SmarTek Systems™, Inc.™

14710 Kogan Drive
Woodbridge, VA 22193
703-680-6554
Sales 410-315-9727

SmarTek Acoustic Sensor - Version 1 (SAS-1)

Installation and Setup Guide

Part-A Introduction and Background

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Note: In all cases, do not work or position equipment over an active traffic lane. Working over active lanes presents a hazard to the installer and to travelers using the highway. Follow local authorized procedures when installing the SAS-1 unit and any associated components or subsystems.

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Introduction

The SmarTek Systems Acoustic Sensor -Version 1 (SAS-1) is a non-contact, passive acoustic (listen only) sensor for multi-lane traffic monitoring at all speeds from free flow to stop and go. It is completely non-intrusive to the highway or to the travelers using the highway. The very compact and lightweight SAS-1 is designed to be quickly and easily installed on existing roadside highway structures and operates from a "sidefire" position. For this position, no lane closures are needed for a typical installation. Reliability for the adverse highway environment is designed into the SAS-1 to eliminate periodic maintenance requirements.

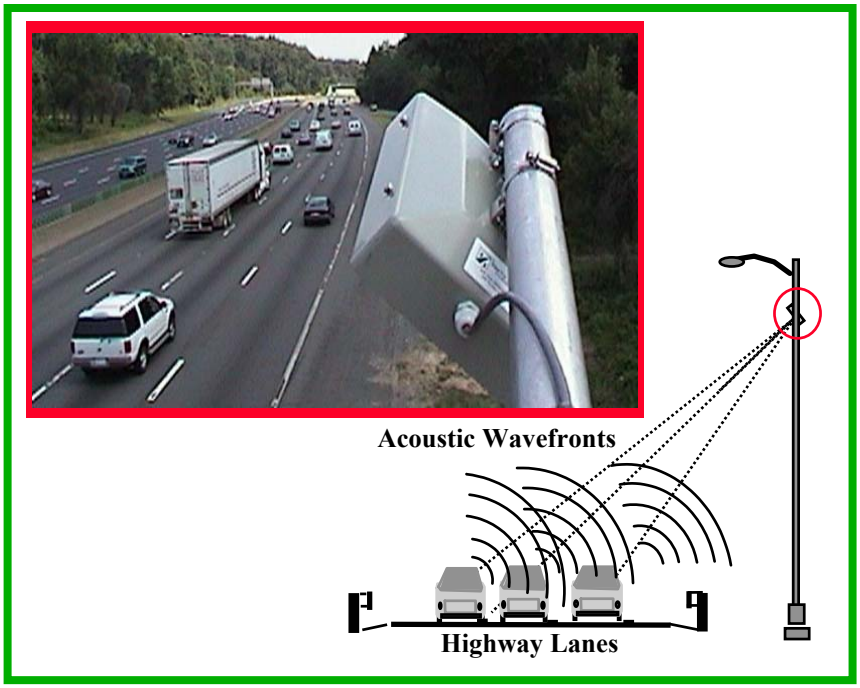

Figure 1 SmarTek Systems Acoustic Sensor (SAS-1)

The SAS-1 utilizes SmarTek Systems' advanced signal and spatial processing technology to provide high resolution "acoustic imaging" of all vehicle traffic passing by the sensor (including shoulder activity). This advanced processing eliminates false vehicle detections caused by out of lane or off road noise. Because the SAS-1 "acoustically images" the highway traffic with a large number of high resolution cells (look directions), the end user is provided with significant flexibility to electronically position each detection zone and to set each detection zone's size and sensitivity. This capability eliminates the need for precise mechanical "pointing" of the SAS-1 during installation. After installation, final detection zone positioning and repositioning is accomplished using SmarTek Systems' **SAS Monitor and Setup** software. This software runs on a Windows PC and displays the position (Traffic Acoustic Image-TAI) of every vehicle in real time as they pass the sensor station. The SAS Monitor and Setup software includes several tools to simplify the installer's task of setting up the SAS-1 for multi-lane traffic monitoring operation. These tools include an **Automatic Lane Finder and Setup Display**, a **Detection Sensitivity Setup Display**, and a **Speed Calibration Display**. Using these tools, the end user can quickly set each detection zone position, size, and sensitivity for operation. The SAS-1 provides effective and accurate **true vehicle presence detection** and associated traffic flow measures on a lane by lane basis for vehicles passing the sensor station at any speed from "stop and go" to free flow.

How "Acoustic Imaging" Is Accomplished

Vehicle generated acoustic signals (engine noise, fans, belts, tire noise, etc.) leave their source (vehicle to be detected) and arrive at the SAS-1 (Figure 1) with an acoustic wave front which is essentially flat. Each acoustic signal from each vehicle will arrive at the SAS-1 with a different signal level and a different wave front angle (arrival angle).

The SAS-1 is comprised of an array of rugged microphones, analog signal conditioning, and sampling circuitry for converting impinging acoustic signal wave fronts to digital signals. These digital signals are processed using a programmable state of the art Digital Signal Processor (DSP) with associated memory and communication circuitry. The processing software implements SmarTek Systems' patented advanced signal processing, spatial processing, and vehicle detection algorithms. The SAS-1 "listens to" and processes every received acoustic signal generated by passing vehicles or stationary (idling) vehicles in real time. The SAS-1 uses SmarTek Systems' advanced signal and spatial processing to create multiple acoustic signal arrival direction channels (look directions) as shown in Figure 2. The SAS-1 implements 91 concurrent listening channels (look directions) along it's short dimension and a single listening channel along it's long dimension.

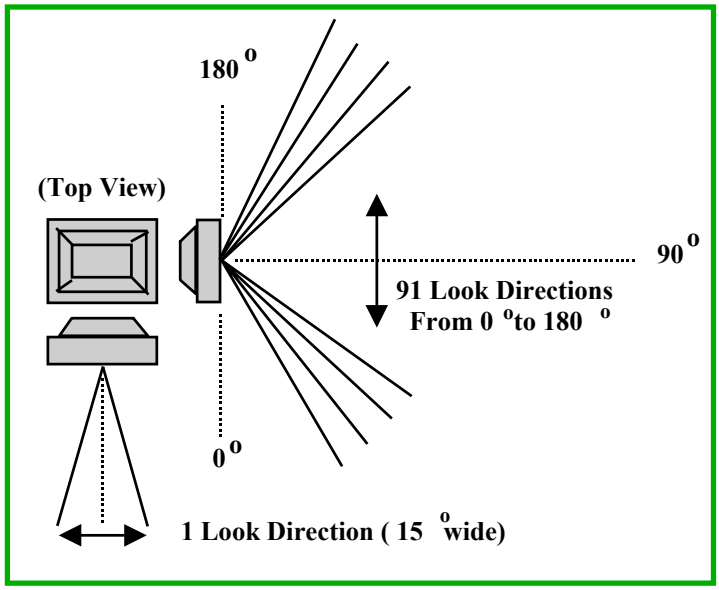

Figure 2 SAS-1 Look Directions

For **multi-lane highway traffic monitoring**, the SAS-1 is mounted roadside. It is oriented so that the single listening channel is in the up/down road direction (SAS-1 mounting tube is approximately parallel to the traffic flow) and the 91 listening channels (look directions) are in the cross road direction as shown in Figures 1 and 3. In this configuration, the SAS-1 effectively divides the highway (cross road) into 91 look directions from which vehicle sounds may originate. The single up/down road look direction allows the SAS-1 to hear sound in a very limited up/down road direction. It therefore, only hears vehicle sounds when the vehicle is passing by the sensor station. As vehicle traffic moves or flows by the sensor station, the SAS-1 processing forms acoustic "images" or "blobs" of high signal intensity. This acoustic "image" is presented as the Traffic Acoustic Image (TAI) display of the SAS Monitor and Setup software (Figure 3). Each "blob" represents the acoustic "image" of a vehicle as it passes the SAS-1.

Up to five (**5**) SAS-1 detection zones are formed by selecting the position and number of contiguous look directions which are combined for actual vehicle detection. This provides the end user with unparalleled flexibility in choosing detection zone sizes and locations. For the

example shown in Figure 3, detection zone sizes and placement were selected to correspond to three active lanes and two shoulders. In the TAI display, each pair of Blue Lines represents the left and right edges of each detection zone. The detection zones for this example are chosen to leave little or no dead space. That is, where one zone ends, the next one begins. For this configuration, any lane switcher will be detected and placed in one zone (lane) or the other. In the TAI display, the blue detection zone indicator lines mimic real highway lane divider lines. The SAS Monitor and Setup display also provides the end user with SAS-1 detection indicator marks (magenta) which are placed in the center of each detection zone. These indicator marks provide the installer with instant real time feedback to show exactly how well the SAS-1 is detecting vehicles and what zone (or lane) the vehicle detections are assigned to. After setup is complete, the SAS-1 will continue to operate in a **default operating mode** as selected by the installer.

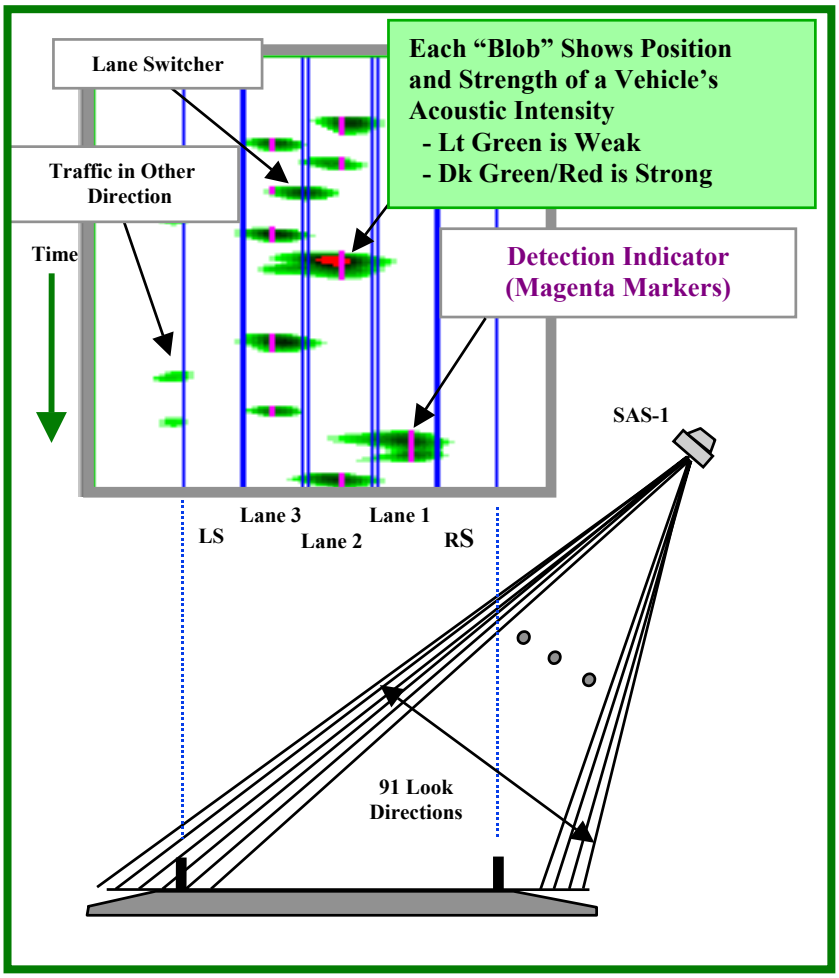

Figure 3 SAS-1 Acoustic "Image" Formation

Default Operating Modes

Multi-Lane Flow Mode - The SAS-1 computes and reports vehicle count, lane occupancy, and average speed for each lane for a specified update period (i.e. 20 sec, 30 sec, 1 minute, etc.). Each SAS-1 can be set to output these measurements every period or wait to be polled by a cabinet controller.

Multi-Lane Single Zone or Dual Zone Relay Signal Mode - The SAS-1 outputs a stream of bit serial relay signals for up to ten (10) relays (5 upstream relays and five down stream relays) for multi-lane monitoring and vehicle presence indication. When used with the **SAS Relay Interface**, the SAS-1 provides a multi-lane single or dual "magnetic loop" equivalent set of sensor hardware that can plug into existing "loop detector" cabinets. The SAS-1 will not "tune out" a vehicle that remains in the detection zone for a prolonged period of time.

Installation Geometry

The SAS-1 can monitor up to five (5) lanes. A side mount installation geometry for monitoring 3 lanes and 2 shoulders is shown in Figure 4. The number of detection zones or lanes is driven by constraints for typical side mount geometries (resolution and occlusion of the far lanes). The ability of SAS-1 to separate or resolve lanes far from the sensor is highly dependent on the installation geometry. When the SAS-1 is installed according to SmarTek Systems recommendations, vehicle detection performance is excellent for all lanes monitored. If SAS-1 is installed at a height lower than recommended or further from the active lanes than recommended, vehicle detection performance for the lanes furthest from the sensor will be degraded. There is no loss of detection performance due to variation in weather, environmental conditions, or visibility conditions.

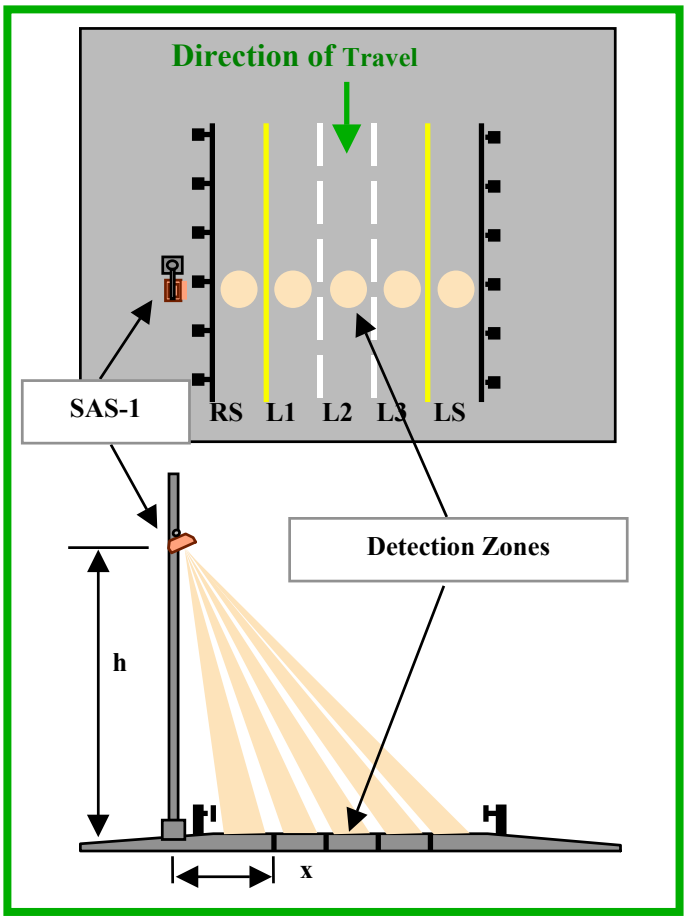

Figure 4 Side Mounting for Multilane Monitoring