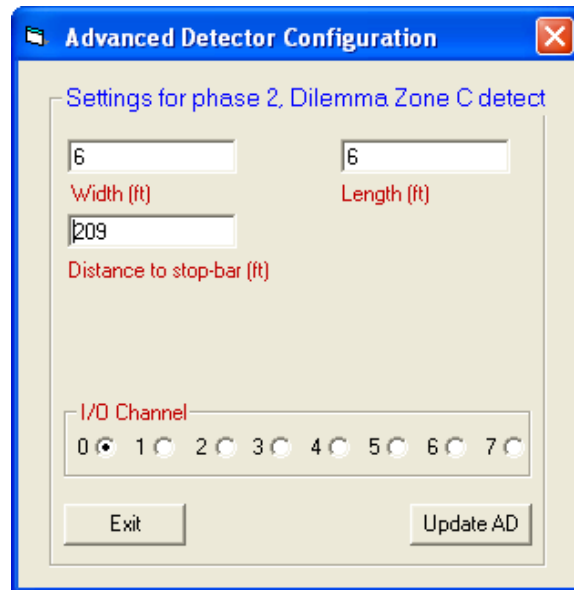
Figure 25. Dilemma Zone Detector Configuration Screen.
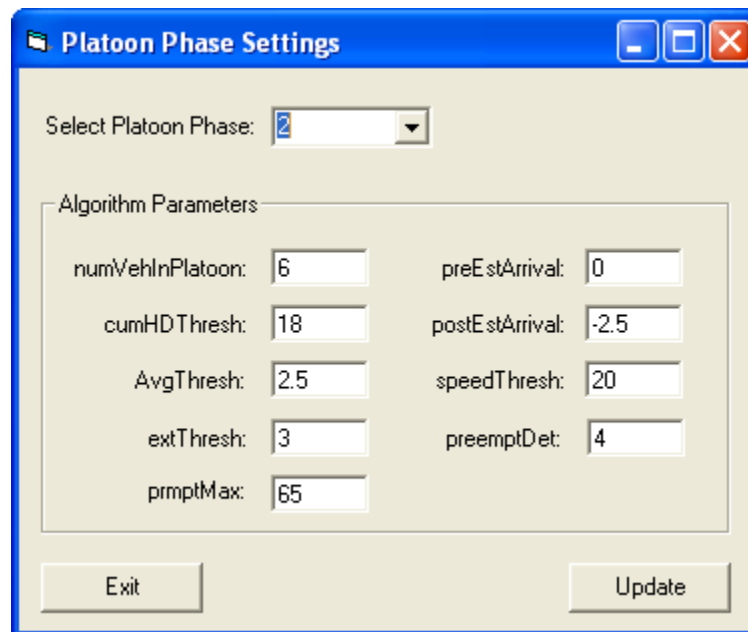
Figure 26. Platoon Phase Settings Screen.

Number of Vehicles in Platoon

The data field labeled "numVehInPlatoon" specifies the minimum number of vehicles that can be accepted as a platoon if they meet the criterion described below.

Cumulative Headway Threshold

These data are specified by the user in the field labeled "cumHDThresh" to establish how compact a group of "numVehInPlatoon" vehicles must be for the program to initially classify it as a platoon. For each priority approach, the initial platoon detection algorithm is active only when there is no currently-detected platoon. For this test, the program uses projected arrival times of vehicles at the stopbar. Each vehicle's project arrival time is calculated using its detected speed and known distance between the advance detector and the stopbar. In Figure 26, the program classifies a group of six vehicles as a platoon if the projected arrival time of the sixth vehicle minus the projected arrival time of the first vehicle is less than or equal to 18 seconds. Furthermore, the program will use these two projected arrival times as the desired beginning and ending times of the initial platoon progression schedule. It should be noted that the program keeps track of the number of vehicles projected to arrive at the stopbar during the red phase, but were detected prior to platoon identification. When possible, the PIA system uses this information to clear the queue by advancing the start of the platoon progression schedule.

Average Threshold

The user specifies data in the field labeled as "AvgThresh." The program uses the data to determine if a new vehicle detected at the advance detector is a part of the already detected platoon, which is scheduled to be progressed or being progressed at the time of new detection. The program performs the following calculation first:

$$H_A = (A_n - A_1)/n$$

where:
H_A = average headway,
A_1 = projected arrival time at stopbar of the first vehicles in identified platoon,
A_n = projected arrival time at stopbar of the new vehicle, and
n = total number of vehicles from first to this new vehicle.

If H_A is less than or equal to the specified value, the program will consider the new vehicle to be a part of previously detected platoon and change the end time of progression schedule to the projected arrival time of the new vehicle. A constraint on this time extension will discussed below.

Extension Threshold

The user specifies this threshold in the field labeled as "extThresh." The program uses this extension criterion in case the average threshold test (described above) fails. The program accepts the new vehicle as part of the previously detected platoon if $(A_n - A_1)$ is less than or equal to the value specified in this field. The statements in the last paragraph of the previous subsection also apply in this case.

Maximum Preempt

This user-specified value (data in field labeled as "prmptMax") sets a limit on the maximum duration of controller override in the presence of demand on conflicting phases. The data identifier has been carried over from the first version of the PIA software and applies to both the preemption and/or phase hold signals.

Pre-Estimated Arrival

The data specified by the user in field labeled "preEstArrival" are an adjustment factor. The program reduces platoon progression start times by the specified amount.

Post-Estimated Arrival

The data specified by the user in the field labeled "postEstArrival" are an adjustment factor that the program adds to the calculated end time of the platoon progression schedule when both extension tests described above fail (that is, there are no more vehicles in the platoon). Setting this value equal to -2.5 is equivalent to providing dilemma zone protection to the last vehicle in the platoon.

Speed Threshold

The data, in miles per hour (mph) specified in the field labeled "speedThresh," are provided for operational adjustments in the field. This adjustment factor is used by the program to ignore vehicles detected to be traveling slower than the specified speed. In the Figure 26 illustration, any vehicle traveling at speeds slower than 20 mph will be ignored. Entering a value of zero will inhibit this override.

Preempt Detector

The data field labeled as "preemptDet" specifies the preempt number in the controller used to override controller operation via preemption to provide platoon progression to the selected approach.

Edit Phase and Detector I/O Settings

Selection of this option brings up a window labeled "TS-1 Cabinet Phase and SBD I/O Settings" (Figure 27) where the user can specify the digital I/O channel and port settings for phase green, phase yellow, phase hold, and stopbar detectors (SBD). To specify the digital I/O channel for inputs and outputs, the user must select an appropriate group. Examples of groups include:

- "TS-1 Phase Grn I/O Mapping,"
- "TS-1 Phase Yel I/O Mapping,"
- "TS-1 Phase Hold I/O Mapping," and
- "TS-1 Stop Bar Detector I/O Mapping."

Once a group is selected, the user selects an option (or radio) button corresponding to the subject phase or stopbar detector. In Figure 27 illustration, channel selection option is disabled because no phase has been selected so far. After entering the required information, the user must click the "Update Phase Channel Mapping" button for the information to be saved into the PIA system memory. The user must select the "System Parameters/Save System Parameters" option from the "File" menu to save the updated information into the PIA.XML configuration file to make any changes permanent.
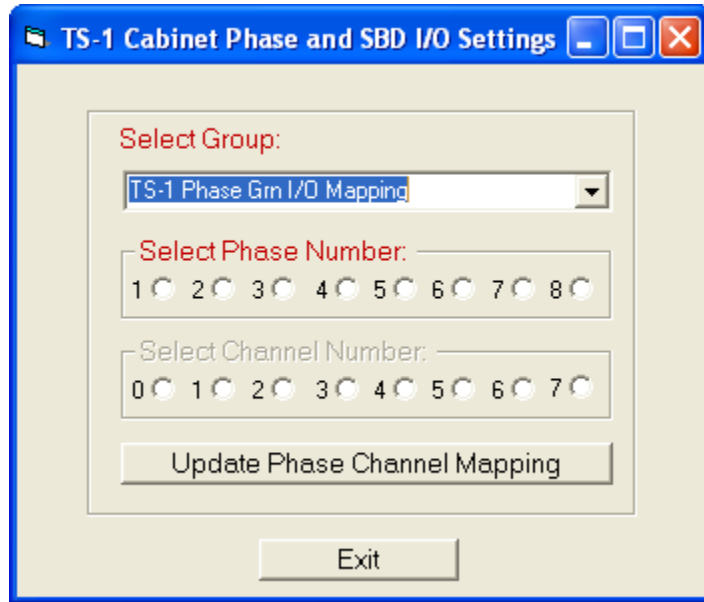
Figure 27. Phase and Detector I/O Settings Screen.

In the case of TS-2 cabinet with enhanced BIU installation, the user would have specified proper selection on the "Configuration/Edit System Parameters" menu described previously. In that case, the user will see the screen illustrated in Figure 28 instead of the above screen. This screen allows the user to map detectors to BIU 9 (detector BIU) channels. It also allows the user to map stopbar detectors to signal phases.

Edit Phase and Detector Port Settings

Selecting this option brings up the "TS-1 Cabinet Digital I/O Port Settings" illustrated in Figure 29, where the user can specify the digital I/O ports, and device (digital I/O card) settings for advanced trap detectors (ADA and BDA), dilemma zone detectors, stopbar detectors, phase hold, phase green/yellow status, and phase check. The user must update the information and then permanently save the changes for the changes to become effective.

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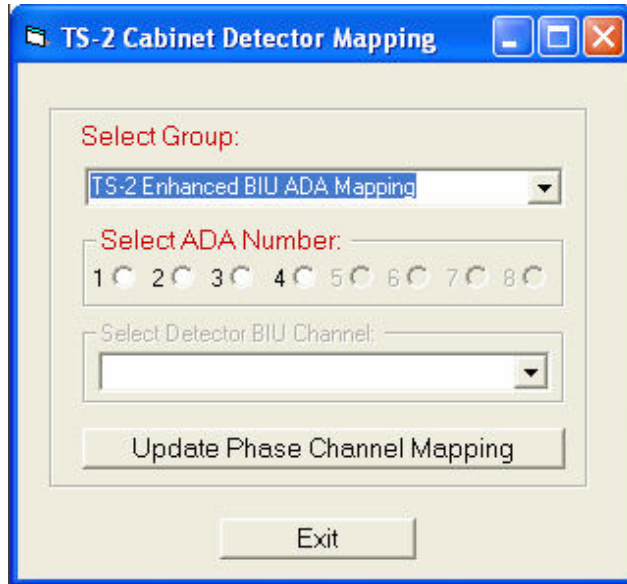
Figure 28. Phase and Detector I/O Selection for Enhanced BIUs.
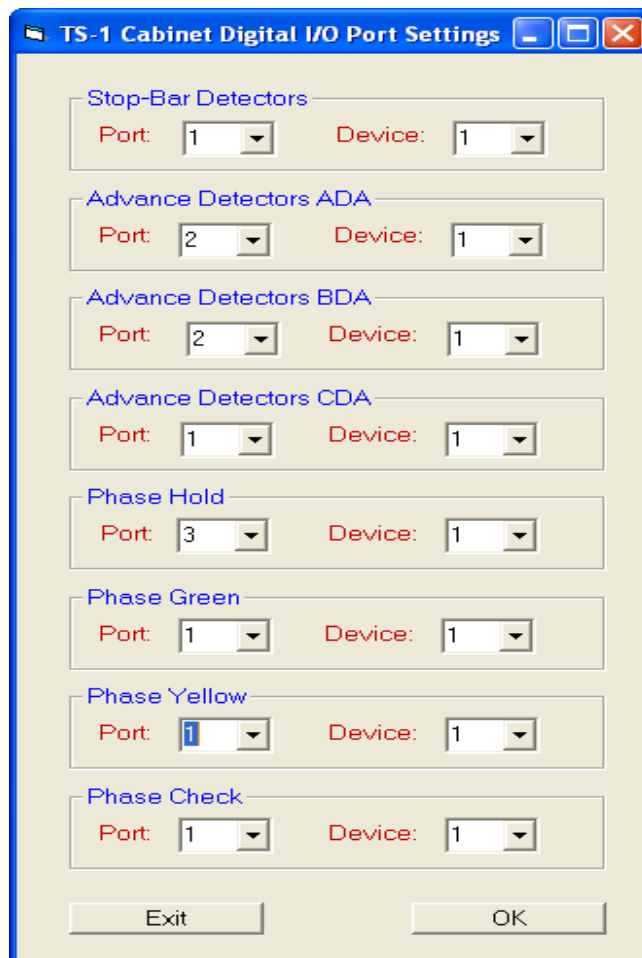
Figure 29. Phase and Detector Port Settings Screen.

Display Menu

The display menu includes several options illustrated in Figure 30. Selecting any one of these options will display a new window that provides the user with specific information about the current status of the PIA system. The following paragraphs describe the contents of these displays.
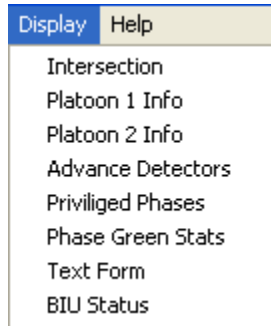
Figure 30. PIA Display Menu.

Intersection Display

This screen (Figure 31) displays a sketch of the intersection and provides real-time status of detectors and phases at the intersection. The illustration in Figure 31 corresponds to the PIA system installation at a T-intersection in Belton, Texas. On this real-time display, vehicle presence at a detector changes the color of the appropriate square-shaped box. Circles identify signal phases. The red, yellow, and green color fill of each circle identifies its real-time status.
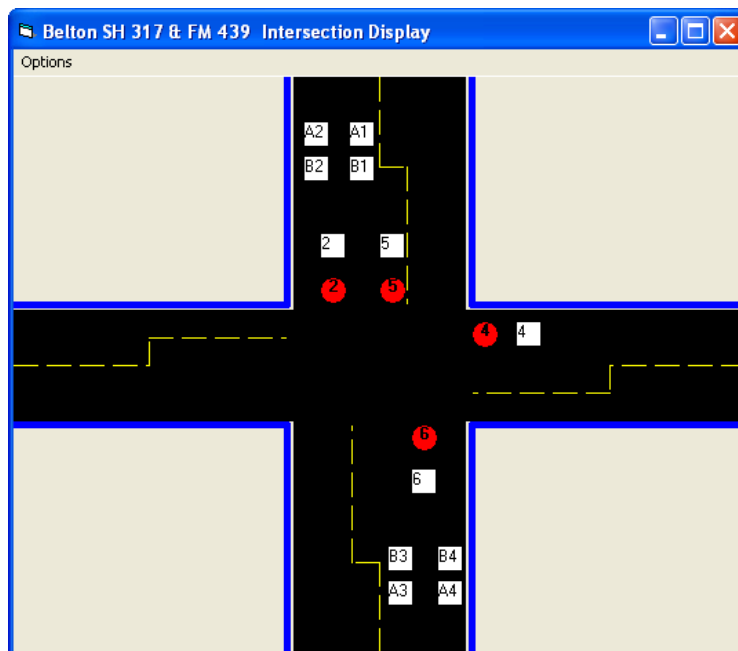
Figure 31. PIA Intersection Display Screen.

Platoon Information Screen

Each platoon phase has a separate platoon information screen. This screen provides real-time information about the detection and progression of platoons. Figure 32 illustrates two instances screens for the same platoon phase. In this case, the minimum platoon size was set to six. The top part of the illustrated screens display speed, length, departure time of vehicle from the advance detector, and projected arrival time for the last six vehicles. When a new vehicle is detected, the information for the oldest vehicle is rolled out of the window. The next line shows whether platoon progression is allowed or not. This decision is based on use-specified importance given to conflicting minor phases. The middle area immediately below shows whether there is no platoon, platoon detected, or a platoon in progress (the case shown in this illustration). The right side of the screen shows information about controller override, where:

- highlighted "P" indicates active preemption,
- highlighted "H" indicates and active hold,
- highlighted "S" indicates a call on a side-street phases (followed by a field showing the length of time for the call), and
- highlighted "A" indicates a call on the opposing arterial left turn phase (followed by a field showing the length of time for the call).
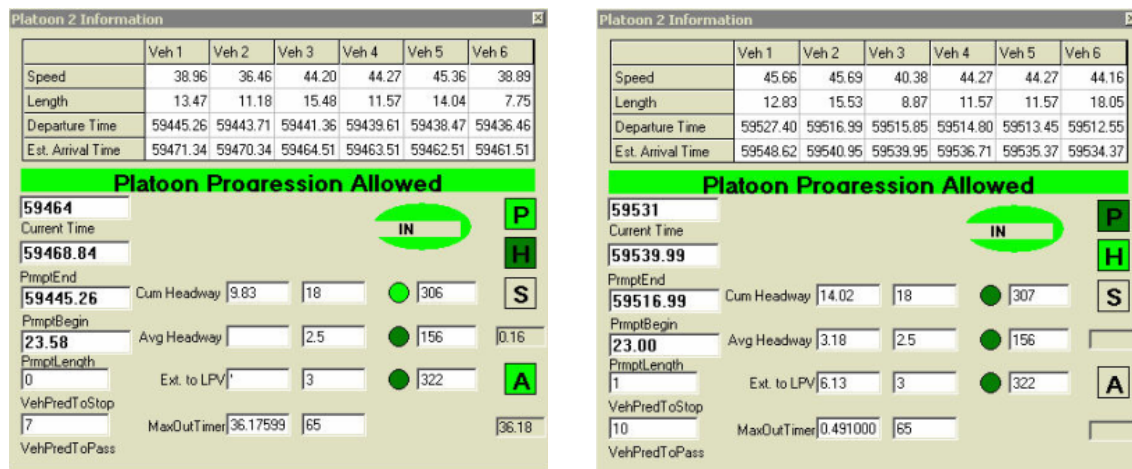
Figure 32. Platoon Information Screen.

As an example of constraint in platoon progression, notice that the screen capture on the left side shows that a platoon is being progressed using preemption and there is a call on the opposing arterial left turn phase, and that this call has been active for over 36 seconds. In this case, progression of a platoon will be prevented for any new platoons as long the demand on this detector has not been served. Other fields show data that have been discussed before. Consider the left-side illustration again, and notice:

- The cumulative headway of 9.83 seconds is less than the 18-second threshold specified, indicating that a platoon exists. This fact is graphically indicated by highlighting the green circle to the right, followed by a field showing that this is the 306th platoon detected since midnight.

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- There are no current values (indicated by blank fields) for average headway and extension because no additional vehicle arrived since the initial platoon progression. Also note these criteria have been true 156 and 322 times, respectively, since midnight.
- The value of the max-out timer is the same as the length time detection became active on the opposing left turn on the arterial, confirming that this timer activates only in the presence of conflicting calls.

Advance Detectors Screen

This window (Figure 33) provides per-vehicle speed, length, and count information for all advance detectors. Columns labeled "A Count" and "B Count" provide data for leading and trailing detectors in each ILD-based trap.

Figure 33. Advance Detectors Screen.

Privileged Phases Screen

The privileged phases screen (Figure 34) provides real-time statistics for all privileged phases. Privileged phases are those minor (arterial left turns or any of the side-street) phases the user considers high-priority. In standard traffic controllers, the user can specify if calls on all conflicting phases are to be ignored or accommodated when a preempt signal is received by the controller. The privileged phase implementation in the original version of the PIA system provided an extension to this all or nothing philosophy implemented in the controllers. The implementation allowed the use to specify which phases could be skipped and which could not. However, this selection remained static. In this version of the PIA system, the original idea of static privileged phases has been extended to a dynamic one, where specifications of additional data allow the system to be responsive to traffic conditions in the field. This screen displays data used in that decision making. The data items are described below the figure.

Figure 34. Privileged Phases Screen

Columns on the Privileged Phases Screen include:
- Column labeled "PP" indicates whether a phase is privileged or not;
- Column labeled "PPL" indicates whether the phase is currently in the privileged state or not. A phase is considered in the privileged state if the phase is a privileged phase, the phase status is red, a platoon is currently being progressed on a conflicting platoon phase, and the demand on the privileged phase has been waiting longer than current delay value on the phase. The real-time value of delay (in seconds) varies between zero and a user-specified number;
- Column labeled "Mins" indicates the number of times the phase was serviced just the minimum green since midnight;
- Column labeled "Maxs" indicates the number of times the phase has maxed out since midnight;
- Columns labeled "< Half" and "> Half" indicate the number of times actual phase green was less than or equal to the average of its minimum and max1 green times and the number of times it was more, respectively.
- Column labeled "DLY" indicates the current delay on demand accommodation for a privileged phase. This is the length of time (in seconds) for which the PIA system will ignore a detector call on that phase before taking action. For each phase, the real-time delay value changes (increases or decreases by one second) based on phase utilization. Delay for a phase drops to zero if that phase maxes out twice in a row.

Phase Green Statistics Screen

This screen (Figure 35) displays phase utilization statistics similar to that described above for all phases. For each day, the summary statistics display is only for that day since midnight. The statistics on this screen indicate the general health of the system and the need for taking corrective action. For instance, if a minor phase is maxing out a lot (say more than 50 times a day), the intersection may be due for retiming. Notice the heading of the last column (> Max). This column displays how many times a phase has extended

beyond its maximum time. This behavior may be true only for platoon phases, showing the number of times platoon progression potentially taxed minor phases. If this number is a significant fraction of the total number of platoons detected, it may be time to tweak system operation.
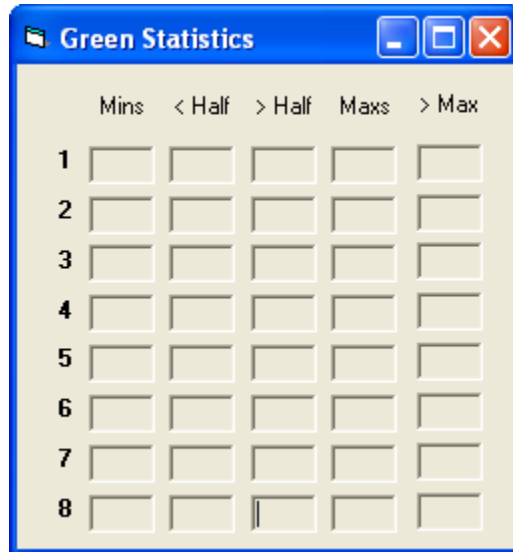
Figure 35. Phase Green Statistics Screen

Help Menu

At this time the only information the Help menu contains is the "About" option that opens a new window (Figure 36), which provides the user with contact phone numbers and e-mail address in case there was a problem with the PIA system installation.
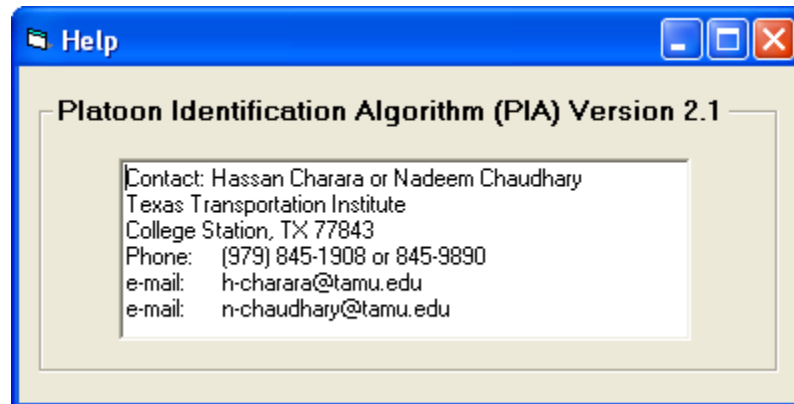
Figure 36. Help Menu.

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APPENDIX A: TS-1 CABINET WIRING DETAILS

EIGHT-PHASE INTERSECTION WITH TWO-LANE APPROACHES

Two National Instruments (NI) Digital I/O Cards (Model 6527) are needed for such intersections. Table A1 provides the input wiring map for card 1. Table A2 provides the input wiring map for card 2. Table A3 provides the output wiring map for card 1. Note that the output ports on card 2 are not used.

Table A1. Digital I/O Wiring Map for Input Ports on First NI-DAQ Card.

Port #	Channel	CB Pin	Input Type
0	0	**47**	Phase 1 - Green
	1	**45**	Phase 2 - Green
	2	**43**	Phase 3 - Green
	3	**41**	Phase 4 - Green
	4	**39**	Phase 5 - Green
	5	**37**	Phase 6 - Green
	6	**35**	Phase 7 - Green
	7	**33**	Phase 8 - Green
1	0	**31**	Phase 1 - Yellow
	1	**29**	Phase 2 - Yellow
	2	**27**	Phase 3 - Yellow
	3	**25**	Phase 4 - Yellow
	4	**23**	Phase 5 - Yellow
	5	**21**	Phase 6 - Yellow
	6	**19**	Phase 7 - Yellow
	7	**17**	Phase 8 - Yellow
2	0	**15**	ADA–1 - Platoon Phase 1
	1	**13**	BDA–1 - Platoon Phase 1
	2	**11**	ADA–2 - Platoon Phase 1
	3	**9**	BDA–2 - Platoon Phase 1
	4	**7**	BDA–3 - Platoon Phase 2
	5	**5**	BDA–3 - Platoon Phase 2
	6	**3**	BDA–4 - Platoon Phase 2
	7	**1**	BDA–4 - Platoon Phase 2

Notes:
1. Platoon Phase 1 with NEMA Number ≤ 4
2. Platoon Phase 2 with NEMA Number > 4
3. ADA-i and BDA-i is the pair of detectors forming a speed trap
   Where, ADA-i is the leading detector and i identifies lane
   (1=inside lane and 2=outside/curb lane)

Table A2. Digital I/O Wiring Map for Input Ports on Second NI-DAQ Card.

Port #	Channel	CB Pin	Input Type
0	0	**47**	Phase 1 - Stopbar Detector
	1	**45**	Phase 2 - Stopbar Detector
	2	**43**	Phase 3 - Stopbar Detector
	3	**41**	Phase 4 - Stopbar Detector
	4	**39**	Phase 5 - Stopbar Detector
	5	**37**	Phase 6 - Stopbar Detector
	6	**35**	Phase 7 - Stopbar Detector
	7	**33**	Phase 8 - Stopbar Detector
1	0	**31**	
	1	**29**	
	2	**27**	
	3	**25**	
	4	**23**	Not Used
	5	**21**	
	6	**19**	
	7	**17**	
2	0	**15**	
	1	**13**	
	2	**11**	
	3	**9**	
	4	**7**	Not Used
	5	**5**	
	6	**3**	
	7	**1**	

**Table A3. Digital I/O Wiring Map for Output Ports on
First NIDAQ Card.**

Port #	Channel	CB Pin	Input Type
3	0	**47**	Platoon Phase 1 Hold
	1	**45**	Platoon Phase 2 Hold
	2	**43**	
	3	**41**	
	4	**39**	
	5	**37**	
	6	**35**	
	7	**33**	
4	0	**31**	Common Preempt
	1	**29**	Platoon Phase 1 Preempt
	2	**27**	Platoon Phase 2 Preempt
	3	**25**	
	4	**23**	
	5	**21**	
	6	**19**	
	7	**17**	
5	0	**15**	
	1	**13**	
	2	**11**	
	3	**9**	
	4	**7**	Not Used
	5	**5**	
	6	**3**	
	7	**1**	

Note:
Controller Preempts 3, 4, and 5 (or 4, 5, and 6) should be used with the highest number
assigned to the Common Preempt, the next preempt assigned to Preempt Phase 1,
and the last assigned to Preempt Phase 2.

EIGHT-PHASE INTERSECTION WITH SINGLE-LANE APPROACHES

Intersections with one lane approaches on the arterial will have one speed trap for each approach. Consequently, only four (one per detector) out of eight channels will be needed on port 2 of the first NI-DAQ card. This difference is illustrated in Table A4. The rest of the wiring (Tables A1 and A2) will not change.

**Table A4. Digital I/O Wiring Map for Input Ports on
First NI-DAQ Card (Both Approaches Single-Lane).**

Port #	Channel	CB Pin	Input Type
0	0	**47**	Phase 1 - Green
	1	**45**	Phase 2 - Green
	2	**43**	Phase 3 - Green
	3	**41**	Phase 4 - Green
	4	**39**	Phase 5 - Green
	5	**37**	Phase 6 - Green
	6	**35**	Phase 7 - Green
	7	**33**	Phase 8 - Green
1	0	**31**	Phase 1 - Yellow
	1	**29**	Phase 2 - Yellow
	2	**27**	Phase 3 - Yellow
	3	**25**	Phase 4 - Yellow
	4	**23**	Phase 5 - Yellow
	5	**21**	Phase 6 - Yellow
	6	**19**	Phase 7 - Yellow
	7	**17**	Phase 8 - Yellow
2	0	**15**	ADA–1 - Platoon Phase 1
	1	**13**	BDA–1 - Platoon Phase 1
	2	**11**	ADA–2 - Platoon Phase 2
	3	**9**	BDA–2 - Platoon Phase 2
	4	**7**	
	5	**5**	
	6	**3**	
	7	**1**	

Notes:
1. Platoon Phase 1 with NEMA Number ≤ 4
2. Platoon Phase 2 with NEMA Number > 4
3. ADA-i and BDA-i is the pair of detectors forming a speed trap
   Where, ADA-i is the leading detector and i identifies lane
   (1=inside lane and 2=outside/curb lane)

SITE-SPECIFIC CUSTOMIZATION

Here we provide the example of mappings for the PIA System installation in Belton, Texas. Figure A1 shows a map of this intersection.

Figure A1. PIA Intersection in Belton.

In this case, only one NI-DAQ card is sufficient. The reason is that the intersection has only four signal phases (Ø2, Ø4, Ø5, and Ø6). The input wiring map for NI-DAQ card and digital I/O wiring map for output ports for this system are shown in Tables A5 and A6.

Table A5. Belton Input Wiring Map for NI-DAQ Card.

Port #	Channel	CB Pin	Input Type
1	0	47	Phase 2 - Green
	1	45	Phase 2 - Yellow
	2	43	Phase 4 - Green
	3	41	Phase 4 - Yellow
	4	39	Phase 5 - Green
	5	37	Phase 5 - Yellow
	6	35	Phase 6 - Green
	7	33	Phase 6 - Yellow
2	0	31	Phase 2 - Stopbar Detector
	1	29	Phase 4 - Stopbar Detector
	2	27	Phase 5 - Stopbar Detector
	3	25	Phase 6 - Stopbar Detector
	4	23	
	5	21	
	6	19	
	7	17	
3	0	15	ADA–1 - Platoon Phase 1 (Ø2)
	1	13	BDA–1 - Platoon Phase 1 (Ø2)
	2	11	ADA–2 - Platoon Phase 1 (Ø2)
	3	9	BDA–2 - Platoon Phase 1 (Ø2)
	4	7	ADA–3 - Platoon Phase 2 (Ø6)
	5	5	BDA–3 - Platoon Phase 2 (Ø6)
	6	3	
	7	1	

Notes:
1. Platoon Phase 1 is Ø2
2. Platoon Phase 2 is Ø6
3. ADA-*i* and BDA-*i* is the pair of detectors forming a speed trap
    Where, ADA-*i* is the leading detector and *i* identifies lane
    (1=inside lane and 2=outside/curb lane)

**Table A6. Digital I/O Wiring Map for Output Ports on
First NI-DAQ Card.**

Port #	Channel	CB Pin	Input Type
3	0	**47**	Platoon Phase 1 Hold
	1	**45**	Platoon Phase 2 Hold
	2	**43**	
	3	**41**	
	4	**39**	
	5	**37**	
	6	**35**	
	7	**33**	
4	0	**31**	Common Preempt & Platoon phase 2 Preempt
	1	**29**	Platoon Phase 1 Preempt
	2	**27**	
	3	**25**	
	4	**23**	
	5	**21**	
	6	**19**	
	7	**17**	
5	0	**15**	
	1	**13**	
	2	**11**	
	3	**9**	Not Used
	4	**7**	
	5	**5**	
	6	**3**	
	7	**1**	

Note:
Controller Preempts 3, 4, and 5 (or 4, 5, and 6) should be used with the highest number assigned to the Common Preempt, the next preempt assigned to Preempt Phase 1, and the last assigned to Preempt Phase 2.

APPENDIX B: COMPONENTS PROCUREMENT SPECIFICATIONS

The components required for installing PIA can be procured from various vendors. This section provides details for components used in this and other similar projects.

Industrial PC

Model # 9301-06I
- 256NU-P133LP-815: PC133 256MB UNB LP 32MX8
- 9301-06IEMPTY: CHAS NODE 6 SLOT 300W AC
- CDW552G-KIT: TEAC CD-RW BEIGE KIT
- SBC-815ET-VE: SBC-815ET-VE
- 602-0053-00: KIT PCI B/P 9301-06I
- 6Y080L0: ATA/133 7200RPM 80GB IDE HDD
- 3-274915-1: CPU PIII 1.2GHZ/133 FCPGA(T)
- FD-1.4M: 1.44MB 3.5-inch floppy drive
- Microsoft Windows 2000 Operating System for TS-1 Cabinet Installations
- Microsoft Windows XP Operating System for TS-2 Cabinet Installations

Vendor
Kontron America, Inc.
Dept. 9073
Los Angeles, CA 90084-9073
Telephone: (800) 480-0044
Website: http://us.kontron.com
Number required: 1
Estimate: $2700

NI-DAQ CARD

Card #: NI-DAQ PCI-6527
- 24 optically isolated digital inputs (0-28 VDC)
- 24 isolated, solid-state relay digital outputs (0-60 VDC, 0-30 Vrms)
- Switch up to 120 mA

CB-50 I/O Connector Block with DIN-Rail Mounting - 776164-90
Termination accessory with 50 screw terminals for easy connection of field I/O signals to NI-DAQ PCI-6527 devices. Includes one 50-pin header for direct connection to 50-pin cables. The CB-50 includes a protective plastic base and hardware for mounting the accessory on either a standard DIN rail or flush on a wall or panel.

Vendor
National Instruments
P.O Box 840909
Dallas, TX 75284-0909
Telephone: (888) 280-7645
Website: http://www.ni.com
Number required: 2
Estimate: $1500 including 2 cards, software, and cables.

ENHANCED BIUs

Vendor
Naztec, Inc.
820 Park Two Dr.
Sugar Land, Texas 77478
Telephone: (281) 240-7233
Website: http://www.naztec.com
Number required: 4   ($400 each)
Estimate: $1600

ELECTRONIC TIMER RELAYS

Vendor/Model
IDEC GT3D-4AD24, 24VAC/DC
Any electronic store
Estimate: $125 per relay

DETECTOR AMPLIFIER
Vendor
Reno Model S Series, Dual-Channel Loop Amplifier with two harnesses
Estimate: $200 per amplifier

NI-DAQ TRAFFIC CABINET INTERFACE

Components illustrated in Table 1 are required for the NI-DAQ Card Traffic Cabinet Interface and can be purchased from an electronic component store.

Table 1. Components of a NI-DAQ Traffic Cabinet Interface.

Parts to Built NI-DAQ Traffic Cabinet Interface			
Name	**Quantity**	**Price**	**Subtotal**
Aluminum DIN Rail	1	$7.32	$7.32
Double Terminal Blocks Idec BNDH15W	24	$3.45	$82.80
Double Terminal Block End Plate Idec BND15W	1	$1.55	$1.55
Fork Terminal Jumper Idec BNJ26FW	5	$1.79	$8.95
DIN Rail Stop Idec BNL-8	2	$4.10	$8.20
Single Terminal Blocks Idec BNH15MW	24	$1.09	$26.16
Single Terminal Block End Plate Idec BNE15W	1	$0.41	$0.41
DIN Rail Stop Idec BNL-5	2	$1.25	$2.50
Dust Cover Idec BNC230	1	$11.87	$11.87
Marking Strip Idec PVC BNP7	1	$0.99	$0.99
End Clip Idec BNM3	2	$0.30	$0.60
Fuse Holder Idec BNF10SW	1	$5.11	$5.11
1/20A fuse	1	$0.84	$0.84
10' of 19 pair 22 AWG wire	1	$20.00	$20.00
1 roll of 22 AWG wire	1	$5.89	$5.89
16 kilo-ohm resistors	24	$0.25	$6.00
Box of red fork terminals	1	$5.00	$5.00
		Total	**$194.19**