System Description and Operator's Guide
for
South Jersey Real-Time Motorist Information System

FINAL AUXILIARY REPORT
June 2004

Submitted by

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In cooperation with

New Jersey
Department of Transportation
Bureau of Research
and
U.S. Department of Transportation
Federal Highway Administration

DISCLAIMER STATEMENT

1. Report No. FHWA-NJ-2004-009	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle System Description and Operator's Guide for South Jersey Real-Time Motorist Information System		5. Report Date June 2004
		6. Performing Organization Code CAIT/ Rutgers Univ., NJIT, L-3 Inc.
7. Author(s) L3 Communicaions, Inc.		8. Performing Organization Report No.
9. Performing Organization Name and Address L-3 Communication Systems- East 1 Federal Street Camden, New Jersey 08103		10. Work Unit No.
		11. Contract or Grant No.
12. Sponsoring Agency Name and Address Federal Highway Administration P.O.Box 600 U.S. Department of Transportation Trenton, NJ 08625 New Jersey Department of Transportation		13. Type of Report and Period Covered
		14. Sponsoring Agency Code

15. Supplementary Notes

16. Abstract

This report describes the architecture and operation of the Southern New Jersey Real Time Motorist Information System and provides instructions for installation and operation of its major system components. Numerous design features have been incorporated into the system to provide a highly portable roadway sensor capable of operating from solar or AC power, secure wireless communications, and an easy to use operator interface.

17. Key Words Traveler Information System, Surveillance Systems, Traffic Sensors	18. Distribution Statement		
19. Security Classif. (of this report) Unclassified	20. Security Classif. (of this page) Unclassified	21. No of Pages 55	22. Price

Form DOT F 1700.7 (8-69)

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INTRODUCTION

This report describes the architecture and operation of the Southern New Jersey Real Time Motorist Information System and provides instructions for installation and operation of its major system components. Numerous design features have been incorporated into the system to provide a highly portable roadway sensor capable of operating from solar or AC power, secure wireless communications, and an easy to use operator interface. Communications have been extensively optimized to reduce wireless service expenses. The system is modular and expandable, ready to meet future needs for growth. The goal of this system is to provide a basic capability to demonstrate proof-of-concept, with minimal engineering development effort. The system is capable of immediate expansion to support larger scale demonstration programs. However, additional development is recommended prior to full-scale deployment to incorporate features that would further reduce operating and maintenance costs.

Theory of Operation of this document provides an overview of the system identifies the major system components and explains how the system and each of these components work. Installation and Setup and Appendix A contain guidelines for installing and configuring the equipment. These guidelines provide sufficient detail to enable the reader to select suitable traffic sensor sites, install/relocate traffic sensors, and reinstall/restart L-3 developed software application programs. User Control and Data Monitoring provides a user's view of how to configure the system to obtain the desired traffic sensor operation and to add or delete clients from the motorist alert directory. It also explains how to monitor traffic data and save and purge old traffic data files.

THEORY OF OPERATION

System Overview

As shown in Figure 1, the principal components of the Motorist Information System are wireless traffic sensors, a secure data server, a Central Monitoring and Reporting Station (CMRS) and alphanumeric pagers. These items are shaded (green) in the figure. They are interconnected using standard commercial wireless services and the Internet.
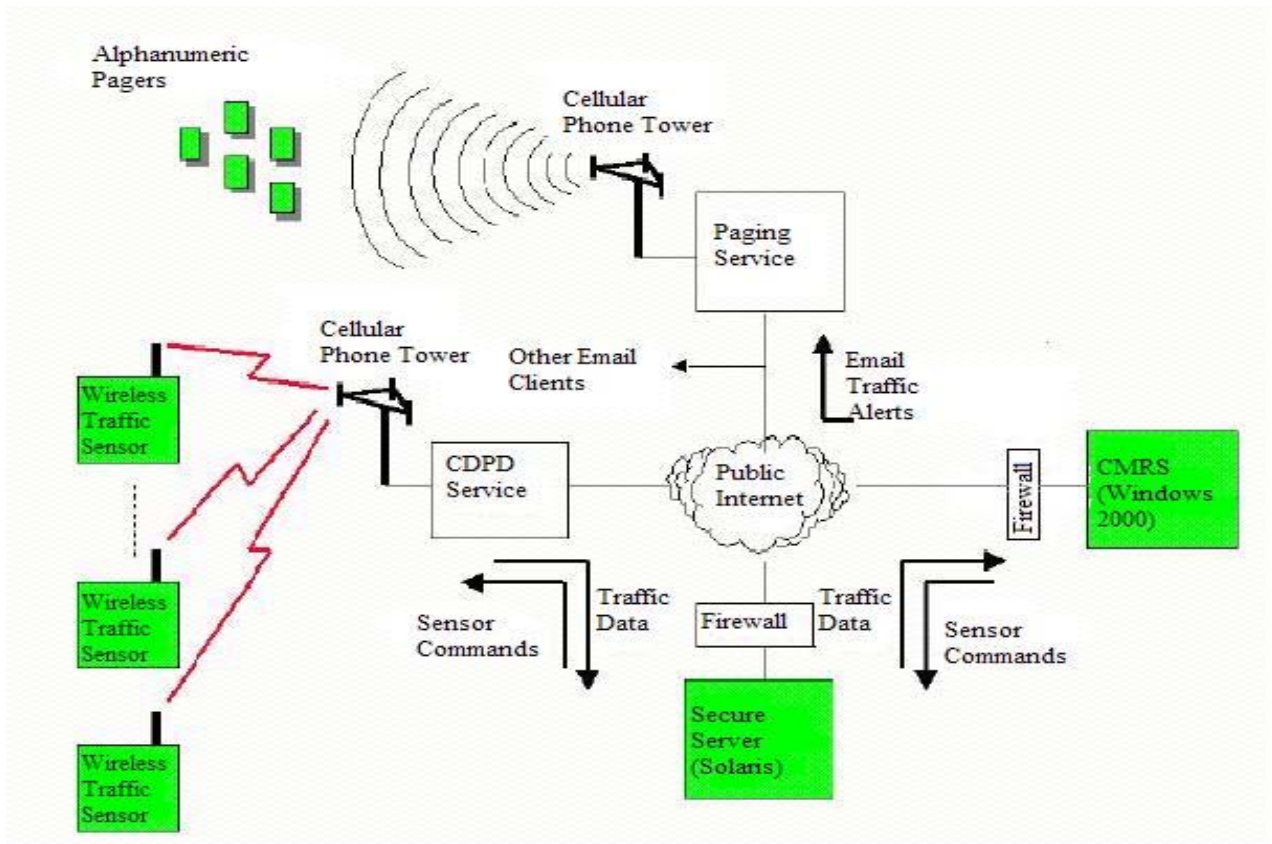
Figure 1 Motorist Information System Functional Block Diagram

Operating on a common, fixed time schedule, the wireless traffic sensors wake up periodically, sample traffic volumes and speeds and report this information whenever significant changes in speed occur, or when their internal data buffer is full, whichever occurs first. Real-time traffic data is transmitted via wireless cellular link to a Cellular Digital Packet Data (CDPD) service provider, then over

the Internet to a secure data server. Data is periodically pulled from the server, over the Internet, processed and displayed by the CMRS. Significant changes in traffic speed result in the CMRS generating a traffic alert message, which is broadcast, to alphanumeric pagers and any other email addresses contained in the CMRS's alert client directory.

Many of the wireless traffic sensor's operating parameters are remotely configurable and can be changed via commands sent from the CMRS. These commands are sent over the Internet to the Server, which, in turn, forwards them over the Internet and CDPD wireless link to the remote traffic sensors. The Server acts to isolate the CMRS from the CDPD wireless links to minimize the potential for unauthorized users and hackers to gain access to the CMRS from the wireless air interface. Firewalls at both the Server and the CMRS aid in this isolation. In addition, the server is designed to send data to the CMRS only in response to a request received from the CMRS.

Wireless data services provide the desired mobile connectivity to traffic sensors and pagers. The cost for both services varies with the amount of data transmitted, hence the system is designed to minimize the number of alerts and to package and transmit traffic sensor data in a highly efficient format.

Wireless Traffic Sensor Equipment

Each roadside wireless traffic sensor station consists of a traffic sensor, a Sensor Processing and Communications Unit (SPCU), an optional Solar Power Panel and a set of interconnecting cables. Each of these is described below.

<u>**Traffic Sensors**</u>

Traffic sensors may be of the acoustic or radar sensing type. The choice of a particular sensor type depends on many factors. Both types of sensors are included in the Motorist Information System to allow comparative evaluation. The principal advantage of the acoustic sensor, especially for solar powered

installations, is lower power dissipation. However, the vendor-furnished calibration software program for the acoustic sensor is somewhat more difficult to use during installation. The acoustic sensor must be mounted higher above grade, which may make some potential installation sites unsuitable. The Motorist Information System will process up to five lanes of traffic; hence, the radar sensor's ability to handle up to eight lanes does not present an advantage since the additional data is not used. Key sensor features are summarized in Table 1.

Table 1 Traffic Sensor Features

	Radar	Acoustic
Ease of Installation & Calibration	Easier	Calibration more difficult
Accuracy	Good	Requires Calibration
Mounting Height (above grade)	17ft	35ft
Power Dissipation	6W	2W
Sensitivity	Good	Good
Max # of lanes	8	5
Cost	Same	Same

Acoustic Sensor: The acoustic sensor utilizes an array of microphones to create a multitude of shaped listening beams that fan out from the sensor in the vertically plane over a wide range of look angles providing coverage from near lane to far lane. Traffic lanes are distinguished from each other by look angle. For this reason, the acoustic sensor must be mounted high on the utility pole, typically 25-35 ft, so that vehicles in adjacent lanes do not appear in the same beam, as might happen if the sensor were mounted lower and looked outward across multiple lanes at a shallower angle. Data measured by the acoustic sensor for each lane includes: vehicle speed, total vehicle count, tractor-trailer count, truck count and percent lane occupancy. The sensor is capable of monitoring up to five lanes.

Radar Sensor: The radar sensor is a low transmitted power (10mW) K-band radio frequency sensor that uses range information to distinguish between adjacent lanes. The sensor must be mounted high enough to prevent vehicles in

the near lane from obscuring vehicles in more distant lanes. Typical mounting height is 17 ft. Data measured by the radar sensor for each lane includes: vehicle speed, total vehicle count, truck count and percent lane occupancy. The sensor is capable of monitoring up to eight lanes. However, the SPCU only reports up to five lanes, to match the capabilities of the acoustic sensor.

Sensor Processing and Communications Unit (SPCU)

The SPCU comes in two versions, one for each type of traffic sensor (acoustic or radar). The two units are identical in design and construction except for the sensor interface electronics and external sensor connector. The latter is keyed to prevent connection of the wrong sensor type to the unit. Solar power and AC power connectors are identical for all units, hence solar and AC power cables may be used on either SPCU configuration. For safety, different size connectors are used on DC and AC inputs to prevent inadvertent connection of DC cables to an AC power source and vice versa.

Time of Day Clock: The SPCU contains an internal processor, clock and cellular wireless data modem. Timing of traffic measurements is controlled by the internal clock according to a schedule that is programmed via wireless command from the CMRS. Once daily, at approximately 12:15 AM, and following a reset of the SPCU, the SPCU automatically contacts the CMRS and resets its internal clock to match that of the CMRS. This keeps all SPCU's on a common time reference. Time synchronization is affected by wireless and Internet network delays and is accurate to 1 minute or less, with typical accuracies of 20 sec.

SPCU Reset: The SPCU may be reset by remote command. In the event of a reset, all configuration parameters are set to factory defaults. The SPCU default configuration is specified in Installation and Setup; SPCU Configuration.

Traffic Sampling Schedule: Traffic samples are taken on a fixed schedule, which is remotely programmable from the CMRS. Different sampling intervals may be assigned for peak traffic hours and non-peak hours. Start and stop times for morning and evening peak traffic windows may also be set. Default sampling intervals are every five (5) minutes during peak hours and every fifteen (15) minutes during off peak hours. All SPCU units must operate on the same sampling schedule. Any changes to the sampling schedule made at the CMRS are automatically broadcast to all SPCU's.

Remote Configuration: In addition to the traffic-sampling schedule, a number of other processing parameters may be remotely programmed from the CMRS via commands sent over the wireless link to the SPCU. These are discussed later in the report. Any configuration commands entered will be scheduled for broadcast to the sensors during the next traffic sampling cycle.

SPCU Processing Timeline: To minimize power dissipation, various components within the SPCU are turned on and off in a fixed, timed sequence. The processing sequence varies slightly with sensor type since the acoustic sensor is powered continuously while the radar sensor is switched on and off. Table 2 shows the traffic measurement and processing timeline for the radar equipped SPCU. When using the acoustic sensor, the first two steps in the table are deleted and the sequence completes 60 seconds sooner.

Table 2 SPCU Processing Timeline for Radar Sensor

Operation	Time from Start of Sequence (sec)
Turn on radar Sensor	0
Measure traffic, discard data (first sample is invalid)	30
Measure traffic, save data, turn off sensor, turn on wireless modem	60
Initialize modem configuration	90
Transmit data	95
Listen for configuration commands	215

The SPCU processing timeline includes a 120 second window during which time the SPCU listens for configuration commands from the CMRS. The CMRS times the transmission of configuration commands to coincide with this window, hence the need for maintaining synchronization between the SPCU internal clock and the CMRS time of day clock. When the SPCU is first powered up, or any time it is reset by remote command, it automatically goes through a time synchronization procedure to align its internal clock to the CMRS. Although it is unlikely, congestion in the wireless network may prevent timely two-way communications required to complete the time synchronization procedure. In this case, the SPCU will not have an accurate time of day clock and will likely not be able to receive configuration commands until a successful time synchronization event has occurred. This would occur at 12:15 AM the following morning.

Traffic Data Reporting: To maximize communications efficiency, two types of traffic reporting messages are used by the SPCU, urgent and non-urgent. Urgent messages are sent whenever there is a significant change in traffic speed. Non-urgent messages are used at all other times. Urgent messages provide more timely reporting while nonurgent messages provide lower transmission costs. Also, urgent messages trigger a traffic alert to motorists, while non-urgent messages do not. Finally, urgent messages are acknowledged by the CMRS to provide greater reliability in message transmission. If an acknowledgement is not received within 2 minutes, the urgent message is retransmitted one time. Non-urgent messages are not acknowledged and may be lost if significant interference occurs or there is a momentary outage or congestion on either the wireless link or the path to the CMRS over the Internet. Such occurrences are possible but rare. The amount of data contained in a non-urgent message is determined by the full buffer threshold parameter, which can be set remotely from the CMRS. The default value on SPCU power-up is 500 bytes which is the maximum length recommended by the wireless service provider. Longer messages are more efficient (less costly) to send, since the ratio of data to fixed header information (eight bytes) is higher. However, longer messages are more

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susceptible to transmission errors since the likelihood of radio interference increases as the transmission time increases. In areas of high interference, it may be necessary to reduce the full buffer size until reliable communications is obtained.

Non-urgent messages may be delayed by up to several hours depending on the traffic-sampling schedule. Since each traffic sample comprises approximately 28 bytes of data, a 500-byte long non-urgent message will contain about 17 samples, or slightly more than 4 hours of data with a traffic-sampling interval of 15 minutes. The amount of data contained in an urgent message varies with the number of traffic samples that have been stored since the last urgent or non-urgent message was sent. When a significant speed change occurs, the current traffic sample is placed in the buffer and the entire buffer is transmitted. After the urgent message is sent, successive traffic samples are once again stored in the buffer until either another urgent message event occurs or the maximum buffer size is reached, triggering a non-urgent message.

Traffic Data Processing: All data received from the traffic sensor (speed, vehicle count, lane occupancy) is transmitted to the CMRS. In addition, vehicle speed data is processed to determine if a significant change in traffic flow has occurred since the last sample. To accomplish this, a volume weighted average traffic speed across all lanes is first computed by multiplying the speed in each lane by the volume in each lane and dividing by the total volume. The resulting average weighted speed represents the total traffic flow rate past the sensor. The average speed value is then compared to internally stored speed thresholds and assigned to a speed bin. A significant change is speed is defined as a change in the speed bin.

The initial installation of the Motorist Information System utilizes three speed bins; however, the system is supports up to six bins, which may be useful for future traffic research studies. Bin edge speeds are remotely programmable from the

CMRS. The default bin edges at SPCU power-up are set to 10 mph, 30 mph, 150 mph, 150 mph and 150 mph, respectively. The Motorist Information System uses the default bin speed definitions shown in Table 3. Color designations correspond to the color used to display the corresponding speeds for that bin on the CMRS. The bin number is also displayed at the CMRS. Use of colored text permits quick scanning of data tables to locate bin changes.

Bins four through six are effectively inactivated by setting the bin edge speeds to 150 mph.

Table 3 Default Speed Bin Definitions

Bin	Bin Edge	Bin Edge	Bin Color	Traffic Conditions
1			Red	Heavily
	1	10		
2			Yellow	Congested
	2	30		
3			Green	Free Flowing
	3	150		
4			Green	
	4	150		
5			Green	
	5	150		
6			Green	

Hysteresis is applied to each of the bin thresholds to prevent nuisance alerts caused by vehicle speeds hovering in the neighborhood of a bin edge where a small change in speed can result in frequent bin changes. Hysteresis works by using different bin edge values for positive and negative going transitions across a bin edge. When the speed value crosses a bin edge in the negative going direction, that bin edge and all higher bin edge values are increased by the amount of hysteresis. When a bin edge is crossed in the positive direction, that bin edge and all lower bin edge values are reset to their original values.

The following example demonstrates how the hysteresis function operates. Referring to Table 3, if the measured speed from one sample to the next

changes from 35 mph to 25 mph, bin edge 2 is crossed in the negative direction and the values for bin edges 2 through 5 are increased to their original values plus the value of the hysteresis. Using the default hysteresis value of 10 mph, bin edges 2 through 5 would be set to 40, 160, 160 and 160 mph, respectively. If the traffic speed begins to increase with the next sample, it will have to exceed 40 mph before a bin change occurs, which prevents small increases in speed from triggering a bin change. As the speed ultimately crosses bin edge 2 in the positive direction, bin edge 2 is reset to 30 mph, which prevents small decreases in speed from triggering a bin change. Bin edges 3 through 6 will remain at 160 mph until crossed, which, practically, will never occur. If, after reaching 25 mph, the speed had continued to decrease below 10 mph instead of increase, then the bin 1 edge value would have been increased to 20 mph and all higher bin edges would have remained at their higher values where they had been set by the previous negative going bin edge crossing from 35 to 25 mph. From the 20 mph point, increasing speed resets each bin edge to its original value as it is crossed. If the speed jumps over a bin, say from bin 1 to bin 3, all lower, and, hence, intermediate bin edge values are reset to their initial values.

The value of hysteresis is remotely controllable from the CMRS. Larger values of hysteresis reduce the sensitivity of the system to traffic changes and reduce the number of traffic alerts; smaller values increase sensitivity and create more frequent traffic alerts. Based on operational experience, a value of 10 mph has been determined to provide adequate sensitivity to detect meaningful changes in traffic speed without falsely triggering on normal variations in traffic flow.

All sensor data is converted from character format to binary format, which is a more compact data format, prior to transmission. The CMRS translates data from binary back to character format for subsequent storage and display.

Power Sources, Conditioning and Grounding: The SPCU may be powered from either 12VDC or 110VAC sources thus providing a great deal of installation flexibility. The DC input is normally connected to a solar power array, but will accept any filtered DC input up to 25 VDC. Both DC and AC power inputs may be connected simultaneously and the SPCU will automatically select the appropriate power source. This may be useful, for example, where line voltage is unreliable and a solar array is needed to provide intermittent backup power.

Input power from either source is internally regulated and used to charge an internal lead acid battery and to power the electronics. The regulated DC voltage may range from 12 to 16 volts without damage to the electronics. At 25 C, typical regulator output levels to the battery and electronics are 14.1 volts for DC operation and 13.8 to 14.4 volts for AC operation. The DC input regulator is temperature compensated and will correct the charging voltage to match the changing electrochemical properties of the lead acid battery. As temperatures decreases, the battery requires a higher charging voltage to maintain full capacity. The DC regulator automatically senses ambient temperature and adjusts the charging voltage –28 mV per C with a 25 C reference. For example, at 15 C, the charging voltage will increase by 280 mV to 14.1 + (0.028 x 10) = 14.38 volts. Likewise, at 35 C, the charging voltage will decrease by 280 mV to 13.82. The AC charger does not provide temperature compensation, since power outages are assumed to be less frequent and the modest loss of battery capacity due to uncompensated charging characteristics are not of concern.

A safety ground stud is provided on the outside of the SPCU chassis and should be connected to earth ground for safety and lightning protection. The grounding stud provides a common connection point for the SPCU chassis, DC power supply common, AC green wire ground and lightning protection circuitry commons. Lightning protectors are provided on all inputs to the SPCU and include the solar array/DC power input, AC power input, sensor input and RF antenna input.

Power Management for Solar Applications: The total power used by the SPCU varies with the traffic sampling rate. As samples are taken more frequently, power utilization increases. In solar powered applications, the power used cannot exceed the average power provided by the solar panels or the lead acid battery internal to the SPCU will eventually discharge and the unit will stop working. Table 4 lists typical SPCU power consumption for two different traffic sampling schedules and two different peak operating durations. A nominally rated 50W solar panel of the type used for the demonstration program will produce between 7and 9 Amp-Hrs per day of electric power in full sunlight, with the lower end of the range corresponding to winter operation and the higher end, summer. Based on field experience, a single 50W panel will not support the 5/15 minute sampling schedule during winter months.

Table 4 Typical SPCU Power Consumption

Peak Sampling Interval	Off-Peak sampling interval	Peak Operating Hours/Day	Radar Power (A-hr)	Acoustic Power (A-hr)
5	15	6	5.28	7.68
5	15	12	6.88	8.88
10	30	6	2.88	5.88
10	30	12	3.68	6.48

In the event, there is inadequate solar power to support the desired sampling schedule; the power utilization of the SPCU can be reduced by setting a longer interval between traffic samples. Proper solar panel location and sizing can provide adequate power to support any practical sampling schedule. Solar panels may also be connected in parallel to increase power capacity.

When operating from solar power, one must also adjust power utilization to match the capacity of the lead acid battery and the expected available sunshine.

Using the default traffic sampling schedule of 5 and 15 minutes for peak and non-peak times, the battery will provide sufficient energy to power the unit for 96 hours without recharging. When daylight is available solar power is used first to power the SPCU electronics then to charge the battery.

In AC powered applications, power dissipation is not of concern, since unlimited power is available.

Short Circuit Protection: A resettable polymeric fuse located between the 12VDC power bus and the SPCU and sensor electronics provides protection against overcurrent. The fuse is tripped by heat generated in the fuse by an overcurrent condition. The nominal trip level of the fuse is 14 amps. Trip time is a function of short circuit (fault) current. At 35 amps, the fuse will trip in approximately 15-20 seconds. The fuse will automatically reset itself when the fault is removed.

A 3-amp automotive-style blade fuse provides additional short circuit protection of the acoustic sensor and is located inside the SPCU on the manufacturer-supplied sensor interface electronics board. Fusing is not required or provided by the radar sensor manufacturer.

Wireless Communications: The SPCU is capable of sending and receiving commands and data to and from the CMRS via wireless link to the nearest cellular phone tower then over the Internet. The wireless service uses the Cellular Digital Packet Data (CDPD) protocol. Transmitted radio frequency (RF) power is a full 3W, the maximum permitted by law, which maximizes the probability of establishing a high quality connection anywhere in the wireless service area with minimal sensitivity to the installation environment. Use of the CDPD service is billed according to the amount of data transmitted; therefore, a number of features have been incorporated into the SPCU design to minimize the required amount of data transfer. These include:

- High accuracy Time of Day clock

- Once daily time synchronization

- Use of urgent and non-urgent messaging protocols to maximize the reliability of critical traffic alerts and minimize the cost for transmission of non-critical data.

- Conversion of character data into a more compact binary format prior to transmission

- Highly-efficient (low byte count) command language

Solar Power Panel

The solar panel is nominally a 50W panel, which provides approximately 3 amps of peak charging current or about 40-45W of useable charging power, to the internal lead-acid battery, in bright summer sunlight. On a clear day, the total charging energy received per day is equivalent to three hours of mid-day sun, or 9 amp-hrs. Less energy is received on overcast days and in winter months. The internal lead-acid battery has a capacity of 48 amp-hrs, which is sufficient to power the SPCU and traffic sensor for four days (96 hours) with no solar power input. Cloudy and partially sunny days will provide varying degrees of power toward operating the electronics and charging the battery.

Solar power output is a function of the size of the solar array. To increase power output, a larger array may be used, or any number of smaller arrays may be connected in parallel. All arrays must be rated for a nominal output voltage of 12VDC.

Solar panel output voltage (V) and current (I) are interrelated as shown in Figure 2. At output voltages below about 13 volts, the panel is current limited and further loading of the panel only draws down the output voltage with no marginal increase in current output. At output voltages above 13 volts, the panel is voltage limited, and further reductions in output current (reduced load) provide negligible gain in output voltage. Under no-load conditions (open circuit), the solar panel output voltage will range from 17 to 23 volts, depending on temperature. When

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connected to the SPCU, the solar array voltage is loaded to within a few tenths of a volt above the internal battery voltage.
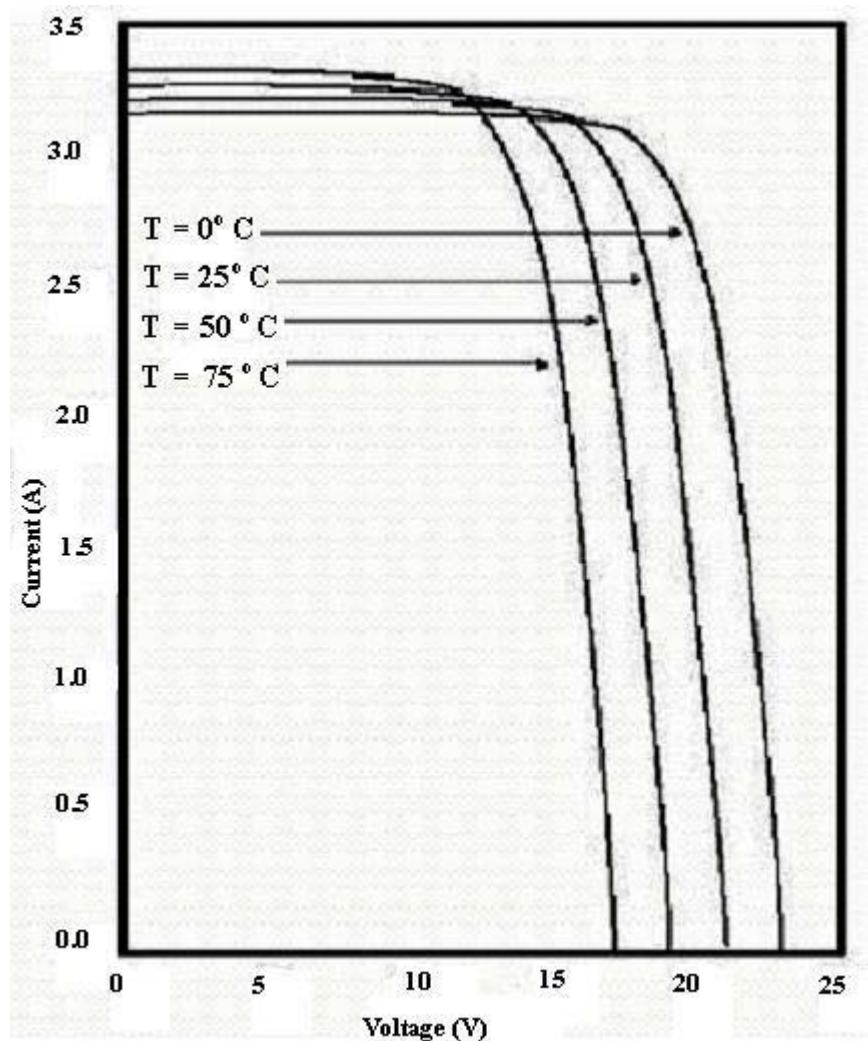
Figure 2 SX 50 Solar Panel I-V Curves

Interconnecting Cables

Prefabricated cables are provided for connecting the SPCU to the sensor and to the solar panel. The sensor-to-SPCU cable employs twisted conductor pairs and an overall shield to minimize the potential for radio frequency interference. The cable shield is grounded internal to the SPCU. Military style circular connectors are provided at each end to provide a weather-resistant seal. The solar panel-to-SPCU cable is an unshielded, heavy-gauge multiconductor cable designed to

minimize the voltage drop between the solar panel and the SPCU. The cable terminates at the SPCU end in a circular military style connector and has flying leads terminated with lugs for attachment to the solar panel terminal block. Circular connectors are of different sizes and pin configurations to prevent inadvertent cross connection of sensor and solar power inputs. An AC power receptacle is provided for connection of an optional AC power line. The receptacle provides a watertight seal when mated to a Hubbel twistlock connector body, model number HBL2313SW.

Secure Server

The Secure Server is a component of the Motorist Information System. It provides a communications interface between the SPCU road sensors and the CMRS reporting system. All communications between the SPCU's and the CMRS go through the Secure Server.

The Secure Server is physically located in the L-3 Communication Systems-East (CSE) enterprise network computer room in Camden, NJ. It is a hardened server that logically sits outside the L-3 CSE enterprise firewall and within the L-3 corporate firewall, as shown in Figure 3.
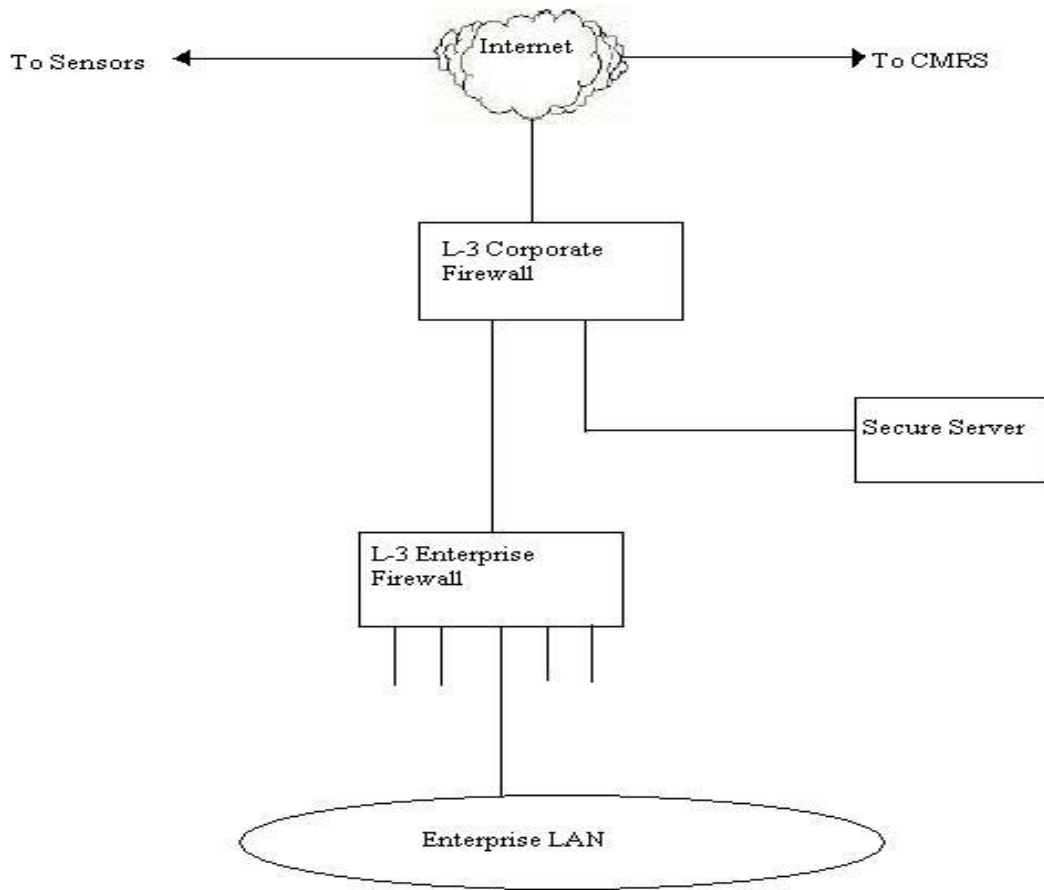
Figure 3 Secure Server Installed Location on Network

SPCU road sensors periodically wake up and send User Datagram Protocol
(UDP) datagrams to the Secure Server. The Secure Server implements a server
program, spcu_srv that listens for and stores these reports.

The CMRS works with the Secure Server to process reports and send messages
to the SPCU's. The Secure Server cmrs_srv server program implements a TCP
interface with the CMRS. The CMRS polls the Secure Server once per minute for

new SPCU reports via this interface. Occasionally, the CMRS requests message transmission to the SPCU. When this occurs, the Secure Server immediately sends a UDP message to the requested SPCU.

The Secure Server contains no information about SPCU or CMRS configuration.

The Secure Server has been designed to be a self-contained, self-sufficient unit. Its main server processes, spcu_srv and cmrs_srv, are fulltime processes that run automatically at system startup. Other processes clean up report and log directories to ensure that the system hard drive does not become full. Another process, njd_watch, wakes up occasionally to verify that the main services are running. If they are not, the services will be restarted.

The secure server equipment consists of a SunSparc 5 workstation running the Solaris 8.0 operating system (including Perl language interpreter) and the L-3 developed secure server application program, which is written in the Perl software language. Additional security software applications have been installed to meet L-3 standards for site security. This equipment has been furnished by L-3 for the duration of the system demonstration program.

The secure server can be relocated to another host network by installing a comparably equipped SunSparc workstation and the L-3 application software. Additional security software applications may be required to meet site-specific security policies.

The secure server requires a fixed IP address on the host network. This address is hard coded into the SPCU's as the destination address for traffic data messages.

Central Monitoring and Reporting System (CMRS)

The CMRS comprises an L-3 developed software program running on an IBMcompatible PC in a Windows 2000 Professional environment. It provides the capability to configure the Motorist Information System, remotely control traffic sensors, and review traffic data. The CMRS also functions as a web server allowing remote control of traffic sensors and viewing of traffic data from any other computer having a web browser and access to the CMRS web site.

Remote computers gain access simply by pointing their web browsers to the Internet (IP) address of the CMRS.

Traffic data and system configuration data are stored in a Microsoft Access database on the CMRS. Configuration data include a directory of email addresses of clients who wish to receive traffic alerts, and a list of active traffic sensors with key descriptive data. With the exception of the SPCU configuration, changes to configuration data must be performed at the CMRS. Archiving and transfer of database files must also be performed at the CMRS. Periodic backup of the configuration and traffic database file is recommended.

Because the web browser on the CMRS machine is utilized periodically by the active traffic monitoring program to process incoming traffic data, viewing of traffic data and remote configuration of traffic sensors is best performed from a remote machine using the CMRS as a web server. If these functions are performed at the CMRS, they are subject to interruption as the background processing program takes momentary control of the browser and closes the browser at the completion of its task.

The CMRS monitors incoming traffic data for changes in speed bin. When a change occurs, the CMRS forms an alert message containing the latest traffic sample from each sensor and sends this alert to all clients in the motorist alert directory having active email addresses. A low traffic volume filter is applied by the CMRS to block transmission of alert messages when traffic volume is below

24 cars per minute. This prevents nuisance alerts caused by an occasional slow driver when roadway conditions are clear.

Motorist Alert Devices and Messages

Motorist alert devices may consist of any device that accepts alphanumeric email messages. For simplicity, a simple alphanumeric pager is used for the demonstration program. The selected pager accepts up to 250 characters per email message.

The motorist alert report contains a header followed by the location, speed condition and actual speed for each of the active sensors. A double asterisk indicates which sensor triggered the alert message with a change in speed bin. Since the pager will not display the carriage return/line feed character, all text in the message wraps to fit the pager display window. A dashed line between sensor fields permits easy separation of reports on the pager display. Clients receiving alerts at a PC desktop email address will see the message as it appears below with the carriage return/line feed character displayed:

```
NJDOT TRAFFIC ALERT: 42N & 55 YELLOW (29**) ---
42N & 295 GREEN (53) ---
42N & 130 GREEN (46) ---
676N & Morgan GREEN (59) ---
676N & Mickel GREEN (69) ---
```

Figure 4 Motorist Alert Message

Wireless Communications Services

A commercial Cellular Digital Packet Data (CDPD) service is used for transmitting data and commands to and from the wireless traffic sensors. A wireless pager service is used to send traffic alerts to alphanumeric pagers. Each of these is described below.

CDPD Service

Verizon Communications is the service provider selected to provide CDPD service for the demonstration program. Selection of a particular provider should be based on cost of service and service area coverage in the planned region of operation.

Service plans are based on total message volume per month in bytes. Message volume includes both message text and transmission protocol overhead (data appended to the message to control delivery and correct errors in transmission). CDPD utilizes UDP (User Datagram Protocol) to transmit data in the form of Internet Protocol (IP) packets. This simple protocol has low overhead (eight bytes per packet) but does not provide guaranteed delivery of messages. The traffic monitoring system makes up for this deficiency by resending (up to one time) urgent messages that have not been acknowledged by the receiver. The traffic system is also designed to minimize the number of required message transmissions. For example, when traffic conditions are not changing, multiple traffic samples are combined into longer messages to minimize the number of packets with UDP headers transmitted.

The basic plan used for the demonstration program is priced at $15.00 per month for 150 kilobytes of total traffic. Additional volume over the 150KB limit is charged at a rate of $0.10 per kilobyte. (These are 2002 prices). Higher volume rate plans are also available.

Pager Service

Arch Wireless, Inc. is the vendor selected to provide wireless pager service for this project. The pager unit is the Motorola Elite model, which provides reception of alphanumeric messages up to 250 characters per message. Selection of a

particular provider should be based on cost of service and service area coverage provided in the planned region of operation.

The nominal cost of pager service is $12.50 per month (large account pricing) including pager unit rental and includes up to 250 text messages per month. Additional messages are billed at the rate of $0.25 per message. Higher volume rate plans are also available.

INSTALLATION AND SETUP

Sensor Equipment Installation

<u>Site Selection</u>

Key considerations for selecting a sensor site are the height of the sensor above the roadway and setback distance from the nearest lane. The radar sensor distinguishes lanes by distance and, therefore, a flat look angle is preferred to maximize the range separation between adjacent lanes. The sensor should not be mounted lower than 17 feet above the roadway, however, or tractor-trailers in closer lanes will obscure vehicles in farther lanes. The acoustic sensor distinguishes lanes by look angle and, therefore, a steep downlooking direction is preferred to maximize the angular separation between lanes. As the setback distance from the nearest lane increases, the height of the sensor must be increased also to maintain this steep downlook angle. Typical mounting heights for the acoustic sensor are 35-40 feet, which may make limit the number of suitable mounting locations due to unavailability of tall poles.

If solar power is to be used, the site must provide full sunlight view for the maximum practical time each day, preferably, from two hours after sunrise to two hours before sunset.

Installation Guidelines

Appendix A provides detailed instructions for installing the traffic sensor equipment at the proper height and orientation. Location of the SPCU and solar panel relative to the sensor is constrained only by the length of the interconnecting cables. However, mounting the SPCU lower will facilitate maintenance by eliminating the need for a bucket lift truck to access the unit.

The optimum orientation for the solar array is geographic or true South. When using a magnetic compass to align the panel a correction factor of 12 degrees must be added to account for the variation between magnetic South and true South. Hence, the panel should be pointed to a magnetic heading of 192 degrees $\pm$ 10 degrees.

The SPCU provides a grounding stud that must be connected to earth ground to provide safety and lightning protection.

Traffic Sensor Calibrating

Traffic sensors must be calibrated following installation. The principal setup parameters include location of lane boundaries, sensor sensitivity and, for the acoustic sensor, average vehicle length that determines measured speed. Other parameters may also require adjustment and are unique to the sensor type and installation.

For each sensor type, radar and acoustic, a vendor-furnished calibration program is provided to setup the sensor. The program is installed on an IBM-compatible laptop computer and connected to the sensor via a prefabricated test and calibration cable. To calibrate the radar sensor, the cable between the SPCU and the sensor is disconnected at the sensor and the test and calibration cable is connected between the sensor and the laptop. Since the acoustic sensor is

hardwired by the manufacturer to the interconnecting cable, there is no direct access to the sensor. Instead, the test cable is connected between the laptop and the RJ-45 data port on the sensor interface board internal to the SPCU. (The data cable to the internal processor is first removed and the test cable inserted in its place.) Calibration procedures for both types of sensors are contained in manuals provided by the sensor vendors.

SPCU Configuration

When the SPCU is powered up, it operates using the internally stored default configuration until it is reconfigured, if desired, via commands from the CMRS. All SPCU's must have the same configuration and configuration commands from the CMRS are automatically broadcast to all SPCU's. Anytime power to the SPCU is lost and later reapplied, the unit reverts to the default configuration. Table 5 lists the default SPCU configuration parameters and values.

Table 5 Default SPCU Configuration

Parameter	Value
Morning Peak Start Time	6.00 AM
Morning Peak End Time	9.00 AM
Evening Peak Start Time	3.00 PM
Evening Peak End Time	6.00 PM
Peak Time Reporting Interval	5 minutes
Off-Peak Reporting Interval	15 minutes
Full Data Buffer Threshold	500 bytes
First Speed Bin Edge	10 mph
Second Speed Bin Edge	30 mph
Third Speed Bin Edge	150 mph
Fourth Speed Bin Edge	150 mph
Fifth Speed Bin Edge	150 mph
Speed Bin Edge Hysteresis	10 mph

Moving to a New Location

All connecting cables should be disconnected from the SPCU and the internal lead acid battery removed. Captive protector caps should be threaded onto all circular style connectors on both the SCPU unit and the mating cable end connectors. The radio antenna should not be removed unless necessary to prevent damage in transit, since repeated removal and replacement of the antenna will eventually degrade the watertight seal. It is also easy for the rubber O-ring and gasket on the antenna connector base to be knocked loose from the unit. Should it be necessary to remove the antenna, a light film of non-conducting grease should be applied to the O-ring and connector threads before reattaching the antenna mast. Grease should be applied sparingly since an excess of grease in the antenna fitting can degrade performance and cause damage to the radio transmitter.

Adding or Deleting Sensors

Sensors may be added or deleted from the network by entering or deleting the sensor ID and other information from the sensor configuration database in the CMRS. Secure server firewall rules may also have to be updated to accept (reject) the new (deleted) sensor's IP address. These will vary with the security policies of the server host organization. Firewall rule updates are required by L-3 for as long as the server is located at the L-3 site. Procedures for adding and deleting sensors are described in Adding and Deleting Sensors Section

Secure Server Installation

Equipment Requirements

The Secure Server is intended to run on a minimally configured, hardened Sun SPARC Server. The keyboard, mouse, monitor, and Ethernet network cable are

the only devices connected to this server. There are no other external peripherals attached. Hardware and software requirements are summarized in Table 6.

Table 6 Secure Server Hardware and Software Requirements

- Sun SPARC 5 Server

- Monitor, Keyboard, Mouse
- 10 Mbps or 100 Mbps Ethernet Network Interface
- 2GB (or more) Hard Drive
- 128MB (or more) RAM
- Floppy Drive for NJDOT SW Installation

- Perl 5.003

- Installed as part of Solaris 8 OS

- Floppy containing njdot.tar file.

njdot.tar stores the NJDOT Secure Server code

Hardware Installation

The Secure Server Workstation should be installed on a host network with Internet access and be assigned a fixed IP address. The unit should be connected to an uninterruptible source of filtered power.

Software Installation and Startup

A knowledgeable technician from the host organization's Information Technology organization should install and configure the operating system software by performing the following steps:

- Install Solaris Operating System
- "Harden" OS Software
- Set up Restricted Port Access within OS Software

Hardening of the operating system should be performed in accordance with security procedures and requirements of the host organization and may involve the installation of additional site-specific software application programs.

The following procedure is then used to install the L-3 Secure Server application program:

- Login to Secure Server as root

- Insert Floppy containing njdot.tar.gz file in Floppy Drive

- Issue Following Commands to Install NJDOT Software

    cd /tmp

    mount -F pcfs /dev/diskette0 /mnt

    cp /mnt/njdot.tar /tmp

    ls -al

    tar xvf njdot.tar

- Reboot the Machine with the following command init 6

- When the machine reboots issue the following commands to verify that the Secure Server is running

    ps -ef | grep srv

    within the output, entries should be observed for the spcu_srv and cmrs_srv processes.

CMRS Installation

Equipment Requirements

The CMRS is an Intel-based, IBM-compatible, Personal Computer running the Microsoft Windows 2000 Professional operating system. Table 7 and Table 8 list

the required hardware and software configuration of the CMRS. The CMRS application software developed by L-3 has been designed to run on any IBM compatible PC with comparable performance to that listed below. However, it has only been tested with the equipment specified below and operation on other equipment is unverified and is not guaranteed.

Table 7 CMRS Hardware Configuration

Item	Description	Mfr	Remarks
1	IBM Compatible PC	Any	• Processor: Intel Pentium, 233 MHz (min) • RAM: 128 MB minimum • Floppy Disk Drive: 1.44MB Standard drive • Hard Disk Drive: 10GB minimum • CDROM Drive: Readable and writeable CD Rom • Network Interface: 10 Base Ethernet • Display: Color CRT, 17"

Table 8 CMRS Software Configuration

Item	Description	Mfr	Version	Remarks
1	Windows Professional 2000	Microsoft		
2	Microsoft Office 2000	Microsoft		Only Microsoft Access 2000 is used
3	CMRS Application Program	L-3	1.0	Installed by L-3
4	Perl	ActiveState	5.6.0.623	
5	Ethernet LAN Communications Software			User Specified

Hardware Installation

Installation of the CMRS consists of connecting the PC base and monitor to a clean source of 115 VAC power, and the Ethernet port on the back of the PC base unit to a LAN or modem that provides continuous access to the Internet. It is recommended that surge protection be provided between the PC and monitor units and the local 115VAC source.

Software Installation and Startup

The CMRS is delivered with application software installed. The following installation procedure is only needed to reload application software programs in the event of a catastrophic failure of the CMRS hardware. The startup procedure may be required anytime the CMRS is shut down and restarted.

Software Installation

< > indicates information field to be entered or key to be pressed.

1. Copy "njdot" directory from CDROM to C: drive on the CMRS.

2. Copy contents of "wwwroot' directory on the CDROM to C:\Inetpub\wwwroot on the CMRS.

3. Enable and configure the IIS (Internet Information Server) component of Windows 2000. (procedure follows)

    a. Line 1

    b. Line 2

4. Set time of day clock in Windows 2000 to correct time.

5. For convenience, open Windows Internet Explorer and set the home page bookmark to the CMRS local IP address.

6. For convenience, create a bookmark in Windows Internet Explorer to point to "http:\\<CMRS IP address>\delete_old_records.html"

7. Add a shortcut to the Windows 2000 start menu to point to the traffic database "C:\njdot\db\dot.mdb"

Startup

1. Close all open windows before beginning the startup procedure.

2. Using the Windows Start menu, open up an MSDOS command prompt window. T

3. Type "cd C:\Inetpub\wwwroot\cgi-bin" <enter>

4. Type "schedpoll.pl" <enter>

5. Minimize (do not close) the MSDOS command prompt window.

6. Repeat steps 2-5 substituting "schedsend.pl" for "schedpoll.pl" in step 4. (This will open a second command prompt window and startup the program "schedsend" in that window.)

USER CONTROL AND DATA MONITORING

The CMRS is the point of control for configuring the traffic monitoring system and viewing traffic data. Configuration information, such as types and locations of traffic sensors, and alert client email addresses, are entered at the CMRS into database tables using Microsoft Access. Real-time traffic data is received from remote sensors and stored by the CMRS into Microsoft Access database tables, which may be viewed using Microsoft Internet Explorer, either at the CMRS, or from any PC that has Internet access to the CMRS. (Netscape is not recommended as a web browser and will provide minor differences in operation). Note that when traffic data is viewed at the CMRS, viewing may be interrupted by processing tasks that share the web browser and will close the browser at

completion of the task. Data viewing from remote PC's is not interrupted, since the web browser is not shared.

From the web browser, any viewer can also review and modify the operating configuration of the remote traffic sensors.

Modifications to database files, other than the SPCU configuration, must be performed at the CMRS using Microsoft Access.

Periodic backup of the traffic database is recommended and must be performed at the CMRS.

System Configuration

CMRS utilizes a single Microsoft Access database comprising four database tables to store traffic data and configuration information. The Pagers table is used by the system administrator to add or delete email addresses of clients who wish to receive/stop receiving motorist information alerts. The ReportData table is used by the application program to store traffic data samples received from all of the systems sensors. The SensorInfo table is use by the system administrator to enter the ID number and descriptive information about each of the active traffic sensors. Finally, the SensorConfig table is used by the application program to store the most recent configuration command sent to the sensors. Additional details on the contents and use of each table are provided in the following sections.

The Motorist Information database is accessed for modification by opening the file C:\njdot\db\dot.mdb" at the CMRS. The file may be opened from a file directory viewer such as Windows Explorer or by using the shortcut on the Windows start menu.

Adding/Deleting Sensors

Sensors are added or deleted from the system by modifying the SensorInfo database table in the Motorist Information database and updating the secure server firewall rules.

To modify the SensorInfo database, open the database file C:\ njdot\db\dot.mdb. Then, from the Microsoft Access main menu, double click on the SensorInfo table icon to open the table. The table will appear as shown in Figure 6. Enter the sensor ID and sensor name (this includes the sensor type and serial number) from the information provided with the sensor unit, and an abbreviated sensor name. The abbreviated name should be as short as practical and contain no spaces. The installed system uses a name comprised of the letter "A" or "R" to indicate an acoustic or radar sensor and an arbitrary but unique unit number. Enter the location name and number of lanes to be monitored and reported and a unique number for the reportorder.

The sensor ID is used as the sensor address when communicating with the sensor or receiving data. The sensor name and location appear on the web page when viewing traffic data and sending sensor commands. The sensorabbr field is used by the application program as a shorthand file name. The reportorder determines the order in which the sensors are listed in pull down menus on the web viewer. Reportorder numbers must be consecutive; do not leave any gaps when assigning these numbers. The GPS latitude and longitude fields are used by the application program to store the sensor location that is reported by the sensor unit in response to a Get GPD Data command from the CMRS. No administrator input is required for these fields. When data entry is completed, save the database table and either open another table or close the Microsoft Access program window.

Depending on the security policies of the organization hosting the secure server, it may also be necessary to update firewall rules anytime a sensor is added or deleted from the network. Common security practice is to maintain a directory of approved wireless IP addresses that have access through the firewall to the server. This directory is updated each time a sensor is added or deleted from the network. Consult the responsible Information Technology organization for rules governing firewall access. Firewall rule updates are required by L-3 for as long as the server is located at the L-3 site.

Adding/Deleting/Modifying Pager Client List

Any client with an email address can receive Motorist traffic alerts. Clients are added or deleted from the system by modifying the Pagers database table in the Motorist Information database. First, open the database by opening the file C:\ njdot\db\dot.mdb. Then, from the Microsoft Access main menu, double click on the Pagers table icon to open the table. Enter the email address of the client to be added and the word "Active" in the groupid field to enable that client to receive traffic alerts. A client name may also be entered in the first column for ease of identification but this is optional. Alert messages may be turned off to selected clients at any time by entering the word "inactive" in the groupid field. Alert messages will continue to be sent to any client whose groupid is active. Clients may be permanently deleted from the database by deleting their associated information from the database table. When data entry is completed, save the database table and either open another table or close the Microsoft Access program window.

ReportData Table

The ReportData table is used by the application program to store all traffic monitoring data received from the sensors. No system administrator inputs are required for this table. It may be viewed by opening the file C:\ njdot\db\dot.mdb and double clicking on the ReportData table icon which appears on the Microsoft Access main menu. The Motorist Information database may be copied and this

table imported into Microsoft Access for detailed analysis using macro routines written in the Microsoft Access application language.

Sensor Configuration Table

The SensorConfig table is used by the application program to store the most recent configuration command sent by the CMRS to all sensors. This single record is accessed and displayed on the View SPCU Configuration page of the CMRS web browser.

SPCU Control and Data Monitoring

SPCU operating parameters can be set remotely from the CMRS. All SPCU's must have the same configuration and the CMRS assures this by simultaneously broadcasting configuration commands to all SPCU units. In addition, certain status parameters can be requested from individual SPCU units and the units can be individually reset from the CMRS.

SPCU control and data monitoring is performed using a web browser and should be performed from a remote PC using the CMRS as a web server. The web browser on the CMRS is shared by the data processing programs and may be redirected or closed by the application as needed. While this will not negatively impact system operation, it can become frustrating for the operator who must reopen the web browser each time it is closed.

The Motorist Information System operator interface is accessed by pointing the web browser to the network (IP) address of the CMRS and the folder "njdot.html", i.e., http://<ipaddress>/njdot.html. This will bring up the main menu shown in Figure 5. The IP address for the initial CMRS installation at CCCTMA in Mount Laurel, New Jersey is shown at the top of the figure. The main menu provides three options:

- Command Page for sending commands to the SPCU

- Data View Menu for viewing the traffic database for selected sensors

- View SPCU Configuration to review the most recent set of configuration

  commands sent to the SPCU's

Each of these options is described in greater detail below.
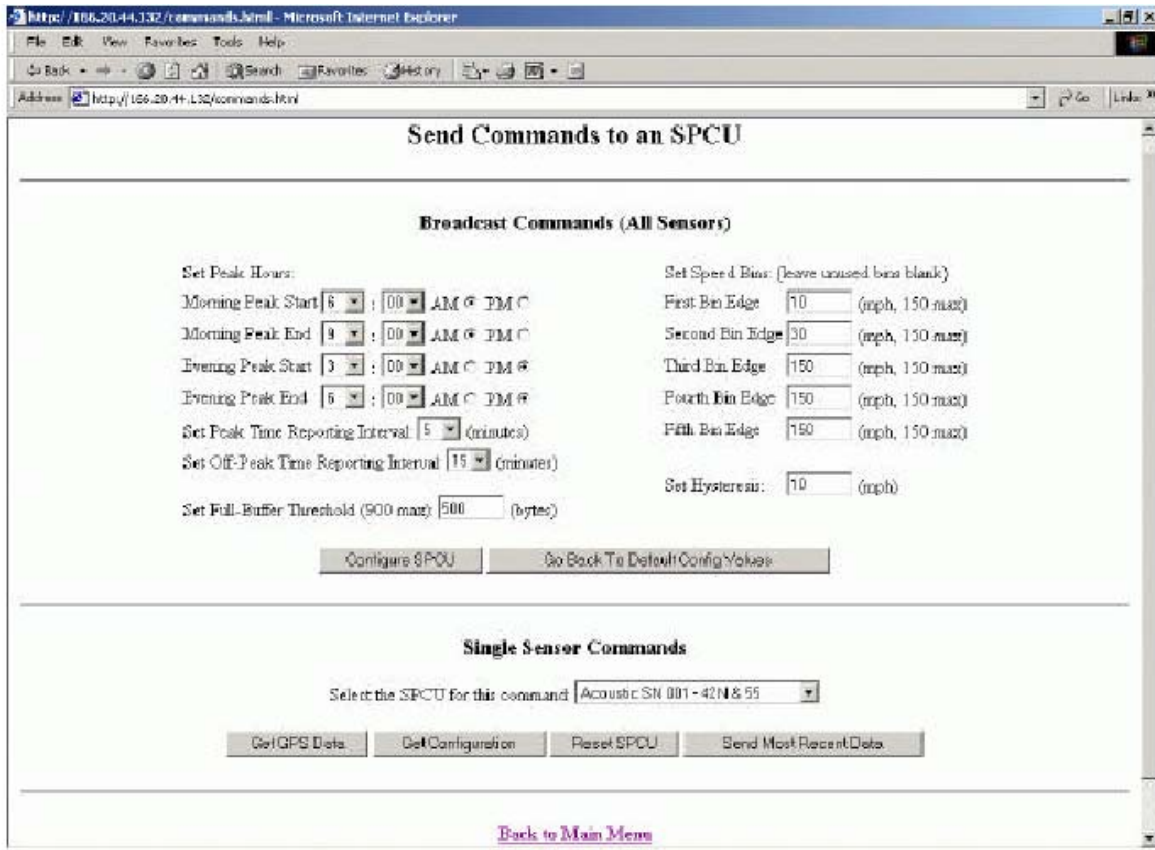
Viewing the Current SPCU Configuration

Clicking on the View SPCU Configuration link on the MIS Main Menu displays the SPCU Configuration page. This data represents the most recent command sent to the SPCU's. This is a read-only page and does not provide for operator inputs. It is useful for confirming the current SPCU operating state before making configuration changes.

SPCU Configuration Commands

Clicking on the Command Page link on the MIS Main Menu brings up the display shown in Figure 5. Commands are sent to the SPCU by changing the data in one or more dialog boxes and clicking on the appropriate action button.

Configuration commands are of two types: broadcast and individual unit commands. Broadcast commands are sent to all SPCU units, while individual commands are directed to the single SPCU unit specified in the unit selection dialog window. Broadcast commands appear in the top portion of the screen, while single sensor commands appear in the bottom portion.

Figure 5 SPCU Command Page

When the command page is opened, the values shown in the dialog boxes are the SPCU power-up default values, not the current SPCU configuration which is viewed from the SPCU Configuration Page.

The Back to Main Menu link at the bottom of the page returns the operator to the Motorist Information System main menu.

Broadcast Commands

The SPCU allows for specification of peak and off-peak traffic periods and individual sampling intervals for each. Typically, the sampling rate is reduced during off-peak hours to conserve power and data bandwidth. Start and stop times may be entered in hours and minutes format for two peak traffic periods;

these normally correspond to the morning and evening rush hours. Sampling intervals may be entered in 5 minute increments up to a maximum of 30 minutes.

The SPCU transmits data either when a change in speed bin has occurred or when the maximum specified message length is reached by accumulation of successive samples. The Set Full Buffer Threshold parameter sets the maximum number of bytes that may be contained in a single SPCU message. In typical operation, the default message length of 500 bytes assures reliable wireless operation and provides an efficient ratio of data to overhead (each message carries a fixed eight bit header). Longer messages are not recommended since they are more susceptible to error caused by radio frequency interference and do not significantly improve transmission efficiency. In the event of heavy radio interference, message length should be reduced until reliable communications is established. Missing samples in the traffic database are indicative of poor radio communications.

The Set Speed Bins section of the menu specifies the speed thresholds to be used in defining the speed bins used by the SPCU to classify traffic speed. Alert messages are triggered by a change in speed bin. Five speed bin edges are available; however, only bin edges one and two are used in the current installation to define three speed bins to represent conditions of congested/stopped, slow, and free-flowing traffic. Bin edges three; four and five are provided as additional capability that may be useful for more detailed traffic studies and experiments.

Hysteresis is applied to each of the bin thresholds to prevent nuisance alerts caused by vehicle speeds hovering in the neighborhood of a bin edge where a small change in speed can result in frequent bin changes. Hysteresis works by using different bin edge values for positive and negative-going transitions across a bin edge. The Set Hysteresis parameter determines the difference between the positive and negative going thresholds. Higher values require greater changes in

speed to trigger a motorist alert. The default value of 10 mph has been determined to work well. If the spacing between speed bin edges is reduced, the hysteresis value should be proportionately reduced.

Two action buttons are provided at the bottom of the Broadcast Commands section of the menu. The Configure SPCU button updates the SPCU configurations using the values entered in the parameter dialog windows. The Go Back to Default Config Values button resets all of the parameter windows to default values. These are the same values which appear when the menu is first opened.

Single Sensor Commands

Single sensor commands may be sent to a selected SPCU by choosing the SPCU unit from the pull down menu in the bottom portion of the Command screen. There are four command types that may be sent to the selected unit by clicking on the appropriately labeled action button. They perform the following functions:

Get GPS Data – This command requests the selected SPCU unit to report its GPS position. The GPS location is automatically entered into the SensorInfo database table.

Get Configuration – This command requests the selected SPCU to report its internal configuration parameters. This command is useful as a troubleshooting aid to confirm that a particular configuration command has been received by the selected SPCU. This command is primarily intended to serve as a diagnostic tool. Data returned by the SPCU can only be viewed at the CMRS. It cannot be viewed from a remote PC.

Reset SPCU - This command resets the SPCU processor and reconfigures the SPCU unit to the default power-up configuration. This command may be used if an SPCU stops responding to attempt to get the unit restarted. Whenever the

SPCU processor is reset, the unit default configuration is loaded and any custom tailoring is lost. Desired changes to the default configuration must be resent to the unit using broadcast configuration commands. Anytime the SPCU is reset or powered-up, the processor initiates a time synchronization procedure to align the SPCU clock with the CMRS clock. If the two clocks are not aligned, the SPCU will not be able to receive commands since it listens for command messages at scheduled times according to the selected sampling interval.

Send Most Recent Data – This command requests the SPCU to send the contents of the data buffer. This command is useful when no traffic alerts have occurred recently and the operator wishes to view recent traffic samples that are accumulating in the data buffer.

Data Monitoring

Data monitoring is initiated by clicking on the Data View Menu link on the Motorist Information System main menu. This will bring up the Traffic Data Menu shown in Figure 6. Traffic from a single SPCU sensor may be viewed by entering the start and stop dates for the monitoring period, and selecting the sensor to be reported and clicking on the Get Data action button. This will display the selected traffic data in the format shown in Figure 7.
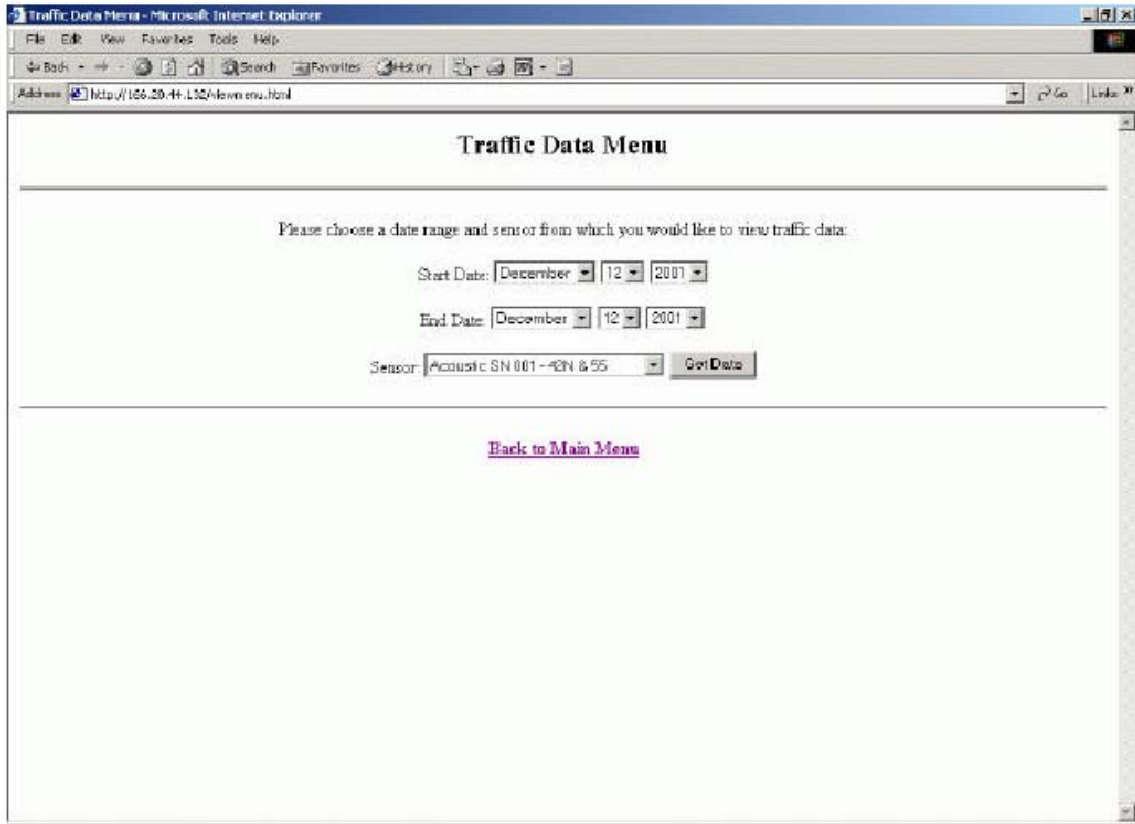
Figure 6 Traffic Data Menu

Figure 7 Traffic Data View Page

The data view displays the date and time the traffic sample was taken, vehicle counts for trucks and total vehicle count (trucks plus cars), percent lane occupancy, measured speed by lane, volume –weighted average speed across the entire roadway and the speed bin number assigned by the SPCU. Speed bin changes are indicated by a double "X" in the rightmost column which aids in quick identification of changes.

Traffic bins are color coded for easy recognition of bin changes. Speeds below the First Bin Edge (bin 1) are coded red. This is the heavily congested/stopped condition. Speeds between the first and second bin edges (bin 2) are coded yellow to indicate slow conditions. All higher numbered bins are color coded green for free moving conditions.

The type of data displayed is partially sensor dependent. The acoustic sensor provides separate counts for tractor-trailers and smaller trucks; the radar sensor provides a single, aggregate truck count. All vehicle counts are in units of cars per minute. The sensor sends car counts observed over a period of 30 seconds. The CMRS doubles this number to obtain cars per minute. Hence, all car counts will be even numbers. The Total Occupancy by lane is in percent of available space. The average speed is a volume weighted average across all lanes and is proportional to the total traffic throughput for the roadway. This speed is calculated by multiplying the volume in each lane by the speed in each lane, summing these together and dividing by the total volume. In this way, lightly traveled lanes have less impact on the average speed than heavily traveled lanes.

Saving and Purging Traffic Data Files

Periodic backup of the traffic database is required and must be performed at the CMRS. Backups should be scheduled to prevent the traffic database from becoming too large. (1-10 MB is a reasonable but not a hard limit). Monthly backups are sufficient for the demonstration system. Backup files should be saved to CD-ROM or floppy disk and must fit completely on a single disk, i.e., the file cannot be split between multiple disks.

The backup process consists of making a local copy of the active traffic database file then purging all data from the active file. Copying the file is done manually. A utility program is provided to erase data from the active database file. The purge utility deletes all data up to midnight of the previous day and leaves the current day's data.

Once data has been purged from the active database, it can no longer be viewed from the web browser. Backup files are in Microsoft Access format and can be accessed and viewed at any PC using Microsoft Access.

Backup Procedure

1. Open Windows Explorer

2. Open folder C:\njdot\db

3. Create a copy of the file "dot.mdb" and name the copy "MM-DD-YY Backup Copy of dot.mdb" where MM is the month, DD is the day, and YY is the year of the backup date.

4. Move the backup file to a suitable archive folder and medium for safe keeping.

Purging Procedure

1. Start Internet Explorer, select the Favorites menu and click on the shortcut for "http://<CMRS IP address>/delete_old_records.html" and follow the instructions provided.
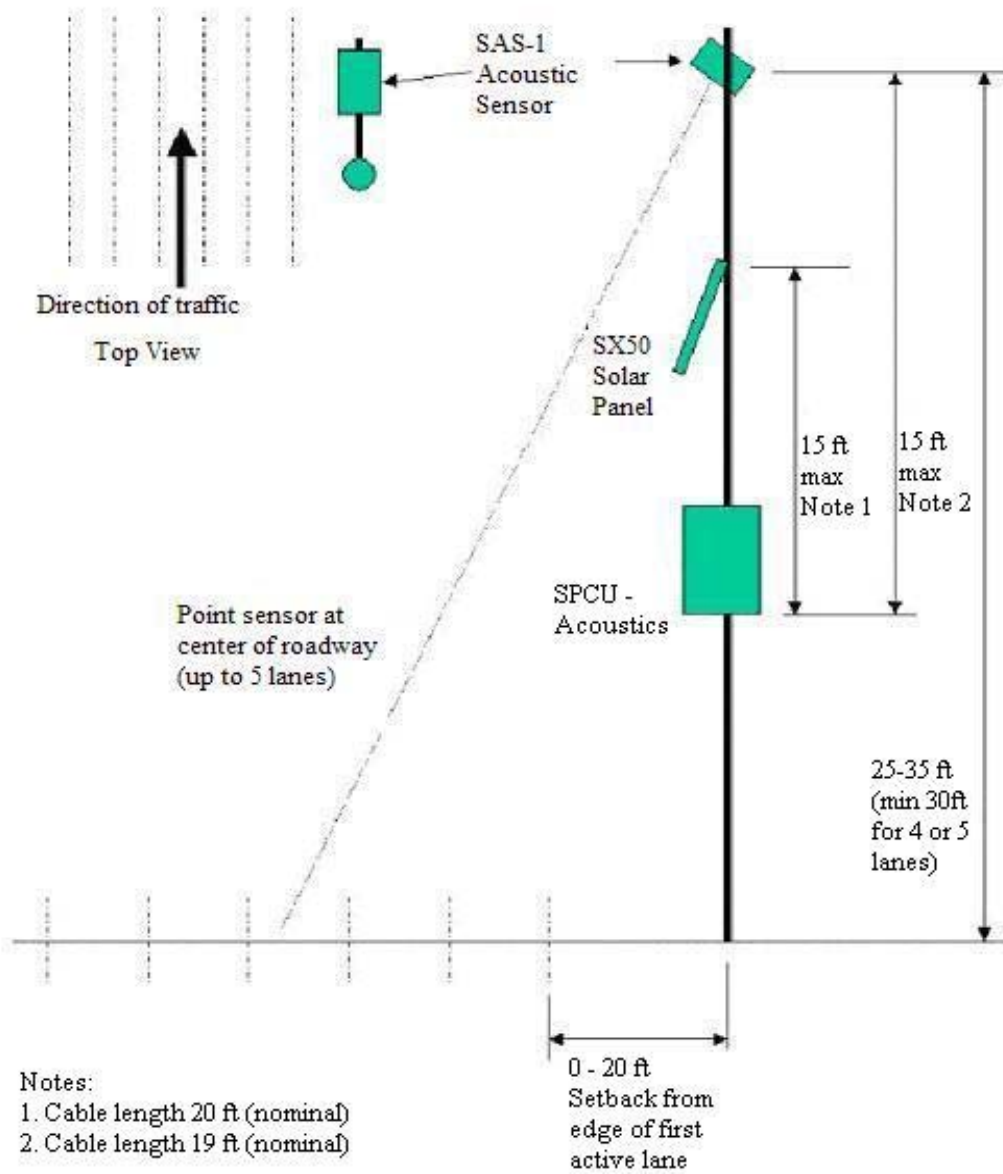
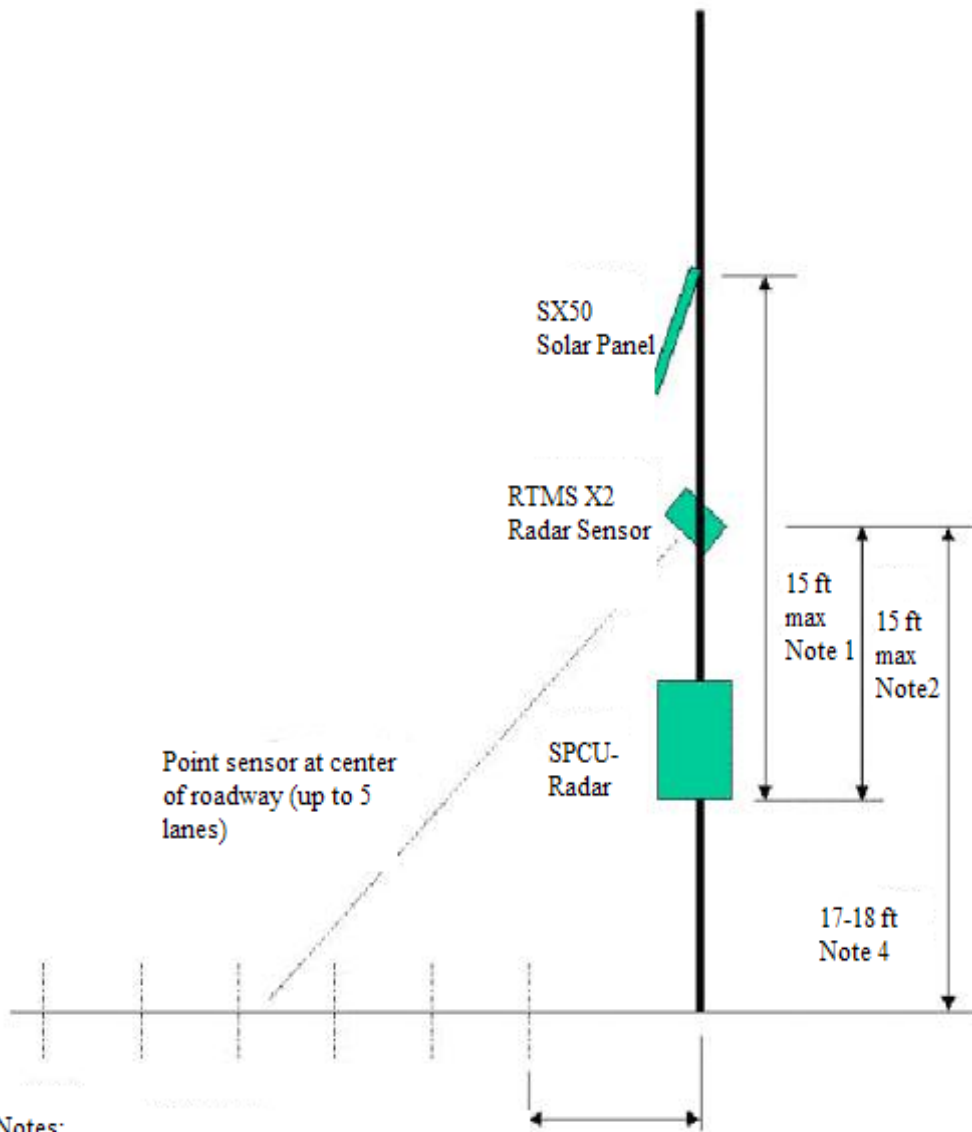# APPENDIX
Traffic Sensor Equipment Installation Instructions

Cautionary Notes:

1. Unfurl cables gently. Connectors are heavy and may separate from cable if permitted to drop freely.
2. Secure cables to pole to prevent wind force damage.
3. SPCU weight is approximately 35 lbs without battery and 70 lbs with battery.
4. Acoustic sensor arm should be on side of pole away from traffic – see figure.
5. Ground stud on SPCU should be connected to earth ground to maintain lightning protection.

Acoustic Sensor Installation

SAS-1
Acoustic
Sensor

Direction of traffic

Top View

SX50
Solar
Panel

15 ft
max
Note 1

15 ft
max
Note 2

Point sensor at
center of roadway
(up to 5 lanes)

SPCU -
Acoustics

25-35 ft
(min 30ft
for 4 or 5
lanes)

0 - 20 ft
Setback from
edge of first
active lane

Notes:
1. Cable length 20 ft (nominal)
2. Cable length 19 ft (nominal)

Radar Sensor Installation

SX50
Solar Panel

RTMS X2
Radar Sensor

15 ft
max
Note 1

15 ft
max
Note2

Point sensor at center
of roadway (up to 5
lanes)

SPCU-
Radar

17-18 ft
Note 4
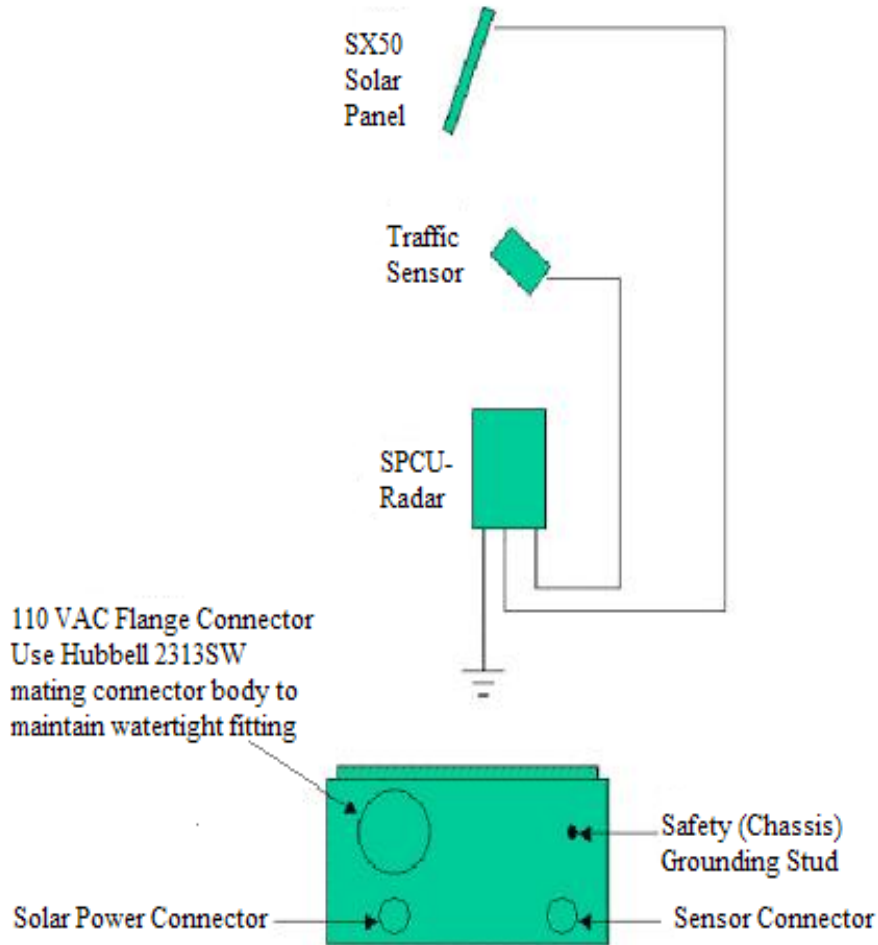
Notes:
1. Cable length 20 ft (nominal)
2. Cable length 20 ft (nominal)
3. Height of sensor is critical; location of SPCU
and solar panel are restricted only by cable
length.
4. For setbacks greater than 20ft, height may
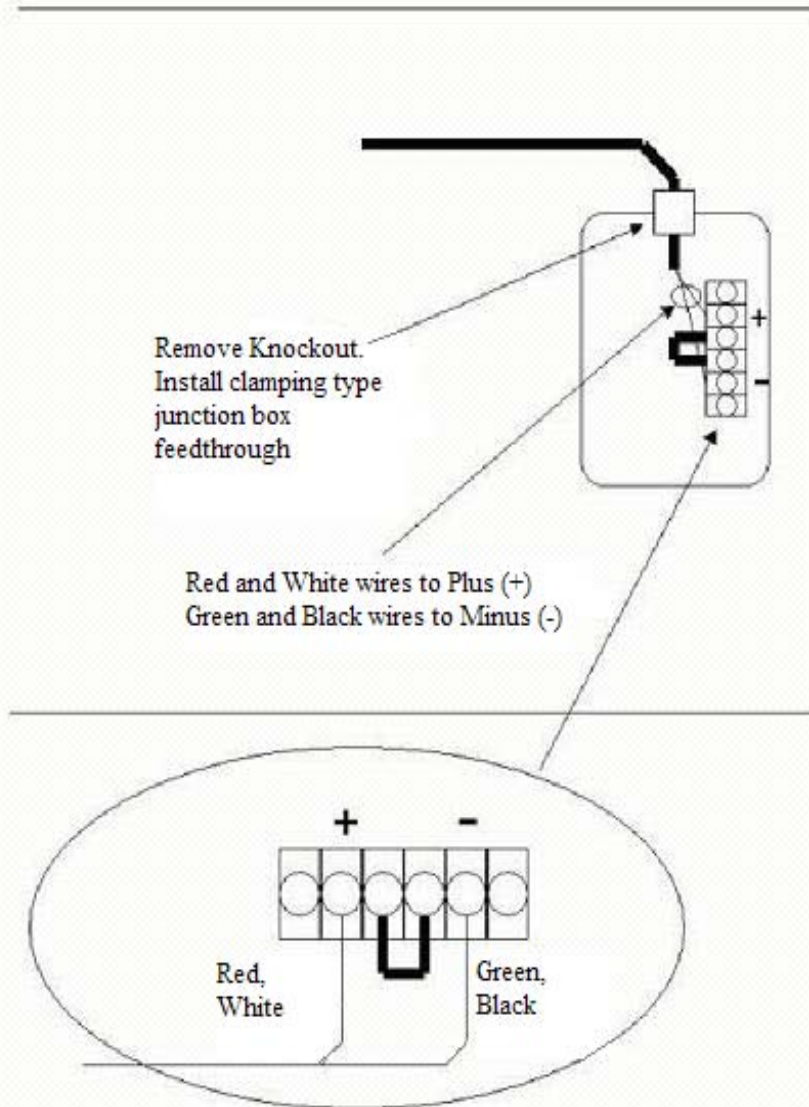increase but should not exceed setback.

15 ft min
setback from
edge of first
active lane

47

Equipment Interconnections

SX50
Solar
Panel

Traffic
Sensor

SPCU-
Radar

110 VAC Flange Connector
Use Hubbell 2313SW
mating connector body to
maintain watertight fitting

Safety (Chassis)
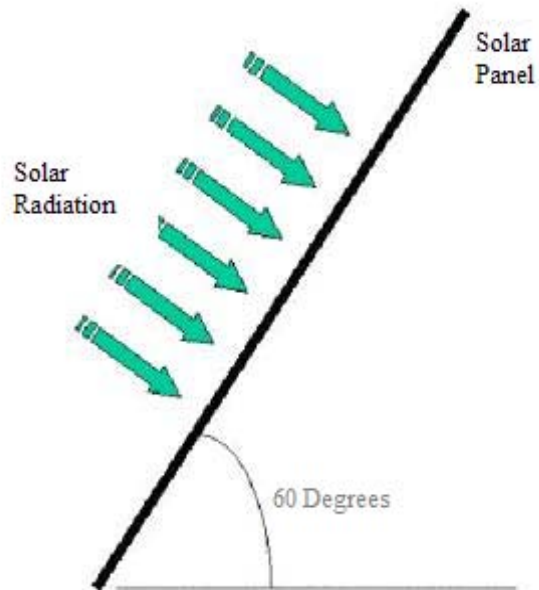Grounding Stud

Solar Power Connector

Sensor Connector

Notes:
1. All connectors are uniquely sized and keyed for sensor
type and function. Data connector is 10 pins, solar power
connector is 7 pins.

Solar Panel Cable Connections

Remove Knockout.
Install clamping type
junction box
feedthrough

Red and White wires to Plus (+)
Green and Black wires to Minus (-)

Red,
White

Green,
Black

Solar Panel Sun Orientation

1. Point solar panel in a true South direction (192 degrees magnetic compass heading) ± 10 degrees.
2. Tilt 60 degrees above horizontal