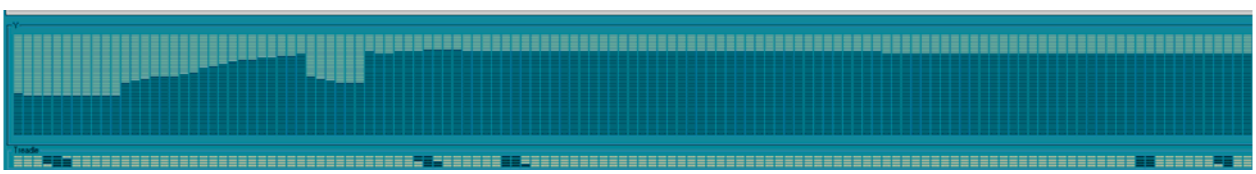
Technical Description

For

Single Lane Modular Remote Vehicle Evalulation System Model 352

Including

Laser Scanner, Doppler Radar, Weigh-In-Motion Sensors, Dual Tire Detector, Image Capture Cameras, and Processor



TRANSPORT DATA SYSTEMS

TDS
TRANSPORT DATA SYSTEMS

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1.0 INTRODUCTION/SUMMARY

The purpose of this document is to define the modular design of the TDS Vehicle Evaluation System. The basic system consists of a Doppler radar, overhead scanner and weigh-in-motion sensors. The basic system can be augmented with a dual tire detector and front and side view cameras to provide additional alarm selection capabilities as well as the capability of recording images of the vehicle for identification.

This system provides the capability of generating vehicle alarms based on a complex structure based on vehicle length, height profile, width profile, axle location, dual tires and weight per axle/tire.

This design is based upon TDS's extensive experience in the field of automatic vehicle classification, license plate capture and violation enforcement. TDS has over 500 lanes of high accuracy vehicle classifiers and image capture systems in operation today.

The TDS Vehicle Evaluation System design includes the use of a highly accurate Doppler radar system to provide vehicle velocity during the profiling process. The addition of the quartz strips to the design in place of the treadle in the TDS AVC design provides a perfect match for weight detection. The accurate velocity that is required when using quartz sensors for weight calculations is inherent in the TDS design.

The integration of image capture with weigh-in-motion and vehicle classification enables the user to improve weight enforcement and related infrastructure planning. The inclusion of this system into a weight enforcement strategy will lead to improved commercial vehicle safety, ensuring equitable competition in the commercial carrier industry and protecting public and private road assets from excessive and accelerated damage caused by overloaded commercial vehicles.

This technology has a number of applications in commercial vehicle weight enforcement, infrastructure development and road asset maintenance planning. It can be used to augment permanent weigh station operations by providing images and classifications for mainline WIM pre-screening systems, monitoring vehicle compliance to WIM sorter traffic signals and traffic signs, and for monitoring weigh stations evasion routes. It may also be deployed in conjunction with mobile and remote weight enforcement as a pre-screening system, or as an automated stand alone monitoring system on remote routes. The data from this system can provide agencies with a visual record from which to engage in discussions with particular carriers detected as chronic violators, or to assign preferred carrier status. The system may also be deployed in support of transportation planning activities to assist traffic engineers to evaluate future capital developments or help road asset managers plan preservation programs across specified segments of the road infrastructure. Other applications include urban weight enforcement and concentrated haul road weight enforcement. Finally the system can be employed on toll roads to provide a more equitable method of assessing costs for patron use of the road.

2.0 CUSTOMER REQUIREMENTS

2.1 Vehicle Alarm Selection

The processor implements a complex table lookup selection system to allow generation of alarms based upon various parameters associated with the vehicle. This table can be easily modified to meet unique customer requirements. Selection criteria include length, width profile, height profile, and speed as well as individual axle/wheel weights. Depending on the sensor set that is implemented, the system can be easily programmed to issue an alarm if any combination of the selected vehicle characteristics are exceeded.

2.2 Image Capture

The system will capture an image of the vehicle for use in determining the ownership of the vehicle. The image capture system can be set up to capture either the front license plate of the vehicle or the rear license of the vehicle. An option is also available for capturing the USDOT number on the door of the vehicle. If required, three cameras can be implemented within the lane processor to simultaneously capture front, rear and door images.

2.3 Accuracy

The system will determine vehicle classes to an accuracy of at least 99%. The weight measurements shall have an accuracy greater than 90%,

2.4 Vehicle Separation Performance

The system will differentiate between vehicles separated by a minimum of 2 meters at speeds of less than 50 miles per hour.

2.5 Interfaces

The processor includes an Ethernet port and an RS-232 port for sending vehicle information including images to a central server.

3.0 SYSTEM DESIGN

The system consists of the laser scanner, Doppler radar, dual tire detector and twin quartz sensors. Each quartz sensor can be from .75 to 2 meters in length. The system can be delivered without the dual tire detector if the customer does not require it.

The block diagram of a generalized system is shown in Figure 3.0-1 below:

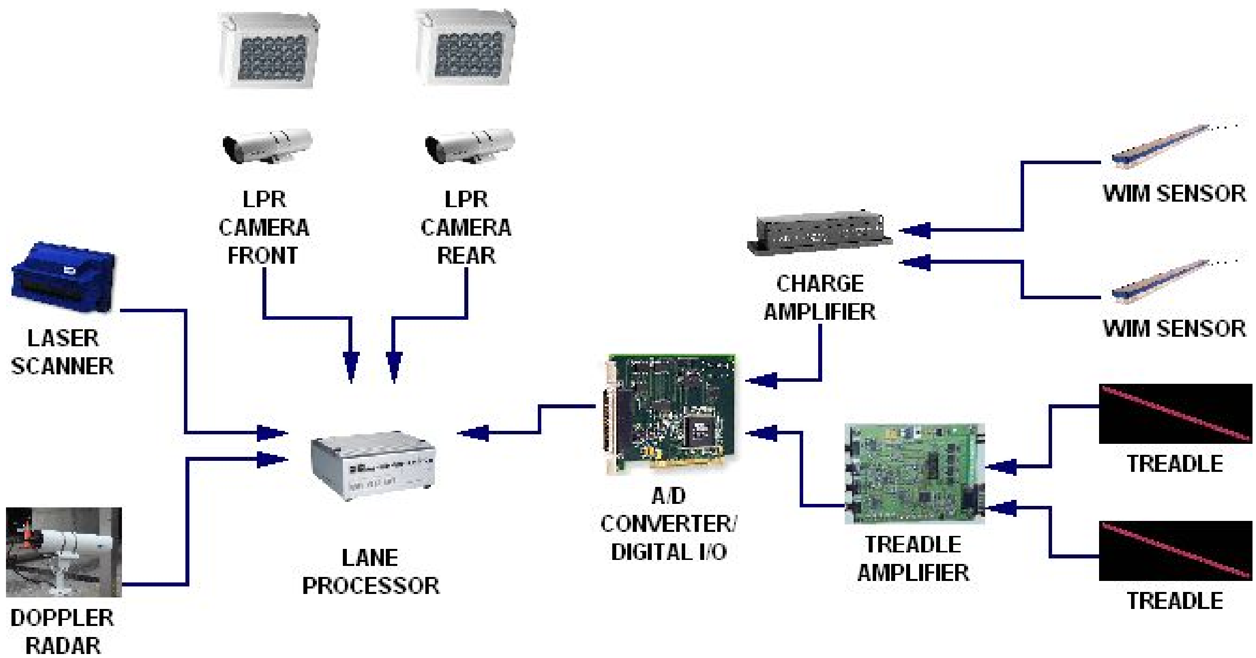


Figure 3.0-1; System Block Diagram

The lane layout for the lane is shown in Figure 3.0-2 below:

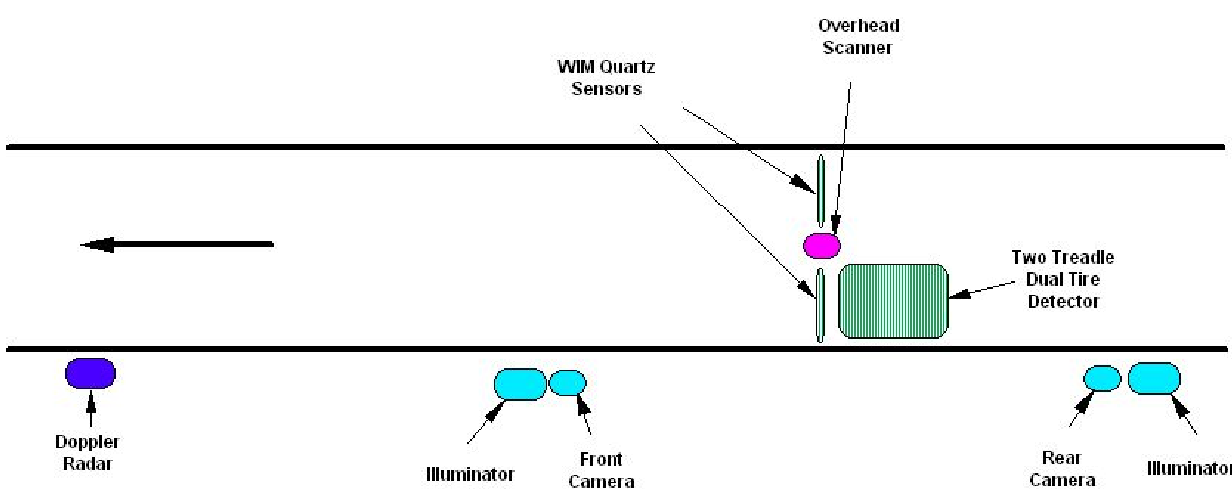


Figure 3.0-2; Lane Sensor Layout

The system will generate alarms according to a set of rules. Table 3.0-1 shows a SAMPLE set of rules. The rule generation is extremely flexible and can be readily matched to particular customer requirements.

Table 3.0-1; Produced Alarms - Sample

Vehicle Type	Alarm Number	Alarm Criteria	Vehicle Detection Criter
2 Axle Truck	1	Rear Axle Weight > 5000 lbs.	Two axles, > 20ft without a van/bus profile (height > 6 feet) - Dual Tires
3 Axle Truck	2	Rear Wheel Weight > 8,000 lbs.	Three axles, Length, Axle Location, Height Profile. Dual Tires
4 or More Axle Trucks	3	Axle Weight > 15,000 lbs. OR Individual Tire Weight > 3,500 lbs. OR width > 9 feet OR height > 14.6 feet	Axle Count

The TDS lane processor:

- Meets all of the individual vehicle discrimination and alarm generation based on axles, dual tires, vehicle weight and length and the height and width profiles of the vehicle.
- Allows easy modification of alarm categories to readily accommodate future requirements.
- Provides accurate vehicle velocity (max and/or average) – accuracy = 1% +/- 0.2 mph.
- Maintains the position of the vehicle at all times while in the collection zone. This includes stop and go operation as well as reverse motion.
- Is composed of off-the-shelf technology from major suppliers.
- Has a system MTBF in excess of 20,000 hours.

3.1 Operational Philosophy

The automatic vehicle classification system described herein is a pattern recognition system that relies on special pattern recognition algorithms to categorize vehicles into a number of distinct types. It uses the length of the vehicle, the number, weight and spacing of axles/tires, and height and width matrix depiction of the vehicle to form a complex pattern. This pattern is then fed to discrimination software that correlates with one of a predetermined set of vehicle types. A picture of an actual profile of a five axle truck is shown in **Figure 3.1-1; Vehicle Profile**.

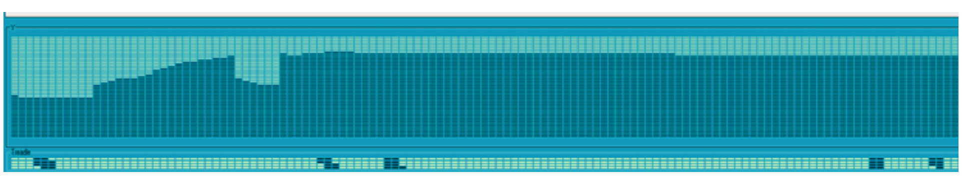


Figure 3.1-1; Vehicle Profile

Vehicle detection and profiling are accomplished by processing the sensor data from the radar, laser scanner, dual tire detector and weigh-in-motion sensors. The lane processor receives frequent sensor messages from the radar and laser scanner. Each radar message reports the distance and velocity of up to seven targets that the radar is currently sensing in its beam. Each laser scanner message provides a report of the beam status of each of the individual beams. The axle sensor inputs are sampled each time a laser scanner message is received. The vehicle detection process begins when the laser scanner reports sufficient penetration concurrent with a radar report of an object moving in the vicinity of the lane in the path of the laser scanner beams. A filter is implemented to eliminate false classifications from being reported due to penetration of the laser scanner by objects other than vehicles.

While the laser scanner is sufficiently penetrated, the processor creates a profile of the vehicle using the Doppler radar velocity information to determine which position in the vehicle profile to store each laser scanner and axle detection samples. This process continues until the laser scanner no longer detects a presence in the path of the laser scanner beams. The vehicle profile is then sent to the correlation process where the classification will be determined.

The correlation process begins with the series of tests to determine the characteristics of the vehicle. These characteristics are the length of the primary vehicle, the presence/location of a hitch, the maximum height and height variance of the primary vehicle, the maximum width of the vehicle, the number of axles and their weights and locations, the existence of dual tires and certain other discrimination criteria. The test results are then correlated with a table of characteristic values that is configured for the user classification schedule. This table of characteristics is stored in a configuration file that is separate from the application software. This provides an easy method for updating the class schedule should the user require modifications. After the classification has been determined the classification message is transmitted to the remote weigh processor application. The classification message includes the maximum velocity of the vehicle measured during the period that it was within the laser scanner. The message also includes the vehicle height, width, weights and length as well as the total axle count.

After the vehicle has been classified the system continues to track the location of the vehicle in the lane.

A key element in this design is the use of the CW Doppler radar. When vehicles are traveling at higher speeds, the problem of resolving two vehicles in close proximity is particularly vexing. However one characteristic that these two vehicles have in common is that their velocities are obviously very nearly the same. Therefore the Doppler return from each of the vehicles is also nearly the same. The laser scanner acts to provide excellent vehicle separation. The current design allows for separating two vehicles that are within 4 foot of each other at a velocity of 100 miles per hour. At more reasonable speeds (60 mph), the vehicles may be within two feet of each other and at manual lane speeds, the vehicles may be within 8 inches of each other. The processor uses the velocity provided by the Doppler radar to determine the positioning of the various samples in the vehicle profile. Since in this particular case the velocities of the two adjacent vehicles and the corresponding Doppler radar outputs are nearly identical, errors in the sampling distance that are due to returns from the adjacent vehicle are negligible.

The output from the Doppler radar provides an excellent measure of the vehicle velocity. This data is used to calculate the weight of each wheel set as the wheel crosses the quartz sensor. This data will be transmitted to the remote weigh processor as part of the primary message.

3.2 Image Capture System

The Transport Data Systems license plate capture system uses a high resolution digital area scan camera capable of operating in the full visible spectrum or in the near IR band.

This camera will provide high resolution lane coverage over a capture area of approximately 10 feet wide by 6 feet high. The size of this coverage coupled with accurate triggering insures that a single image will include the vehicle license plate. The resolution of the camera coupled with the low noise performance provides an excellent image for optical character recognition. TDS has developed a companion OCR package for use with this camera.

TDS can supply the image capture system with one camera for front or side capture or with two cameras for capture of both the front and side images.

TDC can also supply the capture system with the necessary filters and LED illumination to allow operation in the near IR band. This method of operation provides enhanced plate detection and optical character recognition. The use of IR illumination eliminates the bright lights associated with full spectrum operation. This is especially important when front plates are being captured as it removes the safety hazard associated with blinding the driver of the vehicle. The privacy issue is also addressed as the image does not produce a recognizable picture of the driver. However, during nighttime operation, the image also does not include the vehicle. Only the license plate itself is visible. TDS recommends that the front camera operate in the near IR band.

The digital video image is transmitted via a fiber link to a digital capture board located in a PCI slot in the processor. A serial RS422 link from the digital capture board provides a means for initialization and control of the camera by the processor.

3.2.1. Image Capture Software

The image capture software application receives the trigger and triggers the camera to capture an image. The camera captures the image and then downloads the data to the Processor memory via the high-speed digital fiber interface. The image is then stored on the hard drive in an uncompressed raw format. The application then either uploads the image to the next level user or performs the OCR process locally. The remote weigh processor generates a transaction for upload to a central processor.

3.2.2. Image Capture Triggering

Each of the cameras is independently triggered. The LPR image capture software receives a trigger from the triggering application. The trigger is developed from the lane sensor information.

The trigger is generated when a vehicle enters the capture zone defined by the vehicle separator. This integrated mechanism provides an extremely accurate trigger for both cameras. The lane geometry for a two camera installation is shown in **Figure 3.0-2.**

3.2.3. Optical Character Recognition Software

Transport Data Systems has developed and tested a plate locater and associated optical character recognition package specifically designed to extract ASCII representations from license plates that have been photographed using high resolution digital cameras. This OCR can be implemented in the lane processor. The OCR process works best with uncompressed images. This system will perform the OCR process on the uncompressed images and then compress the images for storage and transmission to the next higher level. The extraction of the license number at the Vehicle Evaluation System will also enhance the ability of the local site to select and examine specific transactions and to provide this selection capability externally through the web interface. Furthermore should the end user ever decide to outsource the violation processing, the vendor would not have to deal with the OCR process for the specific image capture process as implemented by the end user.

As each violation transaction is received, it will be processed and entered into the database. The associated images will be processed by the OCR software and then compressed. The compressed images will be stored in the database along with the license plate number and the quality data developed during the OCR process.

3.3 Software

The software can provide any/all of the following functions:

- Receipt of data from the radar
- Receipt of data from the laser scanner
- Receipt of data from the axle detection and weighing equipment
- Camera triggering and image capture for front and side view cameras.
- Image storage and transaction storage – Offending vehicles.
- Vehicle presence detection
- Vehicle position tracking through the collection zone
- Determination of the vehicle classification based on sensor inputs.
- Vehicle speed
- Profiler entry and exit messages
- System diagnostics (remote or local)
- Error reporting to the central server
- Output of data to the central server

The processor will be able to handle all types of vehicle motion including negative speeds. It will identify back-outs and terminate the transaction.

4.0 DETAILED DESCRIPTION - EQUIPMENT

4.1 Laser Profiler

The laser profiler is a model LMS211 produced by Sick Optic-Electronic. It is a non-contact measuring system that scans its surroundings two dimensionally. The scanner does not require any reflectors or positional markers to function as a scanning system.

The LMS 211 operates by measuring the time of flight of laser light pulses. The time between emission and reception of a light pulse, after it has been reflected from a surface, is directly proportional to the distance between the light source and the object. The laser can scan a large area by using a pulsed laser beam deflected by a rotating internal mirror. The LMS can produce the contour of an object using a rapid sequence of distance measurements. The serial data itself is sent to the remote weigh processor in real time via the RS-422 link.

The unit operates at a scanning rate of 75 scans per second. The scan angle that is reported is programmable. For this application it will be set to 68 degrees. The beam width of the laser beam is approximately 1 degree. The reported angular scanning resolution is programmable. For this application it will be set to 4 degrees, resulting in 17 segments being reported per scan. The range resolution of this configuration is approximately 50 millimeters.

The unit includes internal heaters for environmental control. A built-in thermostatically controlled heater and a front screen heater enable the LMS to be used at temperatures to minus -30 degrees Centigrade. The heaters are activated at 10 degrees Centigrade to prevent any thawing from occurring within the unit.

The unit is delivered with an optional dust prevention shield. This shield prevents direct exposure of the front screen to precipitation or sources of dirt.

The scanner unit weighs approximately 9 kilograms. The unit is delivered with a separate mounting bracket that provides adjustment of the device in both of the relative axes.

The electronic part of the sensor is powered directly from a regulated 24 VDC 1 amp power supply. The scanner heater is also powered from 24 VDC at 6 amps. The heater supply does not require regulation. Both the electronics and the heaters can be powered from the same primary power supply if desired.

TDS provides a maintenance screen in the software package that allows a technician to easily align the scanner and configure the height and lane width settings during installation.

4.2 Doppler Radar

The SI-3 was designed to meet a wide variety of demands, including radar message trailers, computers, and conveyer belt controls. A self-contained, stand-alone unit, the SI-3's internal firmware is customizable, allowing changes to range, output format as well as many other options.

4.2.1. Features

- K-Band Antenna
- Directional
- RS232 Serial Port
- Stationary Mounted Radar Systems
- 5-150 mph (8-241 km/h) Speed Range
- Range: 1,500 ft default; 3,000 ft max.

The radar is a very low power device (< 5 milliwatts CW). It has complete FCC approval for operation on the open road and is not an RF hazard to humans under any conditions.

4.3 Axle/Weight Detection System

The axle/weight detection system will consist of two quartz sensors connected to a charge amplifier. Depending upon the width of the lane, each sensor will be 1.0 meter, 1.5 meter or 1.75 meters in length. In the event the user does not require separate weights for each individual tire on the axle, a single quartz sensor can be constructed with a sufficient length to cover the entire width of the lane.

4.3.1. Quartz Sensor

Kistler's LINEAS WIM Type 9195C is a force sensor with quartz elements. The sensor is a modular element that is installed into a slot that is saw-cut across an asphalt or concrete road. When a force is applied to the sensor surface, the quartz disks yield an electric charge proportional to the applied force through the piezoelectric effect. The electric charge is converted by a charge amplifier into a proportional voltage which can then be processed as required. Key characteristics include:

- Excellent long term stability.
- Measures very accurately at both walking and freeway speeds.
- Insensitive to temperature changes.
- Frost-resistant and protective against ingress of water.
- Quasistatic and dynamic calibration is possible.
- Wide measuring range.

The sensor is not dislodged from the road and can be reground by up to 10 mm in the event of road deformations.

The sensors are available in 0.75 and 1.0 meter lengths. Two or more sensors can be connected together to make a longer single sensor strip. Several sensors that are installed adjacent to one another can be connected electrically in parallel and operated with a single charge amplifier. The output signal then corresponds to the sum of the forces acting simultaneously on all sensors connected.

4.3.2. Charge Amplifier

The industrial charge amplifier (Type 5038A2Y43) is a 2 channel amplifier. Each channel converts the charge output of the Lineas sensor to a proportional voltage. The adjusting potentiometers are designed as plug in units to avoid the need for recalibration when an amplifier is replaced. The unit requires an unregulated 15 to 20 volt DC supply. Its key features include:

- Robust aluminum diecast housing
- Vibration proof
- No adjustments required

4.3.3. Remote weigh processor Interface

The outputs of the sensor amplifier are brought to the remote weigh processor over special cables capable of extending the distance from the sensor amplifier to over 80 feet. The signals are fed into a digital processing card that contains a 12 bit analog to digital converter.

4.4 Dual Tire Detector

The dual tire detection will use two fiber optic treadles, each with a length of 1.7 meters. The two fiber optic treadles are placed at a nominal 35 centimeter (14 inch) separation at an angle of 30 degrees relative to the flow of traffic.

4.4.1. Fiber Treadle

The fiber optic treadle is manufactured by Sensor Line. The fiber treadle installation will include the following items:

- SPZ-Series Fiber Optic Traffic Sensors
- SL MD-220 Optical Transmittance Analyzer

4.4.2. SPZ-Series Fiber Optic Traffic Sensors

These sensors can be provided with lengths up to 4m. Sensitivity can be varied from few grams up to many tons by selecting the mode of installation. Their completely non-metallic structure ensures highest protection against any kind of electromagnetic interference. The SPZ-series sensors have a fiber optic structure fitted into a special conduit and are designed for permanent embedding into the road surface. The materials used enable a range of in-ground operating temperature from -40°C to +80°C (-40°F to 176°F). The feeder cables are spliced to the sensor fiber, so the feeder type and length must be specified in advance. They can be obtained with or without connectors.

4.4.3. SL MD-220 Optical Transmittance Analyzer

The SL MD-220 Optical Transmittance Analyzer is a small dynamic (AC-coupled) dual channel interface device in a plastic module housing. It can also be used for simple static (DC) measurements. An internal Schmitt-Trigger with light-level-controlled threshold enables sensor-independent trigger sensitivity. The unit includes internal failure detection to indicate out-of-range conditions (e.g. torn fiber) by a particular output signal.

The unit provides optocoupler outputs for trigger and failure signals. The analog signal outputs are short-circuit-protected. The input power connections include reverse power protection. No adjustment necessary to the unit. The unit uses a powerful IRED transmitter (Laser Class 3A when fiber disconnected). This is suitable for feeder lengths up to 250m.

The SL MD-220 is an interface ideally suited for all common axle detection, axle counting and speed measuring purposes, but also a convenient means to simply feed light into an optical fiber or measure light emerging from a fiber. It is designed in a way that it can easily be configured to meet a maximum number of custom requirements as well as extended by supplementary circuits for additional functionality.

The SL MD-220 feeds a variable amount of light into the fiber thus providing automatic adaptation for much larger variations of the sensor and feeder transmittance.

4.4.4. Fiber Treadle Quick Replacement Frame and Carrier

The fiber treadle is designed to be installed directly into the roadway using a special epoxy to encapsulate the fiber treadle. This provides excellent performance. However in the event of a failure of the treadle, the encapsulation and the enclosed fiber treadle must be physically removed from the roadway and replaced. This will typically remove the lane from service for a minimum of 24 hours while the epoxy cures.

In those applications where a quicker replacement is required, SensorLine offers a steel treadle frame and carrier combination. The frame is installed into the roadway and the carrier is then bolted into the frame. The fiber treadle is encapsulated with resin into the carrier by TDS. The user then installs the carrier into the frame. The fiber cable is routed through the junction box on the end of the frame.

4.5 Camera

The camera will be from the Point Grey Grasshopper product line. These are high resolution digital area scan cameras. The camera will be equipped with a 1624 by 1224 pixel CCD. The camera will provide full color performance using full spectrum illumination.

The camera has the following characteristics:

- Imager: Sony ICX274 1/1.8 inch CCD sensor with progressive scan and global shutter.
- Resolution: 1624 x 1224 pixels color.
- Pixel size: 4.40µm x 4.40µm.
- Aspect ratio: 5:4.
- Frame Rate: 30 per second maximum.
- IEEE 1394B interface for video transfer and for camera initialization and control.
- Signal/Noise ratio = 60 dB.
- Shutter speed: 20µs to 10 seconds
- Gain: 0 to 24 dB.
- Full 24 bit operation in visible spectrum.
- Connectors: 9-pin vertical IEEE-1394 connector and Hirose HR25 (8-pin) for external trigger, strobe, general purpose I/O and onboard serial port

4.5.1. Peripheral Control

The Grasshopper has four I/O pins that can be configured in one of four ways. The pins can be set up for external trigger, strobe or serial communications. This feature is useful for integrating the camera with external devices such as process controllers and for lighting lights. In this application, this interface will be used to strobe the visible LED illuminator and to control the lens iris setting.

4.5.2. Enclosure

For both the license plate camera and the container camera, a Pelco EH8106-1 sealed enclosure is provided for mounting the camera along with the FireWire remoter, serial to analog converter and power supply. It includes a thermostatically controlled heater. Desiccant is included to keep the unit free from moisture. TDS recommends not pressurizing the unit.

The mounting plate can be rotated to the top of the enclosure to allow the camera to be mounted beneath the mating surface.

4.5.3. Illumination

The illumination for the license plate capture and for the container capture is provided by a TDS visible illuminator. The illuminator is mounted in a separate IP67 enclosure that is located 1m from the camera. The illuminator strobe is controlled by the camera with the illuminator only being activated during the exposure period which reduces the average power consumption to less than 20 watts. The illumination is provided by bright white LEDs that have a color spectrum that

resembles a warm incandescent lamp. The illuminator mounts uses the same method as the camera enclosure except that a washer and nut are required for the illuminator.

4.5.4. Firewire Extender

The Firewire Extender allows the Firewire camera to be located up to 1,650 feet from the Lane Image Processor using fiber optic cables. The extender consists of a sender and receiver. The unit operates at transfer rates of 100/400/800Mbps. It is operates on +12VDC provided over the 1394B cable at the PC end or from an external +12VDC supply when located at the remote end of the fiber. The unit has the following specifications:

- Operating temp range – 0 to 70 degrees C
- Max Power - 3.3W
- Fully supports provisions of IEEE P1394b revision 1.33+ at 1-Gigabit signaling rates

The max power consumption is 3.3 watts. The units have an operating temperature range of 0°C to 70°C with humidity ranging from 20% to 80%.

4.6 Lane Processor

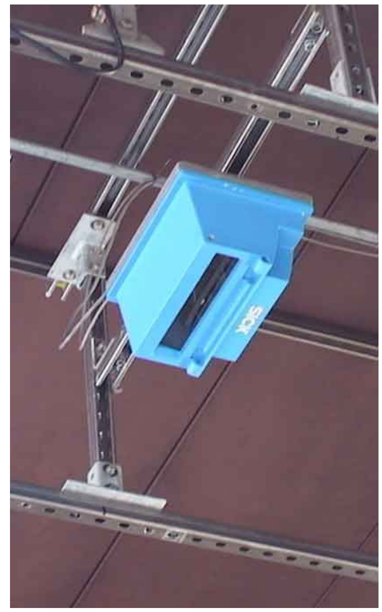
The software module will be installed on a Lane Processor. The Lane Processor is a Advantech ARK Series Industrial controller. It uses an Intel Core2Duo™ processor. It includes 2 gigabytes of RAM and a 200 Gb hard drive. It will contain dual Ethernet ports for LAN connections. The unit will run the Linux operating system.

The processor will include Firewire board(s) for interfacing to the cameras. One processor is required for each lane.

5.0 INSTALLATION

5.1 Laser Scanner Installation

The laser installation consists of:



- Mounting the laser mount on the overhead structure.
- Mounting the laser power supply near the scanner. The laser power supply will need to be put into an enclosure for external mounting.
- Installing a single cable between the power supply and the scanner.
- Installing a single cable between the scanner and the lane processor.

The laser scanners must be installed overhead at a height of approximately 18 feet from the road surface.

5.1.1. Scanner Installation

The scanner is supplied with a mounting bracket for attachment to the structure. The mount is adjustable to allow for alignment of the scanner.

5.1.2. Scanner Power Supply Installation

The scanner requires a special 24 volt DC power supply. TDS will supply this power supply in a separate rugged container for installation near the scanner installation. The power supply for the scanner must be mounted either on the gantry or at the base of the gantry

5.1.3. Scanner Cabling Installation

The scanner is connected to the lane processor via an RS-422 link. A single cable connects the scanner to the lane processor and the scanner power supply. The cable will be supplied with the scanner connector installed and the RVES processor connections left un-terminated. This cable should be run inside of a conduit to the lane processor location.

5.2 Radar Installation

The radar installation consists of:

- Mounting the radar mount on the island.
- Attaching the radar enclosure to the radar mount.
- Installing a single AC power cable to the radar.
- Installing a single fiber cable between the radar and the AVC processor.

5.2.1. Radar Installation

TDS uses a standard Pelco mount for the Doppler radar. The mount is attached to the island with four bolts. The mount is adjustable in both azimuth and elevation to allow for beam alignment of the radar.

5.2.2. Radar Signal Cabling Installation

A single fiber cable connects the radar to the AVC processor. Fiber converters are provided within the radar enclosure and at the AVC processor. The fiber cable will be supplied with the fiber connectors installed on both ends. This cable should be run inside of a conduit to the AVC processor location.

5.3 Quartz Sensor Installation

Special sand/epoxy grout secures the sensor strips into the pavement slots. After curing, the hardened grout and the exposed top surfaces of the sensor modules are ground flush with the surrounding pavement using a belt sander. After grinding, the sensors may be immediately exposed to traffic. An overnight post cure is recommended before calibration and acceptance tests are performed.

Installation instructions for the installation of the sensors will be provided by TDS. The potting compound used to install the sensors will be supplied by TDS.

5.4 Treadle Installation

The treadle will be installed directly below the scanner. The fiber is connected to the fiber interface box located near the AVC processors. The fiber must be run through ducting from the treadle to the fiber interface box. SensorLine will provide the fiber. Installation instructions for the installation of the fiber will be provided by SensorLine. The actual treadle sensor can be either permanently installed in the roadway or can be installed using a treadle frame and carrier for quick replacement.

5.4.1. Permanent Treadle Installation

In the permanent installation, the fiber treadle is potted into the road surface. A slot is cut into the concrete. The fiber treadle is positioned in the slot and the potting compound is poured into the slot. The potting compound used to install the treadle will be supplied by SensorLine.

5.4.2. Quick Replacement Treadle Installation

The use of the treadle frame and carrier allow for quick replacement of the treadle in the event of a failure. In this installation, the treadle frame is permanently installed into the concrete. The treadle carrier is delivered by Sensorline with the treadle already potted in place. Once the frame has been installed, the treadle carrier is bolted into the frame. Then the fiber is pulled through the conduit and the cover plate is installed.

5.5 Camera Installation

5.5.1. License Plate Camera Physical Installations

The camera and the Gefen FireWire extender are mounted inside the Pelco camera enclosure. An IP67 rated LC duplex receptacle allows for fiber entry into the enclosure.

The simplest installation is to use the standard Pelco MM-22 mounts for the license plate and container cameras. The final details of this will be determined by a complete site survey. TDS will provide a bolt pattern for the selected mount and an installation drawing depicting camera position and angle.

5.5.2. License Plate and Container Camera Power Connections

A separate entry hole is provided for AC power connection to the enclosure. The unit requires 115 VAC at 3 amps. TDS recommends 14AWG THHN wire.

5.5.3. FireWire Extender Physical Installation

In addition the small FireWire extenders (1 per camera) need to be mounted in the cabinet. Each unit is approximate 3 inches wide by 4 inches long by 1 inch deep. These units do not require power as they get it through the cable connection to the PC.

5.5.4. FireWire to Lane Image Processor Cable Installation

A standard 1394A 6 pin FireWire cable is used to connect the FireWire extender to the FireWire interface board in the lane image processor. TDS will furnish this cable. A 3 foot cable is provided for connection to the Lane Image Processor.

5.5.5. Camera to FireWire Extender Fiber Cable Installation

The fiber cable that connects the FireWire Extender in the lane cabinet to the camera is a dual strand tactical grade 62.5Mu Multimode Fiber Optic Cable with LC connectors on each end. The connection at the rear of the camera assembly is an IP67 rated connector designed for use with pressurized enclosures. The LC termination on the end that connects to the Firewire extender is a standard LC termination with no additional environment protection. All signal transmission is done via this fiber optic cable allowing for the power and signal cables to reside in the same conduit to the lane.

5.6 Lane Processor Installation

5.6.1. Lane Image Processor Physical Installation

TDS anticipates that the Lane Image Processors will be installed inside a building near the portal.

5.6.2. Lane Image Processor Power Connection

The server comes with a standard AC power cord. It requires 117 VAC at 5 amps. UPS power is required for the lane processor.