APPENDIX D

BACKGROUND ON TRAFFIC SURVEILLANCE SYSTEMS

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This paper briefly summarizes various traffic surveillance systems and technologies in use or being developed. This serves to provide background information that may be useful in responding to the survey being conducted for the I-95 Corridor Coalition's Project #3 on Surveillance Requirements/Technologies.

The purpose of a traffic surveillance system is to acquire traffic, travel, and environmental information in an effective and timely manner to support the safe and efficient movements of people and goods. To achieve this purpose, traffic surveillance information is collected from a variety of sources and processed for use in transportation management functions ranging from traveler information to system operations and planning (see Figure 1).

Various sensor types have been used to monitor and control traffic. New technologies to augment the traffic surveillance capabilities of the ITS are being explored. These sensors perform a wide range of functions, including vehicle detection, vehicle identification, weight measurement, and road surface and atmospheric condition assessment. A brief description of various sensor technologies and their applications in the U.S., Europe, and Japan follows.

1 TRAFFIC DETECTORS

1.1 POINT DETECTORS

Historically point detection has been typified by the inductive loop detector for vehicle presence detection. These devices only provide information on volume, occupancy, and speed at various point locations. In recent years, ongoing concerns regarding the relatively high operational cost and poor reliability of loop detectors have resulted in an upsurge of interest in exploitating new technologies for vehicle detection. Table 1 provides an overview of various detection technology capabilities.

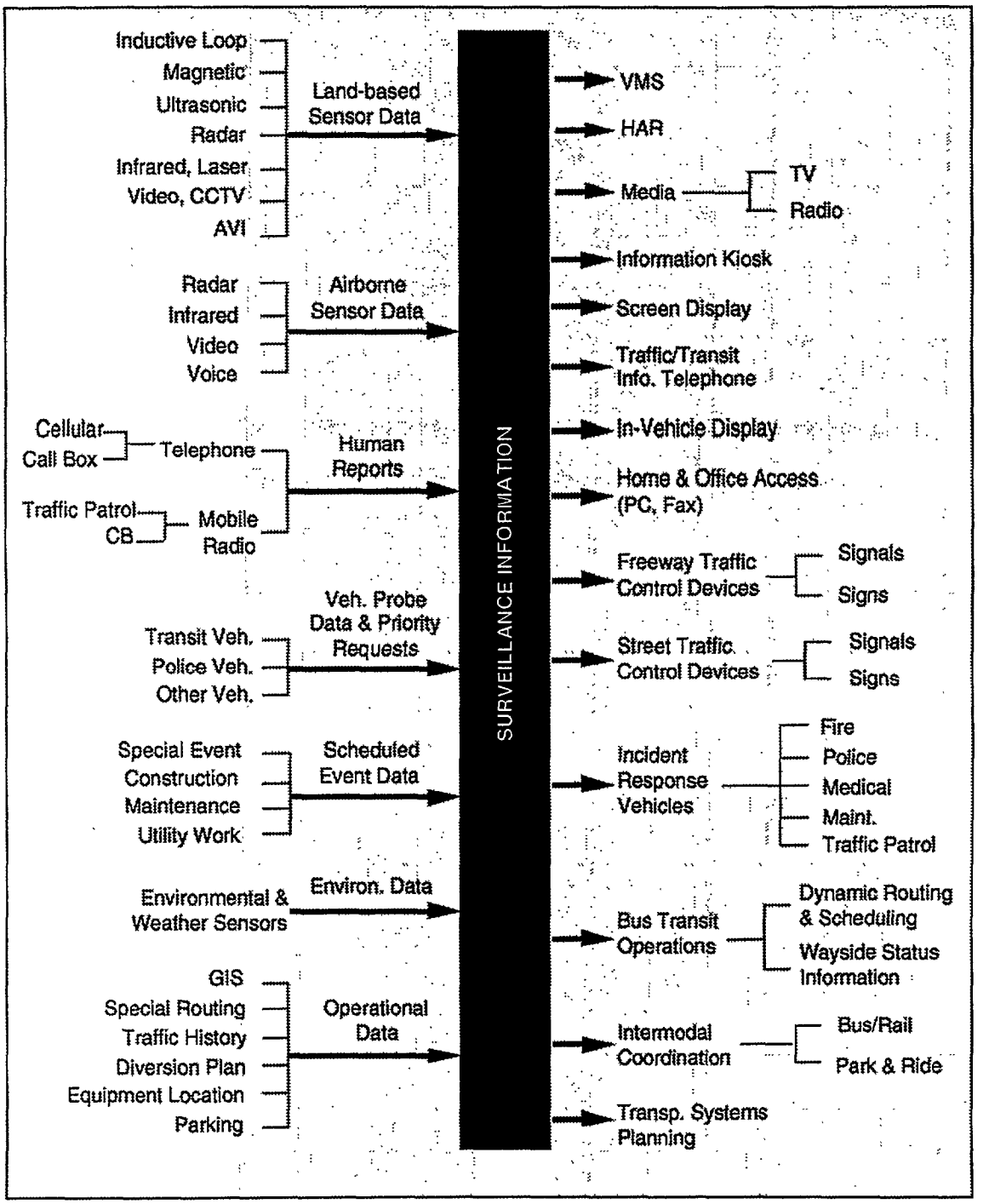

Figure 1. Traffic Surveillance Information is Collected from Multiple Sources for Use in Various Transportation Systems Management Functions

Table 1. Overview of Vehicle Sensor Capabilities

Sensor	Count	Lane Distribution	Presence	stops	Speed	Headway	Occupancy	Queue Length
Inductive Loop	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes'
Magnetic	Yes	Yes	Yes			Yes		
Magnetometer	Yes	Yes	Yes			Yes	Yes	Yes'
Pressure	Yes	Yes				Yes		
Radar	Yes				Yes			
Sonic, pulsed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes'
Sonic, continuous wave	Yes	Yes		Yes	Yes	Yes		
Infrared	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes'
image Processing	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

1 Queue-length determinations are partial depending on the detection zone.
Source: A review and Classification of *Sensors for IVHS*, University of Michigan, **1990.**

1.2 WIDE-AREA SURVEILLANCE

Close-Circuit Television (CCTV) cameras provide the operator in a highway traffic control center the ability to observe a wide area of roadway. This is a basic Wide-Area Detection System (WADS). Image processing technique applications have enhanced the surveillance capability of a human observer.

Video Image Detection System. *Autoscope* is an example of video image processing that takes video image data and extracts traffic information by emulating a loop detector. *Autoscope* requires definition of detection zones within the camera field of view to analyze the image data (i.e., *Autoscope* simply counts vehicles that passes over the detection area). Autoscope locates the "detectors" and defines the size of the detection zone. The same camera may be used for CCTV surveillance and vehicle detection. However, video image processing technology still emulates point detectors.

Traffic Flow Wide-Area Surveillance. Research is being conducted to provide "true" wide-area surveillance. This concept tends to emulate the human approach to sensing subject. A person observes traffic conditions with a wide view, rather than looking at a reference line. Oak Ridge National Laboratory is currently conducting a study (entitled Traffic Flow Wide-Area Surveillance) to design a surveillance system based on this concept.

Mobilizer System. Artificial intelligence image analysis techniques may be applied to wide-area surveillance. The Mobilizer System (developed by Condition Monitoring Systems) represents one such emerging concept. This system improves currently available Video Image Detection System image processing technologies. The *Mobilizer System* analyzes the entire camera view and counts all of the vehicles on a snapshot. Any vehicle that comes into the camera's field of view will be registered by the Mobilizer *System.*

A single camera is able to determine traffic volume, speed, classification, queue length, and other traffic parameters. Using multiple cameras at different sections of a roadway, the Mobilizer System identifies the matching vehicles from different camera views to calculate the travel time between two points. This technology can be used to extract a variety of traffic parameters for a section of the roadway. Vehicle delay, for example, may be extracted by emulating the field data collection technique for stopped delay.

1.3 AUTOMATED VEHICLE IDENTIFICATION

Automated Vehicle Information (AVI) systems have been used to perform many Electronic Toll and Traffic Management (ETTM) functions. Vehicles may be identified using signals emitted from an onboard transponder and recorded by a roadside reader. A variation uses wider range radio to locate onboard equipment with an installed radio infrastructure (e.g., the cellular telephone network or those of various fleet management and theft detection services). Techniques for AVI that do not require onboard equipment (e.g., license plate recognition) are particularly suited to early deployment scenarios, because a large percentage of vehicles are not AVI equipped.

1.4 WEIGH-IN-MOTION

Weigh-in-Motion (WIM) systems measure the weight of the vehicle in motion. WIM systems with a wide range of operating principles, capabilities, and costs are available, including:

+ Bending plate systems.
+ Capacitive systems.
+ Shallow weigh scales.

+ Deep-pit weigh scales.

+ Piezo-electric axle load sensors.

1.5 ENVIRONMENTAL SENSORS

A number of sensors are available to measure various environmental conditions. These include both the pavement and atmospheric conditions. Pavement sensors provide surface temperature and conditions (e.g., ice); while atmospheric sensors provide information on temperature, air quality, wind speed, visibility, etc. Three major categories of information are significant for traffic management:

+ Road condition information is collected by surface sensors and is important to traffic safety. The road condition data (such as wet or icy pavement) can be used to provide advisory information to motorists.

+ Visibility data is crucial to traffic safety. Necessary warnings can be provided to motorists based on visibility conditions.

+ Air quality data is useful to traffic and travel demand management, especially in ozone non-attainment areas.

A description of some of the leading environmental sensor technologies follows.

Surface Condition Analyzer (SCAN). This system provides pavement surface condition information and transmits the real-time data to a central computer. SCAN data include:

+ Surface temperature.

+ Surface conditions (dry/wet/icy).

+ Presence of chemicals on the roadway.

HANDAR™. This system measures the following visibility and atmospheric conditions:

+ Visibility.
+ Air temperature.
+ Humidity.
+ Barometric pressure.
+ Wind speed and direction.

LIDAR (Light Detection and Ranging). The LIDAR system uses laser beams to scan an area to determine the concentration of particles in the atmosphere. It collects real-time information on visibility and air pollution, and transmits the data to a central computer. It can make measurements over a distance of up to 20 miles. The LIDAR system provides visibility and particle concentration information (e.g., snow, fog, sand, and carbon monoxide).

The Storm Warning System operational test in Idaho uses LIDAR technology. The Minnesota Department of Transportation (DOT) is conducting an operational test to assess the feasibility of using LIDAR to monitor air quality (the project is titled Evaluating Environmental Impacts of IVHS Using LIDAR).

2 DERIVED SURVEILLANCE DATA

Some surveillance information is derived by processing the primary surveillance data. Examples include incident occurrence and travel time.

2.1 INCIDENT DETECTION

Incident detection algorithms include the “California” multiple station approach (and variations thereof) and “McMaster” single station-type algorithms. Several suppliers of advanced detection systems also market incident detection algorithms, in most cases, using the single station approach (e.g., the *Autoscope* IDEAS algorithm).

2.2 TRAVEL TIME ESTIMATION

Link travel time estimation is a technique that involves establishing vehicle locations at various times. This technique is becoming increasingly viable and offers many benefits, such as providing information to support Advanced Traveler Information Systems (ATIS), and requiring relatively low infrastructure investment. Technologies to support travel time estimation include Automated Vehicle Location (AVL) and AVI.

3 TYPES OF SENSORS IN USE

3.1 PRACTICE IN THE US

Loop detectors are the most widely used sensors in the U.S., although other types of detectors are also employed. Video image processing technologies are becoming more popular, because they offer the flexibility to vary detection zones and move detection locations. Many State DOTs, such as Connecticut's, have also experimented with traffic monitoring radar detectors. These detectors collect speed data for incident detection using speed-based algorithms. CCTV systems are popular for incident detection and verification.

3.2 PRACTICE IN EUROPE

Traffic management techniques and hardware used in Europe are similar to those found in the U.S. Loop detectors are widely used to collect speed, occupancy, flow, and composition data. Satisfactory experiences with this technology have been reported. CCTV systems are not used as widely in Europe as in America. In Germany, CCTV systems are not popular at all; and incident detection is performed using simple models involving speed and flow. Other types of sensor are also used. In England, for example, Traffic Master (an ATIS service) uses more than 200 infrared sensors to monitor link travel speeds.

3.3 PRACTICE IN JAPAN

Roadway surface-mounted loop detectors are not used at all in Japan. Overhead- and roadside-mounted ultrasonic detectors providing ease of installation and low maintenance cost are widely

used. These devices can work in both pulse and presence modes. Microwave vehicle detectors for sign post application are very popular on expressways. Solar-powered infrared sensors have also been used. CCTV systems are used at critical locations.