

## **5 COST OF NON-INTRUSIVE VEHICLE DETECTORS**

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### **5.1 Introduction**

Under the condition that all the requirements are satisfied to replace the inductive loop at signalized intersections, the cost of non-intrusive vehicle detectors may be the topic of interest to contractors. Contractors tend to choose the cheap and easy to install vehicle detectors that satisfy the requirements.

### **5.2 Parts of Detector Cost**

The cost of non-intrusive vehicle detectors mainly includes three parts: the first is the sensor cost, which is the direct cost for contractors to purchase the sensors from vendors; the second is the installation cost, which is the expense for contractors to install the sensors at the intersection signal systems; the third is the maintenance cost for the vehicle detectors, which will be an important component of the cost of the vehicle detector if the construction period is long. The main components and calculations of each part are as follows.

- In the sensor cost, if multiple lanes are to be monitored and a sensor is capable of only single lane operation, then the sensor cost must be multiplied by the number of monitored lanes.
- Installation costs include fully burdened costs for technicians to prepare the road surface or subsurface to install the sensor and mounting structure (if one is required), close traffic lanes where required, and verify proper functioning of the device after installation is complete. This kind of cost also is relative to technical support from the vendor.
- Maintenance and repair estimates may be obtained from manufacturers and from other agencies and localities that have deployed similar sensors. When the construction period is short, there may little need for maintenance and repair so the cost could be omitted. But if the construction period is very long, this kind of cost will take up an great percentage in the total cost of the vehicle detector system.

When we calculate the cost of a vehicle detector system, all the three parts should be considered. Contractors tend to select the cheap detectors of the sum of all the three parts (also called life-cycle costs).

Although, for cost comparisons, life-cycle costs are most desirable (instead of initial costs only), but finding accurate existing data for the comparison is difficult at best. Therefore, sometimes only initial equipment and installation costs were used. Moreover, there are several factors that reduce the reliability of cost information, and all must be carefully considered. Many of these factors vary somewhat by region of the country and urban areas may have different costs compared to rural areas. Also, initial unit costs vary according to the number purchased at one

time, with lower costs typically associated with a larger number of units purchased. However, it should be emphasized that this variability does not preclude using cost as a decision factor. At the very least, the user agency can bracket the cost factors low to high to make comparisons among detectors being considered. Obviously, the rate-of-return would remain constant, assuming other factors equal (e.g. the purchasing time period). However, other factors like MTBF (Mean Time Between Failure) would vary from one detector to another. Installation costs could be similar for devices of similar difficulty. The actual installation cost estimate might not be exact for two or three detectors being evaluated, but the process would still result in the proper selection.

One thing that should be mentioned, accurate information from user agencies is viewed as more reliable than information from vendors. Vendors are usually willing to provide contact information so that decisions are not made solely on vendor information. Even with many agencies, there are often insufficient resources to thoroughly track detector costs, or there is a lack of emphasis on documenting costs. Therefore, agencies that have accurate detector and component costs are rare, and those that kept records may not have comprehensively tracked costs or they may have not tracked them over a sufficiently long period of time. All these factors should still not discourage an attempt to compare costs, but may affect the weight given the cost results.

### **5.3 Case of Cost Study of Non-intrusive Vehicle Detectors**

As a reference, the guideline lists the results of cost study of non-intrusive vehicle detectors from the report “Vehicle Detection Workshop, Participant Notebook” (reference [2]).

#### **5.3.1 Acoustic Detectors**

##### **5.3.1.1 Smartsonic Detector**

The SmartSonic TSS-1, currently marketed by IRD, provides a detection zone size of 6 to 8 ft in the direction of traffic, and provides one or two lane selectable zone size in the cross lane direction. The TSS-1 processing in the controller card has the capability of computing traffic flow measurements such as vehicle volume, lane occupancy, and average speed for a selectable time period. Power required for the system is low, at 5 to 6 watts, which will allow the use of solar panels.

**Life-Cycle Cost** - The only documented cost on the SmartSonic that was available was the initial cost. However, using consistent assumptions and a basic knowledge of detector performance, one can calculate comparative costs to compare life-cycle costs of one detector with another. The cost of the acoustic sensor is \$1,450 per unit, with one required per lane per detection location. The detection system also requires a controller card at a cost of \$800 that can accommodate up to four acoustic sensors. Therefore, the cost for a six-lane freeway system includes the cost of six sensor arrays at \$1,450 apiece and the cost of two controller cards at a cost of \$800. Cost to install is assumed to be \$400, average life is 5 years, annual maintenance cost is \$200 per system, traffic control is \$4,000, and the rate of return is 5 percent. The annualized annual cost is \$3,841.

**Ease of Setup and Maintenance** - The SmartSonic system requires one sensor array per lane, mounted over the lane but slightly to the side of the lane. Mounting requires traffic control, a bucket truck, and a support such as a sign bridge to achieve the proper position. During setup, it is very important that the installer pay careful attention to the controller LEDs because they indicate whether the sensors are communicating properly with the computer. Another precaution is in installing the transition module which must be handled carefully, because the connected wires may easily overstress the connection terminal. The user can test, configure, and view output of the acoustic system using the Hyperterminal software in Windows™ 95. Data can be stored in the unit, but if the controller loses power, all data collected to that point are lost. Only the setup for data collection will be kept in the memory.

#### 5.3.1.2 SmarTek SAS-1 Detector

The SmarTek Systems Acoustic Sensor – Version 1 (SAS-1) is a passive acoustic (listen only) detector that mounts beside the roadway with the capability of monitoring up to five lanes from its sidfire orientation. Its mounting requirements are less demanding than the SmartSonic, because it is mounted beside the road. It still requires a bucket truck, but a properly positioned luminaire support will suffice as the detector support. The detector needs to be mounted as high as 35 ft above the roadway to accurately monitor five lanes. TTI mounted the detector 20 ft above the travel lanes at the TTI testbed because the detector was monitoring only two lanes and because of the mast arm's height. Its offset from the right lane was 25 ft (as measured at a 90-degree angle with the roadway). After test results became available, the vendor recommended that presence detection accuracy would have been better with a height of 25 ft to 30 ft and smaller offset.

**Life-Cycle Cost** - The SAS-1 was relatively new and documented historical data did not exist to establish life-cycle cost. The current initial cost of the SmarTek SAS-1 is \$3,500. Cabling, mounting hardware, and staff time to install amount to \$500. The mounting requirements for the SAS-1 are minimal. The authors anticipate an average life of 5 years with \$200 per year per system for maintenance. For a six-lane freeway, two systems are needed (one per direction), so the annualized cost of the system would be \$2,248.

**Ease of Setup and Maintenance** - The operations manual has detailed instructions on how to mount the sensor and wire the communication cable for connecting to a serial port on the PC running the Windows™ setup software. The Windows™ setup software is easy to use and calibration is relatively simple. The sensor came with a mounting bracket and can easily be strapped to a pole or mast arm. Precise orientation is not normally required, although adjustments are sometimes necessary. An example of this occurred when TTI mounted the detector behind the mast arm (as viewed by approaching motorists). A diamond-shaped warning sign on that same side of the mast arm initially caused the detector to double-count vehicles. TTI simply moved the detector to the “front” side of the mast arm to solve the problem.

#### 5.3.2 Active Infrared Detectors

##### 5.3.2.1 Schwartz Electro-Optics (SEO)

The Autosense II by SEO is a self-contained non-contact vehicle detection sensor. This sensor operates above the lane of travel, utilizing a scanning laser rangefinder to measure three-dimensional profiles of vehicles as they pass directly underneath the sensor. The sensor processes these profiles directly within the sensor and outputs data through its serial port. The system scans two narrow beams at a fixed angular separation after the rangefinder measures the sensor mounting height. With the measured height and a fixed angular separation of the beams, it measures speeds and utilizes an algorithm for vehicular classification. Each sensor is self-calibrating and does not need to be programmed for data output. Data are continually output through the serial port.

**Life-Cycle Cost** - Life cycle cost information was unavailable for the Autosense II. The AS II alone cost \$10,000 for a single lane; although the Autosense I, at an initial cost of \$6,500, can generate count and speed data and would be sufficient for typical freeway applications. It must be installed directly over the lane to be monitored, so traffic control is required. For a six-lane freeway, assuming a sign bridge or other support is available, one ASI is required per lane, installation cost is \$200 per unit, traffic control is \$1,000 per lane, and annual maintenance averages \$100 per unit, resulting in an annualized cost of \$6,583.

**Ease of Setup and Maintenance**- The Autosense I or II both have to be mounted over the lane, requiring a bucket truck and traffic control for the installation. After proper installation and hook-up, the detector requires little or no user adjustment. The software supplied by the manufacturer provides several formats for the sensor's output data and is not needed for calibration and configuration of the infrared sensor. The LDM 70 modem that is part of the Autosense system has several LEDs that assist the user in the set-up and troubleshooting processes. Checking these functions was critical to the performance of the system.

### 5.3.3 Passive Infrared Detectors

#### 5.3.3.1 Siemens Passive Infrared Detector

TTI tested the PIR-1 series Passive Infrared Detector (PIR-1) from Eagle Traffic control Systems, a subsidiary of Siemens Energy and Automation. The PIR detection technology is based on the fact that all objects above absolute zero emit heat radiation in the remote infrared range of the electromagnetic spectrum. This technology reacts only to movements in or through the active zones. Slow changes in background temperature, caused by changing weather conditions, are not evaluated. In order for the detector to function properly it should be mounted to a stable structure and correctly aligned. The viewing direction for all detection zones must be unobstructed.

**Life-Cycle Cost** - The appropriate application of the PIR-1 is for count detection on freeways (single detector per lane) or at signalized intersections, perhaps for minor street detection. The detector can be oriented so that its area is small enough to cover one lane. Mounting requires a bucket truck, traffic control, and a mounting structure such as a sign bridge. Components of life cycle cost were not directly available, so the authors provide the following estimate. Its initial cost was \$1,100, life is expected to be 7 years, cabling and cost of installation are estimated at

\$200 per unit, and its annual maintenance per unit is \$100. The annualized cost for a six-lane freeway would be \$1,948.

**Ease of Setup and Maintenance** - Researchers had to consult with Eagle Traffic Control Systems to make the PIR-1 detect only one lane. In its original mounting location on the S.H. 6 pole, the PIR-1 could not be orientated to count only one lane. Therefore, it had to be moved from the pole to the mast arm. The horizontal angle between the detector and the road had to be 45 degrees or less to detect only one lane of traffic.

### 5.3.4 Magnetic Detectors

#### 5.3.4.1 Non-Invasive Microloops

The 3M Canoga Vehicle Detection System Model 701 and Model 702 non-invasive microloops use the earth's magnetic field to detect vehicles. TTI installed the Canoga C800 4-channel rack mounted detectors in one of the three roadside equipment cabinets. These detectors are compatible with NEMA TS1, TS2 and Type 170 card racks. The software generates either real-time speed and length, or binned counts and occupancy. The microloop probes slide into a horizontally bored conduit by placing them individually in special interlocking carriers, each one foot in length. The probe carriers snap together, then the assembly is pushed into the conduit from the ground box to the pre-measured position and with a vertical orientation.

**Life-Cycle Cost** - No life-cycle cost information was available for microloops. The cost of the total installation process for the two-lane S.H. 6 site for 3M Microloops includes several factors, including: boring, conduit, ground boxes, microloops, detector amplifiers, and TTI staff time. Traffic control costs are minimal because work occurs off the roadway, and motorist delay is negligible. The total initial cost for two lanes of installation in College Station was \$9,900. Life of the system is expected to be 15 years, with \$50 per year maintenance cost associated with it. For a six-lane freeway, two horizontal bores, and two probes per lane, the annualized cost of a system to monitor speeds and counts would be \$3,181.

**Ease of Setup and Maintenance** - Installing the microloop probes in the conduit was simple. The first probe snapped in to a hole in the first carrier piece. The first carrier has a rope attached that is used to pull out the carriers and mark the location of the probes. Each probe carrier has holes for probes and is one foot long. Multiple probe carriers are snapped together and pushed into the conduit one by one to position them under the lanes. The standard rack detector can be set up with the front switches or by using the software. All the setup procedures are well documented and easy to follow. The available setup procedure guides the user step-by-step through the process of configuring the detector to bin counts and occupancy, or record and display individual real time speeds and lengths. The one parameter that required adjustment to get the highest count accuracy was "bridge time." The bridge time setting holds the "call" for long trucks and is directly proportional to the average speed of vehicles detected. The Windows software always ran reliably and was easy to use, install and understand all its features.

### 5.3.5 Radar Detectors

#### 5.3.5.1 Accuwave Detector

The Accuwave Presence Detector model 150LX is a microwave sensor that can detect a range of vehicles in different environmental conditions. According to the vendor, the detector will perform the same in both sidefire and head on applications. For optimum performance, the detector location should be selected to maximize the return signal from detected vehicles, while minimizing extraneous reflected signals.

**Life-Cycle Cost** - Based on information from a Texas distributor, the cost of the detector plus wiring is \$975, but it also requires an interface panel that costs \$150. Each panel will serve two detectors. Cable cost for the Accuwave is approximately \$1.00 per ft. According to the vendor, the life of the detector should be approximately five to 10 years. Once the detector's sensitivity and delay functions have been set for a particular location, it might have to be readjusted once. Using this information, along with an assumed annual maintenance cost of \$200, average detector life of 7 years, the annualized life cycle cost per unit would be \$386.

**Ease of Setup and Maintenance** - After the Accuwave 150LX Presence Detector was installed, it failed to tune and start detecting vehicles. An early problem was a defective serial communication selection switch, which required returning the unit for repair. Upon reinstallation, it was discovered that the cable had to have individually shielded wire pairs for the detector to function properly. Beyond these two problems, the Accuwave stopped working during heavy rain and did not retune itself until the rain subsided.

#### 5.3.5.2 RTMS Detector

The RTMS (Remote Traffic Microwave Sensor) by Electronic Integrated Systems, Inc. (EIS), is a self-contained microwave sensor that detects and monitors road traffic. It is designed to serve in applications of highway traffic management and intersection control. The RTMS is a true-presence detector that can provide presence indication as well as volume, lane-occupancy, speed, headway, and classification information in up to eight discrete detection zones. The information is provided to existing controllers by contact closures and to other systems by serial communication. The detector can be mounted facing approaching traffic for single lane detection or sidefire for monitoring multiple detection zones. The mode of operation is configured with the setup program using a computer and serial communication.

**Life-Cycle Cost** - The RTMS is very cost-effective for freeway detection in the sidefire mode. TTI calculated life cycle costs for a six-lane freeway, assuming one detector for each direction of traffic flow. Initial cost of the detector is \$3,300 per unit. Detector life was assumed to be 7 years and cost to install the system per freeway station was \$200 per system. The annualized life cycle cost using \$200 per year per unit maintenance cost would be \$1,886. In some cases, only one detector per station will be needed for up to eight lanes. In tests conducted by TTI, concrete median barriers sometimes limited RTMS performance on the far side of a freeway.

**Ease of Setup and Maintenance** -The RTMS had internal clock problems as experienced with some other detectors. The RTMS setup program software would record individual vehicle lane counts, but the software would not start recording its 60-second vehicle count at a consistent point

in time. The software was user-friendly for both modes of operation (sidefire and facing approaching traffic). Maintenance on the RTMS appears to be minimal once the detector is set and calibrated. TTI is planning long-term test monitoring to make a better determination on its stability over time.

### 5.3.6 Video Image Detectors

#### 5.3.6.1 Autoscope 2004

TTI tested the Autoscope 2004 on U.S. 290 in Houston. The data analysis process accumulated all one-minute interval per-lane vehicle counts from the detector to create 15-minute intervals. The analysis concluded with individual lane and total directional vehicle count comparisons between loop values and test system values.

**Life-Cycle Cost** - The Road Commission of Oakland County (RCOC), Michigan, currently represents the largest installation of video detection equipment in the United States. RCOC has documented costs of installation and maintenance of its Autoscope and related equipment. For their recent procurements, the bid prices were \$25,200 for a 2-channel processor, \$20,175 for 4-channel processor, and \$36,175 for a 6-channel processor. The cost of a camera plus line isolation units (for improving the video signal) was approximately \$2,500 per camera. Using mean values from RCOC data, one could anticipate spending approximately \$5.05 per month on camera maintenance and \$26.71 per month on processor maintenance. The annualized cost of a system for a six-lane freeway (one camera required per direction using existing poles or other supports) would be \$4,508.

**Ease of Setup and Maintenance** - The installer sets a number of items through the setup computer. The first step is to open RS232 serial communications with the Autoscope. There are user preferences that must be set, including: video, time, units of measure, latitude/longitude, time slice, speed trap parameters, speed alarm parameters, level of service, and Autoscope options. Then, the user must go to the camera menu and draw count and presence detectors for each lane on the video image. To reduce occlusion, detectors can be connected using detector functions and then draw speed traps last. The final step is to save the detector file, then send the detector file to the Autoscope. In conclusion, setup is complex and takes practice to get optimum performance.

#### 5.3.6.2 Nestor TrafficVision

The Nestor Intelligent Sensor's TrafficVision is a video detection system using computer hardware and software for pattern recognition based on neural networks programmed intelligence that sees and recognizes images. TrafficVision systems, powered by Nestor neural networks and the NI4000 Recognition Accelerator chip, appear to have the potential to provide freeway information not currently available in competing systems. TrafficVision can be used for a wide range of applications, including highway monitoring, tollways, rail crossings, road and traffic studies, and community planning. According to the vendor, it provides more than 12 types of data ranging from vehicle counts and speeds to lane changes and occupancy to vehicle classification.

**Life-Cycle Cost** - The initial cost for the Nestor system was approximately \$20,000. No long-term costs were available for determining life cycle costs. This is anticipated to be similar to the Autoscope whose annualized cost was calculated to be \$4,508.

**Ease of Setup and Maintenance** - The Nestor computer generates a significant amount of heat so fans inside the cabinet are critical. Another problem was the Nestor computer clock drifting approximately five seconds per hour. The solution was a time reference card installed in the computer's motherboard to keep the system clock from drifting. TTI measured reference points on the roadway and used the measurements in the calibration process. The software is very user-friendly. The Nestor system comes equipped with a software utility, called "Wizard," in the Windows software to facilitate setup. This makes setup very simple and quick. The installer must measure one reference point on the ground and input this distance and the height of the camera. One difficulty for setup for research purposes is it must be networked with other computers for the user to communicate with it. There is no keyboard or monitor with the unit to do this. All setup is done remotely through the network computer.

#### 5.3.6.3 Peek VideoTrak 900

The Peek Videotrak 900 is a video image vehicle tracking and detection system. The camera used with this system was a Philips TC590 series high resolution CCD monochrome camera using a 1/3 inch format lens with an 8 mm focal length. The camera was equipped with an auto iris and infrared filter.

**Life-Cycle Cost** - The initial cost to TTI for the Peek Videotrak® 900 detection processor was \$10,000 and the software upgrade was provided at no cost to TTI. The "normal" cost of the processor would be significantly greater than TTI paid, probably in the range of \$20,000. Staff time to set up and calibrate the system was estimated at \$1,500. The camera, lens, housing, cable, and other related component costs were an additional \$1,700 for a total of \$13,200, assuming a pole or other support is available for cameras. The annualized cost for a six-lane freeway using the \$20,000 initial processor cost, two cameras, RCOG maintenance costs, and 10-year life would be \$3,861.

**Ease of Setup and Maintenance** - The VideoTrak 900 hardware is relatively easy to setup. The communications port connects to a computer and the video connects to the Peek harness. The VideoTrak for Windows software has documentation on how to install the system hardware and view the digital image. The software configuration was among the most difficult to set up of all devices tested. The software documentation did not include any tips to help the operator configure the many parameters, tracking strips and detection zones so it would count correctly. The Windows software was easy to use and install but it also crashed occasionally.

## 5.4 Reference Cost

Because of the development of non-intrusive technologies, and the price difference in different areas, it is difficult for the guideline to give a particular price for the non-intrusive vehicle detector. As a reference, the guideline gives some reference cost for different non-intrusive

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vehicle detectors from some research project. The prices of different vehicle detectors are as follows based on the year dollar of the project.

**Table 5-1 Sensor Cost Summary (2002)**

Vendor	Sensor	Unit Cost	Notes
ASIM Technologies Ltd	ASIM IR 254	\$700	
	ASIM DT 272	\$700	
	ASIM TT 262	\$1,600	
Image Sensing Systems, Traffic Control Corporation (Local Distributor)	Autoscope Solo	\$7,000 (Intersection Application)	Cost includes Solo unit, Minihub, interface panel and cable
	Autoscope Solo	\$6,155 (Freeway Application)	Cost includes Solo unit, interface panel and cable
Schwartz Electro-Optics, Inc.	Autosense II	\$6,000 - \$7,500	Depending on configuration /functionality desired
SmarTek Systems, Inc.	SmarTek	\$3,500	\$3,080/unit for quantities over 10
Traficon NV	Traficon	Contact Vendor	
3M ITS	Canoga Detector C822F (2 channel)	\$546	Installation Kit \$114/each Carriers (50/package) \$354.90/package C30003 Home-Run Cable \$390/1,000' spool
	Canoga Detector C824F (4 channel)	\$703.50	
	702 Microloop Probe	\$159.50/probe (+ \$.39/ft for lead-in cable)	
	701 Microloop Probe	\$137.50/probe (+ \$.39/ft for lead-in cable)	

*\*Note: This table comes from reference [4].*

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**Table 5-2 Estimated Operating and Maintenance Costs for Surveillance Systems (1997)**

<b>Description</b>	<b>Base Unit</b>	<b>Estimated Annual Operations Cost/Unit</b>	<b>Estimated Annual Maintenance Cost/Unit</b>	<b>Estimated Annual Combined O&amp;M Costs/Unit</b>	<b>Cost Assumptions</b>
CCTV	each	\$0	\$500 - \$1300	\$500 - \$1300	Costs include routine maintenance for CCTV cameras, as well as the camera controls, housing, and/or support pole.
CCTV Cameras w/ Video Image Processing Capability	each	\$0	\$700 - \$1800	\$700 - \$1800	Costs include routine maintenance for CCTV cameras, as well as camera controls, housing, and/or support pole, and VIP calibrations.
Imbedded Detectors:					
Inductive Loop	per station	\$0	\$200 - \$300	\$200 - \$300	Costs include contract maintenance/replacement of loops. Costs assume four lanes per station, with two loops per lane. Costs also assume loop failure rates of 4% to 6% per year.
Non-Intrusive Detectors:					
Radar, Ultrasonic, Acoustic, Infrared	per station	\$0	\$200 - \$300	\$200 - \$300	Costs include routine maintenance of detectors. Costs assume four lanes per station, with one detector per lane.
Video Image Processing	per station	\$0	\$500	\$500	Costs include routine maintenance and calibration of detectors. Costs assume one video detector per station.

*\*Note: This table comes from reference [3].*

**Table 5-3 Estimated Vehicle Detection Costs (1996)**

CONFIGURATION EXAMINED	Detection Cost Per 4-Lane Site (directional)		
	Equipment	Construction	Total
Presence Type Inductive Loops:	\$8,800	\$11,200	\$20,000
Side-Fired Sweep-frequency Microwave Radar:	\$9,500	\$10,800	\$20,300
Speed Trap Inductive Loop Pair with Piezoelectric Strip	\$9,000	\$14,200	\$23,200
Pole mounted Machine vision Video Image Detector:	\$13,200	\$10,800	\$24,000
Overhead Mounted Sensors on Mast Arms:	\$8,500	\$21,500	\$30,000
Overhead Mounted Sensors on a Sign Bridge:	\$8,500	\$78,200	\$86,700

*\*Note: This table comes from reference [5].*

## 5.5 References for Chapter 5

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- [4] Minnesota Department of Transportation, SRF Consulting Group, Inc. “*Evaluation of Non-intrusive Technologies for Traffic Detection, Final Report*”. Federal Highway Administration , September 2002.
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