1. Report No. FHWA/TX-10/5-5113-01-P1	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle FIELD MANUAL FOR THE OPERATION OF ADVANCE WARNING OF END OF GREEN SYSTEM (AWEGS)		5. Report Date September 2008 Published: October 2009
		6. Performing Organization Code
7. Author(s) Srinivasa R. Sunkari, Hassan A. Charara, and Jeremy D. Johnson		8. Performing Organization Report No. Product 5-5113-01-P1
9. Performing Organization Name and Address Texas Transportation Institute The Texas A&M University System College Station, Texas 77843-3135		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. Project 5-5113-01
12. Sponsoring Agency Name and Address Texas Department of Transportation Research and Technology Implementation Office P.O. Box 5080 Austin, Texas 78763-5080		13. Type of Report and Period Covered Product March 2007–August 2008
		14. Sponsoring Agency Code

15. Supplementary Notes

Project performed in cooperation with the Texas Department of Transportation and the Federal Highway Administration.
Project Title: Implementation of Advance Warning of End of Green Systems (AWEGS)
URL: http://tti.tamu.edu/documents/5-5113-01-P1.pdf

16. Abstract

The objective of this implementation project was to implement four AWEGS across Texas at intersections appropriate for the installation of AWEGS. After a survey across Texas, four sites were chosen in the Atlanta District, Pharr District, Odessa District, `and San Antonio District. The AWEGS design plans were prepared for these four sites and submitted to the districts. These design plans were prepared for an intersection with high-speed approaches having the required dilemma zone detection design. The Atlanta District implementation was typical of the earlier implementation and used the TS-2 TS-1 conversion panel. However, the remaining implementations were configured for using enhanced BIUs. AWEGS software was also modified to account for rail preemption as the site in the Odessa District was being preempted by between 15 to 25 trains per day. Finally the implementation in the San Antonio District was redesigned to use radar detection for both dilemma zone and advance detection. AWEGS at the Atlanta, Pharr, San Antonio, and Odessa Districts have been implemented, and an evaluation of the system showed that AWEGS was performing satisfactorily at all sites.

17. Key Words Advance Warning Flashers, AWEGS, W3-4 Signs, Advance Traffic Warning Devices, Traffic Actuated Control , Enhanced BIU, TS-2Conversion Panel	18. Distribution Statement No restrictions. This document is available to the public through NTIS: National Technical Information Service Springfield, Virginia 22161 http://www.ntis.gov	
19. Security Classif.(of this report) Unclassified	20. Security Classif.(of this page) Unclassified	21. No. of Pages 84	22. Price

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FIELD MANUAL FOR THE OPERATION OF ADVANCE WARNING OF END OF GREEN SYSTEM (AWEGS)

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DISCLAIMER

This implementation was performed in cooperation with the Texas Department of Transportation (TxDOT) and the Federal Highway Administration (FHWA). The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation.

This report is not intended for construction, bidding, or permit purposes. The engineer in charge of the project was Srinivasa Sunkari, P.E. #87591. The United States Government and the State of Texas do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

ACKNOWLEDGMENTS

TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

ADVANCE WARNING OF END OF GREEN SYSTEM (AWEGS)

AWEGS is a dilemma zone protection system designed to minimize vehicles from being trapped in their respective dilemma zones at the onset of yellow (*1*). The objective is achieved by providing advance warning to motorists approaching the intersection with the help of advance warning signs coupled with flashing beacons. Advance warning about the end of green is provided by the activation of the beacons on the warning sign. Figure 1 illustrates the functionality and the various components of AWEGS.

Typically dilemma zone detection is provided on high-speed approaches to minimize vehicles caught in their dilemma zone at the onset of the yellow indication in the traffic signal. However, dilemma zone detection is usually designed to protect passenger cars up to the 85th percentile approach speed. This means that passengers above the 85th percentile approach speed and trucks are not provided the same level of dilemma zone protection. The objective of AWEGS is to provide protection to trucks and passenger cars up to the 99th percentile approach speeds. Figure 2 illustrates the typical approach layout of AWEGS.

Site Selection Criteria

AWEGS is typically applicable at locations that meet the following characteristics:

- High-speed approaches should have a speed limit of 55 mph or greater.
- The intersection should have dilemma zone detection that conforms to TxDOT's practice of using inductive loops.
- The intersection should be operating in a fully actuated mode.
- The intersection should have detection for all non-arterial phases (arterial left turns and cross streets), preferably at the stop bar.
- The location should have an ADT of preferably not greater than 15,000 vehicles.
- There should be a minimum number of driveways between the intersection and the advance detectors.
- The percentage of turning traffic at the intersection should not be unusually high.
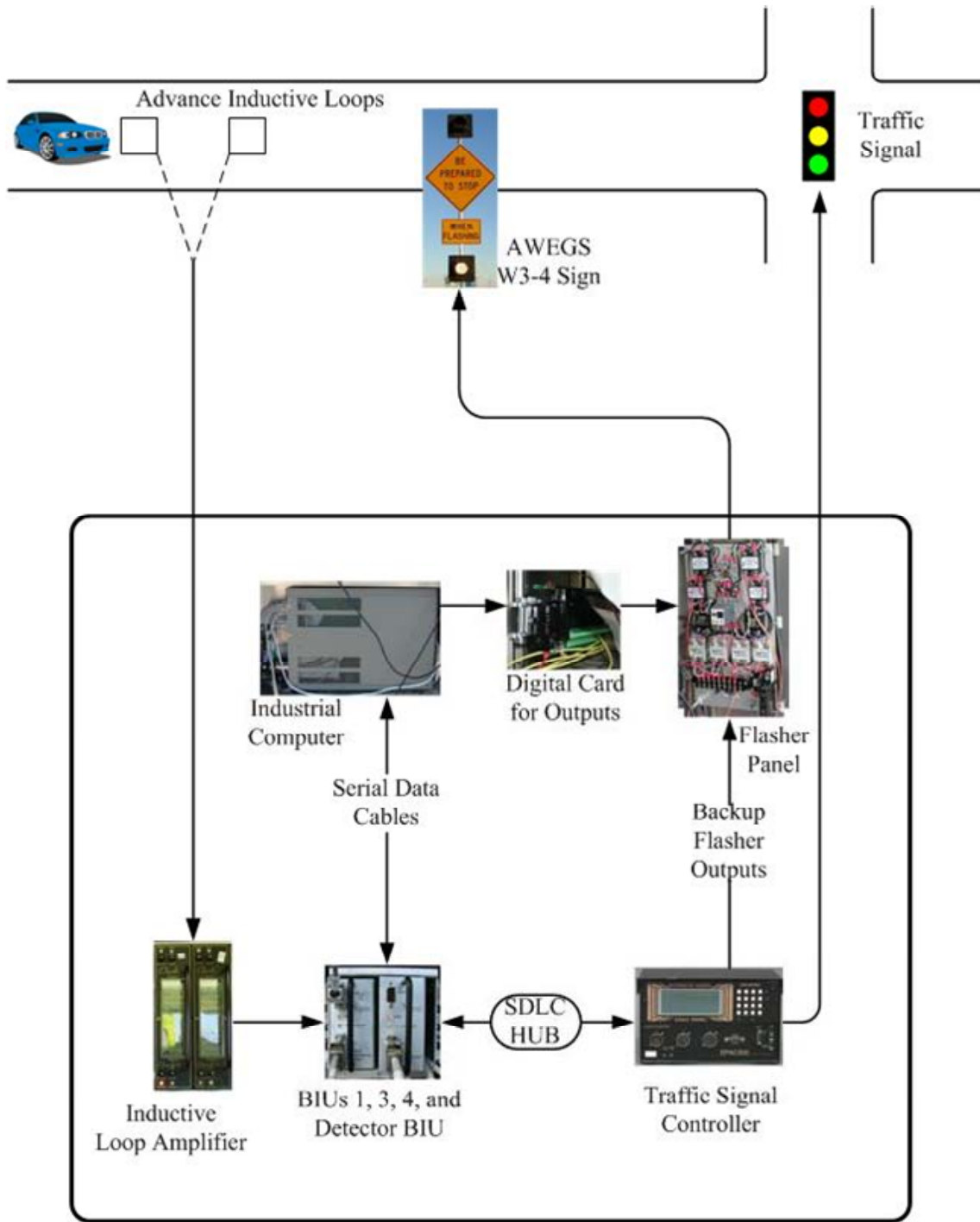
Figure 1. Layout of a Typical Advance Warning of End of Green System (AWEGS).
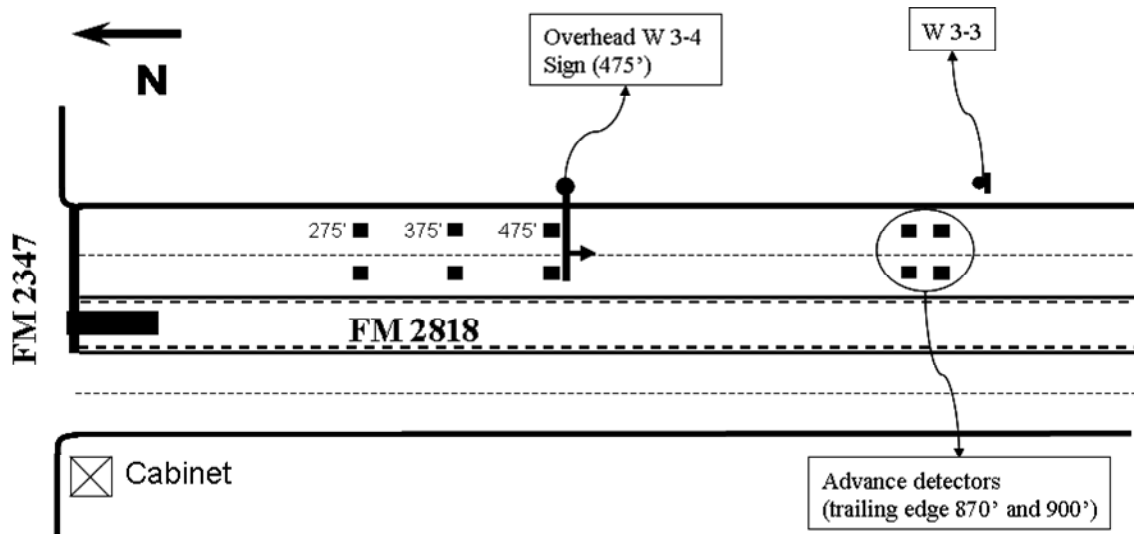
Figure 2. Typical Layout for an Intersection Approach Having AWEGS.

COMPONENTS OF AWEGS

Advance Warning Signs (W3-3 and W3-4)

As mentioned earlier, AWEGS functions by flashing beacons on an advance warning sign also known as a W3-4 sign (see Section 2C.26 of the 2000 Manual of Uniform Traffic Control Devices (*MUTCD*) (*2*). The configuration of the W3-4 sign depends on the approach to the intersection as follows:

- single-lane approach—one roadside-mounted W3-4 sign (Figure 3),
- two-lane approach with a wide median where a roadside sign can be installed— two roadside-mounted W3-4 signs on either side of the approach (Figure 4), or
- two-lane approach with visibility limitations or a small median where a roadside sign cannot be installed—an overhead-mounted W3-4 sign (Figure 5).

Figure 3. AWEGS Sign on a Single-Lane Approach.

Figure 4. AWEGS Signs on a Two-Lane Approach.

Figure 5. Overhead AWEGS Sign.

The TxDOT's new *Sign Crew Field Book* (*3*) and the relevant sections in the *Texas MUTCD* (*4*) and national *MUTCD* (*2*) should always be consulted for official design requirements and guidance. All aspects of the signs noted in this section are in compliance with the 2000 *MUTCD* (*2*).

The configuration of the beacons on the W3-4 sign depends on the configuration of the beacons on the Signal Ahead sign also known as the W3-3 sign. According to the *MUTCD* (*2*), all intersections with a W3-4 sign shall have a Signal Ahead sign. The W3-3 sign can be installed either without any beacons as illustrated in Figure 6 or with beacons as illustrated in Figure 7. If the W3-3 sign has beacons, they are usually installed in the top-bottom arrangement as illustrated in Figure 7. If, however, the W3-3 sign does not have beacons, it is recommended to have top-bottom beacon configuration on the W3-4 sign (Figure 3). On the other hand, if the W3-3 sign has beacons, the W3-4 sign can have beacons in a top-top arrangement as configured in Figure 8. The top-bottom beacon flash arrangement tends to have a higher attention value than the top-top arrangement of beacon flash and is the preferred configuration. However, if the W3-3 sign has the beacons, the top-top beacon configuration is recommended to make a distinction from the beacons on the W3-3 sign.

Figure 6. Signal Ahead Sign (W3-3) without Beacons.

Figure 7. Signal Ahead Sign (W3-3) with Beacons.

Figure 8. AWEGS Sign with the Beacons on Top.

TxDOT's practice about operation of flashing beacons on W3-4 signs is as follows:

- Top-bottom arrangement of beacons on a roadside-mounted sign:
    - W3-4 beacons flashing alternating and
    - the beacons start flashing with the top beacon flashing first.
- Top-top arrangement of beacons on a roadside-mounted sign:
    - W3-4 beacons flashing simultaneously,
    - W3-3 beacons having alternating flash and flashing *only* when the W3-4 beacons are flashing, or
    - The top beacon of the W3-3 flashing first and in sync with the beacons on the W3-4 sign.
- Overhead sign:
    - W3-4 beacons mounted horizontally,
    - W3-4 beacons flashing alternating,
    - the beacons start flashing with the left beacon flashing first, and

o   the top beacon of the W3-3 flashing simultaneously with the left beacons
on the W3-4 overhead sign.

Sign and Beacon Specifications

Following are the specifications of the roadside-mounted sign (*5*):

- 7-inch Series D lettering on 48-inch × 48-inch high-intensity fluorescent yellow sheeting—BE PREPARED TO STOP;
- 6-inch Series D legend on a 36-inch × 24-inch plaque—WHEN FLASHING;
- Two vertically mounted 12-inch LED flashing beacons, with assembly (RFBA-98) for a top-bottom arrangement of beacons;
- two horizontally mounted fish-eye 12-inch light emitting diodes (LED) flashing beacons for top-top beacon arrangement; and
- due to local vertical curves, beacons mounted at 10 and 2 o'clock positions, with assembly (RFBA-98) for the arrangement of beacons.

Following are the specifications of the overhead-mounted sign (Figure 9):

- 8-inch Series D lettering on 48-inch × 96-inch high-intensity fluorescent yellow sheeting—BE PREPARED TO STOP,
- 6-inch Series D legend on a 48-inch × 96-inch high-intensity fluorescent yellow sheeting—WHEN FLASHING, and
- Two horizontally mounted 12-inch LED flashing beacons on both sides of the overhead sign.

More visually attractive advance warning signs could readily be used in AWEGS using a basic on/off switch control. An example could include overhead cantilevered electronic matrix signs, similar to the one installed in Marshall, as shown in Figure 10. This type of sign support structure would appear justified for high-speed, multilane roads having two-way left-turn lanes or no (adequate) median divider.
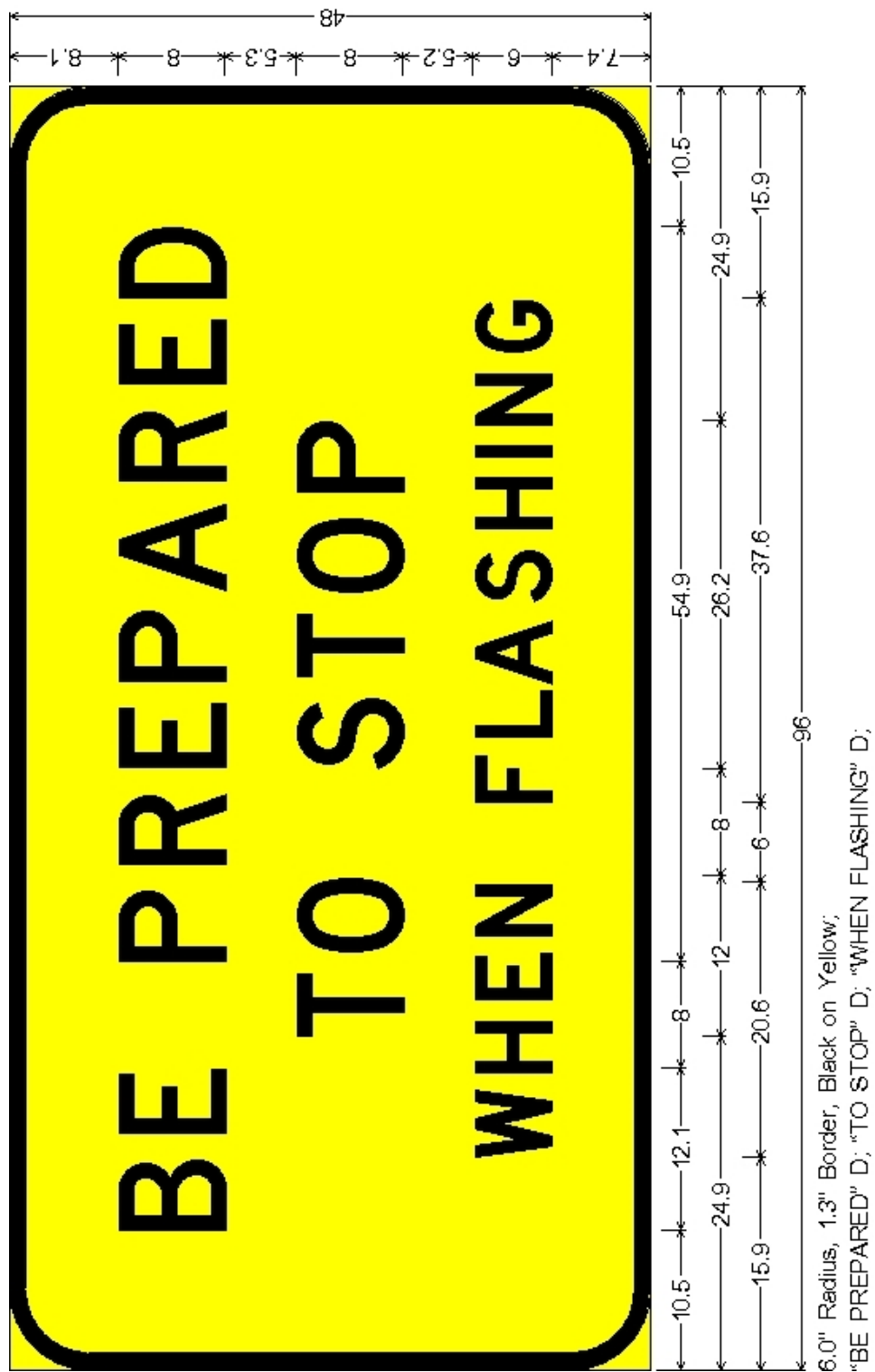
Figure 9. Dimensions of the Overhead AWEGS

Figure 10. Overhead Electronic Matrix Sign.

Sign and Beacon Location

The location along the highway where the W3-4 sign has to be positioned and the target location along the approach roadway where the flashing beacons should be targeted need to be identified. Place the AWEGS W3-4 sign (or functionally similar sign) along the roadway where the Institute of Transportation Engineers (ITE) based stopping distance exists, based on the 85th percentile approach speed (*6*), from:

$$X_{W3-4} = 1.467 * V_{85} * T + \frac{2.151 * V_{85}^2}{2(d \pm gG)}$$

where:

X_{W3-4} =		ITE-based stopping distance for W3-4 sign, feet;
V_{85}	=	85th percentile approach speed, mph;
T	=	perception-reaction to yellow onset, 1.0 second;
d	=	maximum usual (ITE) stopping deceleration rate, 10 fps²;
g	=	gravity, 32.2 fps²; and
G	=	roadway grade, decimal equivalent.

Since the above stopping distance is about the same as that recommended for the leading detector in Nader's guide (*7*), the practical location of the W3-4 sign is near the location of the first dilemma zone detector given in Nader's guide. Local site adjustments of ±50 feet to avoid

driveways and other obstructions are considered acceptable in locating the W3-4 sign (*5*). The focal point of all flasher beacons for an approach is the same. The target location shall be the centerline of the approach roadway at the location of the leading advance detector at the drivers' eye height. Field experience suggests that correctly targeting these beacons must be given high priority, and subsequent field inspection of their targeting during and after construction is imperative.

The electrical wiring of AWEGS W3-4 signs is relatively simple. Power is only required to drive the low-power LED flashing beacons, which is provided from the signal cabinet by the AWEGS computer/terminal switches. Thus, 120 volts alternating current (VAC) electrical power and control of the sign beacons are combined using three conductors of a five-conductor #12 AWG cable or the like. Since the sign is strategically located close to the existing dilemma zone detectors, electrical ground boxes and conduit should already be in place, which may expedite the cable run to the signal cabinet. Engineering judgment should be used to warrant any lightening arrestors for the W3-4 signs.

Advance Detectors

In AWEGS design, the two Inductive Loop Detectors (ILDs), which serve as speed-trap detectors in each lane, are called the ADA and 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-feet × 6-feet 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, install two advance detectors with two lead-in wires. For a two-lane approach, install four advance detectors with four lead-in wires. Figure 11 illustrates the configuration of the pair of loops in each lane where ADA and BDA are the names of the two loops.
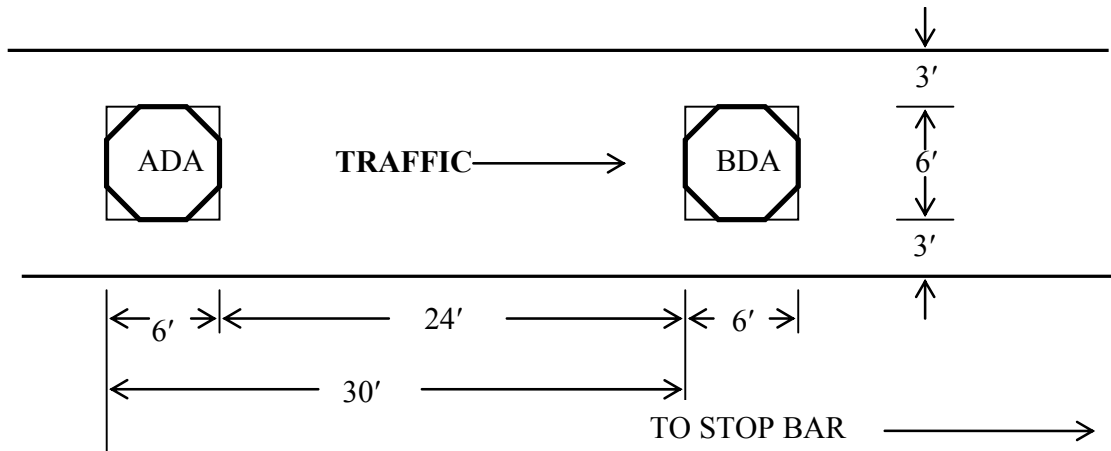
Figure 11. Advance Detector Configuration.

Two advance detectors per approach lane are added to existing signal control systems for each approach to serve three functions in AWEGS. They provide a more distant look into the future regarding the nature of arriving traffic than is typically provided (or needed) by dilemma zone detectors (Nader's guide) (*7*). They also form a well-defined speed trap to better estimate the arrival time of each and every vehicle to the first downstream dilemma zone detector. Lastly, they are used to estimate (classify) the type of vehicle into car or truck categories. Knowing the type of vehicle and its speed, AWEGS estimates their respective dilemma zones in real time (*1*).

The design, location, and construction of the advance speed-trap detectors are critical to the successful operation of AWEGS. TTI researchers recommend the use of ILD for AWEGS applications based on field experience with their operational measurement precision, dependability, and technology requirements. Wireline communication is also recommended due to its dependability, although wireless technology has been used successfully at the AWEGS location in Lubbock. Wireless technology used was based on research conducted in an earlier TxDOT project (*8*) and is providing excellent contact closure information. Long home runs (some over 1000 feet long) to the signal cabinet offer design challenges, but modern ILDs seem to have little problem working as specified when the ILD system is well designed and constructed.

Due to the increase in the cost of installing ILDs with very long lead-in wire, use of wireless detectors was also investigated. Preliminary evaluation of some research projects

indicated that Synsys wireless detectors along with repeaters are more suitable for use as advance detectors. These detectors will be configured similar to ILDs.

Location

The leading edge of the ADA detector provides AWEGS with the first indication of the arrival of a vehicle. AWEGS begins a process of responding to this vehicle as it travels across the ADA detector and then arrives at the BDA detector. A typical travel time between these two arrival events is on the order of 0.3 seconds or so. The activation presence of the ADA detector is also monitored by AWEGS as the vehicle travels over the ADA detector. With the leading edge of the BDA detector strategically placed 30 feet downstream from the leading edge of the ADA detector, providing a 24-feet gap between them, a car will leave the ADA detector (lose its presence) before reaching the BDA detector, but a truck will still have its presence noted on the ADA detector. Thus, AWEGS can distinguish a car (ADA off, BDA on) from a truck (ADA on, BDA on) as the vehicle arrives on the BDA detector. AWEGS can also easily determine its speed. Recent federal legislation aside, trucks have more difficulty stopping than cars. The literature suggests that the maximum acceptable deceleration rate for a truck to stop is 70 to 80 percent of that for a car (*9*).

AWEGS design specification provides a car with enough distance (and time) to permit the 99th percentile approach speed car to slow down to the design speed of the downstream dilemma zone detectors (CDA) at the leading edge of the first dilemma zone detector (CDA 1). An alternative explanation is that AWEGS provides the 99th percentile approach speed vehicle (car) with enough warning that it could safely stop if and when the downstream red signal is displayed, assuming ITE's base deceleration rate. An equation to calculate this location for the ADA detector is (*5*):

$$ADA = 1.467 * V_{99\%} * T_{W3-4} + \frac{2.151*(V_{99\%}^2 - V_{85\%}^2)}{2(d \pm Gg)} + X_{W3-4}$$

where the terms are:

ADA	=	leading edge of the ADA advance warning detector, feet;
$V_{99\%}$	=	99th percentile speed $V_{99\%} = V_{85\%} + 1.3 * \sigma \cong V_{85} + 9$, mph; and
T_{W3-4}	=	input-perception-read-reaction to W3-4 flasher and decision to slow down (time is = 2.7 seconds = 0.2 seconds + 2.5 seconds).
X_{W3-4}	=	ITE-based stopping distance for W3-4 sign, feet (defined on Page 10).

The distance ADA detector should be from the stop-line can be increased due to several factors. Increasing speed increases the stopping distance. Increasing downgrade to the intersection (-*G*) increases the stopping distance. Table 1 illustrates the typical location of the ADA and BDA detectors and the AWEGS sign for various speeds. As noted above, the BDA detector is located 30 feet downstream of the ADA detector. Thus, the relative location of the leading edge of the BDA detector is:

$$BDA = ADA - 30\, feet$$

Table 1. Locations of AWEGS Advance Speed-Trap Detectors and W3-4 Sign for Level Grade Using Nader's Guide for Dilemma Zone Detection.

Design or Approach Speed, mph	AWEGS ADA Detector, Feet	AWEGS BDA Detector, Feet	Sign W3-4 at CDA 1 Detector of Nader's Guide, Feet
45	595	565	330
50	683	653	350
55	776	746	415
60	875	845	475
65	979	949	540
70	1089	1059	600

AWEGS Cabinet Interface

Researchers developed and tested the first AWEGS prototype in a TS-1 cabinet at TTI's TransLink laboratory facilities in College Station. AWEGS algorithm was developed in a field hardened PC and a National Instruments (NI) PCI-6527 Digital I/O (digital I/O) card with CB-100 Connector Kit (connector block) to interface with the TS-1 cabinet's back panel to monitor the phase status and stop bar detector actuations and other inputs and outputs required by AWEGS. However, the first two locations where AWEGS was installed in the field (Waco and Brenham) had TS-2 cabinets. These cabinets did not give access to all the inputs and outputs required for AWEGS. TTI researchers developed a TS-2 to TS-1 conversion panel (TS-2 conversion panel) with engineers working with ITS Siemens that provides the inputs and outputs within a TS-2 cabinet that were available for AWEGS functionality in a TS-1 cabinet. A TS-2 conversion panel consisted of an auxiliary rack used to house BIUs 3 and 4, an SDLC hub to connect BIUs 3 and 4 to the serial bus in a TS-2 cabinet, 4 SDLC cables, and a contact-closure panel that provides access to the inputs and outputs required for AWEGS functionality. The inputs on the contact-closure panel included rings 1 and 2 status bits (A,B,C), Phase On, and

Phase Check for the phases at the intersection. The primary output available and used was the Phase Hold. The panel includes other contact-closure connections to other inputs in the cabinet that TTI researchers did not need for AWEGS. The AWEGS computer used the digital I/O card to interface with the contact-closure panel similar to its interface with a TS-1 back panel. However, the use of TS-2 conversion panel required the assembly of an input connector block that was very labor intensive. This connector block was developed to prevent any malfunction in the cabinet due to the AWEGS interface. An output connector block was also necessary to send the outputs from the AWEGS computer.

However, later research conducted by TTI led to the development of a more efficient interface with the TS-2 cabinet. TTI researchers worked with Naztec, Inc. to develop an "enhanced BIU" that could provide the inputs and outputs required by AWEGS without the need for the TS-2 conversion panel. The interface continued to require BIUs 3 and 4 and the SDLC Hub. Use of enhanced BIUs made the implementation of AWEGS a lot simpler. Use of enhanced BIUs for AWEGS implementation does not require the fabrication of the input connector block which is very labor intensive. The interface requires the digital I/O card and only the output connector block used to flash the beacons and to send a heartbeat of the system to the backup panel.

There are, however, some limitations in the use of enhanced BIUs. Enhanced BIUs send a status message every 100 milliseconds. On the other hand, the status of the digital I/O cards channels are checked every 15-20 milliseconds. Hence, when messages from enhanced BIUs are used, AWEGS can make some errors in the classification of vehicles. Researchers, however, recommend the use of enhanced BIUs due to the ease of installation of AWEGS. This section will describe the components and the interface used by AWEGS in a TS-2 cabinet.

AWEGS Computer and Cabinet

A field-hardened industrial computer is currently used to run AWEGS. The industrial computer used is manufactured by Kontron America and includes an Intel 850 MHz single-board computer, and an 80 gigabyte hard disk. The large hard disk was necessary to store log files collected to evaluate and analyze the system performance during research development.

The cabinet should have enough space to install the AWEGS computer, an auxiliary BIU rack, the flasher panel, and the advance detectors. The cabinet should also have space to install

the output panel. If the TS-2 conversion panel interface is used, select a cabinet large enough to house the panel and the large input panel. The cabinet should have a loop input panel to monitor all the intersection detectors. These include the stop-bar detectors as well as the dilemma zone detectors. In some cases, the stop-bar detectors may include video detectors. Researchers should provide 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 will save space, and maintenance becomes easier.

SDLC HUB

Install additional BIUs (BIU 3 and BIU 4) in a TS-2 cabinet for the implementation of AWEGS. These BIUs must be housed in a separate BIU rack as illustrated Figure 12. These BIUs will communicate with the other components of the cabinet through a SDLC HUB illustrated in Figure 13. Figure 14 illustrates a SDLC HUB installed in a cabinet. This SDLC HUB is required irrespective of whether enhanced BIUs are used or the TS-2 to TS-1 conversion panel is used.
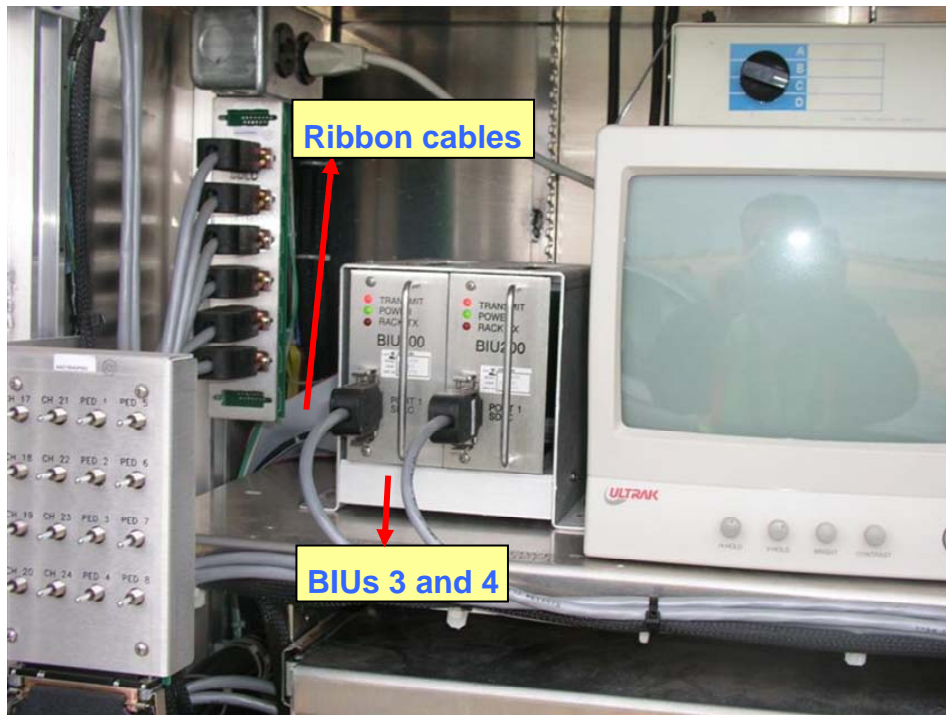
Figure 12. BIU Rack for BIU 3 and BIU 4.
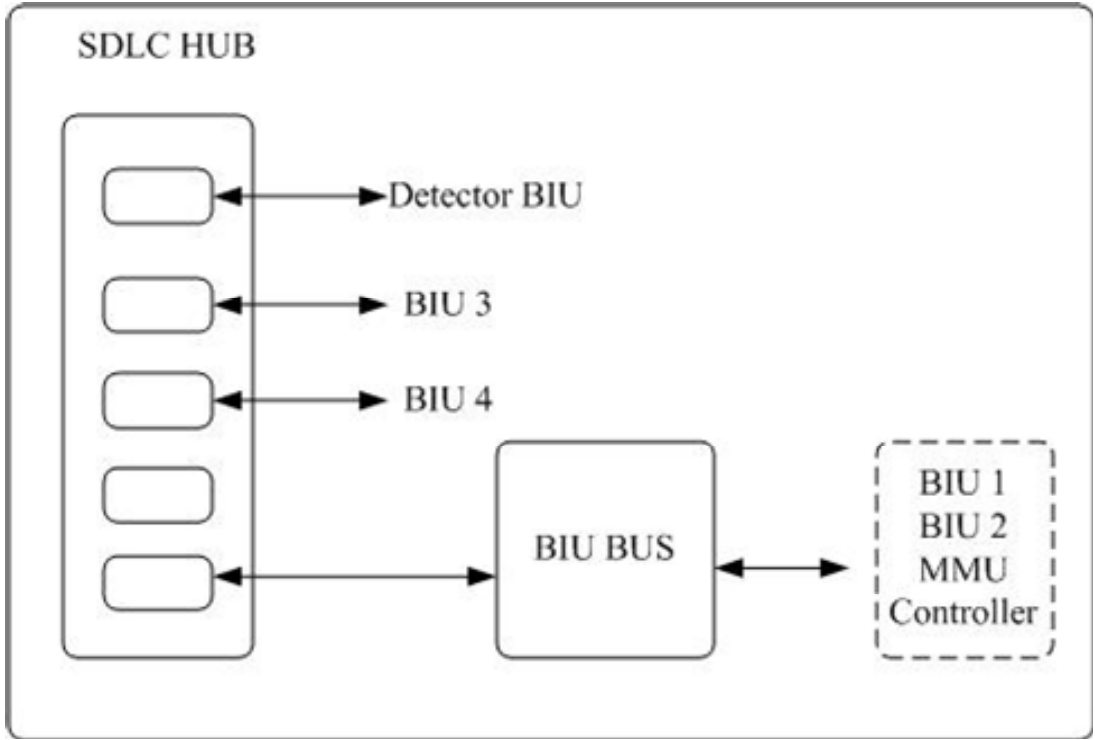
Figure 13. Functionality of the SDLC HUB.
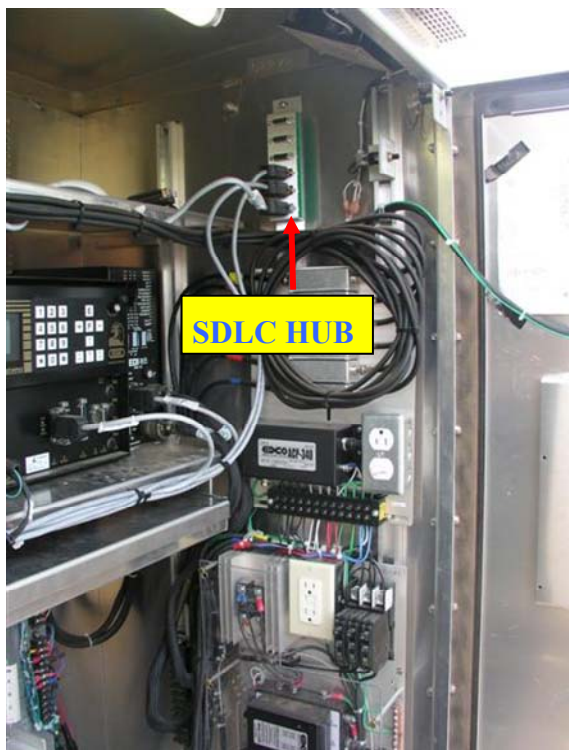
SDLC HUB

Figure 14. SDLC HUB in a Cabinet.

Enhanced BIU Interface with AWEGS Computer

Enhanced BIUs have an extra RS-232 serial port (illustrated in Figure 15) on the front casing that can be used by the AWEGS computer to monitor the necessary controller inputs and to send necessary outputs (like the phase holds) to the controller. Enhanced BIUs send a status message via the serial port every 100 milliseconds. The AWEGS computer requires a serial port expander to increase the number of available serial ports to at least four available ports. Typically, a computer has one or two serial ports. The computer needs to have at least as many serial ports as the BIUs being used. In TS-2 cabinets, all BIUs being used will be replaced with enhanced BIUs. These include BIU 1, detector BIU, BIU 3, and BIU 4. At typical intersections BIU 2 is not being used, and, hence, it may not be necessary to replace BIU 2 with an enhanced BIU. Use of enhanced BIUs has simplified the installation of AWEGS in a TS-2 cabinet. Their use has also reduced the cost of AWEGS slightly. Figure 16 illustrates the enhanced BIUs interface with the AWEGS computer.

Figure 15. Enhanced BIU with a Serial Port.
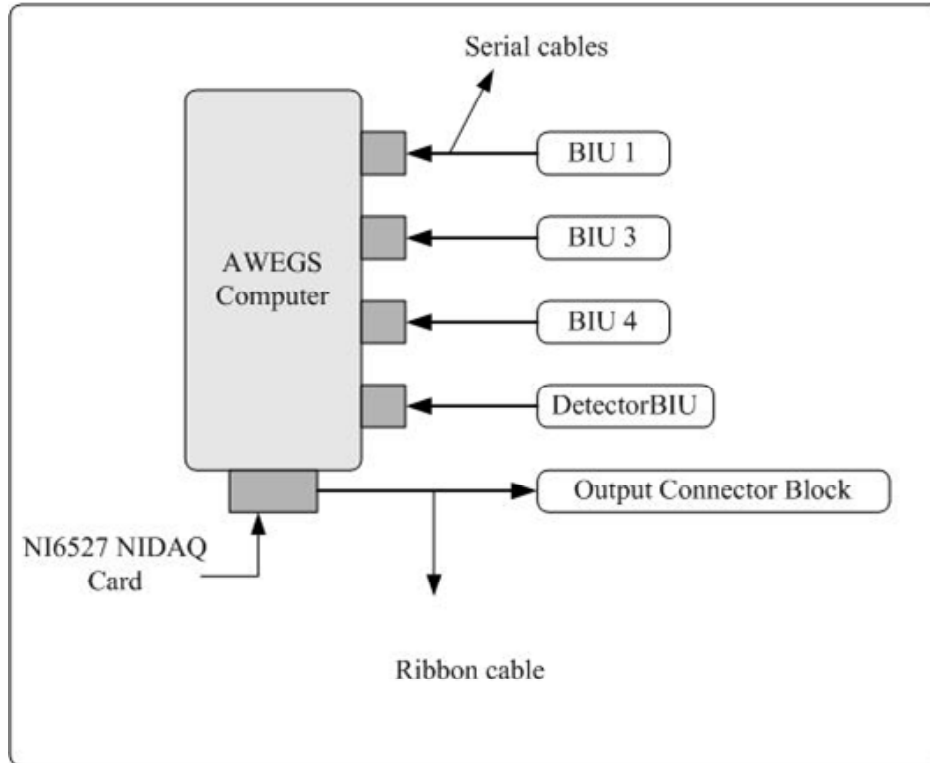
Figure 16. Enhanced BIU Interface with the AWEGS Computer.

TS-2 Conversion Panel Interface with the AWEGS Computer

The TS-2 conversion panel interface requires the use of NI digital I/O cards, a TS-2 conversion panel, and connector blocks for interfacing directly and safely with the conversion panel. Figure 17 illustrates the interface of the BIUs with the conversion panel, connector blocks, and the AWEGS PC.

NI Digital I/O Cards

Two NI digital I/O cards with 24 inputs and 24 outputs each are required to provide an interface between the computer and the cabinet inputs and outputs. The digital I/O cards are used to monitor the Phase On status, stop bar detector status, advance detector actuations, and controller ring status bits (three bits: A, B, and C per ring). These digital I/O cards connect to a TS-2 conversion panel through the input and output connector blocks, and the status is obtained via contact-closures.
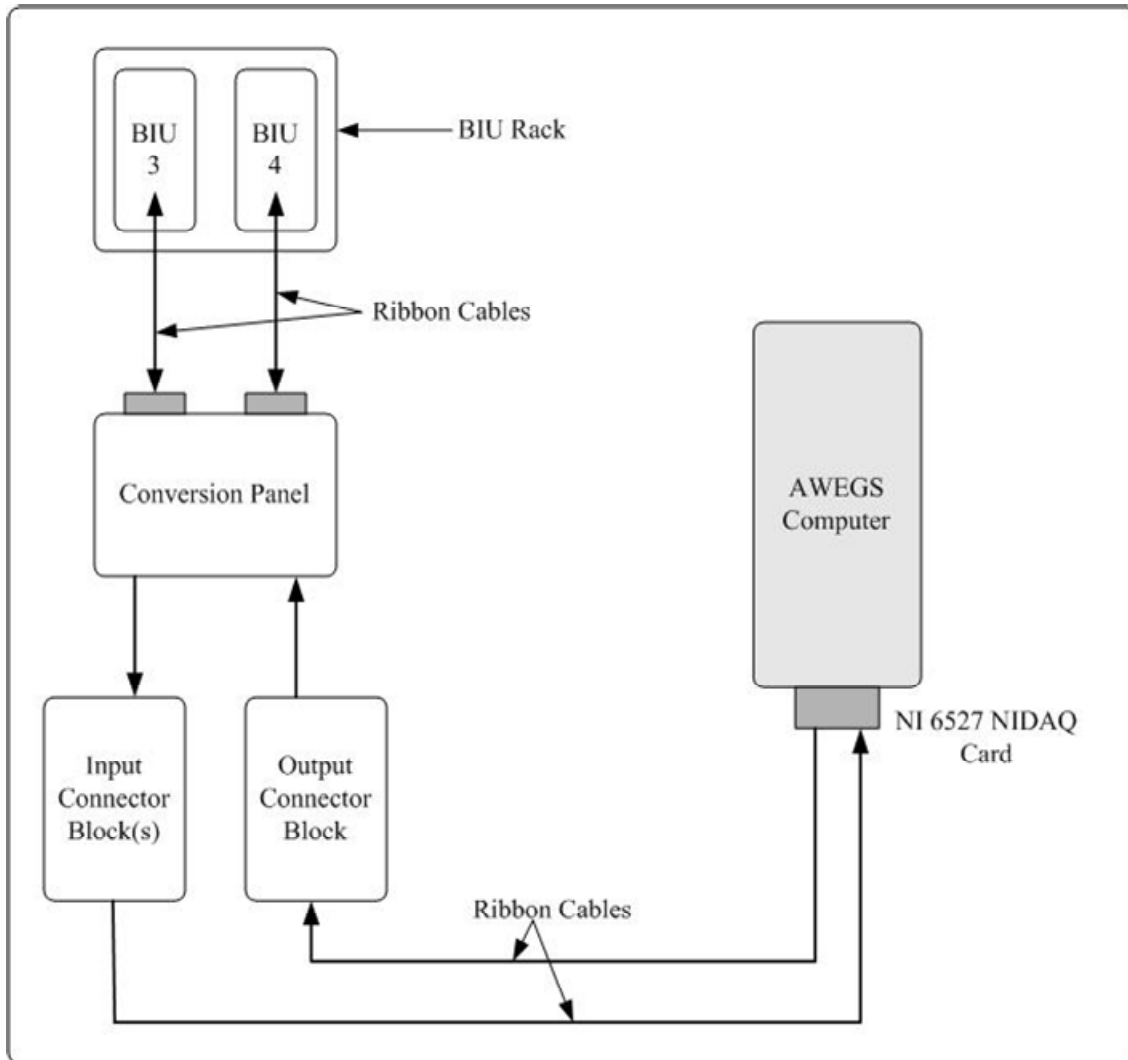
Figure 17. TS-2 Conversion Panel Interface with AWEGS Computer.

Each digital I/O 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. Each digital I/O 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 status using the ring status bits (three bits: A, B, and C per ring) and Phase On from the cabinet's back panel. At some intersections, two digital I/O cards are needed if more than 24 inputs are required. Output channels send a signal to hold the main-street phases, flash the warning signal beacons, and monitor the heartbeat of the system to the backup panel. Appendix A illustrates detailed assignment of the channels for all ports.

Input Connector Block

A bus connecting all 24 bottom-level terminals supplies all 24 16K ohm resistors with 24 volts 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-amp (mA) when the output from the traffic signal controller is active low on a particular output. Each input for the digital I/O card requires 1 mA for the digital I/O 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 digital I/O card's optical isolator, and then out of the digital I/O 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. Figure 18 illustrates actual input and output connector blocks with ribbon cables connecting to the AWEGS computer in a cabinet in the field. This figure shows the input ribbon cables connected to the connector block but the output ribbon cable is not connected to the output connector block. This photograph was taken when the AWEGS system was operating in the shadow mode, and, hence, the outputs were not connected.
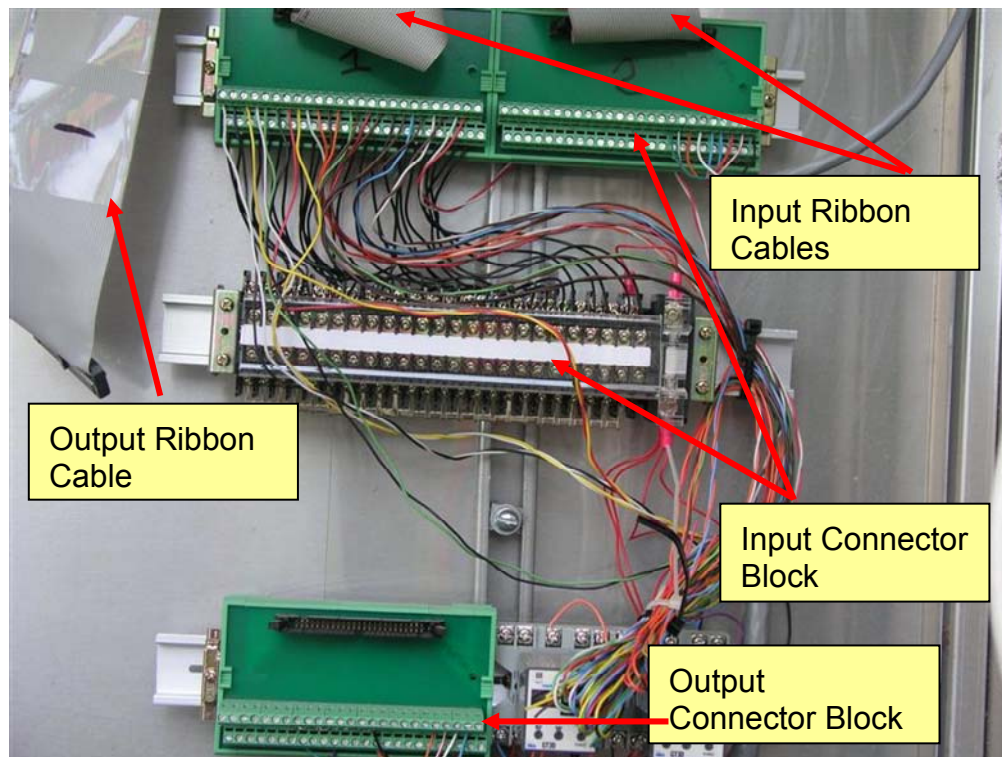
Figure 18. Connector Blocks and Ribbon Cables.

TS-2 Conversion Panel

TS-2 cabinets use a serial bus to communicate the phase status, detector actuations, and other inputs and outputs between the controller and the other cabinet modules in a TS-2 cabinet. In order to have contact-closure access to the various controller inputs required by AWEGS in a TS-2 cabinet, TTI researchers ordered a TS-2 conversion panel from ITS Siemens. The TS-2 conversion panel included a contact-closure panel that provides TTI researchers with access to the following TS-2 controller inputs and outputs:

- Phase On status,

- Phase Next status,

- Phase Check status,

- Phase Hold, and

- Ring Status Bits (3 per ring).

The panel also has other contact-closure connections that are not used by the AWEGS like phase omits, pedestrian omits, and other controller inputs and outputs. Figure 19 illustrates the conversion panel with ribbon cables connected to the BIU rack.
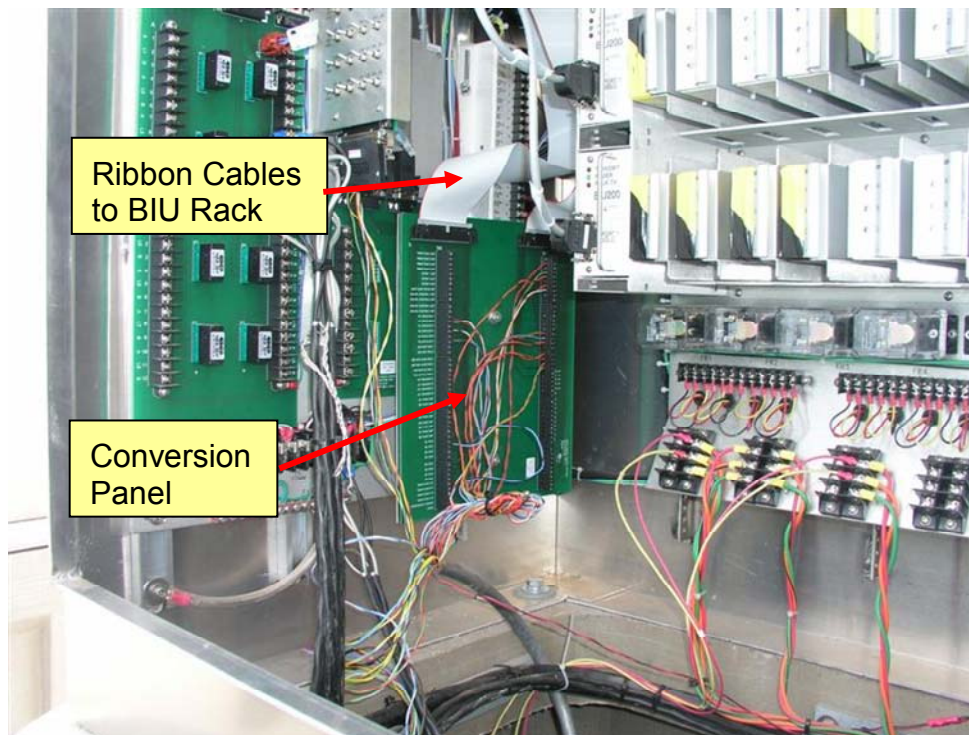
Figure 19. Conversion Panel Installed in a Cabinet.

Timer Relay for Phase Holds

Two electronic timer relays (IDEC GT3D-4AD24) are used to monitor the phase hold signal from AWEGS in case of a malfunction in the system. These relays can only be used when digital I/O cards are used instead of enhanced BIUs. When enhanced BIUs are used, the phase hold signal is sent in the serial data stream via the enhanced BIUs. When digital I/O cards are used, the timer relay is set to mode 3C on the operation mode selector and 8 seconds of delay on the time setting digital switch. In this mode, the relay begins a countdown when a phase hold signal is applied. The phase hold signal passes through closed contacts in the timer relay. If the phase hold signal continues for longer than 8 seconds, the timer relay times down from 8 seconds to 0 and opens the contacts, dropping the phase hold. If the phase hold signal does not last for more than 8 seconds, then nothing happens. The relay resets back to 8 seconds whenever AWEGS drops the phase hold signal. There are two timer relays that work independently for each phase hold. Figure 20 illustrates the layout of the timer relay for phase holds.
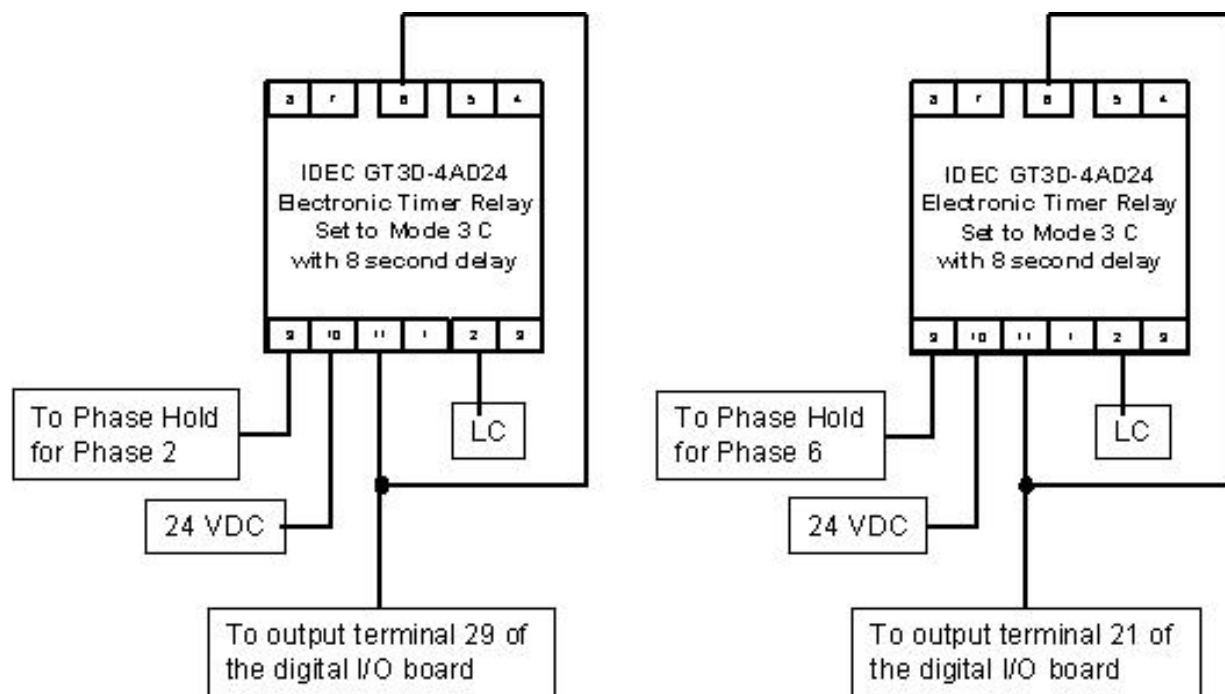
Figure 20. Timer Relay Schematic for Phase Hold.

23

Loop Amplifier Specifications

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

Flasher Panel

TTI researchers designed a flasher panel to operate the beacons on an AWEGS sign. The schematic of the flasher panel is illustrated in Figure 21. The complete fabricated flasher panel installed at all AWEGS locations is illustrated in Figure 22. A requirement of AWEGS is that the flasher must always display a "full on" period within 0.2 seconds of the time the system detects a vehicle at the ADA detector. Surprisingly, the detection-response time of 0.2 seconds is not the real challenge. The real challenge is to always get the "full on" flash time. No off-the-shelf flashers were found in the signal industry that could reliably provide this desired feature. Only expensive microprocessor-based programmable timers were found. Thus, the AWEGS computer is used to "drive the flashers," i.e., the system uses a software flasher to get the desired initial "full on" flash.

Software Flasher System

The software flasher system uses four solid-state relays whose input signal is controlled by AWEGS. When AWEGS turns on one of the four outputs, 24 VDC is supplied to the optically isolated input of a solid-state relay, causing the output of that relay to supply 120 VAC to a particular beacon. By precisely switching the relays alternately on and off, AWEGS creates a software flasher of the desired type of flash.
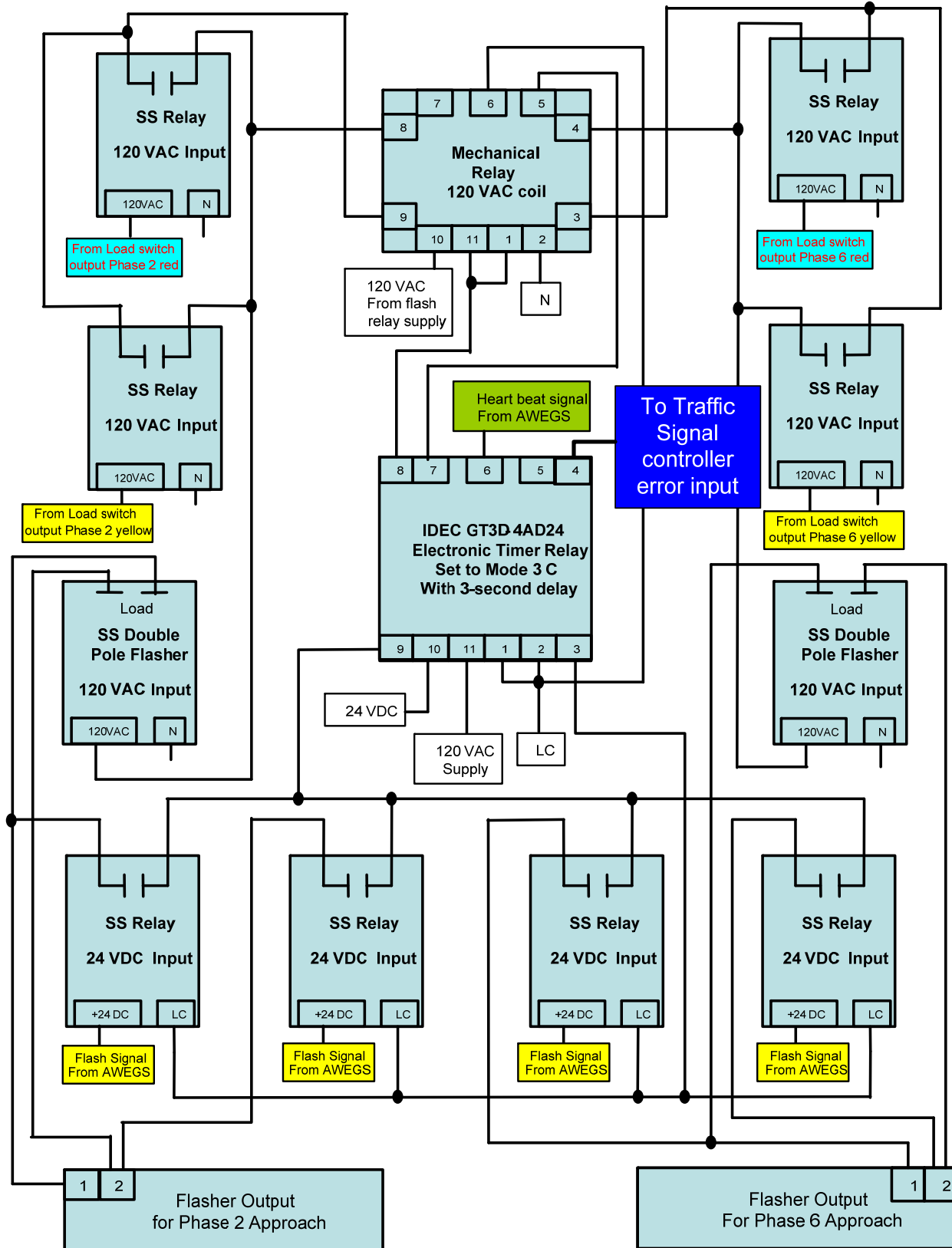
Figure 21. Flasher and Backup Panel Schematic.

Figure 22. Flasher Panel Installed in a Cabinet.

The software flasher was originally used with a 1 second duty cycle, with 0.50 seconds ON and 0.50 seconds OFF. However, a new type of flash pattern called stutter flash was designed and implemented at the AWEGS locations. The objective of the development of stutter flash was to improve the attention value of the flashing beacons. Stutter flash is still experimental for warning signs. However, Section 4L of the *MUTCD* (*2*) provides guidelines for the operation of the stutter flash for in-roadway warning lights. According to Section 4L.02, "The flash rate for In-Roadway Warning Lights at crosswalks shall be at least 50, but not more than 60, flash periods per minute. The flash rate shall not be between 5 and 30 flashes per second to avoid frequencies that might cause seizures." Based on the above requirements, the AWEGS computer was configured to provide a stutter flash of a 1-second cycle with the following on/off configuration:

- 0.1 second — On
- 0.1 second — Off
- 0.1 second — On
- 0.1 second — Off
- 0.1 second — On
- 0.5 seconds — Off

Local conditions may desire a flashing pattern from an alternate flashing top-bottom arrangement of beacons to a simultaneous flashing side-by-side beacon arrangement. This is accomplished by changing the wire connections on the flasher output to the beacons as seen in Figure 21. For simultaneous operation, both beacons for a particular approach are connected to flasher output 1. For alternating flashing operation, one beacon is connected to flasher output 1, and one beacon is connected to flasher output 2.

Backup/Watchdog Flasher System Logic

The flasher panel has been designed to include a watchdog functionality to monitor the heartbeat of AWEGS and provide a backup function if necessary. When AWEGS is operational, the system changes the state of output on the digital output interface every 2 seconds from high to low voltage. The heartbeat (digital output) is connected to the reset terminal of the timer relay that is set to countdown to 3 seconds. The heartbeat signal causes the timer relay to reset its countdown time back to 0 whenever the state changes to low. Whenever the heartbeat is not present for 3 seconds, the timer disconnects the software flasher system and connects the backup flasher system.

During the backup flasher system, beacons on the approaches start flashing at the onset of yellow indication and continue to flash during the red indications of phases for those approaches. The beacons stop flashing at the onset of green indication. The optically isolated inputs of the four 120 VAC input solid-state relays constantly monitor the status of the load switches for the yellow or red indications of those phases. When the backup system is activated, the timer relay's normally closed contact powers the 120 VAC output supply voltage of the solid-state relays monitoring the load switches. When any one of the four solid-state relay's inputs is supplied 120 VAC from a load switch, the relay supplies 120 VAC to the appropriate solid-state double pole flasher that is connected to the flasher beacon associated with that particular phase. When

27

the heartbeat is restored, the timer relay disconnects the backup flasher system power supply and connects the AWEGS software flashers with 120 VAC power supply and logic common connection.

The backup system will also flash the beacons when the cabinet is in cabinet flash, when the Malfunction Management Unit (MMU) detects a malfunction, or if the power to the flash transfer relay's input is not present for any reason. The mechanical relay's 120 VAC input is supplied from the same source as the flash transfer relay's input source. When 120 VAC input is not present on the relay's input due to a fault condition or loss of power, the normally closed contacts in the mechanical relay power both solid-state two-pole flashers. The backup flasher system's control logic was created by combining the inputs and outputs of four solid-state relays with one mechanical relay and one timer relay.

Components Procurement Specifications

The components required for installing AWEGS at a site were procured from various vendors. This section provides details for purchasing the various components.

Industrial PC

Model # KR-4201-PCI951

- KR-4201-PCI951 4U KISS System configured with PCI-951 Single Board Computer
- 4U 19"Wx18.58"D
- 3-5.25" Drive Bays
- 1-Slimline Drive bay
- 2-Front USB Ports
- KR-4201-PCI951BASE: PARTS LIST PCI-951 CONF
- 602-0133-00: 460W P/S W/ AGENCY LABEL
- ST3250820A: ATA-100 7200RPM 250GB 8MB
- DH-20A4H: DVD +/-RW/R DL 20X IDE LTSCRB
- FD-1.4MBR: 1.44MB FLOPPY DRIVE BLACK ROHS
- Qty - 2**,** 512NU-DDR400R: 512MB NON ECC UNBUF PC-3200
- BP10-12P: BP PICMG 1.0 12PCI

Vendor

Kontron America, Inc.

14118 Stowe Dr.

Poway, CA 92064-7147

Telephone: (888) 294-4558

Website: http://us.kontron.com

Number required: 1

Estimate: $2300

Enhanced BIU

This kit consists of a BIU and a serial cable to connect the BIU to the PC.

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

4 Port Serial Card and Cable

The Digi Neo 4 RS-232 serial port card expands the number of serial ports available on the industrial PC to six (industrial PC comes with two serial ports). The serial ports on the industrial PC are used by AWEGS to communicate with enhanced BIUs 1, 3, 4, and the detector BIU.

Digi Neo 4 port Universal PCI (3.3V & 5V) serial board. Digi Part #: 77000857 (http://www.cdw.com/shop/products/default.aspx?EDC=534357)

Digi Network Splitter Cable with 4 DB-9 male connectors. Digi part#: 76000528 (http://www.cdw.com/shop/products/default.aspx?EDC=255964)

Vendor

CDW

Telephone: (800) 750-4239

Website: http://www.cdw.com/

Number Required: 1 each

Estimate: $186 for the 4 Port Universal PCI

              $40 for the Digi Network Splitter

National Instruments Digital I/O Card

Card #: NI PCI-6527

- o 24 optically isolated digital inputs (0-28 VDC)

- o 24 isolated, solid-state relay digital outputs (0-60 VDC, 0-30 Vrms)

- o Switch up to 120 mA

CB-100 I/O Connector Kit - 776164-90

The CB-100 kit includes two CB-50 I/O connector blocks and an R1005050 ribbon cable for connecting to a PCI-6527device. Each CB-50 block includes hardware for mounting the accessory on a standard DIN-rail 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: $1560 including two cards, software, and cables.

TS-2 to TS-1 Cabinet Conversion Kit

This kit consists of a panel and two BIUs in two BIU racks.

Vendor

ACM Highway Products

P.O. Box 1732

Austin, TX 78680

Telephone: (512) 255-1464

Number required: 1

Estimate: $1400 including installation on site

Surge Protectors

These surge protectors are designed to protect the equipment in the cabinet from lightning surges coming in from conductors for each beacon.

Model # DS 150E

Vendor

Citel, Inc.

1515 NW 167th Street, Suite 6-303

Miami, FL 33169

Telephone: (800) 248-3548

Website: http://www.citelprotection.com/citel/din_rail.htm

Number required: 4

Estimate: $500

2 Pole Flashers

These flashers serve as backup flashers and are installed on the flasher panel.

Model # TF-9-60 (60 FPM Solid State, 2 Pole Flasher).

Vendor

Electrosystems Bellingham, Inc.

P.O. Box 9754

Bellingham, WA 98227

Telephone: (800) 668-2254

Website: http://www.es-web.com/TFF12.html

Number required: 3 (including 1 spare)

Estimate: $180

CB-50 Input Connector Block Interface

Components illustrated in Table 2 are required for building the CB-50 input connector block interface and can be purchased from an electronic component store.

Table 2. Components of a NI-DAQ Cabinet Interface.

Parts to Build NI-DAQ Traffic Cabinet Interface	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 Jumpers 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 BNM7	1	$0.99	$0.99
End Clip Idec BNM3	1	$0.30	$0.30
Fuse Holder Idec BNF10SW	1	$5.11	$5.11
End Clip Idec BNM3	1	$0.30	$0.30
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
16K ohm resistors	24		$0.00
Box of red fork terminals	1	$5.00	$5.00
		Total	**$188.19**

Flasher Panel

The parts shown in Table 3 are required to fabricate the flasher panel. These components can be procured from an electronic component store.

Table 3. Components for a Flasher Panel.

Parts of a Flasher Panel	
	Quantity
Idec GT3D-4AD24 timer relay and base	4
Potter Brumfield KRPA 14AG-120 Mechanical Relay with base	2
Potter Brumfield SSR-240A25 Solid State relay	5
Potter Brumfield SSR-240D25 Solid State relay	5
Aluminum DIN Rail	1
Double Terminal Blocks Idec BNDH15W	24
Double Terminal Block End Plate Idec BND15W	1
Fork Terminal Jumpers Idec BNJ26FW	5
DIN Rail Stop Idec BNL-8	2
Single Terminal Blocks Idec BNH15MW	24
Single Terminal Block End Plate Idec BNE15W	1
DIN Rail Stop Idec BNL-5	2
Dust Cover Idec BNC230	1
Marking Strip Idec PVC BNM7	1
End Clip Idec BNM3	1
Fuse Holder Idec BNF10SW	1
End Clip Idec BNM3	1
1/20A fuse	1
10 ' of 19 pair 22 AWG wire	1
1 roll of 22 AWG wire	1
In line fuse holders	4
5 amp fuses	4
15K ohm resistors	24
Box of red fork terminals	1

AWEGS Design and Operational Guidelines

The engineer should design AWEGS with the best traffic and roadway data that can be obtained. In addition, an accurate inventory of the existing traffic detector layouts (e.g., from Nader's guide) must be provided. Even the type of existing signal controller, cabinet features, and signal timings must be determined. Since current AWEGS design requires the installation of a hardened industrial-grade computer, the engineer should determine the available space in the cabinet and the quality of the cooling system as these are important factors. Construction and installation of inductive loop detectors to the designated spacing and sizes are also paramount.

Accurate and relevant data are the key to the design and evaluation of AWEGS. As can be seen from the equation to determine advance detector location, a careful investigation is needed to obtain precise information on the 99th and 85th percentile speeds in addition to the approach gradient. A speed study, therefore, becomes extremely important.
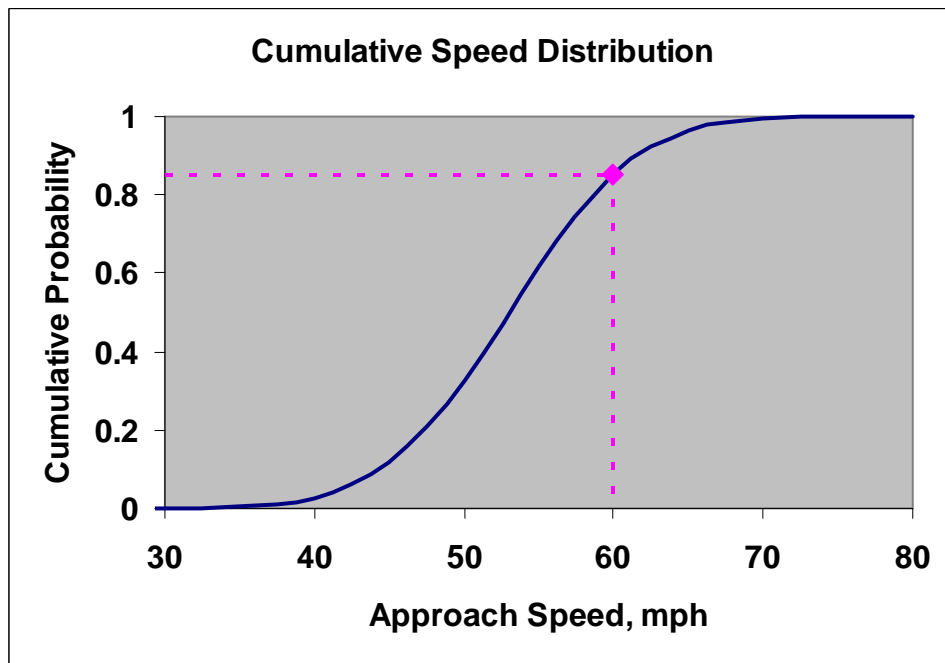
Spot-Speed Data

Important inputs to the design of AWEGS systems include the characteristics of traffic flow, including traffic speed, traffic mix, and degree of interruption by adjacent traffic signals. AWEGS design assumes that the arrival traffic is located in Texas, is isolated from adjacent traffic signals, has mixed traffic of cars (and pickups) and trucks, and has free-flowing speeds that are normally distributed. Spot-speed studies for each high-speed approach should consider TxDOT's *Procedures for Establishing Speed Zones* (*10*). Additionally, record spot speeds only during the green signal display, while locating the sample station approximately 1000 feet in advance of the signalized intersection.

Data Analysis

Figure 23 shows an example distribution of spot speeds for a high-speed rural highway for a mean (50th percentile) speed of 53 mph and an 85th percentile speed of 60 mph for the eastbound approach of TX 16 at FM 475. Note that 15 percent of the traffic will be traveling at speeds exceeding the 85th percentile speed. Thus, some higher-speed drivers may find stopping on red difficult unless warned in advance. Spot-speed data should provide the following speed results for each high-speed approach at the intersection:
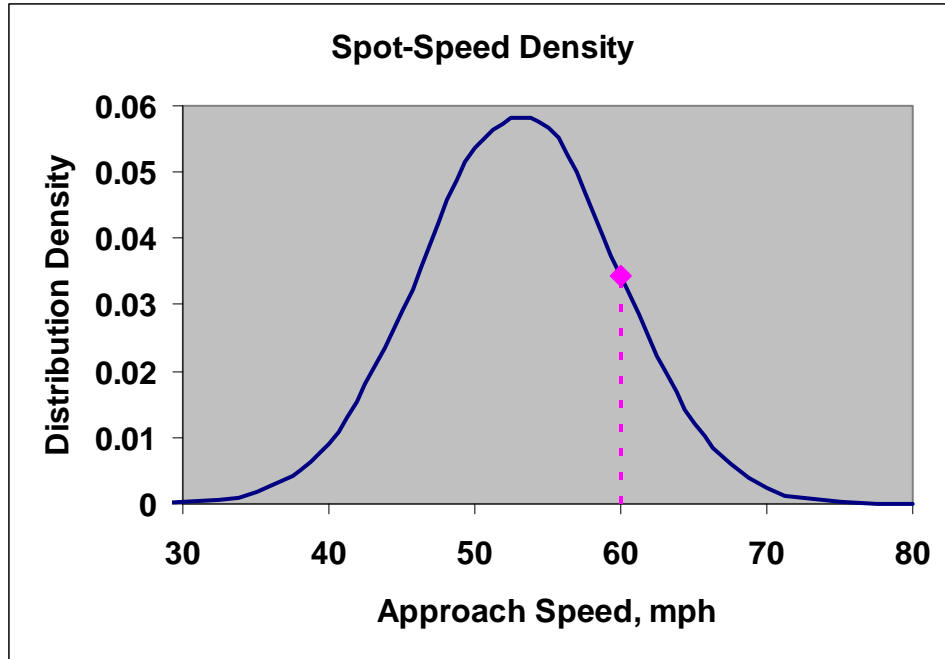
a.   Distribution Density of Approach Spot Speeds.

b. Cumulative Distribution of Approach Spot Speeds.

Figure 23. High-Speed Traffic Not Covered by Typical Dilemma Zone Detection Layouts.

Eastbound TX 16 at FM 475:

    1. 85th percentile speed: $V_{85\%}$ = 60 mph.

    2. 50th percentile speed: $V_{50\%}$ = 53 mph.

    3. std. dev. of speed: σ = 7 mph.

Microsoft Excel makes it extremely easy to calculate the percentile values as well as the average and standard deviation from the spot-speed data collected. The Nth percentile can be calculated in Excel by using the function "=*percentile (array,N),*" where N is the percentile desired (e.g., 15th, 50th, or 85th) and array is the selection of all the spot-speed observations. For calculating the average, the function *"=average (array)"* and, for the standard deviation, the function *"=stdev (array)"* is to be used.

Existing Dilemma Zone Detection Layout

The existing detector layout for each high-speed approach should be accurately measured. Detector locations, marked in feet from the leading edge of the loop to the stop-line, need to be documented. Multiple-loop designs may include as many as three to five advance detectors. Nader's guide identifies only two or three dilemma zone detectors with uniform spacing between them. Stop-line queue detection may also be provided.

Traffic Signal Controller Programming

The AWEGS algorithm requires some signal controller parameters to predict the operation of the traffic signal controller. These include main-street phase numbers, phasing sequence (ring structure), phase minimums, phase maximums, and passage times. AWEGS functions under the assumption that Nader's guidelines (*7*) are used in the placement of the dilemma zone detectors. Nader's guidelines also recommend the passage times to be used. TTI researchers have recommended some modifications in the passage times. Table 4 illustrates the location of the detectors and the passage times recommended by Nader's guidelines (*7*) as well as TTI recommended passage times.

Table 4. Nader's Guide on Detector Installation with TTI's Recommended Passage Times.

Approach Speed, mph	Distance from Head of Detector to Stop-line at Intersection, Feet			Stop-line Area Detector[a], Feet	Passage Gap[a], Seconds	TTI Rec. Passage Gap[b], Seconds
	CDA 1	CDA 2	CDA 3			
45	330	210	---	6 x 40	2.0	2.8
50	350	220	---	6 x 40	2.0	2.8
55	415	320	225	6 x 40	1.2	1.6
60	475	375	275	6 x 40	1.4	1.5
65	540	430	320	6 x 40	1.2	1.6
70	600	475	350	6 x 40	1.2	1.7

[a] Nader's guide
[b] Minimum recommended gap

AWEGS works on the assumption that Nader's detector guidelines are followed for installation of detectors, and appropriate passage times are used to ensure safe and efficient intersection operations. It is also crucial that the engineers and technicians verify the location of the dilemma zone detectors and ensure that the correct controller settings are coded in AWEGS. To predict the controller operations, users will have to make the following minor changes to the detector delay.

Detector Delay

It is necessary to program a delay of 1 to 5 seconds on the arterial left-turn phases and side-street phases in the controller. Note that this delay is programmed in the signal controller and not on the detector amplifier. This delay, which is only effective during red, is necessary for two reasons. A delay placed in the controller will provide vehicle presence data to the AWEGS algorithm before the signal controller detects it. Hence, AWEGS has an opportunity to respond to the call on the side street or arterial left turn by flashing the beacons if necessary.

Second, AWEGS may sometimes start flashing the beacons because of false actuations. These false actuations occur when arterial left-turn vehicles actuate the side-street detector or when left-turn vehicles from the side street actuate the arterial left-turn detector. Placing a delay on these detectors minimizes the occurrences of the traffic signal controller and AWEGS responding unnecessarily to these false calls.

Table 5 illustrates the detector delays recommended in the signal controller to use AWEGS on Phase 2 and Phase 6 at an example intersection. Delays recommended in the table should be programmed *in the traffic signal controller*. The algorithm is monitoring the detector

status on the detector panel. Thus, AWEGS detects the presence of the vehicle as soon as the vehicle actuates the detector. However, by introducing the delay in the controller, the controller does not detect these vehicles until the delay has expired. This time lag permits AWEGS to function appropriately by flashing the beacons and provides warning if necessary. This time lag also prevents the controller from reacting to unnecessary actuations like permitted arterial left turns that turn on a green ball, false actuations, and right turns on red. Reduction in the controller reacting to these unnecessary actuations improves intersection operations as well as AWEGS performance.

Table 5. Recommended Detector Delays for a Typical Intersection.

Phase Number	Movement Type	Condition	Delay, Seconds	Purpose
1 and 5	Arterial left—protected	If no false actuations from side-street lefts	1	To have advance warning before controller
		If side-street lefts actuate arterial left-turn detectors	3–4	To filter false calls and have advance warning before controller
	Arterial left—protected-permitted	None	3–4	To filter permitted arterial left-turn traffic, to filter false calls from side street and have advance warning before controller
3 and 7	Side-street left	If no false actuations from arterial lefts	1	To have advance warning before controller
		If arterial lefts actuate side-street left-turn detectors	3–4	To filter false calls
4 and 8	Side-street through	If side-street right-turn traffic actuates the detectors	7–8	To filter right-turn-on-red vehicles

AWEGS Programming

The AWEGS algorithm requires some input parameters for the system to start functioning. These parameters include signal controller data, intersection detector location data, advance detector location data, and the location of AWEGS signs from the stop bar. The signal controller data include phase numbers, phasing sequence (ring structure), phase minimums, phase maximums, and passage times. Figure 24 illustrates the AWEGS application display screen. More details of the programming of the AWEGS software are illustrated in Appendix B.
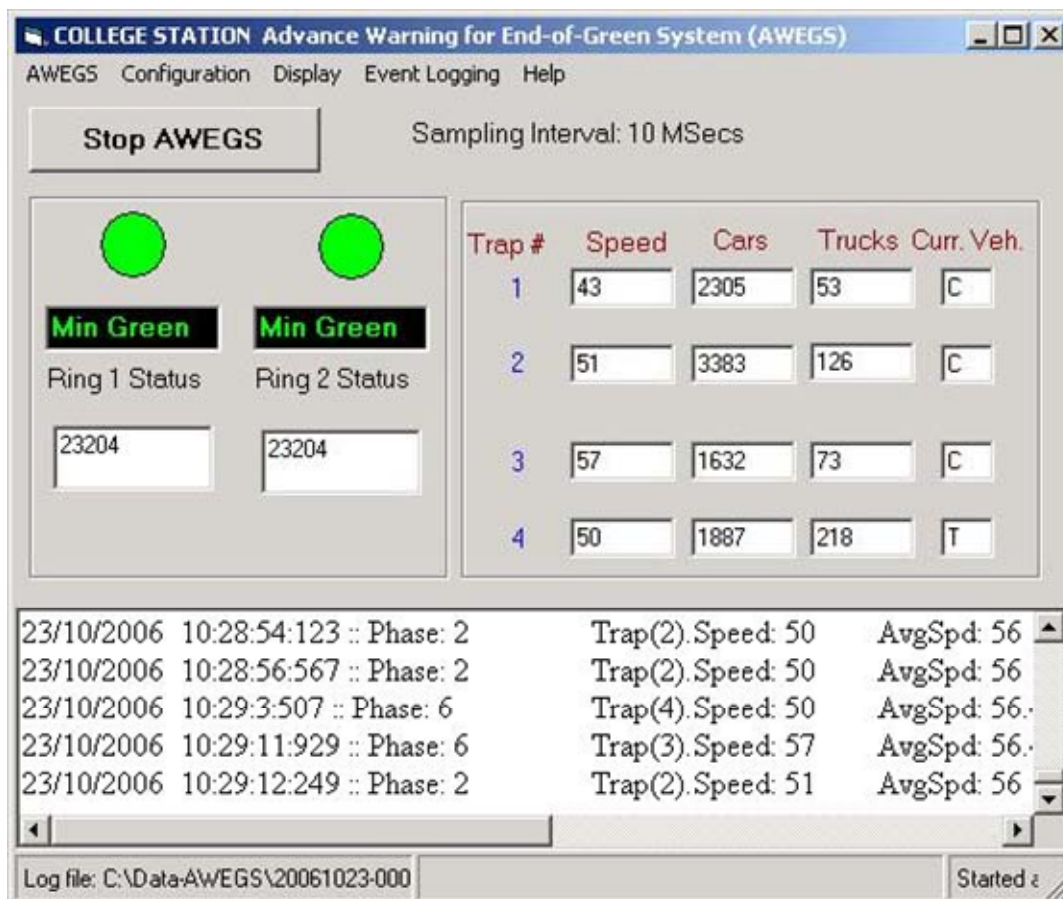

Figure 24. AWEGS Application Display Screen.

MAINTENANCE GUIDELINES

Maintenance of various components needs to be given careful attention to properly operate AWEGS. These components are listed below.

Beacons and Signs

The alignment of W3-4 signs and LED beacons should be maintained as specified. They should always target the road at drivers' eye height near the advance detectors. Signs and beacons can rotate due to high winds and lose their orientation if they are not tightened properly. The beacons should also be verified to ensure that the LED beacons continue to provide the necessary illumination and provide acceptable flashing operation.

The agency must check W3-4 sign assemblies (signs and beacons) frequently for damage due to vandalism. These W3-4 sign assemblies have an important function by providing motorists with critical information about signal indication changes. Hence, efforts should be made to ensure continuous functionality of these assemblies.

The technicians or engineers can easily identify if AWEGS is operating in its backup mode by observing the beacons flashing for a few cycles. If AWEGS was implemented with a stutter flash, AWEGS operation is normal when the beacons are having a stutter flash. If the beacons are having a normal flash, it would mean that AWEGS is operating in the backup mode. However, if AWEGS was implemented with a normal flash, the technician or the engineer may have to observe more than one cycle to see if the beacons start flashing before the onset of yellow. If the beacons start flashing before the onset of yellow, AWEGS is operating properly. However, if the beacons are always starting at the onset of yellow in the traffic signal indication, AWEGS may be in its backup mode.

Traffic Signal Controller Data

It is essential that AWEGS uses the data residing in the traffic signal controller. Any change made in the signal controller settings also needs to be made in the AWEGS database. Failure to do so could result in AWEGS not performing properly. The signal controller data to be verified include phasing sequence (ring structure and/or alternate sequence), phase minimums, phase maximums, passage times, and phase detector delays.

Detectors

Properly functioning detectors are critical for AWEGS functionality. These include the intersection detectors (including dilemma zone detectors) as well as the advance detectors. Regular inspection for the functionality of these detectors is essential. Detector amplifiers should also be checked for their settings and confirmed in the AWEGS database.

AWEGS SYSTEM VERIFICATION

How to Verify AWEGS Is Working Properly

1. Observe the W3-4 signs on one of the main street approaches for about 15 minutes. Attention should be paid to when the beacons on the warning sign start flashing with respect to the start of yellow for the respective approach.

2. AWEGS will usually start flashing the beacons about 5 – 6 seconds before the start of yellow. If the beacons start flashing at least once before the onset of yellow, it implies the AWEGS is functioning properly.

3. If the beacons start flashing at the onset of yellow every time during the 15 minute period, this implies that AWEGS is down, and the backup flasher is operating the beacons. If this is the case, please restart the AWEGS as described next.

4. If the beacons are either continuously flashing or not flashing at all during the 15 minute period, this implies that AWEGS and the backup flasher are not functioning properly. Please contact Texas Transportation Institute (TTI) at one of the following phone numbers:

    Texas Transportation Institute
    Srinivasa Sunkari: (979) 845-7472
    Hassan Charara: (979) 845-1908

How to Restart the AWEGS System

1. Turn off the power to the PC, either by unplugging the power cord on the back of the PC or turning off the power switch on the front of the PC. Wait for about 1 minute before powering it on again.

2. If you have a monitor, plug it into the video connector on the back of the PC, and verify that the PC booted properly and the AWEGS screen is displayed.

3.   If the PC boots up properly and the AWEGS intersection screen is displayed, then repeat the system verification steps described above by observing the beacons for 15 minutes. Beacons should flash before the onset of yellow at least once in the 15 minute period. If not, contact TTI.

4.   If the PC does not boot up properly or the AWEGS screen does not get displayed after booting up the system, contact TTI.

5.   If you don't have a monitor, wait for about 5 minutes after booting up the industrial PC, and then repeat the system verification steps described above by observing the beacons for 15 minutes. Beacons should flash before the onset of yellow at least once in the 15 minute period. If not, contact TTI.

REFERENCES

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2 *Manual on Uniform Traffic Control Devices.* U.S. Department of Transportation, Washington, D.C., December 2000.

3 *Sign Crew Field Book.* Second Edition, Traffic Operations Division, Texas Department of Transportation, Austin, Texas, April 1998.

4 *Texas Manual on Uniform Traffic Control Devices.* Texas Department of Transportation, Austin, Texas, 2006.

5 Messer, C.J., S.R. Sunkari, H.A. Charara, and R.T. Parker. *Design and Installation Guidelines for Advance Warning Systems for End-of-Green Phase at High Speed Traffic Signals.* Report 4260-2, Texas Transportation Institute, College Station, Texas, September2003.

6 . Technical Council Task Force 4TF-1 (B. Thompson, Chair). *Determining Vehicle Signal Change and Clearance Intervals.* Institute of Transportation Engineers, Washington, D.C.,August 1994.

7 *Detector Chapter/Applications Manual (draft).* Traffic Operations Division, Traffic Management Section, Texas Department of Transportation, Austin, Texas, circa 1996.

8 Sunkari, S.R., R.T. Parker, H.A. Charara, T.A. Palekar, and D.R. Middleton. *Evaluation of Cost-Effective Technologies for Advance Detection.* Report 5002-1, Texas Transportation Institute, College Station, Texas, September 2005.

9 Retting, R.A., A.F. Williams, and M.A. Greene. Red-Light-Running and Sensible Countermeasures. *Transportation Research Record 1640*, Transportation Research Board, National Research Council, Washington, D.C., 1998.

10 *Procedures for Establishing Speed Zones.* Texas Department of Transportation, Austin, Texas, August 2000.

APPENDIX A – INPUT OUTPUT CHANNEL DETAILS

Input Ports - Intersection with One-Lane Approaches

AWEGS Digital I/O Wiring Map for First NI Digital I/O Card 6527

Input Port 0

Channel 0 - **47**   Ring 1 – Bit A
Channel 1 - **45**   Ring 1 – Bit B
Channel 2 - **43**   Ring 1 – Bit C
Channel 3 - **41**   Ring 2 – Bit A
Channel 4 - **39**   Ring 2 – Bit B
Channel 5 - **37**   Ring 2 – Bit C
Channel 6 - **35**   Main Phase 1 – Phase On
Channel 7 - **33**   Main Phase 2 – Phase On

Input Port 1

Channel 0 - **31**   Phase 1 – Stop-bar Detector
Channel 1 - **29**   Phase 2 – Stop-bar Detector
Channel 2 - **27**   Phase 3 – Stop-bar Detector
Channel 3 - **25**   Phase 4 – Stop-bar Detector
Channel 4 - **23**   Phase 5 – Stop-bar Detector
Channel 5 - **21**   Phase 6 – Stop-bar Detector
Channel 6 - **19**   Phase 7 – Stop-bar Detector
Channel 7 - **17**   Phase 8 – Stop-bar Detector

Input Port 2

Channel 0 - **15**   ADA – 1   Main Phase 1
Channel 1 - **13**   BDA – 1   Main Phase 1
Channel 2 - **11**   ADA – 2   Main Phase 2
Channel 3 - **9**   BDA – 2   Main Phase 2
Channel 4 - **7**   Main Phase 1 – CDA
Channel 5 - **5**   Main Phase 2 - CDA
Channel 6 - **3**
Channel 7 - **1**

Main Phase 1 = Main Phase with Number <= 4
Main Phase 2 = Main Phase with Number > 4
Every ADA and BDA is a speed trap. ADA is the leading detector in the trap.

Output Ports – Intersection with One-Lane Approaches

AWEGS Digital I/O Wiring Map for First NI Digital IO Card 6527

Output Port 3

Channel 0 - **47**   Main Phase 1 - Flasher – Beacon 1
Channel 1 - **45**   Main Phase 1 - Flasher – Beacon 2
Channel 2 - **43**   Main Phase 2 - Flasher – Beacon 1
Channel 3 - **41**   Main Phase 2 - Flasher – Beacon 2
Channel 4 - **39**
Channel 5 - **37**
Channel 6 - **35**
Channel 7 - **33**

Output Port 4

Channel 0 - **31**
Channel 1 - **29**   Main Phase 1 Hold
Channel 2 - **27**
Channel 3 - **25**
Channel 4 - **23**
Channel 5 - **21**   Main Phase 2 Hold
Channel 6 - **19**
Channel 7 - **17**

Output Port 5

Channel 0 - **15**   System Heartbeat
Channel 1 - **13**
Channel 2 - **11**
Channel 3 - **9**
Channel 4 - **7**
Channel 5 - **5**
Channel 6 - **3**
Channel 7 - **1**

Input Ports – Intersection with Two-Lane Approaches

AWEGS Digital I/O Wiring Map for First NI Digital IO Card

Input Port 0

Channel 0 - **47**	Ring 1 – Bit A	
Channel 1 - **45**	Ring 1 – Bit B	
Channel 2 - **43**	Ring 1 – Bit C	
Channel 3 - **41**	Ring 2 – Bit A	
Channel 4 - **39**	Ring 2 – Bit B	
Channel 5 - **37**	Ring 2 – Bit C	
Channel 6 - **35**	Main Phase 1 – Phase On	
Channel 7 - **33**	Main Phase 2 – Phase On	

Input Port 1

Channel 0 - **31**	Phase 1 – Stop-bar Detector
Channel 1 - **29**	Phase 2 – Stop-bar Detector
Channel 2 - **27**	Phase 3 – Stop-bar Detector
Channel 3 - **25**	Phase 4 – Stop-bar Detector
Channel 4 - **23**	Phase 5 – Stop-bar Detector
Channel 5 - **21**	Phase 6 – Stop-bar Detector
Channel 6 - **19**	Phase 7 – Stop-bar Detector
Channel 7 - **17**	Phase 8 – Stop-bar Detector

Input Port 2

Channel 0 - **15**	ADA – 1	Main Phase 1 Left Lane
Channel 1 - **13**	BDA – 1	Main Phase 1 Left Lane
Channel 2 - **11**	ADA – 2	Main Phase 1 Right Lane
Channel 3 - **9**	BDA – 2	Main Phase 1 Right Lane
Channel 4 - **7**	ADA – 3	Main Phase 2 Left Lane
Channel 5 - **5**	BDA – 3	Main Phase 2 Left Lane
Channel 6 - **3**	ADA – 4	Main Phase 2 Right Lane
Channel 7 - **1**	BDA – 4	Main Phase 2 Right Lane

Main Phase 1 = Main Phase with Number <= 4
Main Phase 2 = Main Phase with Number > 4
Every ADA and BDA is a speed trap. ADA is the leading detector in the trap.

AWEGS Digital I/O Wiring Map for Second NI Digital IO Card

Input Port 0

Channel 0 - **47**   Main Phase 1 - CDA
Channel 1 - **45**   Main Phase 2 - CDA
Channel 2 - **43**
Channel 3 - **41**
Channel 4 - **39**
Channel 5 - **37**
Channel 6 - **35**
Channel 7 - **33**

Input Port 1

Channel 0 - **31**
Channel 1 - **29**
Channel 2 - **27**
Channel 3 - **25**
Channel 4 - **23**
Channel 5 - **21**
Channel 6 - **19**
Channel 7 - **17**

Input Port 2

Channel 0 - **15**
Channel 1 - **13**
Channel 2 - **11**
Channel 3 - **9**
Channel 4 - **7**
Channel 5 - **5**
Channel 6 - **3**
Channel 7 - **1**

Output Ports - Intersection with Two-Lane Approaches

AWEGS Digital I/O Wiring Map for First NI Digital IO Card

Output Port 3

Channel 0 - **47**   Main Phase 1 - Flasher – Beacon 1
Channel 1 - **45**   Main Phase 1 - Flasher – Beacon 2
Channel 2 - **43**   Main Phase 2 - Flasher – Beacon 1
Channel 3 - **41**   Main Phase 2 - Flasher – Beacon 2
Channel 4 - **39**
Channel 5 - **37**
Channel 6 - **35**
Channel 7 - **33**

Output Port 4

Channel 0 - **31**
Channel 1 - **29**   Main Phase 1 Hold
Channel 2 - **27**
Channel 3 - **25**
Channel 4 - **23**
Channel 5 - **21**   Main Phase 2 Hold
Channel 6 - **19**
Channel 7 - **17**

Output Port 5

Channel 0 - **15**   System Heartbeat
Channel 1 - **13**
Channel 2 - **11**
Channel 3 - **9**
Channel 4 - **7**
Channel 5 - **5**
Channel 6 - **3**
Channel 7 - **1**

APPENDIX B – AWEGS PROGRAMMING SCREENS

AWEGS Configuration

  The AWEGS system has four drop down menus: AWEGS Menu, Configuration Menu, Display Menu, and Help Menu. Each menu includes a number of sub-menus that allows the user to either enter data or turn on/off some selections.

AWEGS Menu

  The AWEGS drop down menu (Figure 25) lists the following options:

| Stop |
| Event Logging |
| Save XML Configuration File |
| Exit |
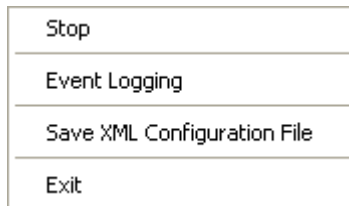
Figure 25. Options in AWEGS Menu.

- **Stop**: The stop option allows the user to stop the AWEGS system. Once stopped, the Stop option is changed to "Start," and the user can select it to restart the AWEGS system.

- **Event Logging**: The Event Logging option opens a new window (Figure 26) that includes a list of the seven data logging events provided by AWEGS. The user can select/deselect each option by checking/un-checking the Check Box next to the option in the list. The seven data logging options provided by AWEGS include:

    - General Events (.Ada Files): This option enables the user to log actuations in the stop-bar detector, dilemma zone detectors, advance detectors, and traffic signal system events like phase status into a daily log file with ".Ada" extension;

    - Detector Failure Events (.DetFail Files): This option logs failures of any advance detectors, dilemma zone detectors, or stop-bar detectors into a daily log file with ".DetFail" extension;

    - Flashing Events (.Flash Files): This option logs a record of every time AWEGS makes a decision to flash the beacons into a daily log file with ".Flash" extension.
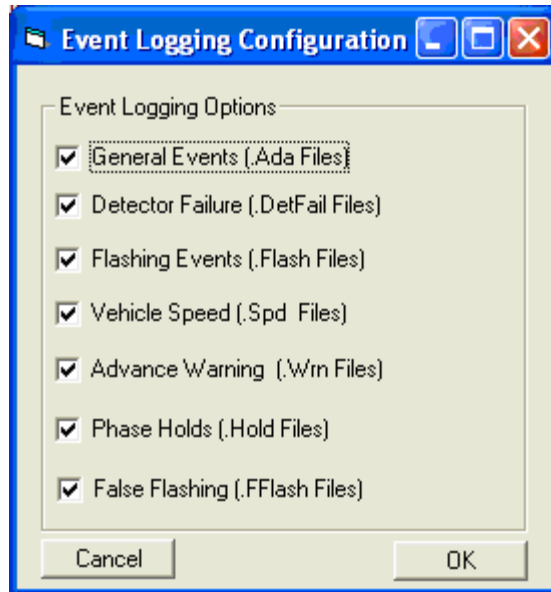
Figure 26. Event Logging Menu.

- Vehicle Speed Events (.Spd Files): This option logs the estimated speed of every vehicle detected by AWEGS advance trap detectors into a daily log file with ".Spd" extension.

- Advance Warning Events (.Wrn Files): This option logs the duration of advance warning provided to motorists into a daily log file, with ".Wrn" extension.

- Main-Street Phase Hold Events (.Hold Files): This option logs the duration of each phase hold placed by AWEGS into a daily log file with ".Hold" extension.

- False Flashing Events (.FFlash Files): This option logs each false flash decision made by AWEGS into a daily log file, with ".FFlash" extension.

- **Save XML Configuration File**: This selection enables the user to save any changes made to the AWEGS configuration in the AWEGS.XML configuration file. Any time the user makes any changes to the AWEGS configuration, he must select this option to save the changes to the configuration file so that AWEGS will remember these changes when stopped and started again. Otherwise, the changes are lost when AWEGS is stopped, and the user must reenter them again.

- **Exit**: This option enables the user to terminate AWEGS.

Configuration Menu

The Configuration menu (Figure 27) includes the following options:

56
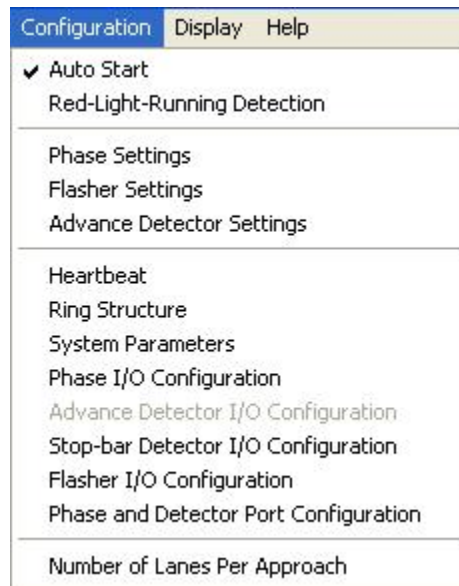
Figure 27. Configuration Menu.

- **Auto Start**: Selecting this option will enable AWEGS to run automatically when AWEGS is started. Otherwise, the user has to select the "Start" option from the AWEGS menu and start the system manually. This option is included and must be selected when the system is running in the field so that AWEGS will start automatically any time the PC restarts due to a power failure in the field. The check-mark before the "Auto Start" option in the menu indicates it is currently selected. The check-mark is turned on/off by selecting/deselecting the menu option again.

- **Red-Light-Running Detection**: Similar to the "Auto Start" option, the "Red-Light Running Detection" option can be selected/deselected. This selection enables the logging ".vda" extension and red-light running events for further evaluation by the user into a daily log file. However, in order to collect any red-light running events, the user must install video cameras at the intersection and define the red-light running detection zones properly in front of the stop-bar for main street phases.

- **Phase Settings**: Main street phase data required by AWEGS can be entered in a window called "Phase Settings" (Figure 28). The phase data required by AWEGS include:

  - Main street phases minimum green in seconds,
  - Main street MAX # 1 in seconds,
  - Main street Passage time in seconds,

57

- "C1 to SB Dist"; i.e., the distance from the leading edge of the first dilemma zone detector (furthest from the stop-bar) to the stop-bar in feet,
- "C2 to SB Dist"; i.e., the distance from the leading edge of the middle dilemma zone detector to the stop-bar in feet,
- "C3 to SB Dist"; i.e., the distance from the leading edge of the third dilemma zone detector (closest to the stop-bar) to the stop-bar in feet,
- Average speed on main street approaches,
- 85th percentile speed on main street approaches, and
- Detector delay required by AWEGS and entered in the controller for each minor street or arterial left turn stop-bar detector.

The user must also select the following settings:
- Identify main street phase by selecting the proper check-boxes in the "Main" row.
- Identify minor street phases in the "Minor Phase" row.
- Identify the phase direction of the main street phase from the pull down combo boxes in the "Phase Direction" row.
- Display the main street phases in the intersection display by checking the proper check-box in the "Phase On" row.
- Identify phases that AWEGS is monitoring either from the detector input or phase check input in the "Phase Check" row.
- Identify phases that have "Memory On" turned on in the controller.
- Identify arterial left-turn phases from the "Arterial Left Phase" row.
- Select the left-turn phasing sequence by checking in the "Lagging Left" row to indicate whether an arterial left-turn phase is leading or lagging.
- Select in the "Omitted During Prmpt" row whether a phase is omitted during train preempt events at the intersection or not.
- Select in the "Track Phase" row whether a phase is a track phase during train preempt events or not.

Once the required information is entered in the "Phase Settings" window, the user must click the "Update Phase Settings" button to save the entered information.

Figure 28. Phase Settings Screen.

- **Flasher Settings**: This screen (Figure 29) allows the user to select the Flashing Mode (Stutter or Normal), the duration of the ON interval of the flashing beacons (Half Cycle ON Interval), and the duration of the completely OFF interval during which both beacons on the W3-4 warning signs will be off (Half Cycle OFF Interval). In case the Stutter flash mode is selected, the user needs to enter the duration for the ON and OFF portions of

each of the three intervals "Interval,1," "Interval,2," and "Interval,3" under the Stutter

Flash Parameters section in the window. The total value of all of the ON and OFF portion

of the three intervals should be equal to the value entered for the "Half Cycle ON

Interval." By clicking the "OK" button, the new values entered are saved. However, if the

user wants AWEGS to use the new flasher settings next time it is stopped and started, the

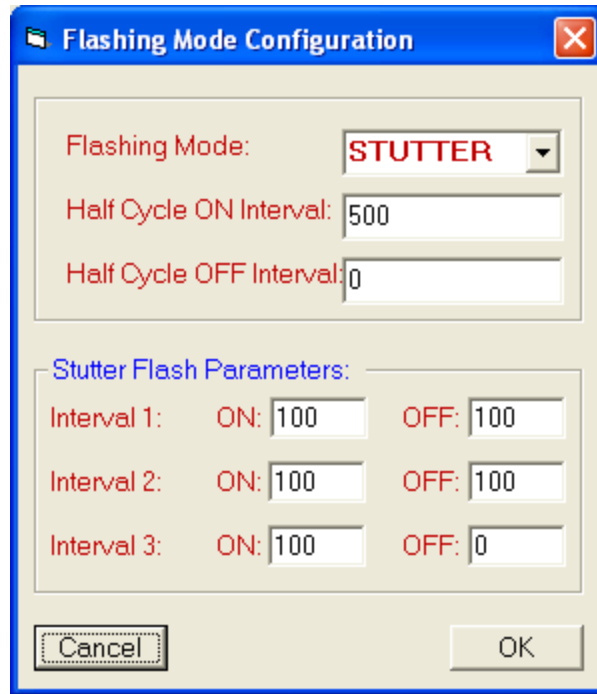user must save the new settings into the configuration file under the AWEGS menu.

Figure 29. Flashing Mode Configuration Screen.

- **Advance Detector Settings**: The user can configure the advanced detectors, dilemma

  zone detectors, and video detectors at the intersection. The video detectors in this screen

  are designed to be used for quantification of red-light running at the intersection. The

  detectors are organized by the main street phase that they belong to. The first window is

  the "Advance Detector Selection" (Figure 30). The user selects the main street phase the

  detectors belong to. Once the user selects a main street phase from the pull down list,

  depending on the direction chosen for the main street phase in the "Phase Settings"

  window, a series of detectors are drawn in the middle section of the "Advanced Detector

  Selection" showing the advance trap detectors, dilemma zone detectors, and video

  detectors that belong to that phase. By clicking on each detector in the middle section, a

new window called "Advanced Detector Configuration" (Figure 31) is provided to the
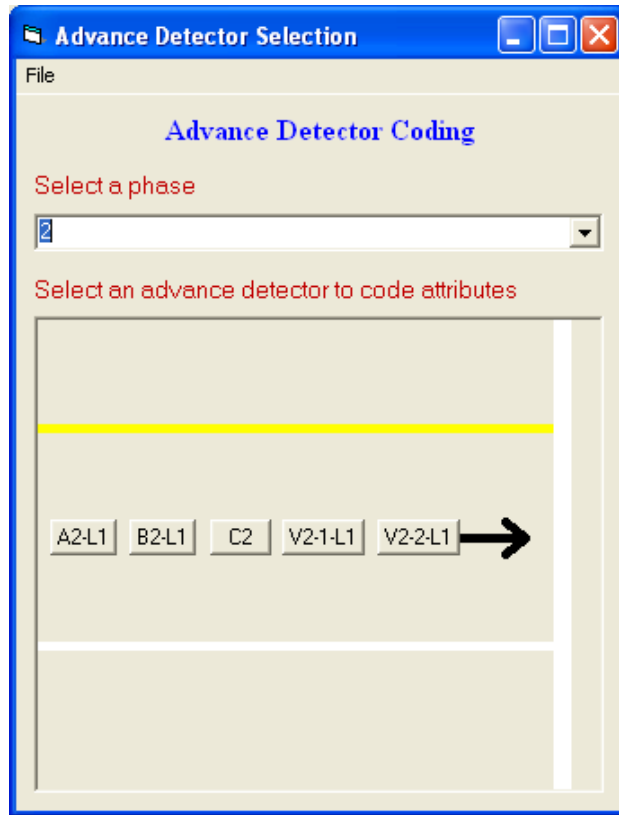user where the relevant information required by AWEGS for that detector can be entered.

Figure 30. Detector Configuration Selection Screen.
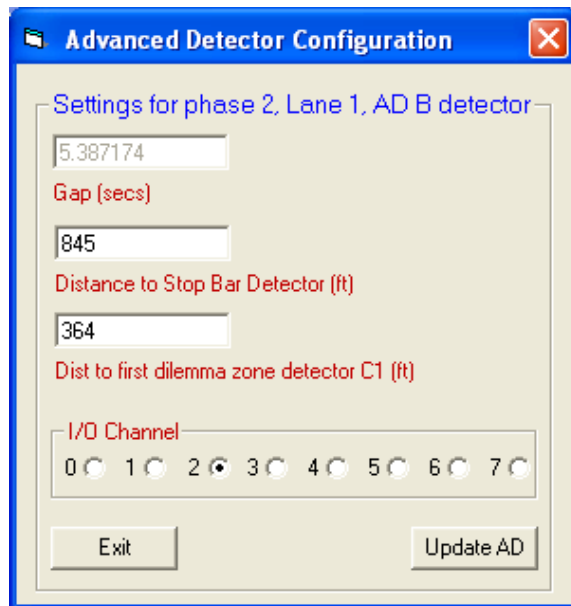

Figure 31. Advance Detector Configuration Screen.

Figure 31 shows the data elements required by AWEGS for each advance detector. The data elements required include the distance to stop-bar from the leading edge of the advance detector and the distance from the leading edge of the advance detector to the leading edge of the first dilemma zone detector (furthest from the stop-bar) for the given approach. If a digital I/O card is used to receive inputs from the advance detectors, the user must also specify the digital I/O channel on the digital I/O connector block that receives the advance detector input. If the advance detectors are wired according to the provided standardized configuration files and the standardized digital I/O connector block drawings, the proper digital I/O channel will be already selected for the user. If enhanced BIUs are instead used to receive inputs from the advanced detectors, the user can ignore specifying the digital I/O channel fields and can specify the BIU channels corresponding to the advance detectors in the "Advanced Detector I/O Configuration" screen discussed later. After entering the required information, the user must click the "Update AD" button to save the configuration.

Figure 32 shows the data elements required by AWEGS for the dilemma zone detectors of the selected phase. The passage time (Gap) and the distance of the first dilemma zone detector C1 (furthest from the stop-bar) are shown as they were entered in the "Phase Settings" window by the user. These values cannot be changed in this window. If the user would like to change these values, they can be changed in the "Phase Settings" window. However, the user must specify the digital I/O channel the dilemma zone detectors input is feeding into on the digital I/O connector block. If the dilemma zone detectors input is wired according to the provided standardized configuration files and the standardized digital I/O connector block drawings, the proper digital I/O channel will be already selected for the user. If, however, enhanced BIUs are used to receive inputs from the dilemma zone detectors, the user can ignore specifying the digital I/O channel the dilemma zone detectors feed into and can specify the corresponding BIU channels in the "Advanced Detector I/O Configuration" screen discussed later. After entering the required information, the user must click the "Update AD" button for the information to be saved into AWEGS memory.
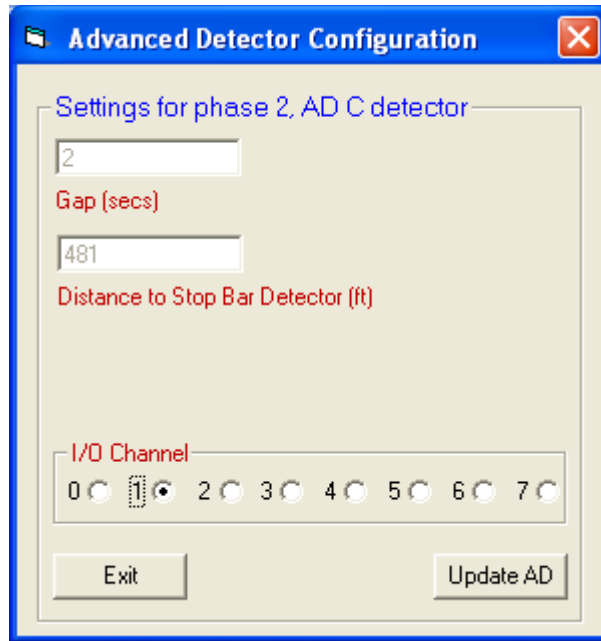
Figure 32. Dilemma Zone Detector Configuration Screen.

Figure 33 shows the data elements required by AWEGS for video detectors setup for logging red-light running events for the selected phase. The only input required for each video detector is the digital I/O channel the detector is connected to on the I/O connector block. If the video detector input is wired according to the provided standardized configuration files and the standardized digital I/O connector block drawings, the proper digital I/O channel will be already selected for the user. After entering the required information, the user must click the "Update AD" button for the information to be saved into AWEGS memory. However, these detectors are only used if red-light-running evaluation is being conducted.
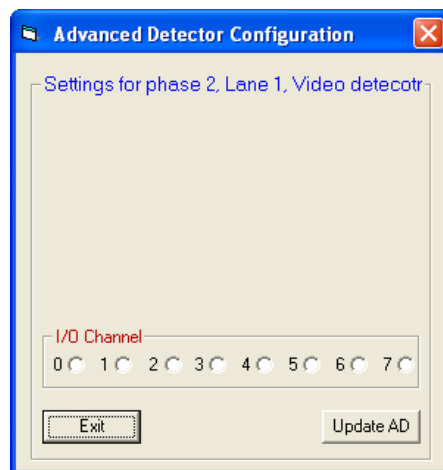

Figure 33. Video Detector Configuration Screen.

- **Heartbeat**: This option opens a new window called "Heartbeat Signal Settings" (Figure 34) that allows the user to configure the digital I/O channel and port settings for the heartbeat signal sent from AWEGS to the backup flashing panel every second while AWEGS is up and running. The backup flasher panel is independent of AWEGS. The heartbeat signal is used by AWEGS to indicate to the backup flashing panel that it is up and running fine. The signal is connected to a timer on the backup flashers panel. The timer is reset and starts counting down from 3 to 0 every time it receives the heartbeat signal from AWEGS. If for any reason, AWEGS is down or stops sending the heartbeat signal, the backup flasher panel takes over once the timer reaches zero. During a system failure, the flasher panel functions in a backup mode by flashing the beacons on the advance warning sign at the onset of yellow and stop flashing the beacons at the onset of green for main street phases. The data elements required for the configuration of the heartbeat signal screen include the digital I/O device, port, and output channel used to send the signal to the backup flasher panel. If the heartbeat signal output is wired according to the provided standardized configuration files and the standardized digital I/O connector block drawings, the proper digital I/O device, port, and channel will be already selected for the user. After entering the required information, the user must click the "OK" button for the information to be saved into AWEGS memory.
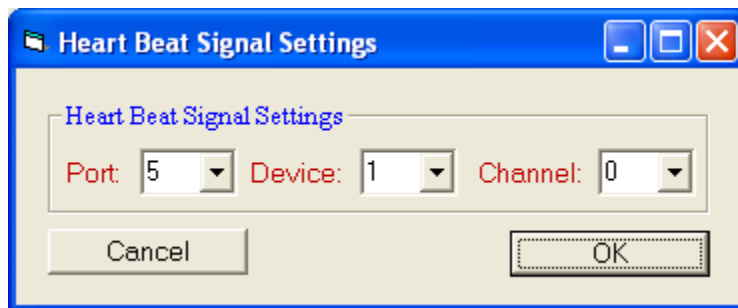

Figure 34. Heartbeat Configuration Screen.

- **Ring Structure**: This selection opens a window called "Ring Structure" (Figure 35) that enables the user to define the ring structure for the phases at the intersection. The user can enter for each phase, the concurrent phases, next phase in the phasing sequence, and the ring the phase belongs to. The user can also enter whether the "Simultaneous Gap-Out" feature is turned on or off in the controller. If a digital I/O card is used to receive

the ring status bits inputs, the user must also specify the digital I/O device and port that the ring status bits are connected to on the digital I/O connector block. If the ring status bits inputs are wired according to the provided standardized configuration files and the standardized digital I/O connector block drawings, the proper digital I/O device and port will be already selected for the user. If enhanced BIUs are instead used to interface with the controller cabinet, the AWEGS will automatically get the phase status and ring status bits through the BIUs. After entering the required information, the user must click the "Update Ring Structure" button for the information to be saved into AWEGS memory.
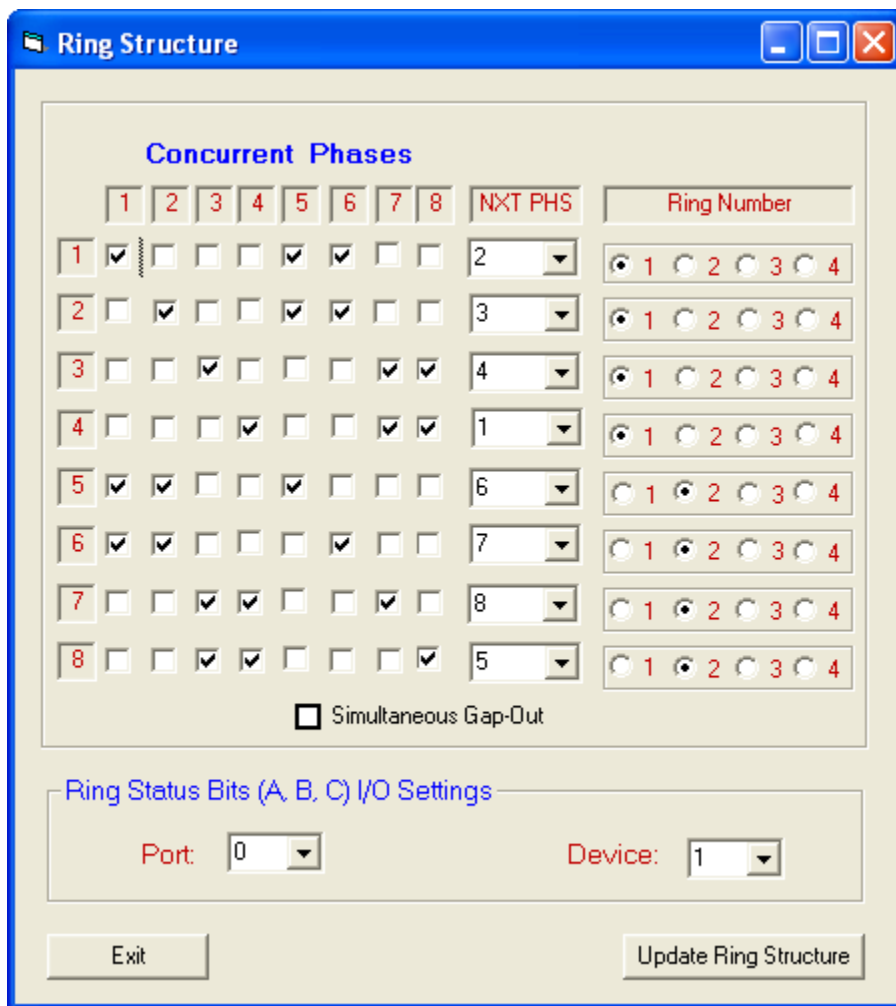

Figure 35. Ring Structure Configuration Screen.

- **System Parameters**: This screen opens a window called AWEGS System General Parameters" (Figure 36) that enables the user to enter data elements that are site specific. These data elements include:

    o city and street/highway names at the intersection;

    o availability of stop-bar detectors on the main street phases;

    o parameters like ZDelMax, ProbT, ZDelHold, and System Timer; and

    o extra phase hold.

The user must also specify whether digital I/O cards or enhanced BIUs are used to receive the phase status, stop bar detector inputs, and ring bits status by selecting the proper option in the "Cabinet Interface" option group. Similarly, the user must select the proper option in the "Classifier Interface" option group to indicate whether enhanced BIUs or a digital I/O card is used to receive the advance loops inputs. The user must not change the options selected for "Cabinet Logic" or "Classifier Logic." After entering the required information, the user must click the "OK" button for the information to be saved into AWEGS memory.
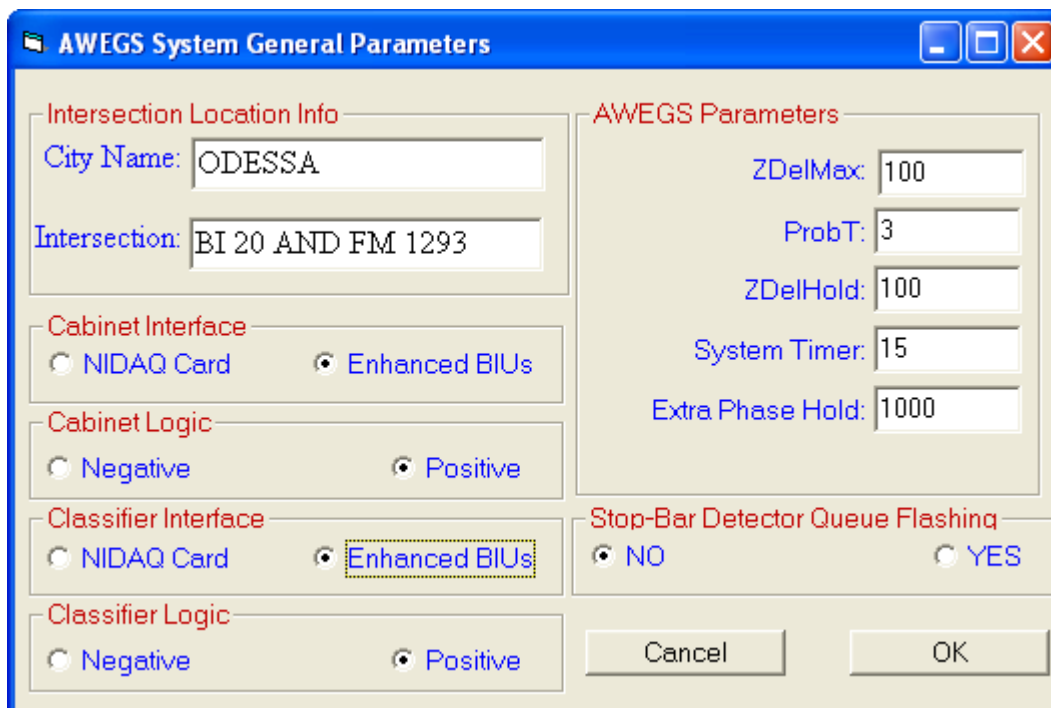

Figure 36. AWEGS System General Parameters Configuration Screen.

- **Phase I/O Settings**: This screen illustrated in Figure 37 will be enabled in the configuration menu if the user has selected the digital I/O cards option for "Cabinet Interface" in the "System Parameters" screen. The option will be disabled in the configuration menu if the user selects the enhanced BIUs option in the "System Parameters" screen for "Cabinet Interface." The user needs to specify the digital I/O channel, port, and device settings for the "Phase On" input, "Phase Check" input, and "Phase Hold" output settings in this screen. Once a phase group is selected, the "Select Phase Group" pull-down list, the user then selects an option button that corresponds to the phase the user is selecting from the "Phase Number" option buttons group. The AWEGS system will display the selected channel for that phase if it has been entered earlier, and the user can change it by selecting an option button that corresponds to the desired channel from the "I/O Channel" option buttons group.
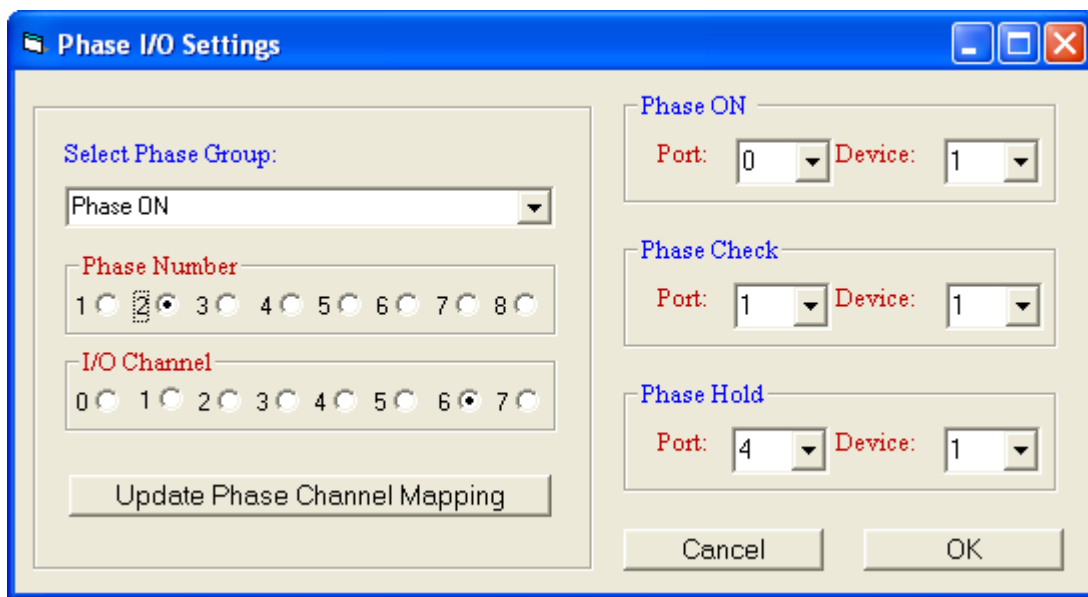

Figure 37. Phase I/O Settings Screen.

After entering the required information, the user must click the "Update Phase Channel Mapping" button for the information to be saved into AWEGS memory. To update the digital I/O device and port information for the phase inputs and outputs, the user can select the proper values from drop down combo boxes and click the "OK" button to save the updated information into AWEGS memory. If the phase inputs and outputs are wired according to the provided standardized configuration files and the standardized digital

67

I/O connector block drawings, the proper digital I/O device, port, and channel will be already selected for the user.

- **Advance Detector I/O Configuration**: This option will be enabled in the configuration menu if the user has selected the "Enhanced BIUs" option for "Classifier Interface" in the "System Parameters" screen. The "Advance Detector I/O Configuration" (Figure 38) screen allows the user to specify the BIU channel settings for the inputs from the advanced detectors (ADA and BDA) and dilemma zone (CDA) detectors. For specifying the BIU channel for each detector input, the user must select a detector group from the "Select Detector Group" pull down list first. Once a detector group is selected, the user then selects an option button corresponding to the number of the detector the user is selecting. AWEGS will display the selected BIU channel for the selected advanced detector if it has been entered earlier, and the user can change it by selecting the number that corresponds to the desired BIU channel from the "Select XXX-BIU Channel" pull down list. After entering the required information, the user must click the "Update BIU Channel Mapping" button for the information to be saved into AWEGS memory.
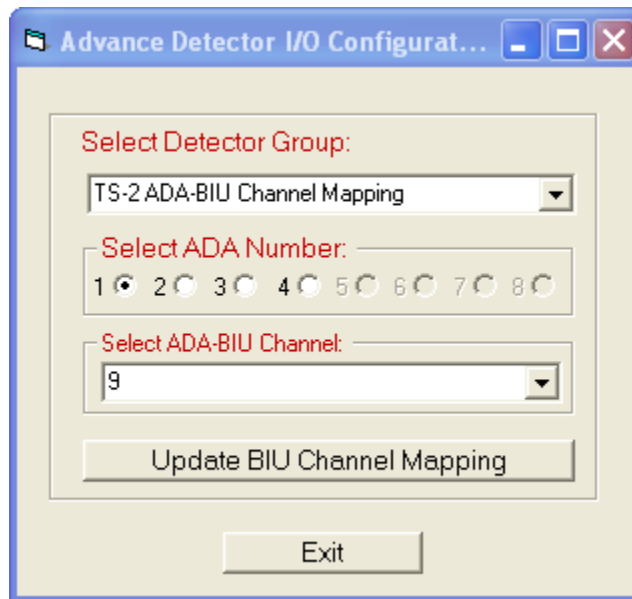

Figure 38. Advance Detector I/O Configuration Screen.

- **Stop-Bar Detector I/O Setting**: This option provides the user with a window labeled "Stop Bar Detector I/O Configuration" (Figure 39) to specify the BIU channel settings if enhanced BIUs were used to receive stop bar detector inputs or the digital I/O channel

settings if a digital I/O card was used to receive the stop bar detector inputs. The user can also specify the phase that the detector is mapped to by selecting the option button that corresponds to the phase from the phase option group under the "Phase Called" label. After entering the required information, the user must click the "OK" button for the information to be saved into AWEGS memory.
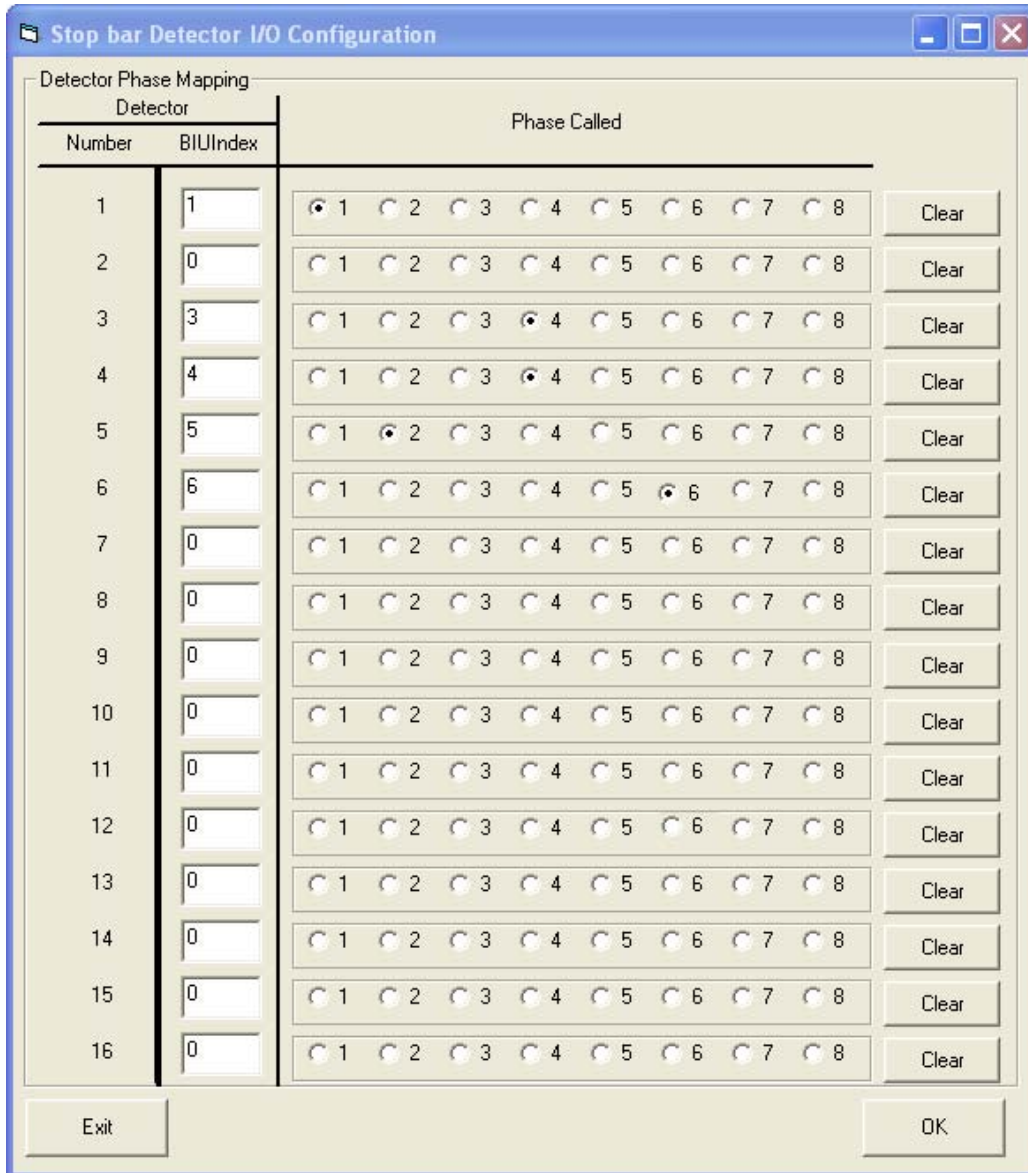

Figure 39. Stop Bar I/O Configuration Screen.

- **Flasher I/O Configuration**: This option provides the user with a window called "Flashing Beacon I/O Settings" (Figure 40) where the user can specify the digital I/O channel, port, and device settings for each flashing beacon on the advance warning signs.

Each approach's advance warning sign has a set of two beacon heads that can either flash simultaneously or alternate in flashing. In specifying the digital I/O channel for each phase head, the user must first select a phase number from the "Phases" pull-down list. Once a phase is selected, the user then proceeds to select a beacon head from the "Beacon Heads" pull down list. The "I/O Channel" option button group will be enabled and the AWEGS system will display the selected channel for the selected beacon head if it has been entered earlier. The user can proceed with selecting an option button that corresponds to the channel the beacon head output is connected to. The user must click the "Update Flasher" button to save the information to AWEGS memory after updating each beacon-head data. To update the digital I/O device and port information for the beacon heads outputs, the user can select the proper values from the drop down combo boxes and click the "OK" button to save the updated information into AWEGS memory. If the beacon heads outputs are wired according to the provided standardized configuration files and the standardized digital I/O connector block drawings, the proper digital I/O device, port, and channel will be already selected for the user.
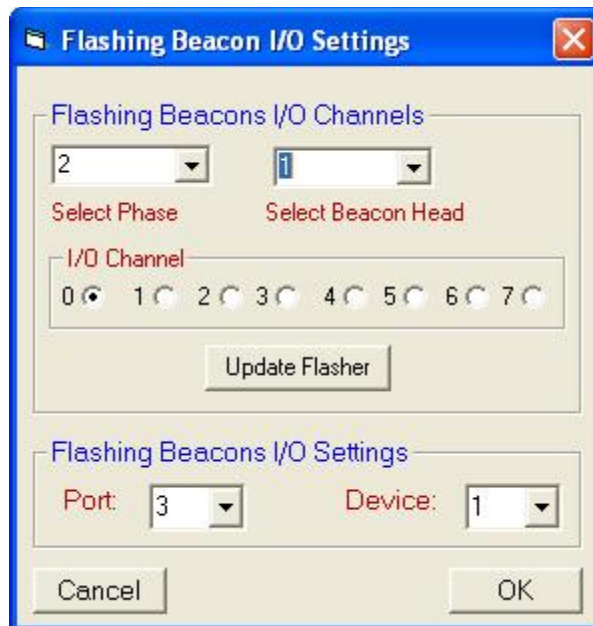

Figure 40. Flasher I/O Configuration Screen.

- **Phase and Detector Port Setting**: If the user selected Enhanced BIU option, the user gets "BIU Serial Port Settings" (Figure 41) screen to configure. If, however, the user selects the digital I/O card option, the user will get the "Digital I/O Port and Device

70

Settings" ([Figure 42](#)) screen to configure. The "Digital I/O Port and Device Settings"
screen enables the user to specify the digital I/O ports and devices for the various input
and output data element groups required by AWEGS including advanced trap detectors
(ADA and BDA), dilemma zone detectors (CDA), stop-bar detectors, and red-light
running (RLR) video detectors. To update the digital I/O device and port information for
the detector inputs, the user can select the proper values from the drop down combo
boxes and click the "OK" button to save the updated information into AWEGS memory.
If the inputs and outputs are wired according to the provided standardized configuration
files and the standardized digital I/O connector block drawings, the proper digital I/O
devices and ports will be already selected for the user. The "BIU Serial Port Settings"
screen allows the user to specify the industrial PC RS-232 serial port numbers where the
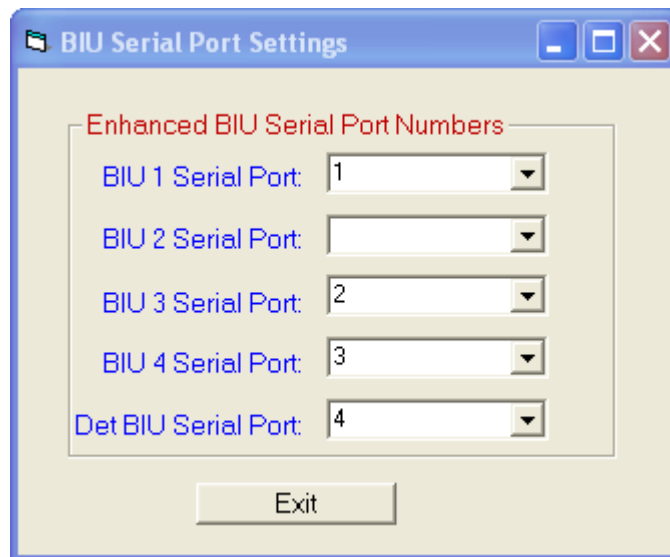BIUs of interest are connected to.
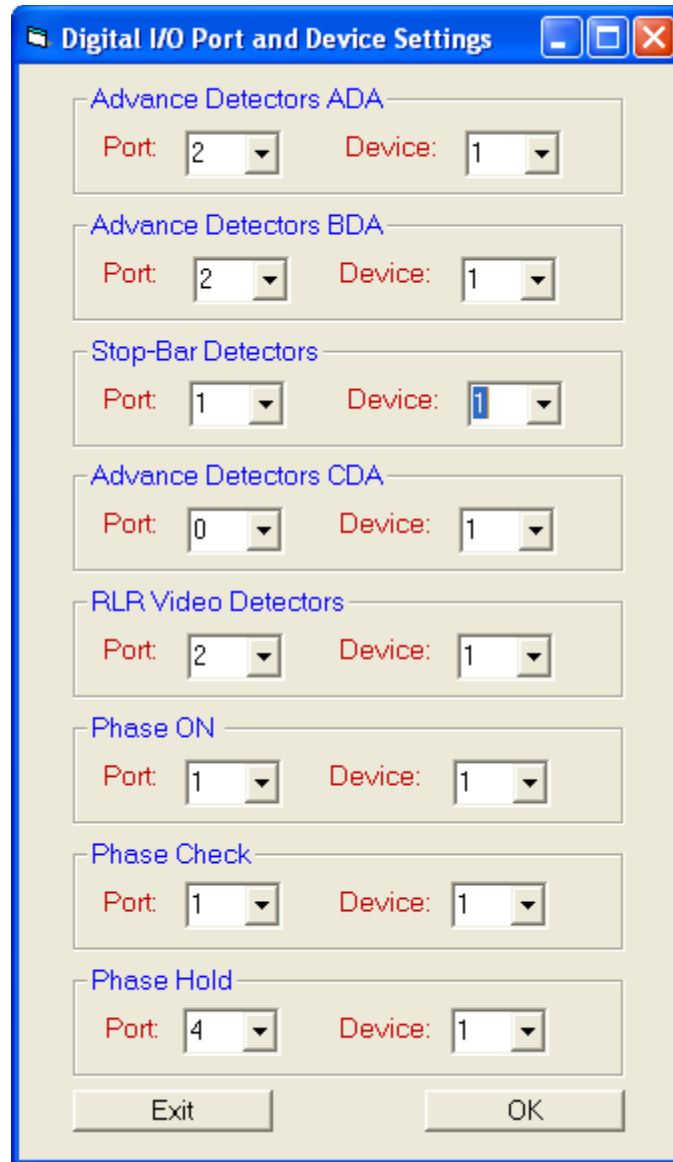

Figure 41. BIU Serial Port Settings Screen.

Figure 42. Digital I/O Port and Device Settings Screen.

- **Number of Lanes per Approach**: This option (Figure 43) enables the user to change the number of lanes per approach from 1 to 2 or vice versa. After changing the number of lanes per approach and saving it to the configuration file, terminate the AWEGS by choosing the "Exit" option from "AWEGS" menu and restart again. The proper method to changing the number of lanes per approach is for the user to start AWEGS with the two lanes per approach XML configuration file provided by TTI with the software instead of changing a one lane per approach configuration file to a two lanes per approach or vice versa.
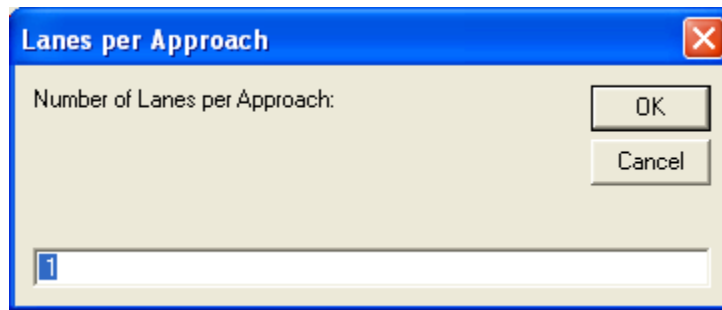
Figure 43. Approach Configuration Screen.

Display Menu

The display menu (Figure 44) includes only one option — the Intersection option. Selecting the Intersection option displays a window with a drawing of the AWEGS intersection being monitored along with the status of the following elements:

- main street phases,
- advance trap detectors,
- dilemma zone detectors,
- stop-bar detectors,
- ring status,
- classification of the last vehicle detected on each advance trap detector,
- duration of the last advance warning provided by AWEGS, and
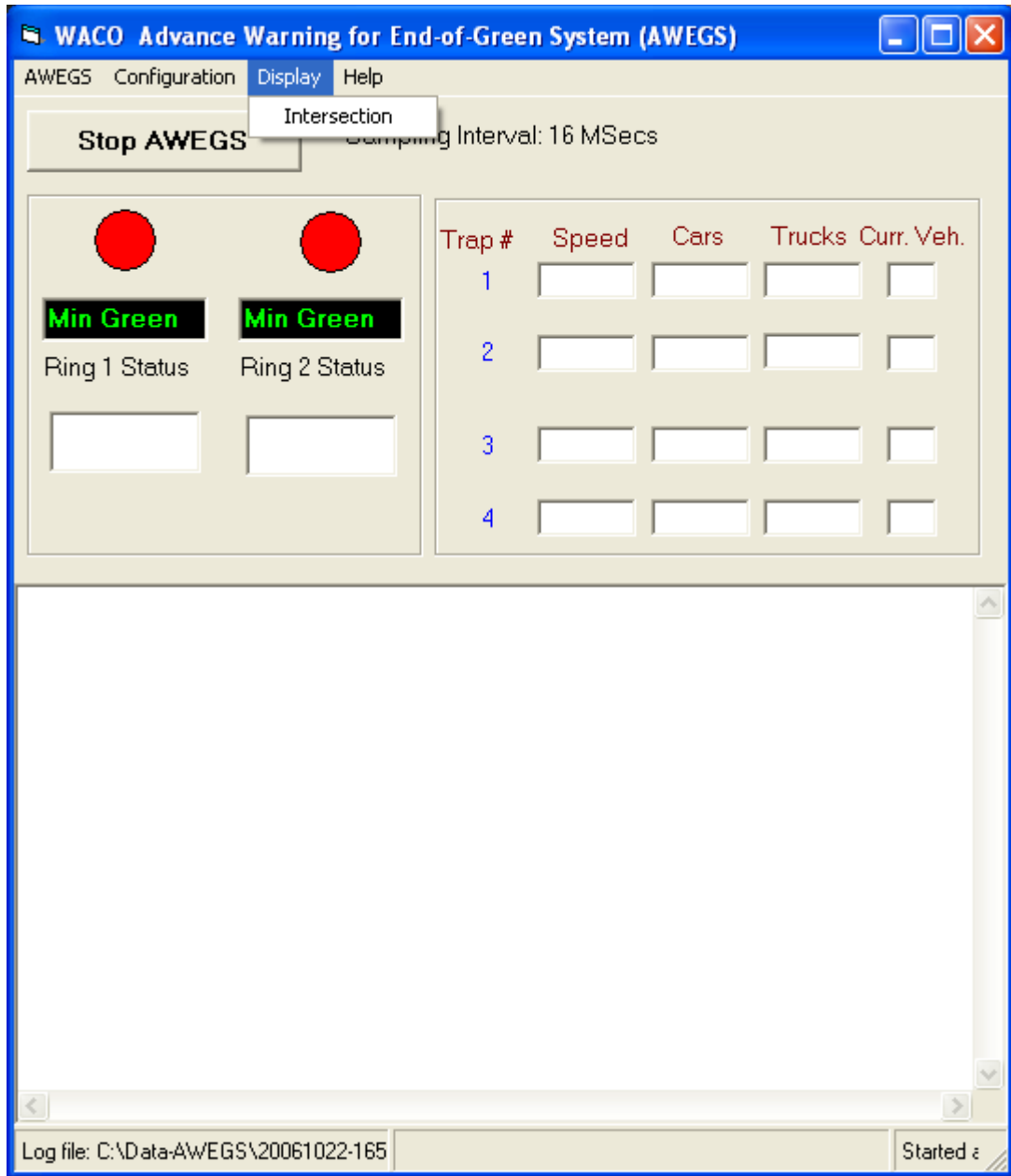- status of the advance warning beacons (On/Off).

Figure 44. Display Menu.