TECHNICAL REPORT STANDARD TITLE PAGE

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FHWA/TX-84/61+290-4F		

4. Title and Subtitle	5. Report Date
Developing a Data Collection System for Urban Freeways	December 1983
	6. Performing Organization Code
7. Author(s)	8. Performing Organization Report No.
William R. McCasland	Research Report 290-4F
9. Performing Organization Name and Address	10. Work Unit No.
Texas Transportation Institute The Texas A&M University System College Station, Texas 77843	11. Contract or Grant No. Study No. 2-18-81-290
	13. Type of Report and Period Covered
12. Sponsoring Agency Name and Address Texas State Department of Highways and Public Transportation; Transportation Planning Division P. O. Box 5051 Austin, Texas 78763	Final - September 1980 - December 1983
	14. Sponsoring Agency Code

15. Supplementary Notes

Research performed in cooperation with DOT, FHWA.
Research Study Title: Developing a Freeway Data Collection System

16. Abstract

The need for large quantities of timely and comprehensive data on traffic and travel conditions on urban freeways is increasing. Data are needed for planning, design, operations and maintenance activities. Automatic systems for the collection, recording and processing the data are required. Permanent and portable systems of detectors and data collection recorders must be designed and installed on freeways now operating at or near capacity.

Large numbers of loop detectors must be installed on the urban freeways to provide data for traffic information, traffic control and traffic management systems.

17. Key Words	18. Distribution Statement
Traffic Data Collection, Detectors, Urban Freeway Data Needs.	No restriction. This document is available through the National Technical Information Service, 5285 Port Royal Road, Springfield, Virginia 22161.

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	53	

Form DOT F 1700.7 (8-69)

DEVELOPING A DATA COLLECTION
SYSTEM FOR URBAN FREEWAYS

By

William R. McCasland
Research Engineer

Research Report 290-4F

Developing a Freeway Data Collection System
Research Study Number 2-18-81-290

Sponsored by

State Department of Highways and Public Transportation
in cooperation with the
U.S. Department of Transportation
Federal Highway Adminstration

Texas Transportation Institute
The Texas A&M University System

December 1983

ABSTRACT

The need for large quantities of timely and comprehensive data on traffic and travel conditions on urban freeways is increasing. Data are needed for planning, design, operations and maintenance activities. Automatic systems for the collection, recording and processing the data are required. Permanent and portable systems of detectors and data collection recorders must be designed and installed on freeways now operating at or near capacity.

Large numbers of loop detectors must be installed on the urban freeways to provide data for traffic information, traffic control and traffic management systems.

DISCLAIMER

Key Words: Traffic Data Collection, Detectors, Urban Freeway Data Needs

SUMMARY

This report is concerned with the methods of collecting, recording and analyzing traffic data on urban freeways. Freeways are being reconstructed to replace pavements and structures; to increase capacities to accommodate special facilities for priority vehicles. These design changes require more data than the original construction.

Traffic management systems are being installed to facilitate traffic operations, reduce congestion and promote safety. These systems require large quantities of data processed in real time, as well as historical data for planning. Ramp control, incident detection and location, motorist information displays are a few of the functions of the freeway management system.

These are three general methods of collecting and processing traffic data: manual, automatic with manual assistance; automatic. The quantity and type of data requires the use of automatic systems. This study has examined the portable data collection systems for volume, speed and vehicle classification measurement. An electronic tachograph has been developed and tested. Finally, the detection system for an urban freeway network has been investigated.

Loop detectors are the heart of a data collection system. Because of the high volumes of traffic on the existing freeways, loops should be installed whenever work zones for construction and maintenance are established. Loops should be placed on all access points to the freeway and on the main lanes at intervals approaching 0.5 miles. Two loops per lane should be placed in the freeway main lanes at intervals of 2.0 miles or less. The extra loops provide insurance against equipment failures

that would require additional main lane construction and the resulting traffic congestion.

The data collection, recording and analysis equipment and procedures should be designed for automatic operation where ever possible.

IMPLEMENTATION STATEMENT

A master plan should be developed for each urban area that describes the location of loop detectors on the urban freeway network. All entrances and exits to the freeway and the main lanes at frequent intervals (approximately 2 miles) should be instrumented with induction loops. The loops can be used as the sensors for the data collection activities and for the surveillance system of freeway management operations. The costs of installation can be reduced if advanced planning is available to include the loops with other construction or maintenance projects (see Attachment B). The costs will be further reduced as the data analysis procedures become more automated through the application of the State's computer systems. Portable traffic data collection systems such as the electronic tachograph and the speed and vehicle classifier should be obtained for each District. In the major urban areas, traffic management systems with central computer systems should be established.

TABLE OF CONTENTS

TABLE OF CONTENTS CONTINUED

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Traffic data can be a perishable commodity or a historically significant record. Data from a traffic sensor that are only used to detect the presence of a vehicle for the operation of a traffic signal are lost as the vehicle passes through the zone of detection. Traffic counts from the State's Automatic Traffic Records (ATR) Stations are processed and stored in computer files and become a permanent record for an indefinite time period. There are situations in which data may be collected and recorded, but lose their effectiveness with the passage of time and should be discarded. Traffic speeds and flow rates measured at maintenance and construction sites to develop and evaluate traffic control plans are often site specific in their applications. Rapid changes in land development and size and function of roadways often negate the usefulness of historical data.

Electronic data processing systems offer to the transportation field the possibility of collecting, recording, and storing large amounts of data. This report discusses the need for traffic data and techniques for collecting and processing data in a cost-effective and timely manner. The emphasis of this study is on the design of a Freeway Data Collection (FDC) System. The development of a Freeway Data Base is the subject of Project 2-18-84-421 which is now underway.

A FDC system has several ways to collect, record, process, and analyze data that range from fully automatic to fully manual. This study proposes systems and procedures that favor automatic processes.

Automatic traffic data collection systems can collect large amounts of data in short time periods. Decisions on how much and what type of data to collect and process are a part of the Data Base Study. Automatic FDC Systems consist of sensors, activated by the vehicles and connected to processor units by data transmission systems. From sensors embedded in the roadway and connected by cable to a fixed field processor or a central computer unit, data can be collected continuously. An automatic system may use either temporary or permanent sensors connected to portable field processors and the traffic data are collected for specific time periods to sample traffic conditions.

The sensors may be loops embedded in the pavement or axle sensors placed on the surface of the roadway, attached to one of several types of portable data collection systems as shown in Figures 1 and 2. A portable data collection system of the type pictured in Figure 3 may measure the performance of a single vehicle by monitoring sensors attached to a test vehicle. The data collected are distance traveled, elapsed time and fuel consumed.

For some data requirements, the sensors must be manually operated as illustrated in Figure 4. For example, the measurement of the number of persons in vehicles (vehicle occupancy) requires manual observations, but the data can be recorded in an automatic processor unit. Special studies; such as, intersection delay, turning movements, vehicle classification, and volume counts at specific locations can be conducted in this manner.

The same studies may be conducted manually if portable automatic processors are not available. The data can be processed manually and entered in a computer system through a terminal for automatic processing and analyses.

Figure 1

Pneumatic Tube and Portable Data Collection System

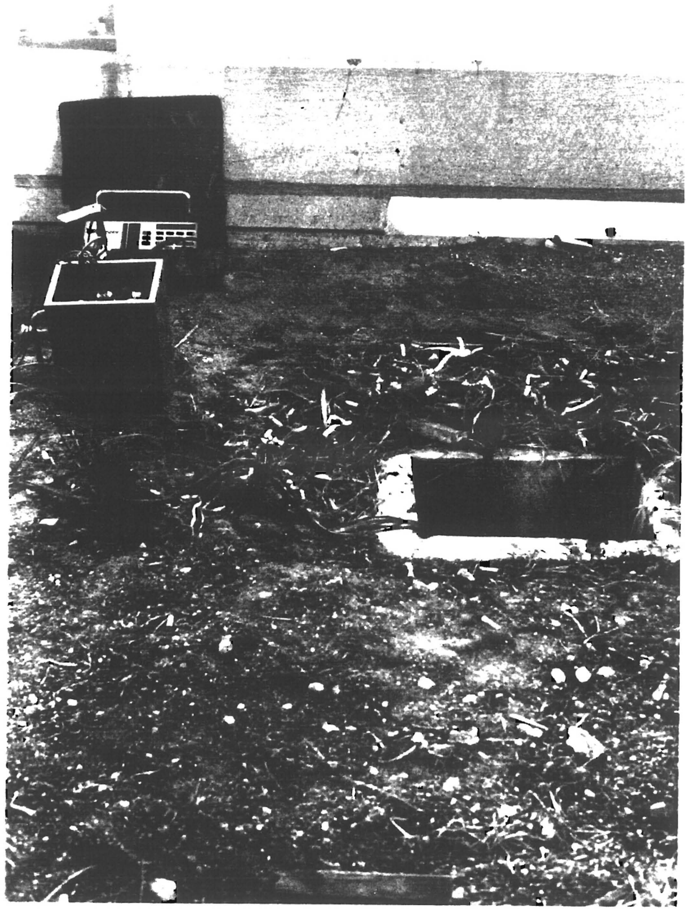


Figure 2

Loop Lead-Ins and the Portable Data Collection System

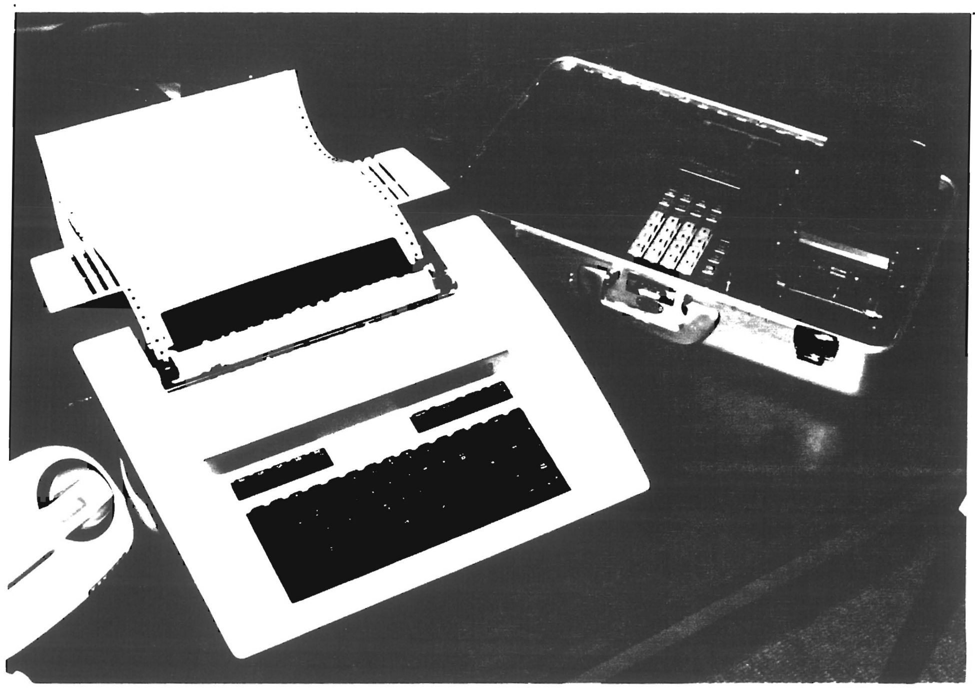


Figure 3

TRIDAQS

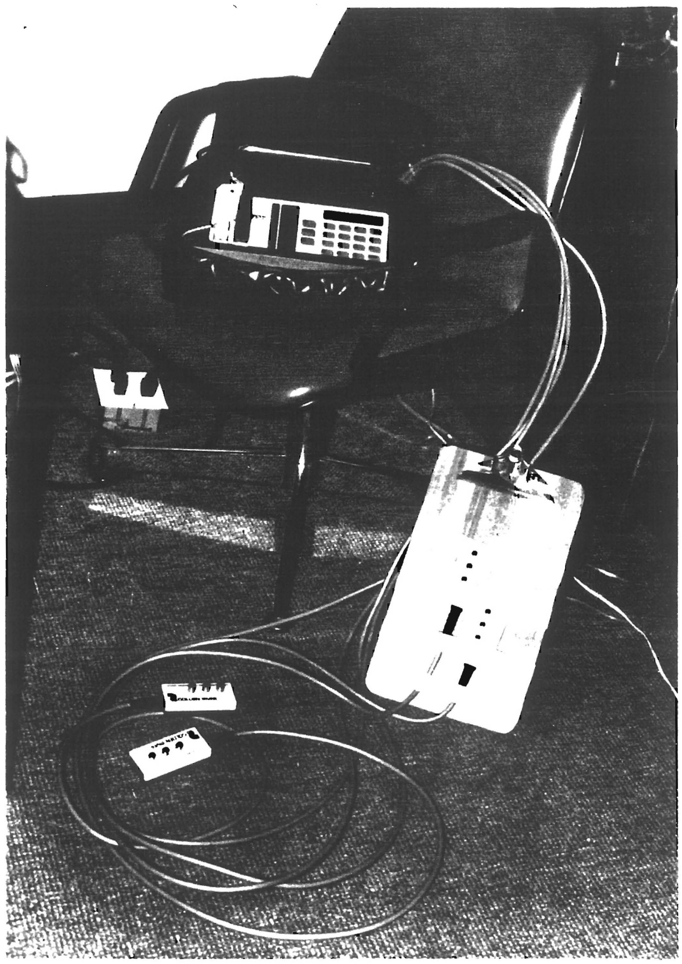


Figure 4

Push Button Inputs to the Golden River Marksman Recorder

Objectives of the Study

The objective of this study is to define a freeway data collection system that provides an effective method of collecting large amounts of traffic data at frequent intervals of time and space with the least amount of manual intervention and disruption to the motoring public.

The foundation of the freeway data collection system is the detection system. Research Report 290-1 discussed the advantages and disadvantages of permanent sensors (loops) embedded in the roadway and temporary sensors (pneumatic tubes) placed on top of the roadway surface [1]. The report concluded that for the collection of large amounts of data over long time periods the permanent loops provided a more accurate and cost effective method of detecting traffic.

Portable data collection systems utilize microprocessors to record and store traffic data. Many of the systems provide for limited amount of data processing and reporting. In Research Report 290-2 computer programs were developed that transfer the data from the microprocessor and store the data in a larger computer in a manner that permits further analysis and reports as specified by the user [2].

A special portable data collection system that operates as an electronic tachograph has been developed for the SDHPT in an earlier HPR study. The current revisions in the design operations manual and data analysis packages for the Travel Information Data Acquisition System (TRIDAQS) are presented in Research Report 290-3 [3].

This report examines the design of the detection system in terms of location, configuration, and costs of installation of the detection loops on urban freeways.

DATA NEEDS FOR URBAN FREEWAYS

Data needs have been documented in a statewide survey conducted for the SDHPT in 1978 and in Project Report 290-1 in 1980 [1&4]. The most important data are traffic volumes at frequent time intervals for every critical location on the freeway network. In addition, data on vehicle speeds, travel times, vehicle classifications, and lane occupancies are useful in operation and evaluation functions.

The remodeling, reconstruction and repair of the existing freeway networks have generated greater demands for traffic data than the development of the original freeways. Computer models are now available to analyze traffic conditions before, during and after freeways are modified. Some of the models now being used are:

- FREQ
- FREFLO
- TRAFLO
- HEEM
- QUEWZ
- PASSER MODELS

The data requirements for these models vary for ADT's to flow rates, speed - volume curves to modal splits. Obviously, the more complete the data, the better the results of models. The FDC System should collect, process and store the data in computer files for ease of application to these models.

Some of the major applications of traffic data are listed below:

Justification Reports - Alternative designs must be considered in terms of their costs and benefits. Adding HOV facilities to an existing freeway requires considerable study since there may be three or more possible designs. Establishing priorities between projects requires assessment of current and potential traffic conditions.

Freeway Design - Freeways that are being remodeled may have as many design decisions as the original freeway. The effects of adding capacity to the main lanes, relocating access points, improving interchanges, adding new facilities such as U-turn lanes and direct connections must be calculated. Existing traffic patterns and growth trends are used in these analyses.

Traffic Control Plans - Reconstructing urban freeways under the heavy volumes of traffic is difficult under the best conditions. Alternate routes are not always avaliable, and extreme measures, such as narrow lanes, shoulders for travel, restriction of heavy vehicles and cross street closures, are operational techniques that must be employed. The impact that these plans will have on traffic operations and safety must be known prior to the beginning of the construction.

Traffic Management Systems - Managing traffic operations on freeway networks requires large amounts of data on traffic conditions to be collected and processed in real time. The information is then used to control traffic and communicate with the motorists by various means.

- Ramp Control System - Ramp control can be in the form of ramp closures or ramp metering. The data collection system provides main lane information on which to adjust the flow rates on the ramp from zero (closure) to 15 vehicles per minute. Additional information on queues and merges is provided from the ramp detection system.

- Motorist Communications System - Changeable message signs and lane use signals provide information to the motorists on traffic conditions. These systems require large amounts of real time data to be effective.
- Incident Detection System - One of the most important functions of a freeway surveillance system is the detection of lane blockages and one of the most important functions of a freeway management system is the quick removal of the blockage. Automatic detection of an incident requires data from closely spaced loops, transmitted in real time to a control computer for processing in an incident detection model. Research in the early 1970's provided information on the relationships between detector spacing and time required to detect incidents [5]. From these and other studies, models have been tested and implemented on many large freeway surveillance and control projects. The consensus of these projects is that an acceptable spacing of freeway detectors for incident detection is 0.5 miles or less. (Table 1).

Evaluation - Many of the new freeway designs and traffic management systems involve restrictions on some elements of traffic. HOV lanes are to be used by authorized vehicles only; shoulder lanes are to be in operation for specific times; ramp controls are to restrict the flow onto freeways. These and other controls must be monitored to access their effectiveness and to determine if special enforcement is required.

In summary, the data collection system must be capable of providing the following:

Table 1

SUMMARY OF DETECTION SYSTEMS
FOR OPERATIONAL TRAFFIC MANAGEMENT
PROJECTS

Name of Project	Implementation Date	Type of Detectors	Number of Detectors	Detector Spacing (Miles)
Black Canyon Freeway Phoenix, Arizona	1979	Loop	206	1
Los Angeles Metropolitan Area California	1971 & on	Loop	7800	1/2
Chicago Metropolitan Area Illinois	1961 & on	Loop	1650	1/2
SCANDI Detroit, Michigan	1981	Loop	1350	1/3
Twin City Traffic Management Minnesota	1970 & on	Loop Magnetometer	450 18	1/2
N.J. Turnpike SC&C New Jersey	1976 & on	Loop	875	1/2
North Central Expressway Dallas, Texas	1971 & on	Loop Magnetometer	225	1/2
North and Southwest Freeways Houston, Texas	1975 & 1979	Loop	154	variable
The FLOW System Seattle, Washington	1981	Loop	500	1/2
Q.E.W. SC&C Project Toronto, Canada	1975 & on	Loop	180	1/2
Howard Frankland Bridge Tampa, Florida	1982	Loop	115	1/3
IMIS - Northern Long Island New York	1984	Loop	1754	1/2
Van Wyck Expressway Queens, N.J.	1983	Loop	233	1/3
I-66/I-395 Traffic Management Virginia	1984	Loop	590	1/2
MAGIC New Jersey	Indefinite	Loop	1857	1/2

- Hourly and daily traffic volumes and traffic flow rates at 5- and 15-minute intervals at freeway access points, frontage roads and selected freeway locations.
- Spot speed data at frequent locations on the freeway.
- Lane occupancy data from freeway detectors.
- Vehicle classification counts in critical freeway sections.

This information can be collected from sensors placed in the roadway and monitored by electronic recorders. Additional information can be collected by other methods. These include:

- Environmental measures
- Travel times and speed profiles
- Turning movements at intersections
- Vehicle occupancies
- Fuel consumption rates

Many of these surveys are conducted with special portable equipment that records and processes data in a manner to minimize the manual intervention. Figure 4.

DESIGN OF DETECTION SYSTEM

Location and Configuration of Loops

The critical decisions in a freeway detection system design are the number and location of loops to be installed on the main lanes of the freeway. In addition to the cost of installing the equipment, there are costs for traffic control and the resulting congestion and delays suffered by the public when lanes are closed. If the installations are made on new roadways that are not opened to traffic, or on existing roadways that are closed to traffic during reconstruction, these traffic related costs are reduced. The possibility exists that after the roadway is opened to traffic some of the loops will fail and have to be replaced. Then the alternatives are: replace the loop under traffic, switch to another existing loop that provides essentially the same information, or eliminate that data input from the data collection system. The last alternative is to be avoided, if possible.

Basic Main Lane Detection

The typical main lane detection station of one loop for each lane is illustrated in Figure 5. This configuration can provide a total freeway count by lane, measures lane occupancies for use in ramp metering strategies and, with estimates of average vehicle lengths, calculate average speeds. If detection stations are spaced at intervals of 0.5 miles or less, an effective incident detection program can be implemented.

If one of the loops malfunctions, information from a loop in an adjacent lane is used as a substitute. Information and control functions are not seriously affected by this situation, but incident detection capabilities in the freeway section are reduced.

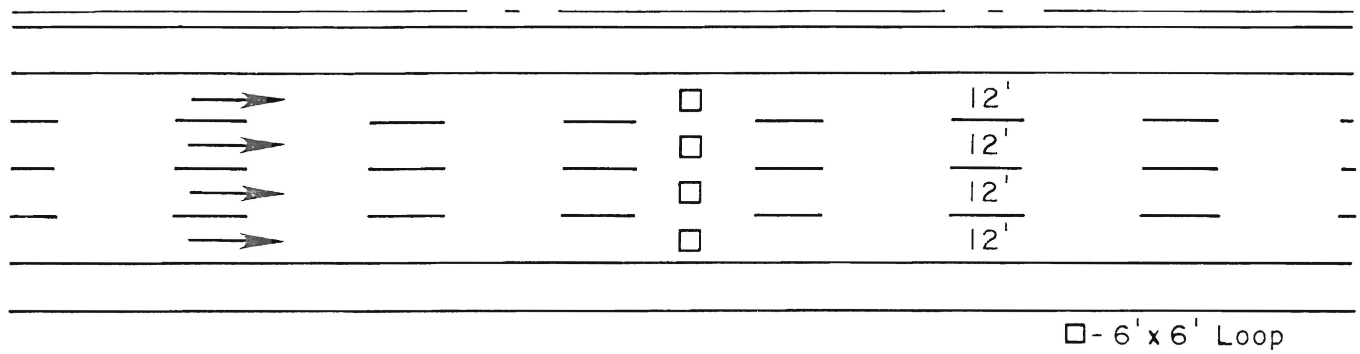


Figure 5.

Basic Main Lane Detection - One Loop Per Lane

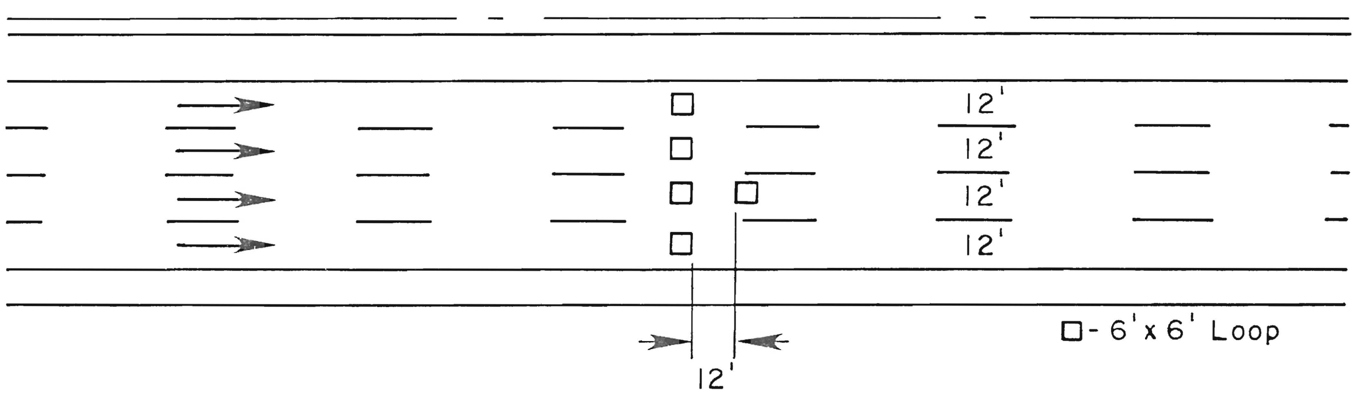


Figure 6.

Freeway Bottleneck Detection With Speed Trap

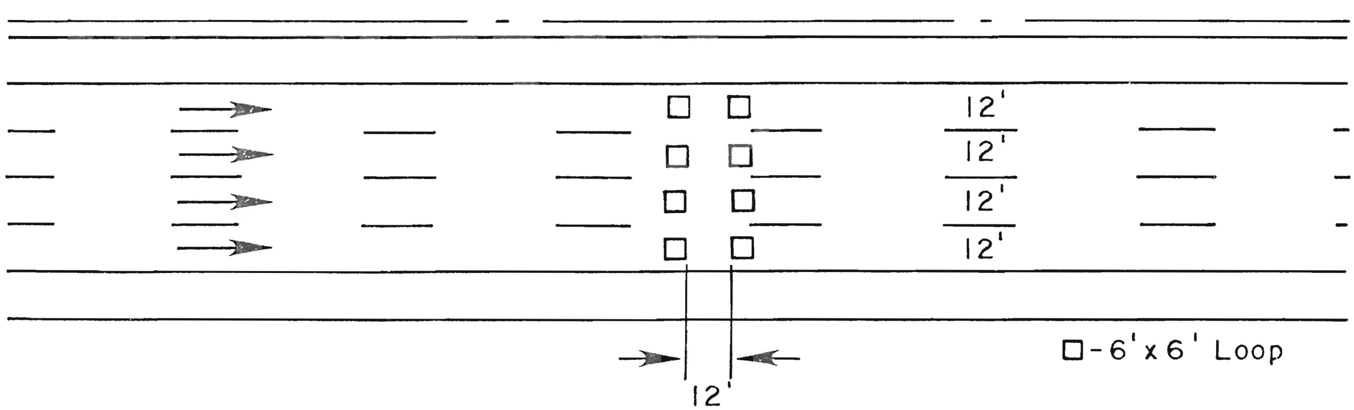


Figure 7.

Vehicle Classification Detection - Double Loops Per Lane

It is recommended that this configuration of loops be installed at 0.5 mile intervals.

Bottleneck Detection

In a freeway control system, speeds are important in the detection of traffic conditions in freeway bottleneck sections. Measures of speed are made by measuring travel time between two loops in the same lane as shown in Figure 6. The extra loop can serve as a backup for volume and incident detection.

It is recommended that this configuration with one or more lanes instrumented with double loops be installed at each bottleneck or critical freeway section, with intervals not to exceed 2.0 miles.

Vehicle Classification Detection

The detection and identification of trucks on freeways is important for planning and operations. Most of these types of surveys have been done manually. There are new developments in vehicle classifiers that will provide adequate surveys from sensors in the roadway [6&7]. It may be necessary to add other types of axle sensors at a later time, but at the present the configuration in Figure 7 with double loops in a lane will provide the necessary input to measure vehicle length.

It is recommended that this configuration of loops be installed at locations that are critical to truck movements over the freeway network. In most urban areas, two classification stations on radial freeways and two or more on circumferential freeways would be sufficient.

Ramp Meter Input

The typical ramp meter detection system using only local actuated control is shown in Figure 8. The control can function with only one loop on the main lanes, but a malfunction in that loop, or a local traffic

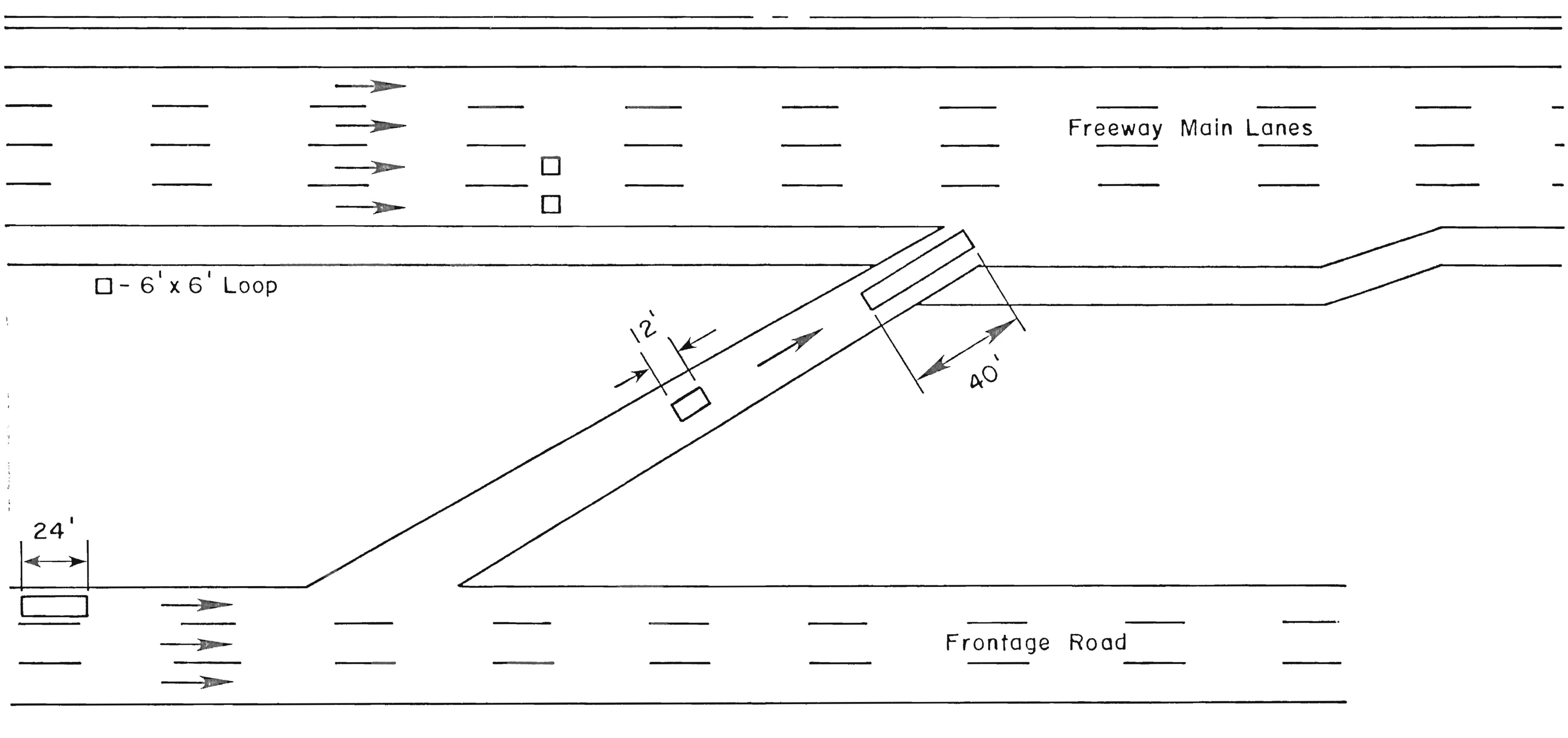


Figure 8.

Ramp Meter Detection - Local Responsive Detection

Disturbance near the loop would greatly affect the metering rates.

It is recommended that at least two loops be available to supply data on freeway conditions to the local controller.

If one of the three full freeway detection configurations is to be installed near an entrance ramp as shown in Figure 9, one or more of those loops can be used for ramp control.

Entrance/Exit Ramp Detection

The installation of loops on ramps are not as critical as those on the mainlanes. Ramps can be closed or traffic easily directed around the construction zones, so that costs of traffic handling and traffic congestion are low.

If the entrance ramp meets tha warrants for ramp control, it is recommended that the full detection system as shown in Figure 9 should be considered. (Attachment A) The detection for queues and merge operation are optional, depending on the design of the ramp.

If the entrance ramp does not meet warrants, then only a single loop for counting traffic volumes should be installed.

It is recommended that each ramp and connecting roadways between freeways should have loop detection on each lane of travel for obtaining traffic counts as illustrated in Figure 10.

Frontage Roads Detection

Traffic on the frontage roads is important to freeway operations. Diversion to the frontage roads to avoid construction and maintenance zones, traffic congestion caused by accidents or stalls may overload the cross street intersections. Some ramp control strategies also require diversion of traffic along the frontage road. The detection that is designed for

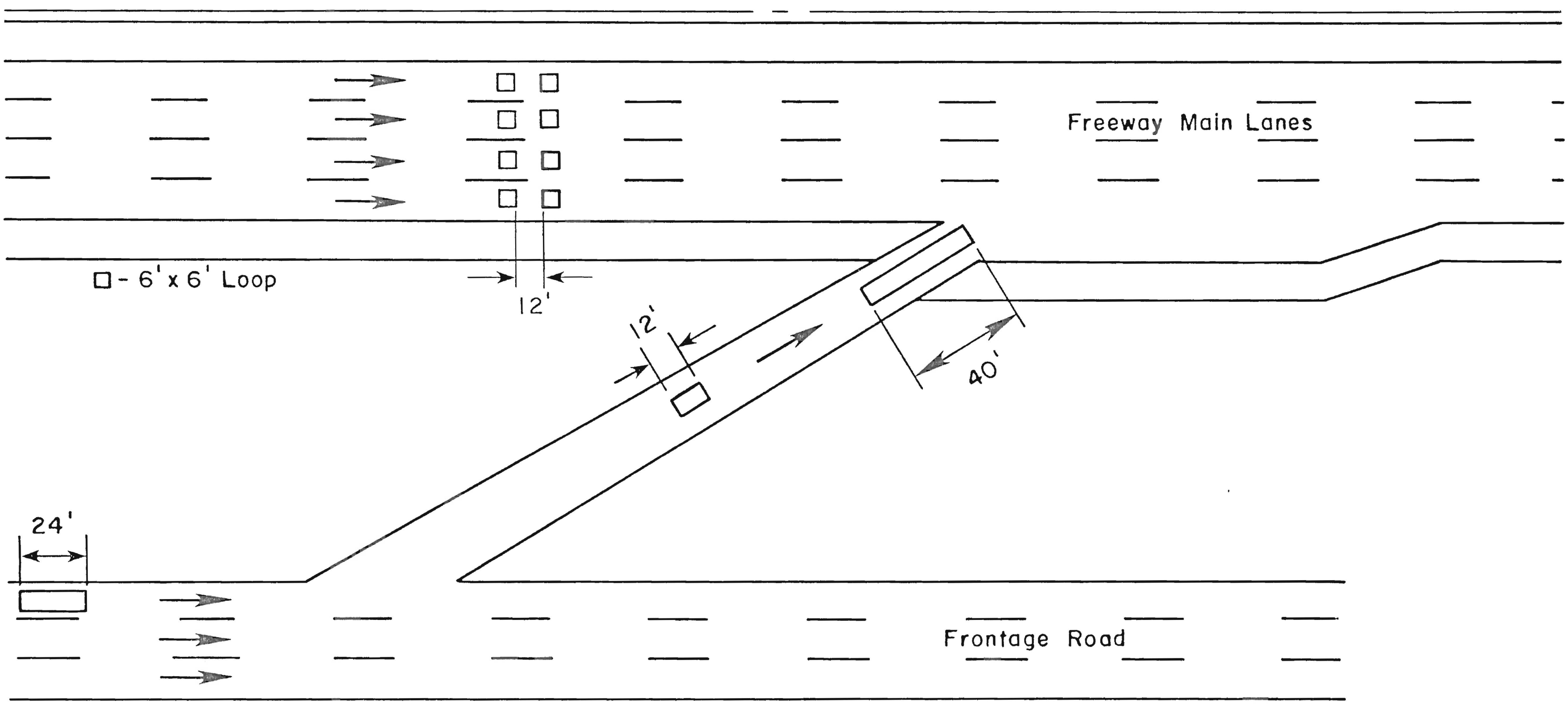


Figure 9.

Ramp Meter Detection - System Mode of Control

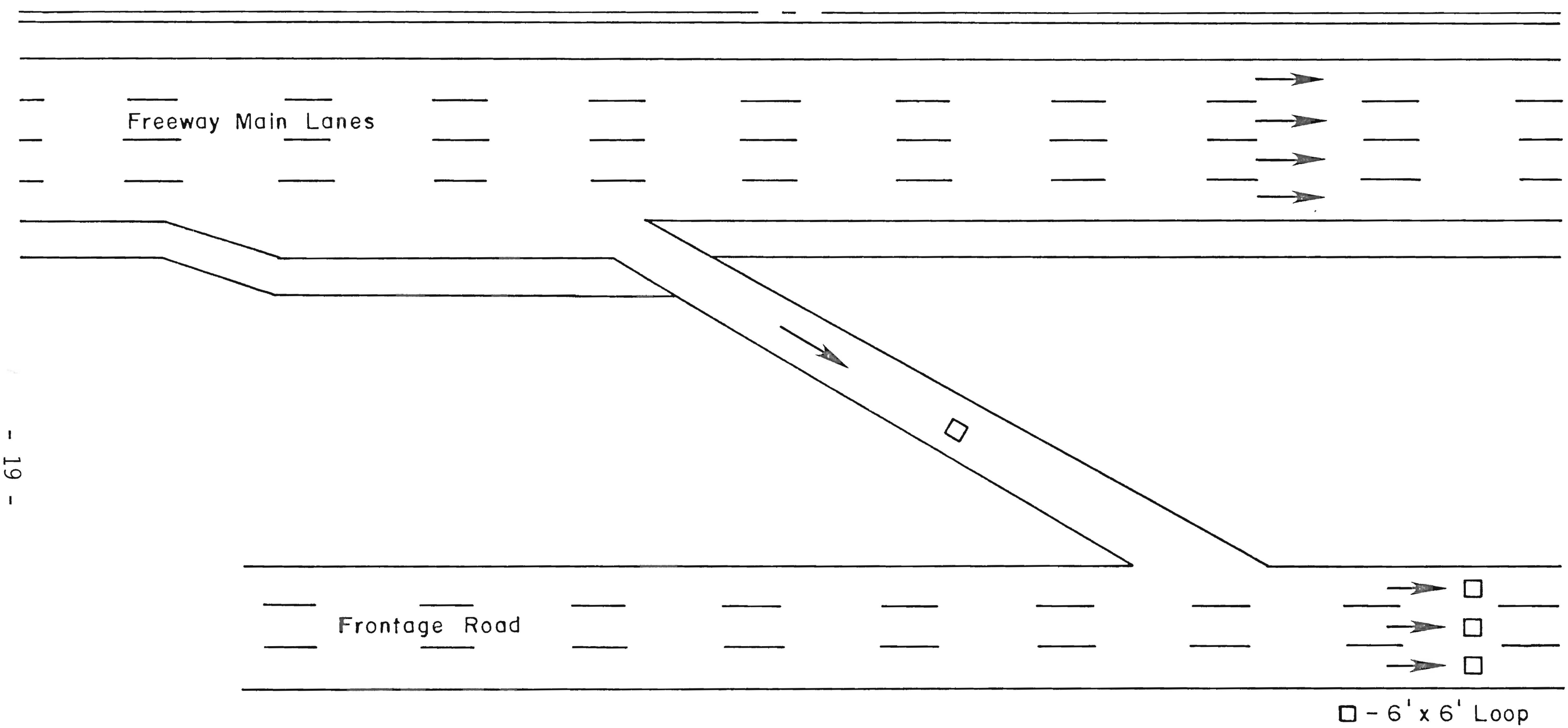


Figure 10.

Exit Ramp and Frontage Road Detection

on frontage road would serve as data input to the freeway surveillance system as well as the intersection traffic signal control.

It is recommended that detection is placed on the frontage road downstream of the freeway ramp on the approach to the cross street intersection as illustrated in Figure 10.

Summary of Proposed Design

It is the recommendation of this report that a full freeway detection station be installed at 0.5 mile intervals on the urban freeways in areas that are to be eventually served by an automobile incident detection system. These stations should coincide with ramp control detection where possible.

At two-mile intervals, double loops should be placed in at least one lane. Costs to provide extra loops in all lanes are not excessive and careful consideration should be given to this option.

At two or more stations on each freeway, double loop installation should be provided for vehicle classification surveys.

All access points to the freeway network should have loops for recording counts.

Traffic responsive ramp metering system detection should be provided at each entrance ramp that satisifies the warrants for control.

Frontage road approaches to cross street intersections should have loops in each lane of travel.

COST OF LOOP DETECTION INSTALLATIONS

To calculate the cost to install loops in the pavement on a freeway, the following factors must be considered:

- Installation - sawing the pavement, laying the wire and applying the sealant.
- Traffic Handling - closing the work zone to traffic with barricade cones, flashers, signs, etc.
- Traffic Delay - delays to the motorists driving through the work zones.
- Safety - increased hazards to the workers and motorists driving through the work zones.

Estimates for the first two factors are readily available from bids received on contracts negotiated in 1983:

<u>Installation</u> (Excluding costs of Materials)

P.C. Concrete Pavement	\$6.00 per foot of saw cuts
Asphalt Concrete Pavement	\$3.75 per foot of saw cuts

<u>Traffic Handling</u> (Lane Closurers of 4 Hours or More)

One-Lane Closure	\$ 500
Two-Lane Closure	\$ 800
Three-Lane Closure	\$ 1,000
Total Freeway Closure	\$ 1,500

<u>Traffic Delays</u>

The impact of lane closures on traffic delays is dependent on the traffic demands and the available capacity. Experience on Houston freeways indicates that a work zone that reduces the capacity by 50 percent during the off peak period will result in traffic delays with queue lengths of 1 mile on the average. This would result in an average delay of 2 to 3 minutes per vehicle during the time of lane closure. For all peak volumes of 3,000 vehicles per hour (vph) the estimated delay costs to motorists are:

3,000 vph x 3 minutes/vehicle x 1 hour/60 minutes = 150 veh-hrs

If we assume a delay cost of $10 per vehicle hour for the off peak operation because of the high percentage of truck traffic, an estimated cost for traffic delays of $1,500 per hour of lane closure can be used in the analysis. Locations with good alternate routes or lower off peak traffic demands would have lower delay costs.

Safety

The cost of safety to workers and motorists driving through the work zones increases as the time of exposure increases. This study will not attempt to quantify the cost of safety in this study, but acknowledges its presence in the analysis.

The study proposes to provide additional loop detection to provide a backup for the primary detection as well as additional information. Each of the several freeway detection configurations are analyzed for costs required to place the additional loops in the original contract, and to install or replace loops at a later date.

Ramp Metering Installations-Freeway Detection

The minimum detection requirement is one loop in the outside lane. The expanded design proposal adds a second loop in the second lane.

- Minimum Detection Design

A 6-foot X 6-foot loop placed in the center of the right lane of a P.C. Concrete Pavement, with a 10-foot paved shoulder:

Installation: 37 ft X $6/ft	$ 222.00
Traffic Handling: 2 lanes	800.00
Delay: 4 hrs @ $1,500/hr	6,000.00
TOTAL	$ 7,022.00

The replacement of a defective loop at a later time requires the same cost.

- Expanded Detection Design

Two 6-foot X 6-foot loops placed in the center of the two right lanes of P.C. Concrete Pavement with a 10-foot paved shoulder:

Installation: (37 feet + 49 feet) X $6/ft	$ 516.00
Traffic Handling: 3 lanes	1,000.00
Delay: 4.5 hours @ 1,500/hr	6,750.00
TOTAL	$ 8,266.00

The time required to install two loops in one work zone is only 30 minutes longer than that for one loop. The closure of 3 lanes will cost more because of extra equipment and time required for the set-up. The estimate of delay is not changed, because the extra effort in traffic handling provides additional capacity by shoulder usage for travel or alternate route assignments.

The addition of the second loop at a later time would be:

Installation: 49 feet X $6/ft	$ 294.00
Traffic Handling: 3 lanes	1,000.00
Delay: 4 hours @ $1,500/hr	6,000.00
TOTAL	$ 7,294.00

Main Lane With One Speed Trap Detection

- Minimum Detection Design

The minimum detection design is one loop in each lane with one additional loop in an interior lane. For a three lane freeway section, the installation under traffic would require two closures of two lanes:

Inside Lane

Installation: 61 feet X $6	$ 366.00	
Traffic Handling: 2 lanes	800.00	
Delay: 4 hours @ $1,500/hr	6,000.00	
TOTAL	$ 7,166.00	

Middle and Outside Lanes

Installation: 135 feet X $6	$ 810.00	
Traffic Handling: 2 lanes	800.00	
Delay: 5 hours @ $1,500/hr	7,500.00	
TOTAL	$ 9,110.00	
TOTAL COSTS		$16,276.00

The replacement of a defective loop at a later time would require:

Middle and Outside Lanes

Installation: 45 feet X $6	$ 270.00
Traffic Handling: 2 lanes	800.00
Delay: 4 hours @ $1,500 /hr	6,000.00
TOTAL	$ 7,070.00

Therefore, an average cost for the replacement of one loop would be approximately $ 7,100.00.

Main Lane with Vehicle Classification Detection

The expanded detection design has two loops in each of the main lanes. For a three-lane freeway section the costs to install 6 loops would be:

Inside Lane

Installation: (61 + 61)feet x $6/foot	$ 732	
Traffic Handling: 2 lanes	$ 800	
Delay: 4.5 hours x $1,500/hour	$ 6,750	
SUB TOTAL	$ 8,282	

Middle and OUtside Lanes

Installation: 172 feet x $6/foot	$ 1,032	
Traffic Handling: 2 lanes	800	
Delay: 5.5 hours x $1,500/hour	$ 8,250	
SUB TOTAL	$10,082	
TOTAL		$ 18,364

This analysis indicates that if loops are to be added to a surveillance system, or if loops are to be replaced, the installation can be more cost effective if done initially. Table 2. If the impact that lane closures have on traffic is considered, as many loops as practical should be installed during each installation period when the work zones have been established. Even disregarding the costs in traffic delay, the reduction in traffic handling costs would offset the cost of the extra loop installation.

There are other costs associated with the installation of loops, but for this comparative analysis, the cost of wire, sealant, conduit and pull boxes were considered to be essentially constant for all cases. There are major costs for the loop amplifiers and data transmission equipment,

Table 2

Summary of Loop Installation Costs
Three Lane Roadway

	Number of Loops	Initial Cost	Replacement Cost	Addition Detection Cost	Total Cost
1. Ramp Meter Installation					
Minimum Design	1	$7,022			$7,022
Replacement Defective Loop	1		$7,022		$7,022
Expanded Design (Initial)	2	$8,266			$8,266
Expanded Design (1+1)	2	$7,022		$7,294	$14,316
2. Main Lane - One Speed Trap					
Minimum Design	4	$16,276			$16,276
Replacement Defectice Loop	1		$7,200		$7,200
Expanded Design (4+2)	6	$16,276		$14,400	$30,674
3. Mainlane - Double Loops					
Expanded Design	6	$18,364			$18,364
Replacement Defective Loop	1			$7,022	$7,022

if the loops are added to a surveillance system. These costs must be considered if the extra loops are to operate continuously. However, if the loops are to serve as reserves for the primary detection system or if the loops are used with portable recording devices, then no additional costs must be considered.

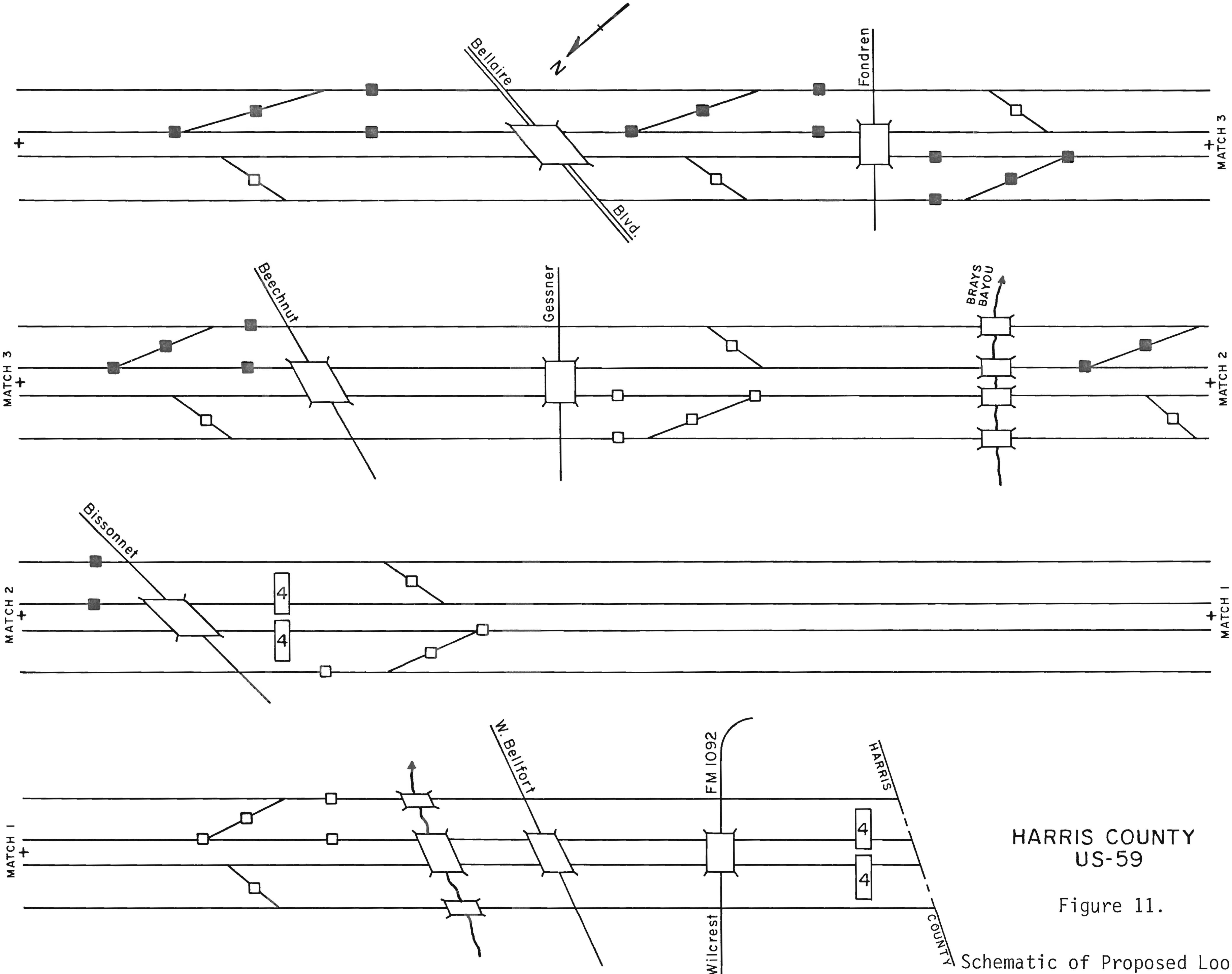
It is the opinion of the author that loops embedded in the freeways and properly terminated in the roadside cabinets are good investments for the future data collection needs, as well as for the replacements of defective loops in the traffic management systems.

IMPLEMENTATION OF DETECTION SYSTEM

Advanced Planning

Using the guidelines for detector locations, Figure 11 illustrated a schematic of the freeway network that can be developed with existing and proposed sensors. This schematic can then be used to coordinate the installation of detectors with construction projects or other projects which involve freeway surface modification such as shown in Figure 12. (See Administration Circular No. 38-80 in Attachment B.). The schematic should present the total detection system with explanatory notes concerning the priorities for installation. For example, the detection on entrance ramps may consist of only one detector for volumes until a decision on the installation of ramp metering or ramp closure is made. Exit ramp detection on ramps with low volumes have low priorities. The number and spacing of main lane detection will vary, depending on the plans for initiating an automatic incident detection system. Even though some detectors may not be needed for several months, it may be practical to install the loops when the construction activities permit, and then add the electronics for sensing and transmitting the data at a later time.

These loops can be used for the collection of data by the portable recorders until such time that they are included in a traffic control function, or a systemwide surveillance system. Until that time, there is no need to provide an amplifier and A.C. power to the loop. The terminals of the loop lead-ins may be stored in the pull box below ground level, Figure 13, but these boxes usually fill up with water. A more acceptable design would bring the lead-ins in a small cabinet mounted on a pole as shown in Figure 14 or a concrete pedestal similar to the permanent count station installations pictured in Figure 15.



HARRIS COUNTY
US-59

Figure 11.

Schematic of Proposed Loop Detection

Figure 12

Freeway Lane Closed for Pavement Reconstruction

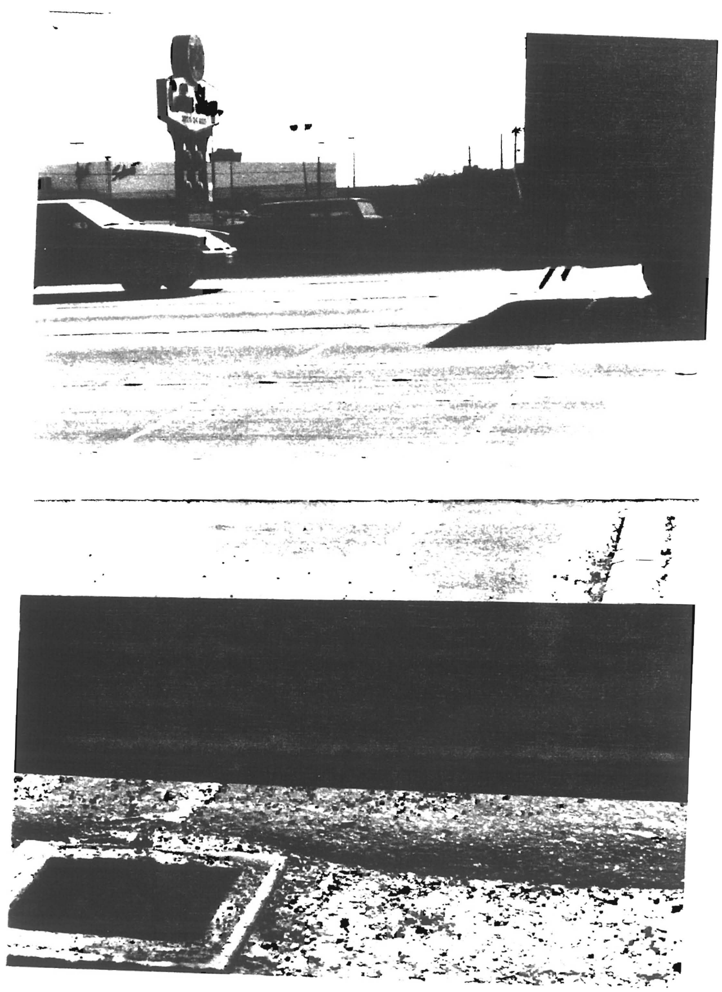
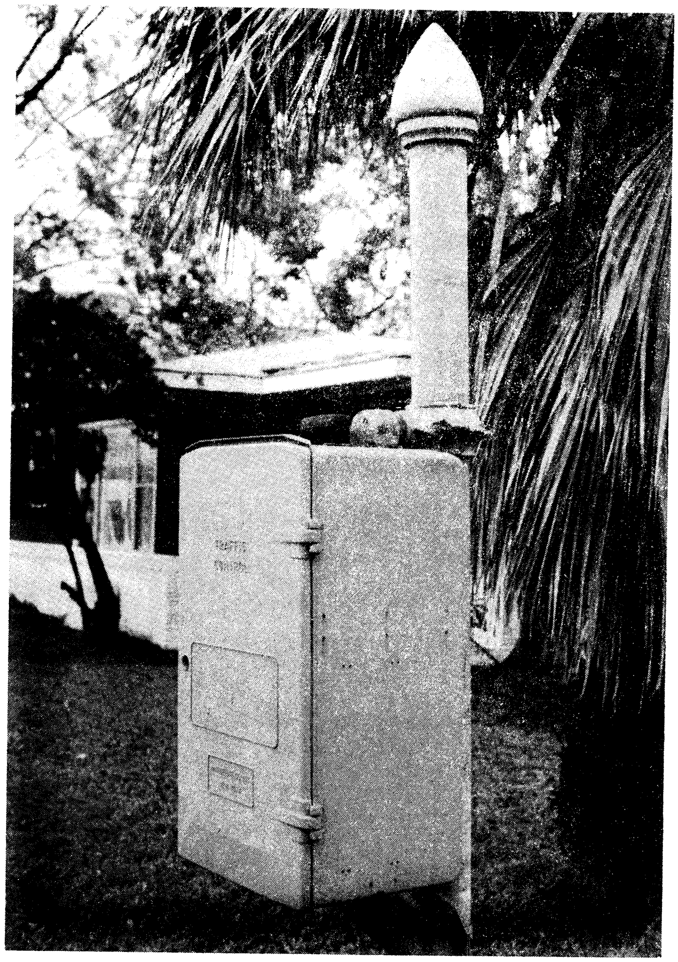


Figure 13.

Pull Box Installation



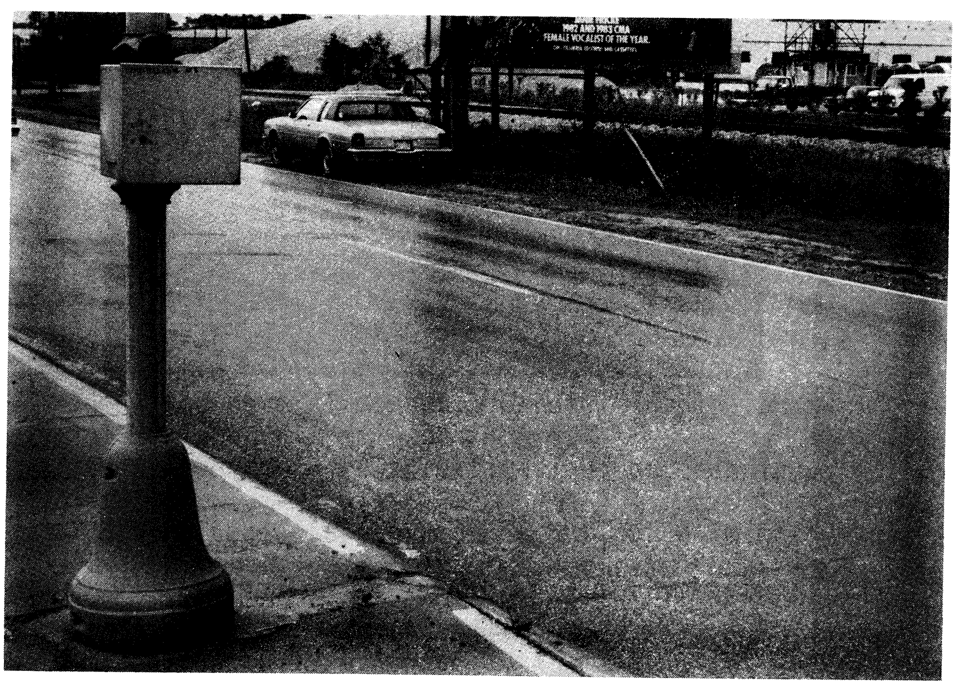


Figure 14.

Detection Cabinets Installed in Poles

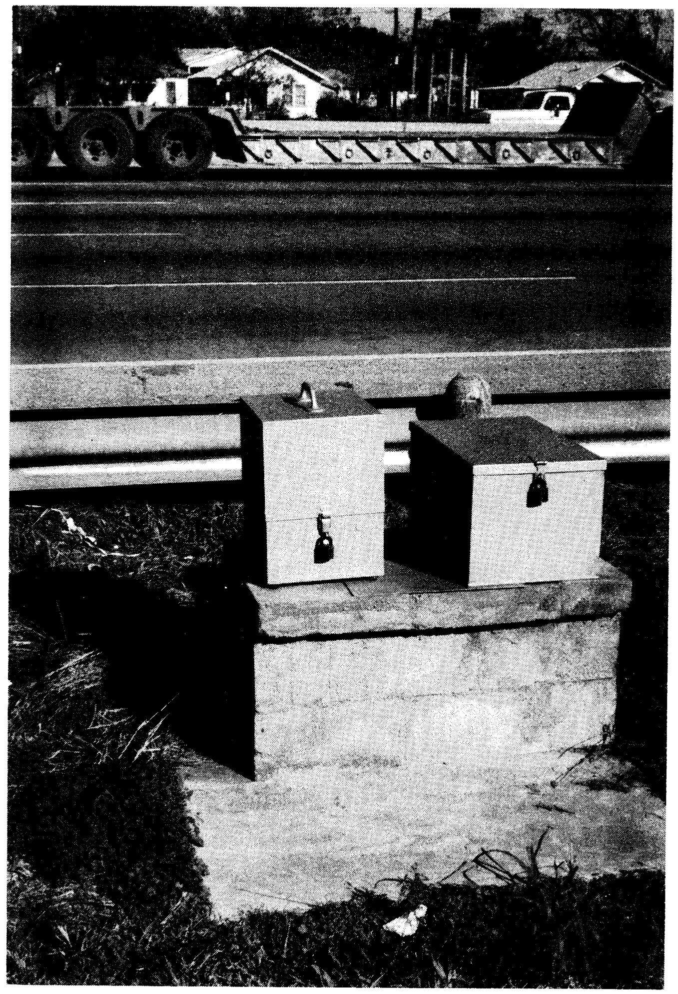


Figure 15.

Detection Cabinets Installed on Concrete Pedestal

Justification For Expanded Designs

The number of loops recommended in this study may seem to be larger than necessary. However, the need for accurate and timely data continues to increase. Many of these loops perform functions other than providing traffic data. The costs for the installation of loops are low in comparison to the total cost of a roadway. A typical one mile section of freeway with 4 lanes in each direction and interchanges spaced at one mile intervals would require a maximum of 32 main lane detectors, 6 ramp detectors and 8 frontage road detectors. Using the cost estimates to install the loops in the pavement during construction phases (that is, with no costs for traffic handling or traffic delays) the total cost would be between $30,000 and $35,000.

Other arguments for providing extra loops in the detection system are presented below:

Detector Loop Malfunctions - Loops embedded in pavement fail for several reasons. Many failures are the result of errors of installation. In Detroit on the SCANDI Project, 175 of the 1342 detector loops did not meet the contract specifications at the time of installation. Some installation errors, such as improperly applied sealant or cuts in the insulation of the loop wire may not become evident for several months. Careful inspection during installation and strict adherance to specifications on techniques on laying wire and applying sealants can reduce, but not eliminate these loop failures.

Another common failure is due to the mechanical wear caused by pavement displacements. Figure 16 shows how cracks form, pavements separate from shoulders, and sections of pavement break up under heavy loads. Loop and lead-in wires can break, or the insulation can

Figure 16.

Loop Detection Failure Caused by Pavement Failure be damaged, resulting in a reduction in detector sensitivity. In some cases these failures can be reduced by adjusting the loop locations. Loops should be moved to avoid joints and cracks in the pavement. If loop or lead-in wires must cross joints, the wire should be placed in a PVC conduit sleeve to protect against mechanical friction. If the pavement is of a type or condition to produce large cracks or movements in the roadway, the entire loop installation can be encased in the PVC conduit. (Attachment C)

Alternate Data Inputs for Control Systems - The effect of a loop failure is low if there is another operational loop that can perform the same tasks. The data on freeway conditions to operate a local actuated ramp meter controller can be collected from either of the two right lanes. For a system control mode, the traffic volumes in a freeway section can be calculated from upstream and downstream detectors and speeds measured in the inside lane can be used to estimate speeds in the other lanes. Incident detection programs will be slightly reduced in effectiveness by the substitution of loops in the same area of the freeway.

Data Collection Programs - Extra loops may be used to collect information until called on to replace a failed loop. All of the loops in the speed traps and vehicle classification designs can be used to measure flow rates and lane occupancies. Loops placed at the 1/2 mile intervals can be used in the incident detection program while serving as a back-up to the ramp control detector and traffic information detectors.

Replacement Costs - The discussing on installation costs indicates that the incremental costs for extra loops will be 1/2 to 1/3 the costs to replace the loops at a later time. Experience in the urban areas of Texas has been that the replacement of a loop on the main lanes of a freeway will either be postponed until other construction work in the area can be scheduled, or not replaced at all. An expanded detection system can improve on this situation. Providing extra loops in the detection system design should be considered a part of the preventative maintenance program, an insurance policy for protecting the integrety of the operation of the data collection and the traffic management systems.

REFERENCES

1. McCasland, William R., "Design Considerations for an Urban Freeway Vehicle Detection System", Texas Transportation Institute, Research Report 290-1, July 1982.

2. Lee, Jae Y. and Ritch, Gene P., "Data Reduction System Utilizing Golden River Counting and Recording Equipment", Texas Transportation Institute, Research Report 290-2, November 1983.

3. Blumentritt, Charles W., "Travel Information Data Acquisition System (TRIDAQS) Users Manual - Revision 1", Texas Transportation Institute, Research Report 290-3, December 1983.

4. Lin, Han-Jei, Clyde E., Machemehl, R.B., "Texas Traffic Data Acquisition Program", Center for Highway Research, Research Report No. 245-1F, February 1980.

5. Nuckles, Nelson B., Dudek, Conrad L., and Messer, Carroll J., "Automatic Detection of Urban Freeway Incidents" Texas Transportation Institute, Research Report No. 165-12, May 1983.

6. Lyles, R.W. and Wyman, J.H., "Evaluation of Speed Monitoring Systems", Main Department of Transportation and University of Maine at Orono, Final Report No. FHWA/PL/80/006 for U.S. Department of Transportation, FHWA, July 1980.

7. Lyles, R.S. and Wyman, J.S., "Evaluation of Vehicle Classification Equipment", Maine Department of Transportation, University of Maine at Orono and Richard Lyles Associates, Final Report to U.S. Department of Transportaion, FHWA, July 1982.

8. Blumentritt, C.W. Pinnell, C., and McCasland, W.R., "Guidelines for Selection of Ramp Control Systems", National Cooperative Highway Research Program Report 232, May 1981.

ATTACHMENT A

Division or Maintenance Operations

TRAFFIC SURVEY - COUNT LOCATIONS

RAMP CONTROL WARRANTS

Traffic Engineering Section

DIST. No.

FREEWAY AND RAMP LOCATION:

CONTROL:	SECTION:	CITY:
DATE OF SURVEY:		POPULATION (LATEST FEDERAL CENSUS):

Check applicable characteristics: *

1. _____ (a) The expected reduction in delay to freeway traffic exceeds the expected delay to ramp users plus added travel time for diverted traffic and traffic on the alternate surface routes; and

   _____ (b) There is adequate storage space for the vehicles which will be delayed; and

   _____ (c) There are suitable alternate surface routes available having capacity for traffic diverted from the freeway ramps; and

   _____ (d) The total volume of traffic on the main lanes and the entrance ramp at a bottleneck location exceeds (or is espected at the time of installation) the Level of Service C (beginning of Level of Service D) volumes shown in the Table during at least one hour of the day on recurring basis.

MINIMUM PEAK HOUR WARRANT VOLUMES (MAIN LANES PLUS RAMP) AT BOTTLENECK LOCATION** IN METROPOLITAN AREA OF APPLICABLE SIZE SHOWN (COMPLETE APPLICABLE TABLE)

FOUR-LANE FREEWAY (TWO LANES, ONE DIRECTION)

METROPOLITAN AREA SIZE +	LESS THAN 500,000	500,000 - 1,000,000	OVER 1,000,000	EXISTING MAINLANES	EXISTING RAMP	EXISTING TOTAL
	2,350	2,450	2,650			

SIX-LANE FREEWAY (THREE LANES ONE DIRECTION)

METROPOLITAN AREA SIZE +	LESS THAN 500,000	500,000 - 1,000,000	OVER 1,000,000	EXISTING MAINLANES	EXISTING RAMP	EXISTING TOTAL
	3,600	3,900	4,250			

EIGHT-LANE FREEWAY (FOUR LANES ONE DIRECTION)

METROPOLITAN AREA SIZE +	LESS THAN 500,000	500,000 - 1,000,000	OVER 1,000,000	EXISTING MAINLANE	EXISTING RAMP	EXISTING TOTAL
	4,950	5,350	5,950			

EACH ADDITIONAL LANE ABOVE FOUR IN ONE DIRECTION AND ONE LANE RAMP CONNECTIONS AT INTERCHANGES

METROPOLITAN AREA SIZE +	LESS THAN 500,000	500,000 - 1,000,000	OVER 1,000,000	EXISTING MAINLANES	EXISTING RAMP	EXISTING TOTAL
	1,350	1,450	1,600			

* See discussion on pages III-K-2 and III-K-3 of the 1973 Texas Manual on Uniform Traffic Control Devices for determining the location of ramp control under these warrants.

** Based on the 1965 Highway Capacity Manual table shown on page 253, (reduced for 3% truck traffic traffic), and the peak hour factor-city size relationship on page 249 of 1965 Highway Capacity Manual.

*** Metropolitan area is considered to be the principal city plus adjacent incorporated towns (or cities) and unicorporated communities using current estimated population.

2. _____ Installation of freeway entrance ramp control signals may be warranted when there is a severe accident hazard at the freeway entrance because of inadequate ramp merging area of high entrance ramp volumes. Number of accidents in latest 12-month period _________ . (Attach Collision Diagram)

3. _____ Installation of freeway entrance ramp control signals may be warranted to reduce sporadic congestion on isolated sections of freeway caused by short-period peak traffic loads from special events or from severe peak loads of recreational traffic equal to or exceeding those shown in the Table when considered on an hourly basis.

4. Ramp gates may also be justified alone or in conjunction with ramp meter signals when Warrant requirements 1a, c or d or Warrant 3 is met and at least one of the following additional requirements are met:

   a. _____ There is a heavy entrance ramp movement which cannot be adequately stored behind the ramp meter signals during a portion or all of the ramp control operations.

   b. _____ The main lane bottleneck condition is such that ramp metering at a rate of 180 vph (minimum practical rate) is too high.

   c. _____ A combination of high main lane volumes together with a short weaving and/or merging distance creates an undesirable operation due to vehicle turbulance.

   d. _____ The entrance ramp design, when combined with heavy volumes makes it difficult for on-ramp traffic to enter safely during a portion or all of the peak period.

   e. _____ The entrance ramp and/or the main lanes downstream of the ramp are on a steep incline which makes it difficult for truck traffic entering on the ramp to accelerate to a resonable speed thereby creating an artificial bottleneck.

   Ramp gates can be used for a short period of time (i.e., 10-15 minutes) in conjunctions with ramp meter control or they can be used alone for the entire peak period.

RECOMMENDATIONS: ____

____

____

____

____

State Department of Highways
and Public Transportation

ATTACHMENT B

ADMINISTRATION CIRCULAR NO. 38-80

To: All District Engineers and Engineer-Manager | Date: July 22, 1980

Subject: Vehicle Detector Loops on Urban Freeways | Expires: Upon Receipt

Reference: | File: D-10

Gentlemen:

Urban Freeway traffic data continue to become more difficult to obtain, while the need for such continues to increase.

In an attempt to ultimately obtain needed data, reduce the hazards involved with equipment installation and minimize inconvenience to the traveling public, the following procedures are to be implemented immediately. Whenever projects are proposed which involve urban freeway surface modification (Seal Coat, Overlay, Extensive patching, etc.) and which involve temporary lane blockage, File D-10 should be advised at an early date. This will allow time for arrangements for loop detector placement as determined to be necessary by that office. Also, detectors for possible freeway operational needs as determined by the District and/or others should be installed at this time when different from, or in addition to, locations selected by File D-10.

Similar consideration should also be given to any proposed new urban freeway construction projects.

Sincerely yours,

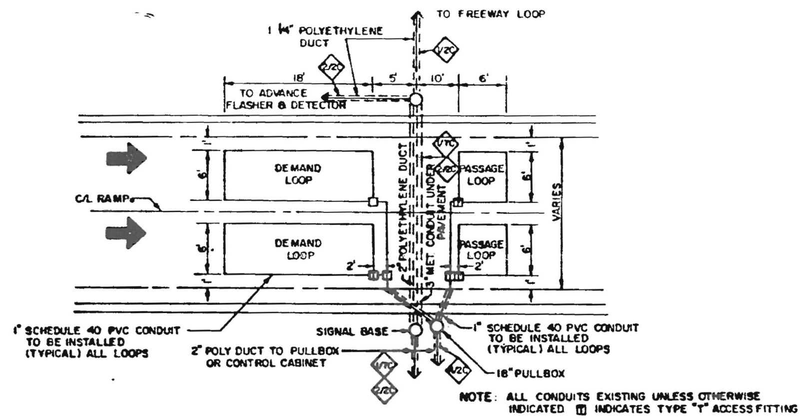
(Original signed by M. G. Goode)

M. G. Goode
Engineer-Director

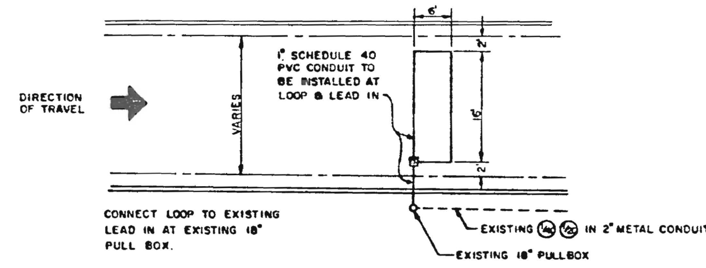
DISTRIBUTION:

District Engineers
Engineer-Manager

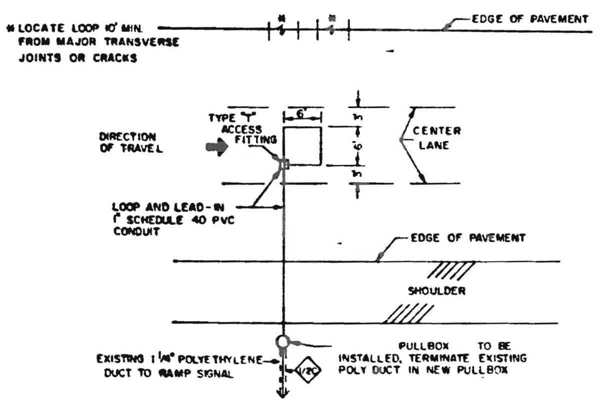
STATE PROJECT NUMBER	SHEET NO
1228 - 00 - 79	2.13
INSTALLATION DETAILS AND SUMMARY OF QUANTITIES FOR PVC ENCASED DETECTOR LOOP WIRE IN EXISTING PAVEMENT FOR RAMP METERS	



TYPICAL RAMP SIGNAL, DETECTOR AND CABLE LAYOUT - TYPE A



TYPICAL QUEUE LOOP DETECTOR FOR RAMP SIGNAL



TYPICAL MAINLINE DETECTOR FOR RAMP SIGNAL

(LOCATE AT EXISTING MAINLINE LOOPS)

SUMMARY OF MISCELLANEOUS QUANTITIES

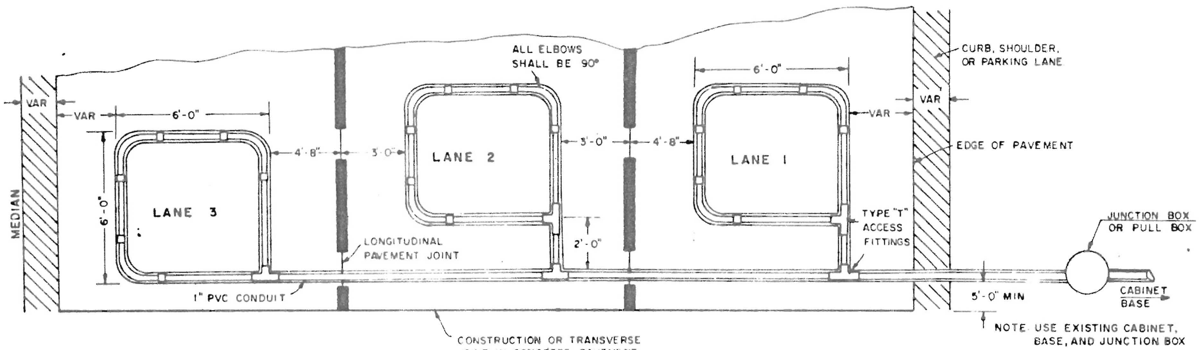
RAMP METER DETECTOR LOOPS-1 LUMP SUM

LOCATION "RAMPS"	DETECTOR INSTALLATION TYPE	NUMBER OF LOOPS TO INSTALL	NUMBER OF TURNS IN EACH LOOP	1"-INCH P.V.C. CONDUIT SCHEDULE 40 (FEET TOTAL)	DETECTOR LOOP WIRE #12 A.W.G. (FEET TOTAL)	LEAD-IN CABLE 2-CONDUCTOR #14 A.W.G. (FEET TOTAL)	18-INCH PULL BOX INSTALLED (EACH TOTAL)	2-INCH POLY. DUCT INSTALLED (FEET TOTAL)	REMARKS
HAMPTON AVE.-S.B.	A	MAINLINE-1	4	300	830	360	2	86	INSTALL NEW DETECTORS AND LEAD-IN CABLE TO EXISTING CONTROL CABINET
		QUEUE-1	5						
		DEMAND-2	2						
		PASSAGE-2	3						

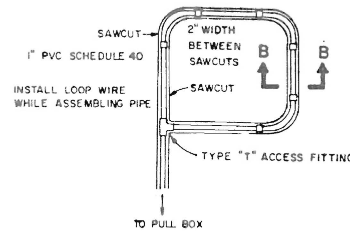
ATTACHMENT C

STATE PROJECT NUMBER	SHEET NO
1228-00-77	2.8

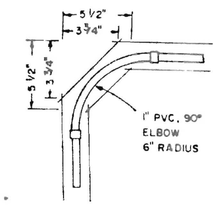
INSTALLATION DETAILS FOR P.V.C. ENCASED, DETECTOR LOOP WIRE IN EXISTING PAVEMENT FOR TRAFFIC COUNTERS.



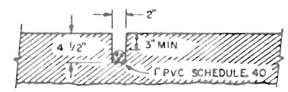
3-LANE NON-TELEMETRY VEHICLE DETECTOR SYSTEM (TOP VIEW)
INSTALL AT N.B. I-43 AT W. CAPITOL DRIVE
S.B. I-43 AT W. CAPITOL DRIVE



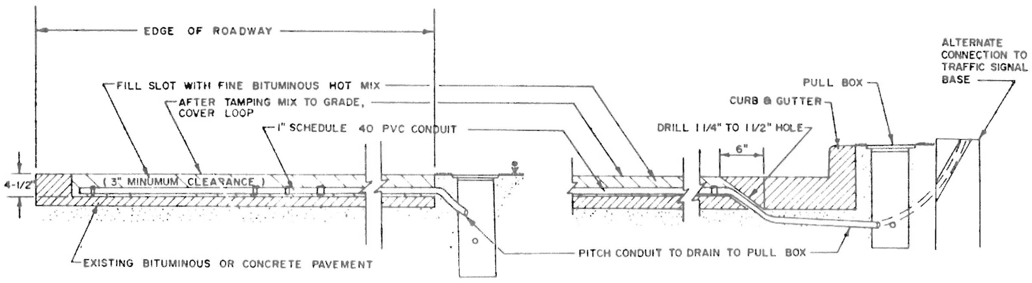
LOOP SLOT CONSTRUCTION
(TOP VIEW)



CORNER SAW SLOT DETAIL
(TOP VIEW)



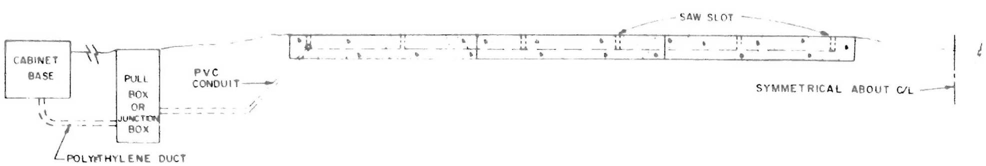
SECTION B-B
LOOP AND LEAD-IN WIRES IN PAVEMENT
(CROSS SECTIONAL VIEW)



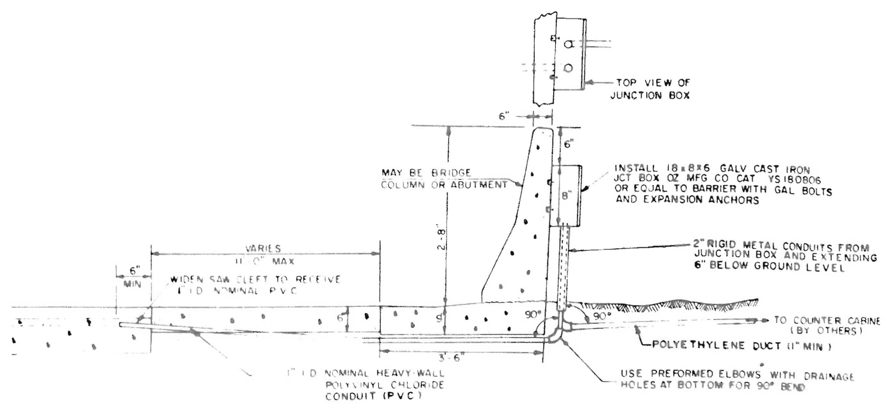
CROSS SECTIONAL VIEW

CROSS SECTIONAL VIEW
WITH CURB & GUTTER

1" PVC LOOP INSTALLATION IN EXISTING CONCRETE PAVEMENT



DUAL CABINET BASE
DIVIDED HIGHWAY INSTALLATION
(CROSS SECTIONAL VIEW)



AT TRAFFIC COUNTER LOCATIONS WITH CONCRETE BARRIER