APPLICATION OF CLOSED CIRCUIT TELEVISION FOR TRAFFIC SURVEILLANCE IN TEXAS

by

William R. McCasland
Research Engineer
Texas Transportation Institute

and

Raymond G. Biggs
Engineering Technician
Texas Highway Department

Research Report Number 139-11

Freeway Control and Information Systems

Research Study Number 2-8-69-139

Sponsored by
The Texas Highway Department
In Cooperation with the
U.S. Department of Transportation
Federal Highway Administration

TEXAS TRANSPORTATION INSTITUTE
Texas A&M University
College Station, Texas

August 1971

ABSTRACT

Closed circuit television (CCTV) has been used for surveillance of traffic and transportation facilities for many years. However, the number of operating systems are few because their effectiveness as a long term surveillance system has been suspect due to the inclusion of human observers in the surveillance loop. The use of CCTV for short intensive observations necessary to research and traffic studies has been successful. The accelerating development of area wide traffic surveillance, control, and communications systems for urban areas will increase the interest in the use of CCTV as part of the surveillance system. There are four operating CCTV systems in Texas that are used for traffic surveillance. Each system has different design and operating characteristics.

DISCLAIMER

The opinions, findings, and conclusions expressed or implied in this report are those of the research agency and not necessarily those of the Texas Highway Department or the Federal Highway Administration.

SUMMARY

There are four closed circuit television systems in Texas that are designed and operated for traffic surveillance. Each system has different design and operating characteristics to satisfy the surveillance requirements.

Baytown-La Porte Tunnel

A seven-camera system is installed to detect lane blockage events over a one-mile section of two lane roadway. The CCTV system is designed to operate 24 hours a day. Since the field of view is limited and the light level is relatively constant, remote control of camera functions is not required. The short distance from camera to control room permits the use of direct video transmission over coaxial cable.

Gulf Freeway - Houston

A fourteen-camera system is installed to monitor traffic operations for research and traffic studies. Limited use is made of the system for the detection of lane blockage incidents over the six-mile section of the six-lane freeway. The CCTV system is designed to operate during daylight hours and to cover fields of view 1500 feet in all directions. Pan and tilt units and zoom lens functions are controlled remotely over a multiconductor control cable. Video transmission is accomplished by balanced paired cables to produce a picture rated at 600 lines of resolution.

North Central Expressway - Dallas

An eight-camera system is installed to monitor traffic operations for research and traffic studies over ten miles of freeway.

The installation is of a temporary design to permit the movement of cameras from one position to another. The CCTV system is designed to operate during daylight hours and to cover fields of view of 1500 feet in all directions. Pan and tilt units and zoom lens functions are controlled remotely by a time division multiplexor over a coaxial cable. Video transmission is by low band RF that can accommodate five channels on one coaxial cable. The system is designed to produce a picture rated at 400 lines of resolution.

Microwave Television System

A one camera system has been designed to be used in remote locations to monitor the operation of traffic and traffic control devices. The CCTV system is designed to operate under good lighting conditions and to cover large fields of view by remote control of pan and tilt and zoom lens functions by a time division multiplexor over leased telephone lines. Video transmission is by low powered microwave transmission with a ten-mile range.

Experience has shown the CCTV systems can only be as efficient as the observers. Full time television surveillance is so difficult that many organizations use an electrical surveillance system as an alarm and the CCTV as the analytical system.

Maintenance of large and complex CCTV systems should be contracted from qualified firms.

CCTV systems will be a part of the area wide traffic surveillance systems of the urban areas. The effectiveness of the system will depend more on the efficiency of the operators than on the technical ability of the equipment.

IMPLEMENTATION STATEMENT

For facilities that require visual surveillance, the application of closed circuit television should be considered. If the facility requires full time surveillance by two or more persons, CCTV system will probably be economically feasible on the basis of reduced manpower alone. For facilities that require only part time surveillance, the benefits must be calculated on the basis of the advantages of centralized visual surveillance with recording capabilities. The more use that can be made of a CCTV system, the more cost effective it becomes. Therefore, the considerations for implementation of a CCTV system for traffic surveillance must include long range plans on the use of the system and the personnel who will be responsible for its operation.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Scope of Study

Closed circuit television (CCTV) in the fields of education, industry, science and engineering has been proven to be a most versatile and productive instrument. The recent telecasts from the surface of the moon serve to emphasize the value of visual surveillance from a remote control center. But more mundane applications are seen daily in the airline terminals, banks, department stores, along the assembly lines of industry, and in hundreds of other locations. Systems for traffic surveillance by closed circuit television (CCTV) have been in operation for several years, but except for some specific applications, such as bridges and tunnels, the outlook for the expanded use of these systems is one of cautious optimism. The reasons for this will be discussed in the paper, but are certainly not due to technical requirements. The advancements in electronic design and operations during the past few years have provided better systems at less costs.

This report will discuss the designs of CCTV that are now, or soon will be in operation in Texas, the operational and maintenance experience, and the potential applications to the urban transportation system.

Objectives

Most of the closed circuit television systems for traffic surveillance have been installed as experimental or research projects. In the United States there are few operating agencies that have the responsibility of real time surveillance of traffic. However, there are indications that in the near future, every major urban area will have some form of centralized

traffic control that will sense and respond to traffic conditions in real time. CCTV systems should become an integral part of the surveillance system.

Therefore, it is the objective of this paper to report the experience of traffic surveillance by CCTV in Texas and to propose modifications to design, operation, maintenance and application of future systems.

DISCUSSION OF OPERATIONAL SYSTEMS

Four CCTV systems have been designed for traffic surveillance in Texas. Each system has unique characteristics of design which are discussed in the following sections.

Baytown-La Porte Tunnel

The Baytown-La Porte Tunnel CCTV system was designed by the Texas Highway Department (THD) and installed by Phonoscope Incorporated of Houston in 1963-64. After several years of unsatisfactory maintenance operations by the contractor, the system was purchased by the THD. The system was financed through the maintenance budget set up for the operation of the tunnel by District 12 of the Texas Highway Department.

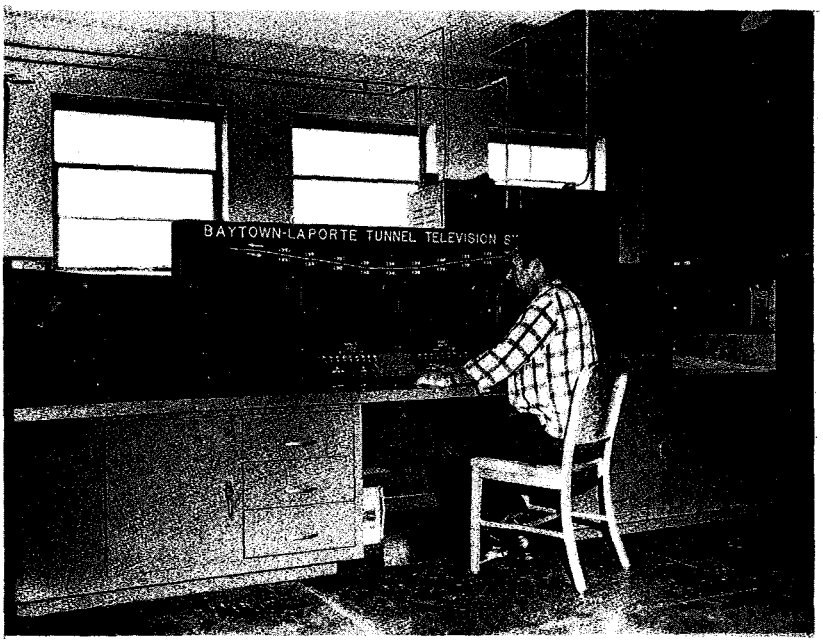
System Description

The Baytown-La Porte Tunnel CCTV system consists of seven television cameras spaced along a one-mile section of roadway passing through the tunnel. There is one camera on each approach to the tunnel, and five cameras are inside the tunnel. The system has been operational since June 1964 (Figures 1 and 2).

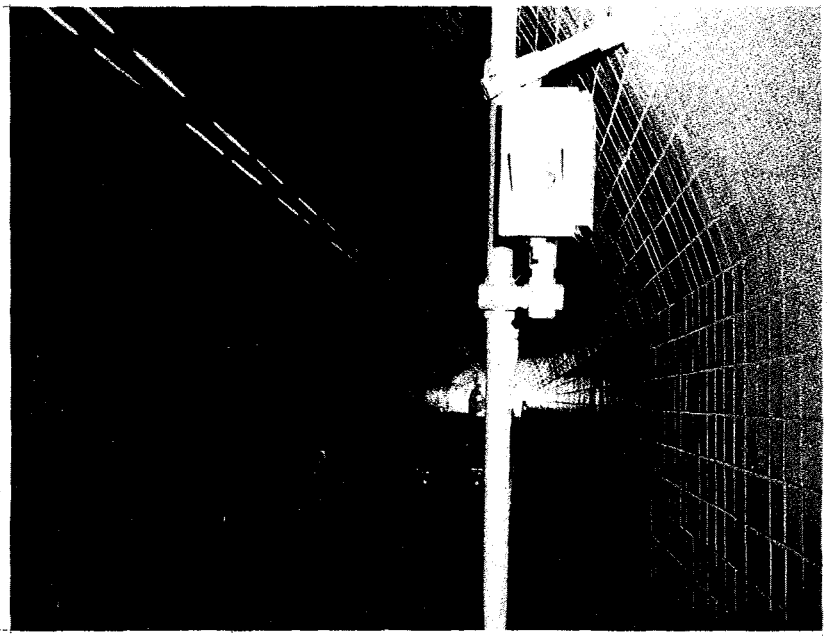
The video system utilizes direct video transmission by coaxial cable to send the signal to the control room located at the east entrance of the tunnel.

The television system has no remote control features and a two-inch lens is used to provide the necessary area of coverage.

The cable system, consisting of one RG-11-U Coaxial cable for each camera, is located in conduits in the tunnel.



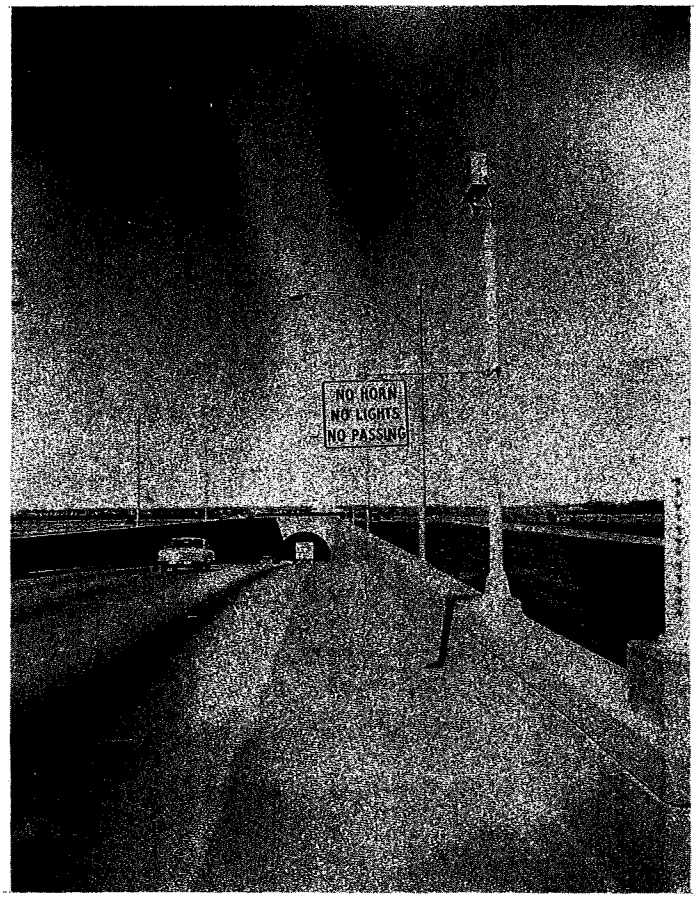
Eight-Monitor Display - Desk Installation



Camera Installation Inside the Tunnel

BAYTOWN-LA PORTE CCTV INSTALLATION

Figure 1



Camera Installation on Approach to Tunnel

BAYTOWN-LA PORTE CCTV INSTALLATION

Figure 2

System Operation

This system was designed as a 24-hour surveillance system for the detection of incidents in the tunnel and on the approaches to the tunnel that would adversely affect traffic flow. The system replaced two-full time guards and utilizes one part-time television observer. The observer also performs two other duties. First, he operates the traffic signals in the tunnel when an incident or normal maintenance activities affected flow on the tunnel lanes; second, he assists in the clearance procedures when an incident is observed.

The objective of this system has been satisfied and the surveillance operation is continuing. Some problems on the reliability and quality of video signals were encountered with the original system design, but these have been essentially eliminated by the existing system which is described in Table 1.

There has been no recent study of the detection and reaction time of the television observer to incidents that occur in the tunnel. This is the major problem with surveillance systems of this type as shown by the action of the Port of New York Authority in providing an additional electronic surveillance system as an alarm system for their television observer. But the Baytown Tunnel has small travel distances and relatively low traffic volumes; and the existing surveillance system appears adequate and certainly much superior to the two-guard configuration.

Some limited studies on traffic flow and the reliability of some vehicle sensors were conducted in the tunnel utilizing the

TABLE 1

EQUIPMENT DESCRIPTION OF THE
BAYTOWN-LA PORTE TUNNEL TELEVISION SURVEILLANCE SYSTEM

Television Camera -	Two Diamond Electronics Model ST1: Silicon transistorized vidicon camera; Horizontal Resolution 800 lines; random interlaced. Five GBC Model CTC-3002: Silicon transistorized vidicon camera; Horizontal Resolution 650 lines; random interlaced.
Television Monitor -	Conrac Model CVA 14-R: Resolution 800 lines
Camera Lens -	Two-inch 50mm Cosmieor
Transmission Cable -	RG-11 U Belden Coaxial Cable
Camera Housing -	Environmental: two cylindrical and five rectangle
Control System -	Designed by THD for this project to provide control of the following functions: Monitor switching Control of traffic signals in tunnel
Display -	Console designed by THD and houses eight 14" monitors, video switches and traffic signal control switches.

surveillance system. These studies essentially substantiate the work accomplished in New York. Because of the lack of electronic surveillance and monitoring equipment, additional studies have not been undertaken at this location.

In summary, the system performs its designed tasks in a cost-effective manner.

Maintenance

System maintenance which was unsatisfactory under the original maintenance contract with Phonoscope Incorporated, prompted the purchase of the entire system and the end of the lease contract. System reliability has improved since that time.

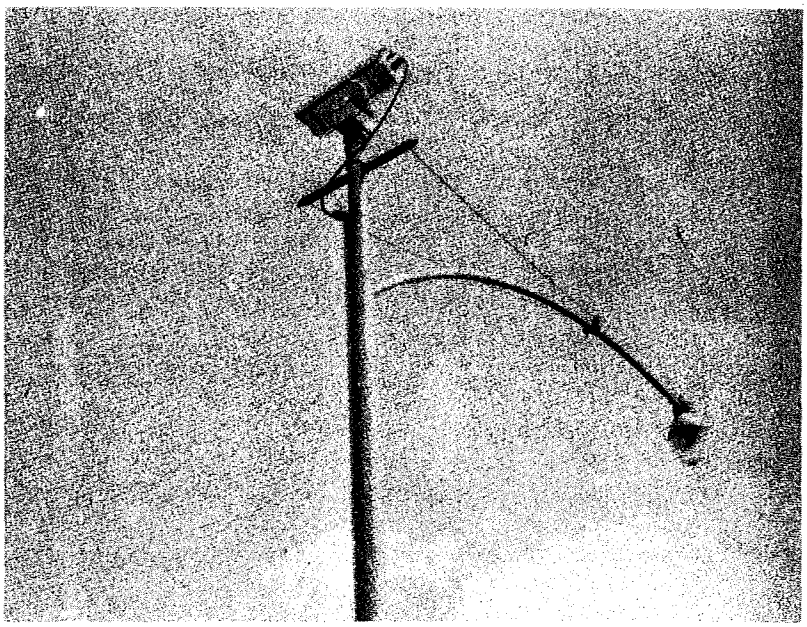
The original camera housings were inferior and during tunnel washing activities, the water and detergents from high pressure sprays often entered the housings causing failure.

Gulf Freeway - Houston

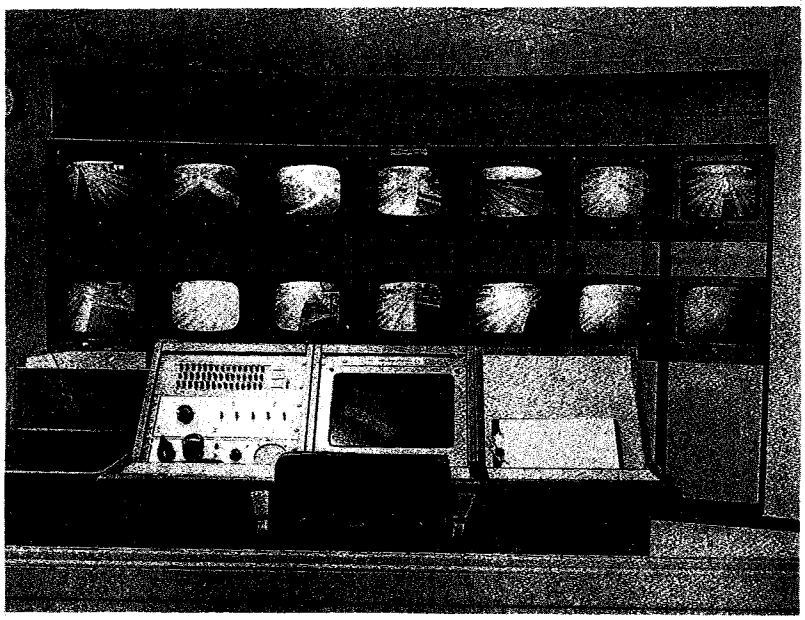
The Gulf Freeway CCTV system was designed by the Texas Highway Department and installed by Taft Broadcasting Company of Houston. The system was originally financed through the Highway Program of Research, but recently the system was transferred to District 12 Maintenance Division of the Texas Highway Department.

System Description

The Gulf Freeway CCTV system consists of fourteen television cameras located on top of metal poles at 2,000-foot spacing along a six-mile section of freeway. The system has been operational since December 1966 (Figure 3).



Camera Installation on Existing Luminaire Pole



Monitor Display and Control Console

HOUSTON GULF FREEWAY CCTV INSTALLATION

Figure 3

The video system utilizes balanced paired cables and amplifiers to transmit the signal to the control room located approximately in the center of the six-mile section.

The television system has remote control of pan and tilt units that provide 360 degree horizontal coverage and ± 45 degree vertical coverage, of zoom lenses with a focal length range of 15 to 150mm, and of the lens focus and iris. The camera will pan through 350 degrees but the field angle of the lens provides complete horizontal coverage. The control is accomplished by D.C. pulses transmitted on dedicated control wires that were installed with the video cables.

The cable system is buried in the freeway right-of-way and is the property of the Texas Highway Department.

The video display is accomplished by fourteen 17-inch monitors, rack mounted in a wall arrangement. There is one monitor at the control console and two monitors in a portable enclosure that are connected to a 14-position switcher. These auxiliary monitors are used in other rooms of the office and with video recorders.

More detail on the description of the components of the system is found in Table 2.

The design provides excellent coverage of every section of the freeway, all entrance and exit ramps, and adjacent frontage roads. Some cameras are located at major interchanges and can be rotated at right angles to the freeway to view arterial street approaches to the freeway.

TABLE 2

EQUIPMENT DESCRIPTION OF THE
GULF FREEWAY TELEVISION SURVEILLANCE SYSTEM

Television Camera -	Diamond Electronics Model ST-2: Silicon transistorized vidicon camera: Horizontal Resolution 800 lines; Positive interlace
Television Monitor-	Conrac Model CVA 17-R: Resolution 800 lines
Pan and Tilt Unit -	Pelco Medium Duty Model PT-550-M
Camera Lens -	Zoomar Mark X-B-15mm-15-mm focal length range with f 2.8
Transmission Cable-	Superior Cable Company: Balanced video pair - cable of two #16 conductors. Each pair separately shielded. 50 pair #22 AWG Telephone solid control wires.
Transmission Equipment -	Video Amplifier and equalizing equipment - Dynair Corporation
Camera Housing -	Taft Broadcasting Company - Designed for this project with the following features: Cylindrical shape with 4-inch diameter viewing end, front and rear plates sealed with "O" rings and connected by stainless steel wing nuts, camera mounting sled attached to back plate. The rear plate has moisture proof quick disconnect plugs for all electrical connections, including the intercom system.
Amplifier Cabinet -	Field cabinets designed by Taft Broadcasting Company: 10 gauge steel, hot dip galvanized, 3 point lock and outfitted to accept 19" rack mounted equipment.
Control System -	Designed by Taft Broadcasting Company for this project to provide control of the following functions: camera pan, tilt, lens focal length, focus and iris. The remote controls are located in the television control room and local controls are provided in each amplifier cabinet.
Video Switches -	Dynair Corporation 3-15 position switches on the control room console to select one of the fourteen video outputs for 3 spare monitors.
Display -	Emcor 19" Radio Racks houses the 14 monitors - Emcor Control Console houses: 1 monitor, control system, video switches and intercom controls.
Intercom System -	A hands free party line system designed by Taft Broadcasting Company for this project with terminals at the camera, amplifier cabinet, control room terminal strip and the control room console.

System Operation

The Gulf Freeway CCTV system was designed as a research installation to be used in the study of traffic flow on an urban freeway. The major emphasis was on peak period traffic operation, and the system was not designed for 24-hour surveillance. Although the video installation was designed primarily for research, the cable was included as a part of the data transmission system for the electronic surveillance and control.

Experience in traffic studies of urban freeways has shown that the collection of data from visual records is tedious but necessary, if sufficient detail on complicated traffic maneuvers is required. Also, experience indicates that the disadvantages of using aerial photographic surveys and ground mounted motion picture studies to record the information are the discontinuity of data collection in time and space. A television system with sufficient area coverage and trained observers can overcome these surveillance disadvantages.

The Gulf Freeway CCTV system has provided excellent visual surveillance of six miles of the freeway that experience heavy traffic congestion. At each of the eight entrance ramps that form the freeway ramp metering control system, a television camera is located just upstream to provide visual coverage of the merging maneuver, the ramp signal, length of ramp queues, and traffic flow on all lanes approaching and leaving the ramp merge area. Cameras are located at approximately 2,000-foot intervals so that shock wave action on the freeway lanes can be observed throughout the system. Detailed counts, classification studies, and travel time measurements can be made at any location and in either direction

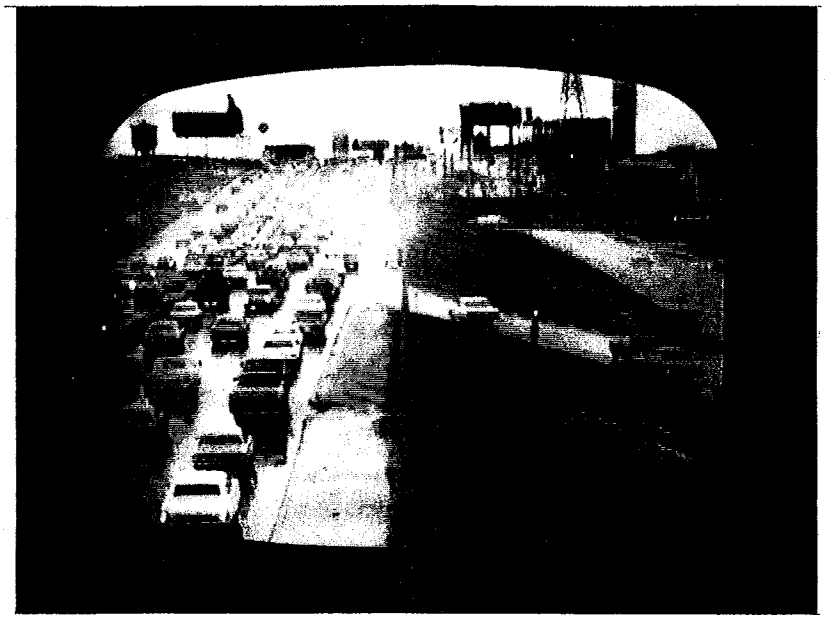
along the six mile section. Finally, the traffic conditions caused by unscheduled incidents, such as vehicle accidents or breakdowns, can be analyzed in real time or recorded on video tape for subsequent analysis. (Figures 4 and 5)

This system has performed very well in the study of traffic conditions. Two modifications to the system that would improve this function would be: (1) to improve night time visibility, so that peak periods in the winter months could be viewed more clearly; and (2) to add more cameras at the extremities of the system and in the I 610 Interchange area.

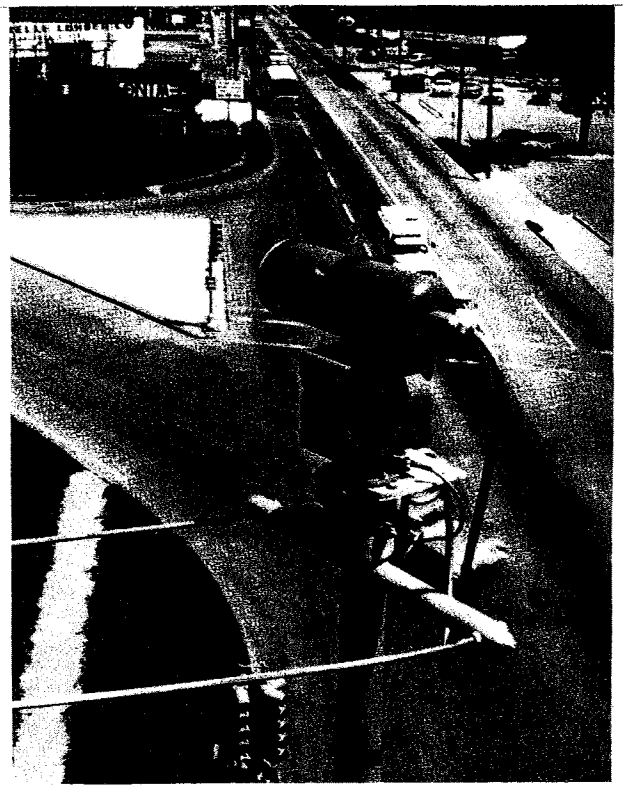
The television system was designed for research and, for the most part, has been devoted to that objective. The system could be an effective part of the operational surveillance system of the urban freeway. This is aptly demonstrated when the system is manned by City of Houston Policemen who have radio communication to the Police Department. However, the use of the system for the purpose of reporting and clearing obstacles on the roadway falls far short of its potential for the following reasons:

a. The police officer is on duty during peak periods only.
b. The police officer does not assist in the clearance procedures.
c. The police officer does not communicate directly with the emergency units, such as wreckers, maintenance crews, ambulances, etc., but must report through the central dispatching office.

These comments are not given as criticism of the Houston



CCTV Surveillance of Ramp Metering System



CCTV Surveillance of Arterial Streets

Figure 4

CCTV Surveillance of Unscheduled Events

Figure 5

Police Department, because the full implementation of the television system can only be accomplished if certain administrative and managerial policies are changed. These policies involve both the City of Houston and the Texas Highway Department.

System Maintenance

The CCTV system is maintained by Taft Broadcasting Company as part of the lease contract. The costs of replacement parts are included in the lease costs. The experience to date has been exceptionally good. As problems were detected, the repair procedure included modifications to the system to improve performance and reliability. For example, the system was susceptible to failure due to damage by lightning. Components that improved the isolation characteristics of the design were added when failures occurred.

A summary of the maintenance activities has been prepared for the last 12 months of operation (Table 3). Of the 111 service calls in one year, 44 were related to outtages caused by lightning. This means that 67 service calls, or approximately one every three days, was due to component failure. Some of these calls were not to repair outtages, but to improve the quality of the picture as, for example, the replacement of vidicon tubes. Therefore, the outtage rate due to equipment failure approaches one every four days.

The response by Taft Broadcasting to system failures has been good. Although penalty clauses are provided in the lease contract, there has been no justification to impose fines to improve service.

North Central Expressway - Dallas

The North Central Expressway CCTV system was designed by the Texas Transportation Institute and the City of Dallas and installed by Taft Broadcasting Company of Dallas. The system was purchased by the City of

TABLE 3

MAINTENANCE ACTIVITIES FOR
GULF FREEWAY CCTV SYSTEM
SEPTEMBER 1, 1970 to SEPTEMBER 1, 1971

	Number
Service Calls	
Repair or Replace Units	111
Preventative Maintenance	4
Component Failures	
Cable Break	2
Amplifiers	69
Cameras	25
Monitors	4
Power Supplies	11
Known Causes of Failures	
Lightning	44
Vidicon Tube Degradation	20
Cable Cuts	2

Dallas and leased to the Texas Transportation Institute for use in the design and operation of traffic control systems in the North Central Expressway Corridor. The Institute is conducting a research project for the Federal Highway Administration on traffic surveillance and control in an urban network.

System Description

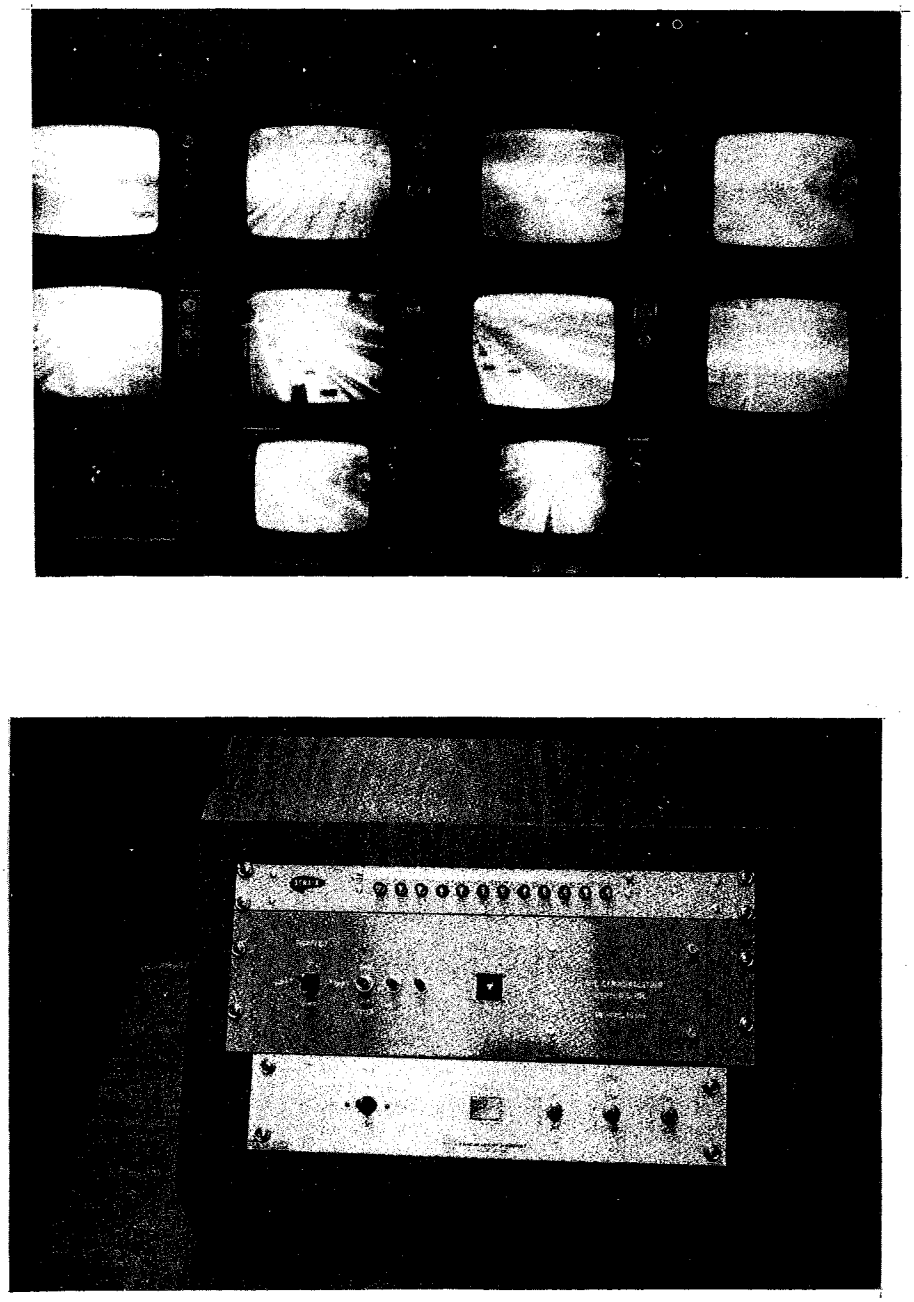
The North Central Expressway system consists of eight television cameras located on top of luminaire poles at spacings of 2,000 to 6,000 feet along a 10-mile section of freeway. The system has been operational since June 1971 (Figure 6).

The video system uses a low band RF transmission system which uses the television broadcast frequencies from 54 to 88 megahertz (channels 2 through 6). A single coaxial cable is used to send the video signals to the control room which is located at the approximate center of the 10-mile section.

The surveillance system has remote control of pan and tilt units that provide 360 degree horizontal and ± 45 degree vertical coverage, of zoom lenses with focal length range of 50 to 250 mm, and of focus and iris control. The control is accomplished by a time division multiplexing system of D.C. pulses on a single coaxial cable.

The cable system on one-half of the system is attached to a barrier fence in the median of the roadway and is thus exposed to weather and traffic. The other half of the cable system is buried in the freeway right-of-way.

The video display is accomplished by eight 23-inch monitors, arranged in a bookshelf cabinet. There are three auxiliary monitors: one to be used with a video recorder and the other two to be



Monitor Display and Control Console

DALLAS NORTH CENTRAL EXPRESSWAY
CCTV INSTALLATION

Figure 6

placed in remote offices at the control center.

More detail on the description of the components of the system is found in Table 4.

The design does not give continuous coverage of every section of freeway, but provides alternate camera locations for reconfiguring the system. Adjacent arterial streets and intersections are included in the field of view of the cameras.

System Operation

The North Central Expressway system is similar in operation to the Gulf Freeway System in that it was installed as part of a research project, but the application is primarily for the calibration, evaluation and operation of the ten-mile ramp metering system. Therefore, the system was designed to operate during daylight hours and to monitor traffic flow in the area of the entrance ramps.

The television system is completely separate from the control system. Since there are only eight cameras for ten miles of freeway, the coverage is not complete. There are provisions in the design of the transmission cable that will permit the relocation of cameras at several points along the freeway, if close surveillance of particular areas is needed.

The television system is owned and operated by the Transportation Department of the City of Dallas. There are no plans at present to set up continuous monitoring of the system for the purpose of detecting and reporting unscheduled events on the roadway.

System Maintenance

The CCTV System is maintained by Taft Broadcasting Company for two years as part of the purchase contract. At the end of that

TABLE 4

EQUIPMENT DESCRIPTION OF THE
CENTRAL EXPRESSWAY TELEVISION SURVEILLANCE SYSTEM

Television Camera -	Diamond Electronics Model ST-2: Silicon transistorized vidicon camera; Horizontal Resolution 800 lines; Positive interlace
Television Monitor-	Magnavox T5900-23" Resolution 400 lines
Pan and Tilt Unit -	Pelco Medium Duty Model PT-550-M
Camera Lens -	Pelco TV-5 (20mm to 100mm with 2 to 1 extender with f 4.0)
Transmission Cable-	Superior Cable Company: Aluminum Shielded AL-500J for Video Transmission RG-59 Cable for Control Function Transmission
Transmission Equipment -	Low Band UHF: CAS TVM-213 Modulators using Channels 2, 3, 4, 5, 6; Demodulators included in T5900 Magnavox Receivers; CAS Low Bank Amplifiers
Camera Housing -	Taft Broadcasting Company EHX - Designed for this project with the following features: cylindrical shape with 4-inch diameter viewing end, front and rear plates sealed with "O" rings and connected by stainless steel wing nuts, camera mounting sled attached to back plate. The rear plate has moisture proof quick disconnect plugs for all electrical connections, including the intercom system.
Amplifier Cabinet -	Field cabinets designed by Taft Broadcasting Company: 10 gauge steel, hot dip galvanized, 3 point lock
Control System -	Designed by Taft Broadcasting Company for this project to provide control of the following functions: camera pan, tilt, lens focal length, focus and iris. The remote controls are located in the television control room and local controls are provided in each amplifier cabinet. All controls are multiplexed over RF-59 Cable, using Time Division Multiplexing (Capable of 80 functions).
Video Switches -	A 10-position switcher on the control room console to select one of the eight video outputs for one spare monitor
Display -	Custom Built Wood Cabinet houses the eight monitors, video recorder and two auxiliary monitors.

period, the City of Dallas will probably take over the maintenance activities (see Appendix A).

The system has not been in operation too long, but there are indications that maintenance will be a greater problem on this system than the one in Houston. This can be attributed to the semi-permanent design of the system which specified exposed transmission cable, and to the use of a time division multiplexing system for control.

Microwave Television System

A one-camera television system using a microwave transmission system was designed by the Texas Transportation Institute and the Texas Highway Department. The system is financed through the Highway Program of Research and will become the property of District 12 of the Texas Highway Department.

System Description

A one-camera system using microwave transmission has been specified for application in both the Houston and Dallas areas. The initial installation will be in Houston.

The video system will use a low power microwave transmission with a line of sight range of ten miles (Table 5). The system will have remote control of a pan and tilt unit that provides 360 degree horizontal and ±45 degree vertical coverage and, of a zoom lense with focal length of 15 to 150 mm, and of focus and iris control. The control will be accomplished by a time division multiplexing system of D.C. pulses on a pair of dedicated telephone lines.

The video display will be accomplished by one 17-inch monitor that will be used with the video recorder.

TABLE 5

EQUIPMENT DESCRIPTION OF THE
PROPOSED MICROWAVE TELEVISION SURVEILLANCE SYSTEM

Television Camera -	Diamond Electronics Model ST-2: Silicon transistorized vidicon camera; Horizontal Resolution 800 lines; Positive interlace (Or Equal)
Television Monitor-	17-inch Portable Monitor with resolution greater than the transmission system. Capable of receiving commercial broadcasts.
Pan and Tilt Unit -	Pelco Medium Duty Model PT-550-M (Or Equal)
Camera Lens -	Zoomar Mark X-B-15mm-150mm focal length range with f 2.8 (Or Equal)
Transmission Cable-	Video Cable as required. One pair #22 AWG telephone solid control wires (Or Equal)
Transmission Equipment -	Microwave Associates MA-12C Low Power Microwave System (Or Equal)
Camera Housing -	Cylindrical shape with 4-inch diameter viewing end, front and rear plates sealed with "O" rings and connected by stainless steel wing nuts, camera mounting sled attached to back plate. The rear plate has moisture proof quick disconnect plugs for all electrical connections, including the intercom system. (Or Equal)
Amplifier Cabinet -	Field cabinets designed to protect equipment from vandals and the environmental conditions in Texas.
Control System -	A time division multiplexing system to provide control of the following functions: camera pan, tilt, lens focal length, focus and iris over one pair of dedicated telephone wires. The remote controls are located in the television control room and local controls are provided at the field cabinet.

More details on the description of the components of the systems are found in the copy of the system specifications, Appendix B. The system is expected to be operational by January, 1972.

System Operation

The one camera television system using microwave transmission of the video signal will be in operation by March, 1972. The purpose of this system is to broaden the television surveillance coverage to adjacent intersections and arterial streets that affect traffic flow on the urban freeway. Specific uses of the system will be to: monitor traffic operations at arterial intersections that are controlled by a digital computer; monitor the operation of changeable message signs that will be located out of view of the urban freeway CCTV systems; and monitor other critical traffic situations such as traffic generators, railroad crossings, transit terminals, and other freeway interchange connections.

As the electronic surveillance and control systems expand into the urban arterial street systems, the same needs for visual surveillance that resulted in the freeway television systems will become apparent. The application of microwave transmission may solve the problems of area surveillance and temporariness of installations.

Video Tape Recorder (VTR)

CCTV systems that are used in the collection of traffic data for research and traffic studies should be equipped with a recording device. Video tape recorders will usually provide adequate pictures for replay and analysis and have the distinct advantages of instant replay and reusuable tapes.

There are many recorders at all price ranges, but for the application of traffic surveillance and study, the one-half inch tape units provide the required quality of recording at a reasonable price (approximately $700). One inch recorders usually offer higher resolution and more editing capability but the cost of tapes is also much greater than the smaller recorders. A typical set of specifications for a one inch VTR is presented in Appendix C, however, newer equipment will probably exceed these specifications and provide additional features.

Some one-half inch recorders offer two or more selections of recording speeds with time lapse play back capability. This feature permits extended time for recording from the usual one hour to as long as sixty hours. The cost for these recorders is two to three times that of a one speed recorder. A typical set of specifications for a one-half inch VTR is presented in Appendix D. A usual design is a VTR that has normal speed, one-seventh normal speed, stop action and, single frame playback at 1/30 second interval.

SUMMARY OF EXPERIENCE

The following sections discuss the significant findings, opinions and conclusions drawn from the experience of designing, procuring, operating, and maintaining the four CCTV systems described in the previous section. The statements presented in this section represent the opinions of the authors and the research agency and not necessarily those of the Texas Highway Department or the Federal Highway Administration.

System Design

A CCTV system consists of the following subsystems: television camera and lens, video transmission, television monitor and camera control system. There are many design configurations with several levels of quality and cost available for traffic surveillance. This is illustrated by the four different systems described in this report. The determination of the best design for a specific application is difficult because there are several alternatives which may be capable of meeting the surveillance requirements. In the following discussion some of the more important aspects of design are presented with the assumption that in all cases, the most cost effective system for a set of conditions is preferred.

Camera and Lens Subsystem

The two requirements of a CCTV system for traffic surveillance are reliability and picture quality. In the design of the television camera, reliability is more important because the installation will be exposed to the outdoor environment twenty-four hours a day,

and the cameras will be positioned so that direct access will be difficult. This is necessary to provide the desired coverage of the traffic and to reduce the opportunity for vandalism. Therefore those characteristics of the camera that describe its reliability and durability under a wide range of light, temperature, and moisture conditions are of primary importance.

The characteristic of picture resolution is of secondary importance since the camera will not be the critical component in the CCTV system. Most cameras that are selected for this type of surveillance have resolution capabilities far greater than the requirement for the system. Still, the resolution specification is important to establish the quality of the system and to define a level of acceptance. In general, there are three broad levels of quality for television cameras. The requirements of traffic surveillance can be satisfied by a CCTV system that produces 300 to 400 lines of resolution, but the camera subsystem should be capable of producing in excess of 600 lines of resolution.

The lens system to be used in the CCTV system will be determined by the field of view required of each camera. Most systems prefer a zoom type lens with focal lengths ranging from 0.5 to 6.0 inches. The quality of the lens should be high enough so that the horizontal resolution of the system is not restricted. If visibility under poor light conditions is required, a lens that provides a greater lens opening at the extended position must be used. The lens controls should have the same reliability and durability as the camera.

Video Transmission

Picture resolution and detailed cost analyses will probably dictate the type of video transmission system to be used:

- The use of coaxial cable for direct video transmission, such as that used in the Baytown Tunnel, is usually limited to short distances since the attenuation of noise increases with the length of the cable.
- The balanced pair video cable such as that used in Houston, provides a high quality picture, but the cost is higher because of the special amplifying, balancing, and equalizing equipment.
- The use of radio frequency modulation on a coaxial cable, such as that used in Dallas, provides an economical installation, since one cable can transmit up to thirteen channels. Long distance transmission would favor this system design, although the quality of the picture would be less than the balanced system.
- The microwave system such as that proposed for Houston, provides flexibility for location and portability that is an advantage in the study of large traffic systems. The cost is higher than the other systems, unless the cost for providing many different camera locations is included. The license requirement may restrict the use of this medium in urban areas.

There is not a cut-and-dried procedure for determining the minimum picture resolution required for traffic surveillance.

Resolution will vary widely for different light conditions and, as the system ages, for different components. Picture resolution of 400 lines was set for the Dallas Project and 650 lines for the Houston Project. Both systems produce good usable pictures for traffic surveillance. The Dallas system has relatively less clarity and sharpness; but it accomplishes the task.

The best approach to the selection of the resolution requirement is to obtain a field demonstration of two comparable systems that produce pictures of minimum (400 lines) and a maximum (650 lines) resolution and simulate the desired surveillance tasks.

Television Monitors

As in the case of the television camera, the monitors selected for the CCTV system should not limit the picture resolution. The Baytown Tunnel and the Houston system use monitors especially designed for closed circuit surveillance. These sets are similar to the commercial television but have the following differences: there are no tuning systems and sound systems; the electronic circuits are more refined and stable; and the picture resolution is greater.

The monitors in the Dallas system are commercial television sets adapted to receive video signals over a coaxial cable. The tuning system of the set is the demodulator for the radio frequency transmission system.

Size of the monitors depends on the viewing distance. A desk installation at the tunnel uses 14-inch monitors, and the 10-foot viewing distance in Houston required 17-inch monitors. The Dallas project uses 23-inch television receivers for an expected viewing distance of 20 feet.

The monitor controls should be located on the front panel of the set if the monitors are to be displayed in equipment racks or shelves. Special attention must be given to air conditioning if solid state monitors are not used. A one ton window unit was used in the Houston project to counteract the heat produced by the 14 monitors.

Since the monitor is a low cost item in the CCTV system, much higher quality can be obtained with a small increase in price.

Camera Control Systems

If a CCTV system is to provide surveillance of traffic operations over a large field of view and under varying light conditions, it will be necessary to control the position of the camera and the condition of the lens. The function to be controlled are:

Camera Position	Lens Condition
Pan - Left	Increase Focal Length
Pan - Right	Reduce Focal Length
Tilt Up	Open Iris
Tilt Down	Close Iris
	Move lens in (Focus)
	Move lens out (Focus)

If a camera is in a fixed position with a small variation of light levels, such as exist in tunnel installations, these controls are not necessary. For cameras that do require remote control of these functions, there are standard control units that have a camera selector switch and toggle switches for activating the ten channels.

The transmission of the control commands can take several forms. The cost of the system is the predominate factor in the selection of the design. In Houston, a multiconductor control cable was installed with the video cables. One conductor is assigned to each function, and one conductor is assigned to each camera position. A common

ground provides the completed circuit for the system to transmit D.C. voltages that operate the control relays.

In Dallas, a time division multiplexing system transmits D.C. pulses over a single coaxial cable to address a camera and command the various functions.

The microwave television control system will utilize the same type of time division multiplexing system, but a leased pair of telephone lines will be provided for the interconnect.

It is strongly recommended that a complete remote control system be provided for every traffic surveillance system that is to be installed on freeways and arterial streets.

System Operation

The efficient operation of a closed circuit television system is very difficult because the task of viewing a number of monitors continuously for a period of time is difficult. The technical aspects of operation usually take precedent over all other considerations in planning and the design of the systems, but it is the human element that causes most problems. The reasons for these failures is that television is a passive surveillance system and is only as effective as the human observer. The efficiency of observation will vary between individuals and within each individual.

Therefore, it is of considerable importance to define the objectives of the surveillance system, to outline the operational procedures to be taken for all expected situations, and to provide for the employment, training and supervision of personnel to accomplish these tasks.

There are two general categories of applications of television to traffic surveillance: research and operations. It is possible of course for one CCTV system to serve both functions. The more common uses made of the television surveillance system can be summarized in the following statements:

Detection of Hazardous Conditions

The location and identification of events, such as accidents, disabled vehicles, spillages, etc., that adversely affect traffic flow on limited access facilities such as bridges, tunnels, freeways, are the principal advantages of television for operational applications. Electronic surveillance alone can not provide detail on the causes of the problem and what steps should be taken to solve them.

Study of Complex Traffic Operations

The ability to record and play back the traffic operations at an intersection, freeway ramp merge, etc., provides for detailed analysis after the event. Also, many studies can be conducted by having the observers input the information in real time to a computer or other data recorder.

Study of Unscheduled Events

The evaluation of effects of environmental conditions, maintenance and construction activities, disabled vehicles and their associated emergency vehicles, and personnel on traffic operations can best be made by observing the operations for some distance on both sides of the event.

Study of Scheduled Events

The evaluation of the application of new traffic control or driver communication devices and/or techniques is done in the same manner as above, but specific studies and measurements are obtained.

Confirmation of Communications, Surveillance, and Control Systems

The ability to record events and to perform as a back up for confirmation to the electronic systems has been considered necessary as the complexity of the systems increase. This activity is, of course, of particular importance during the development and calibration stages of the new systems.

In all of these uses of the CCTV system, the human observers must be trained or programmed to respond to the visual data in the same manner that a computer responds to electronic data. The potential of video surveillance is great because the human observer is also a computer, but considerable effort must be expanded to maintain a high degree of efficiency. It is not too difficult in research applications to achieve this high level of efficiency since the studies are usually short in duration and intense in execution. But the daily routine surveillance requires greater concentration by the observers and more direct supervision by the project manager.

System Maintenance

CCTV Systems that are expected to operate full time in an outdoor environment as extreme as that in the Texas area require considerable maintenance. Although most of the failures will be minor, an experienced technician with adequate tools, shop facilities, and spare parts is

essential to minimize the time of outage and the maintenance costs. Most governmental agencies that will be responsible for the operation of a traffic surveillance system do not have the personnel or facilities to do this work and must contract for the services.

This approach can be successful if a qualified company is employed and if certain provisions are included in the maintenance contract. Some of the more important provisions of the contract are:

a. To establish a maximum down time with liquidated damages to be assessed for excess outage time.
b. To require a number of spare parts (10 to 15 percent) so that repairs can be made on the work bench, not in the field.
c. To require monthly service calls to clean and adjust the system.

A copy of maintenance requirements are included in the typical specifications included in the Appendix.

Procurement of the System

During the course of designing and operating the four CCTV systems, there has been a variety of procurement procedures tested. The following sections discuss the experiences, both good and bad, and the recommendations of the authors for improving the development of plans and specifications.

Lease versus Purchase

The first two CCTV systems in Texas (the Baytown Tunnel and the Houston System) were obtained by lease contracts. Options to purchase the systems were included in the request for bids. A lease contract was attractive at that time because it permitted the

financing to be extended over several years and it included the maintenance contract in the performance specifications. It was the opinion at that time that performance of the maintenance would be greater on a leased system than on a purchased system.

However, the quality of maintenance proved to be a function of the company and not the type of contract. After four years the THD purchased the Baytown Tunnel system and assumed the maintenance responsibility to improve the operation of the CCTV. The maintenance is provided by independent contracts on an "as needed" basis and is satisfactory since the system is small and uncomplicated. In contrast, after five years of operation, the THD has renewed the lease contract for the Houston system. This contract is essentially a maintenance agreement which is renewed on an annual basis. Service and performance on this project has been very good.

It is the authors' opinion that subsequent systems should be purchased outright and a maintenance agreement negotiated with a qualified firm. The total cost of the system should be reduced. A summary of the costs of the four systems is presented in Table 6.

Preparation of Plans and Specifications

A CCTV system is made up of many components that are available from many different suppliers. It is not necessary to describe in all the technical details these various components, since the manufacturers will supply this information on request. It is important, however, to describe in detail how the system should operate and to what conditions it will be subjected. In other words, the buyer should give the functional requirements of the system and the prospective

TABLE 6

COST OF CCTV SYSTEMS IN TEXAS

System	Terms of Contract	
Baytown - La Porte Tunnel	Lease*:	$580/Month for first 24-month period (June, 1964 to June, 1966)
		$240/Month for second 24-month period (June, 1966 to June, 1968)
		**$3,600 for purchase after 48-month lease
Gulf Freeway - Houston***	Lease*:	$9,000/Month for first 40-month period (December, 1966 to April, 1970)
		$2,000/Month for next 18-month period (April, 1970 to October, 1971)
		$2,000/Month for next 18-month period (October, 1971 to March, 1973)
North Central Expressway-Dallas	Purchase:	$82,265.60 - Includes maintenance for two years (June, 1971 to June, 1973)
Microwave Television	Purchase:	$14,600 - Includes two-year warrantee of equipment (March, 1972 to March, 1974)

*Lease contracts include cost of maintenance.

**Maintenance costs are random since service is on an "as needed" basis.

***Lease contract specifies that the cable system shall become the property of the Texas Highway Department when the contract is terminated.

contractor should provide a detailed description of the components which will satisfy these system requirements.

This approach appears to be simple, but there are some difficulties. The most obvious problem is the evaluation of the designs submitted with the bids. One solution is to obtain the services of a qualified and unbiased consultant to review the designs and to recommend the acceptable system.

This approach may appear to be reversed, but since most agencies do not have persons qualified to design a system, this activity can best be accomplished by those persons in the CCTV profession. Also, a prospective contractor, who designs his own system, can better estimate the costs since he will negotiate with his own suppliers.

If this approach seems to be too loose and undefined, a second method is to describe an acceptable system that will meet the functional requirements. This can be done by naming one or more particular models of cameras, monitors, etc., and stating that this equipment or equal will be accepted. This approach may alleviate the review process, but may also result in a system that is not the best available for the same costs.

A further extension of this approach would be to provide generalized specifications for the equipment, describing in detail it operating characteristics. A set of specifications that provides too much detail can present as much a problem as one that presents too little.

Sample copies of specifications that resulted in acceptable bids are shown in the appendix.

CONSIDERATIONS FOR FUTURE INSTALLATIONS

Even though television can now provide the traffic researcher and traffic engineer with the most complete surveillance system of traffic operations, there are still many improvements that can be made over existing installations.

First, the visibility under conditions of low light levels can be improved to provide 24-hour surveillance. This requires the same camera system to operate from low light levels to bright sunlight. Very sensitive vidicon tubes are available than can accomplish this task.

The systems should have more flexibility and mobility to cover the large areas of traffic surveillance in the urban networks. Low powered microwave or laser transmission systems can be used in conjunction with a cable system to expand the area of coverage.

Improved maintenance can be achieved today with modular construction of the electronic equipment. Some camera designs have separated the optical and electronic subsystems so that the major elements of the circuitry can be placed in a cabinet at the base of the camera mount. Quick replacement of inoperative units is possible, so that the outage time can be reduced. The removal of the electronics from the exposed position of the camera mount reduces the size and weight of the camera housing and improves the environmental control for the electronics.

These technical improvements will be available for the new systems in the near future. The question of whether these systems will be used in an efficient manner can only be answered by the organizations that have the responsibility for operation.

APPENDIX A

SPECIFICATIONS FOR
PORTABLE CLOSED CIRCUIT TELEVISION SYSTEM

I. General Description

The City of Dallas proposes to purchase a portable closed circuit television (CCTV) system which will be used to make observations of traffic operations on various streets and highways in Dallas.

The CCTV system must have high reliability in outdoor operation and the capability of providing picture quality adequate for discerning the movement of vehicles at a distance of approximately 2500 feet and the changing of traffic signal indications at a distance of 500 feet under normal daylight conditions. The CCTV system shall be installed by the contractor along the North Central Expressway with monitors and remote control unit in Suite 410, Noel Page Bldg., 6400 No. Central Expressway, Dallas, Texas.

The cameras will be mounted on luminaire poles, utility poles, buildings, or other suitable locations in the Dallas area. The cameras and accessories, transmission system, and field control components must have adequate protection from and be capable of operating in ambient weather conditions in the Dallas area.

More detailed specifications are presented in subsequent paragraphs.

II. System Design Considerations

1. Cameras - The CCTV system shall include eight (8) cameras with the following components, characteristics, and capabilities:

A. Minimum horizontal resolution - 650 lines
B. Camera to operate on 117 Volt AC circuit with fluctuations of ± 15 volts
C. Signal transmission - Video or RF
D. Zoom lens - 5:1 with added extender to provide 150 mm or greater field width
E. Weather proof housing
F. Must be able to operate in Dallas outside environmental conditions
G. Must be compatible with a Model 2200 Sony video tape recorder
H. Camera to be fully transistorized except for vidicon and input stage. Vidicon protection circuit to be transistorized

2. Camera Locations

A. Cameras shall be located at any one of the cross streets on Central Expressway as shown on attached sketch and Table I.
B. Installation will be on top of highest liminaire pole in vicinity of crossover structure.

C. Cameras will be located on luminaire or utility poles at various other major intersections on either side of the freeway.

D. A maximum of five (5) cameras shall be located on either side of control center. Attached sketch shows where line drops are located.

3. Signal Transmission System

A. Camera transmission signal will be transmitted via cable installed by the contractor in median of freeway. Where guard rail exist, transmission cable and control cables will be attached to posts. Where grass median exists, cables will be buried.

B. Where crossover structure center post exists, the cable shall be attached to the center post to reach the camera location. Where no center post exists, cable shall be installed such that it will be in place only when that particular location is in use. In either case, the cable shall be secured in such a manner that wind and traffic will not cause it to be moved where vehicle contact may be possible.

C. Camera transmissions from locations other than freeway crossovers (up to two miles either side of freeway) will be transmitted via temporary lines laid by the City of Dallas. Terminals for tying in these temporary lines with freeway trunk line will be provided at freeway camera locations.

D. The CCTV transmission system shall be capable of handling up to eight cameras located in the corridor area (as noted in "C" above). No more cameras will be located on either side of the freeway than are indicated in the attached sketch by line drops. For example, two cameras might be located on either side (total of four cameras) of the freeway on Henderson/Knox since four lines are indicated. Similarly, two cameras might be located on the East side of the freeway on Haskell since two lines are indicated.

4. Portability

A. Cameras, control cabinets, and associated equipment shall be designed so that all components on one camera chain can be readily moved within four to six hours. The equipment will be moved either to other freeway locations or to remote areas mentioned above. Only normal hand tools shall be necessary for this change of location.

B. Mounts for camera/pan-tilt assembly

(1) Mounting bracket for each camera/pan-tilt unit shall be provided for top of luminaire pole.

(2) Four (4) adjustable mounting brackets for attaching camera/pan-tilt unit to building or bridge parapet.

(3) Four (4) adjustable mounting brackets for attaching camera/pan-tilt unit to utility pole.

5. Receivers - Eight monitors shall be provided with the following components, characteristics, and capabilities:

   A. Minimum horizontal resolution corresponding to that of camera provided (650 lines horizontal at center)
   B. Each monitor mounted in individual standard cabinet
   C. Nineteen-inch (19") picture tube
   D. Located in control center, 410 Noel Page Building, 6400 North Central Expressway, Dallas

6. Control System

   A. Each camera shall be equipped with pan and tilt control. Pan shall be capable of from 0^{o} to 350^{o} horizontal placement. Tilt shall be capable of -45^{o} to $+45^{o}$ vertical placement.
   B. One (1) remote control unit shall be located in control center. Unit shall be capable of adjusting pan, tilt, zoom, focus, and iris of any one of the eight cameras. (Common to all cameras with switching unit to select desired camera)
   C. A control cabinet with necessary control components, hardware, and terminals shall be provided with each camera. The cabinet shall be capable of being mounted securely to luminaire or utility pole. Control cabinets shall be of such design to prevent vandalism and shall be provided with locks and keys.
   D. One (1) portable monitor with pan, tilt, focus, iris, and zoom controls shall be provided for positioning any one of the eight cameras at the camera location. This feature will be used when camera feeds a portable video tape recorder located at the camera position.

7. Power Sources - Power of 117 volts A.C. will be provided at desired camera locations.

8. Other Design Requirements

   A. Bidders shall show in their proposals that no hazardous condition will exist in the event that the cable in the freeway median is severed.
   B. Design of mounting brackets for cable installation, control cabinets, cameras and other hardware not directly associated with the transmission of the television picture shall be submitted as a part of proposals for approval by the City Engineer.

III. Maintenance

1. The contractor shall be responsible for all maintenance, service, and repairs upon CCTV system including cameras, receivers, transmission system, and associated equipment furnished as a part of this contract.
2. The contractor shall indicate in his proposal that adequate personnel will be stationed in the Dallas area and an adequate stock of component replacement parts will be on hand to insure the level of service specified.
3. No camera chain shall be out of service for more than twenty-four (24) hours during scheduled operations from 6:00 a.m. through 8:00 p.m., Monday through Friday, without invoking liquidated damages. A camera chain shall consist of one (1) camera, the transmission link, associated remote controlled functions, and associated monitor.
4. Maintenance personnel shall be available by telephone between the hours of 6:00 a.m. and 8:00 p.m., Monday through Friday. Liquidated damages shall be accessed in the amount of fifty dollars ($50.00) for each hour or portion thereof a camera chain is out of service. Outage hours shall begin to be counted twenty-four (24) hours following notification of contractor. Only the hours of 6:00 a.m. to 8:00 p.m., Monday through Friday, will be counted for liquidated damages.
5. It is the intent of these maintenance provisions to insure prompt service when outages occur. The liquidated damages may be waived by the City Traffic Control Engineer or his representative when the contractor can show valid, justifiable reasons.

IV. Other General Requirements

1. Three copies of proposed plans and specifications shall be submitted with bid. All major items of equipment shall be indicated by make, model, and specification sheet.
2. Bids shall include the purchase price of the entire system and the price for the maintenance agreement.
3. Proposals shall have the lump sum purchase price broken down as follows:

   Labor
   Overhead
   Equipment Costs
   Other Direct Costs
   Maintenance Cost per year for two years

4. Proposals shall include a list of principal personnel who will be involved in design and installation of this system, along with a brief sketch of their qualifications.
5. Estimated completion date shall be specified.
6. The contractor may propose an alternate design that satisfies the functional requirements described above. The bid for the alternate system shall be presented in the same form as outlined in paragraph

3 and will contain a statement as to the advantages of the alternate over the primary system.

7. Prior to awarding this contract, the City and/or their authorized representatives shall be allowed to inspect the bidder's equipment and maintenance facilities if it is so desired.
8. Bidders will provide certification from the equipment manufacturers to indicate which of their (the contractor's) service personnel have attended factory service school.
9. The Texas Highway Department will on weekdays (Monday through Friday) provide proper signing and other equipment for protecting personnel installing cable in freeway median. The contractor shall provide at his expense one (1) off-duty, uniformed policeman for directing traffic during times when a freeway lane must be blocked. The contractor shall notify the Texas Highway Department through the City a minimum of one week prior to this installation.
10. Work on the freeway lanes or median shall not be allowed during the hours of 6:00 a.m. to 9:00 a.m. and from 4:00 p.m. to 6:30 p.m.
11. The contractor shall submit his plan for work on the freeway lanes and/or median for approval by the City Traffic Control Engineer. It is the intent of this and previous provisions that the work be done in a safe order by manner with a minimum of hazard and delay to the motoring public.
12. Prior to picking up bid specifications, the bidders shall submit to the City of Dallas a resume of their firm's qualifications to perform work of this nature. This resume shall include agencies or firms which may be contacted for verification of previous work, and a short background of the firm.

APPENDIX B

TEXAS HIGHWAY DEPARTMENT
SPECIAL SPECIFICATION FOR
CLOSED CIRCUIT TELEVISION SYSTEM
USING MICROWAVE TRANSMISSION

0.0 SYSTEM DESCRIPTION

Closed Circuit Television System using Microwave Transmission. Single camera and monitor closed circuit television system using video transmission by microwave with a ten (10) mile range. Mobile design so that camera can be moved to another location in one day or that total system can be moved to another city in Texas. Rugged design to operate in the environmental conditions in Texas. Remote control of pan-tilt, and zoom lens functions over one pair of telephone lines. System shall be in accordance with attached Special Specification for Closed Circuit Television System using Microwave Transmission.

0.1 GENERAL

1.1 This specification describes the minimum acceptable design and operating requirements for a single camera and monitor closed circuit television system using microwave video transmission.

2.0 DESIGN REQUIREMENTS

2.1 Functional

The closed circuit television system shall provide the following operational features:

2.1.1 Television Camera

Positive interlace, horizontal resolution greater than 800 lines; Model Diamond Electronic ST-2, or equal.

2.1.2 Camera Lens

Zoomer Mark X-B15 mm. to 150 mm. focal length range with f2.8, or equal.

2.1.3 Camera Housing

Compatible with television camera capable of operating in all weather conditions experienced in Texas. Cylindrical shape with sun shade.

2.1.4 Pan and Tilt Unit

Pelco Medium Duty Model PT-550M, or equal.

2.1.5 The mounting base for the pan and tilt assembly shall be designed to fit snugly over the top of a standard thirty (30)

foot Strain Gage Pole. Pole is to be furnished by Texas Highway Department. Pole specifications are available on request.

2.1.6 Video Transmission

The video signal is to be transmitted by a microwave system capable of signal transmission of ten (10) miles line of sight in an urban area. (Microwave Associates MA-12C system, or equal). All necessary accessories to provide an operational system are to be included in the bid. The contractor shall provide all FCC licensing permits. The license shall be in the name of the Texas Highway Department. System shall be licensed as portable throughout the State of Texas.

2.1.7 Television Monitor

One seventeen (17) inch portable monitor with resolution greater than the transmission system and with a selector switch for normal commercial television reception will be provided. A video outlet will be provided to interface with a Javalin Video Recorder, Model X-400.

2.1.8 Control System for pan and tilt and lens operation will be provided which can utilize one pair of dedicated telephone lines (voice grade) for remote control at the monitor location. Control functions are pan left and right, tilt up and down, zoom in and out, focus near and far, and iris control open and close. Capability shall exist for control of these functions at the camera location or remotely at the monitor location.

2.1.9 Equipment Housing

The system shall be designed to be mobile. The field Transmission and control units shall be housed in a weatherproof cabinet that can be mounted to a pole (see Figure 1). The cabinet shall have terminals for external power and transmission lines. The housing shall protect the equipment from vandals and the environmental conditions experienced in Texas.

The office equipment (monitor and control console) shall be housed in individual, portable cabinets.

The microwave transmitter and antenna shall be mounted to the camera pole approximately twenty-two (22) feet from the base. The microwave power supply and control unit shall be installed in the television cabinet mounted to the pole.

2.1.10 Installation

The contractor will furnish all materials and equipment necessary to provide a complete operational system as described herein. The contractor shall a 90-day installation and checkout

period. Said 90-day period will commence upon issuance of work order. This installation period shall be followed by a 30-day operational period. The contractor will maintain the system until the system operates satisfactory for a period of 30 days.

2.2 Electrical

The Closed Circuit Television System and Microwave Transmission System shall be electrically designed to meet the following requirements. These design requirements shall be considered to be minimum acceptable.

2.2.1 The camera, controls, monitor, and microwave shall operate on 117 V AC $\pm$ 10%, 60 Hz. power, and shall not draw more than 2 KW at either transmitter or receiver site.

2.2.2 All functionally operating equipment except the monitor receiver shall employ solid state circuitry.

2.2.3 All internal wiring shall be of copper and shall be neat and firm.

2.2.4 All printed circuits shall be of epoxy glass with extra heavy 2 oz. copper per sq. ft. All printed circuit boards shall be plug in type.

2.2.5 Terminals shall be barrier type and suitably identified as to funcion.

2.2.6 Load side polarity shall be same as line voltage polarity.

2.2.7 Duplex outlet to be provided, polarized, inside the cabinet.

2.2.8 Thyractor protection shall be provided on line side.

2.2.9 The Closed Circuit Television System, including the Microwave Transmission System shall be capable of sustained operation in an ambient temperature range between minus twenty (-20) degrees Fahrenheit to plus one hundred and sixty (+160) degrees Fahrenheit.

2.2.10 All cabling shall be of a heavy duty design to withstand the stress caused by relocation of the system. The cables, except primary power, shall be terminated at standard AN connectors for ease in disconnection for mobility.

2.3 Mechanical

The Closed Circuit Television System and Microwave Transmission System shall be physically constructed in accordance with accepted practice in commercial television and microwave industry. The system shall be designed to be so mobile that relocation can be accomplished in twenty-four (24) hours. The field transmission and control units shall be housed in a metal cabinet that can be mounted to a standard thirty foot Strain Gage Pole furnished by the State. The housing slhall be rugged enough to protect the equipment from vandals and environmental conditions to include an ambient temperature range of from minus twenty (-20) degrees Fahrenheit to plus one hundred and sixty (+160) degrees Fahrenheit. The cables shall be terminated at standard AN connectors for ease in disconnection for mobility.

2.3.1 All field equipment at the camera site shall be installed on a pole (standard 30-foot Strain Gage) to be furnished by the Texas Highway Department. Specifications for the pole and its concrete base mount are shown in Figure 1. All equipment mounted to the pole shall be so cabled and fastened as to permit ease of dismantling and remounting for mobility.

2.3.2 The receiving antenna will be installed by the contractor on the roof of the Gulf Freeway Surveillance Project Office at 6333 Gulf Freeway, Houston, Texas.

2.3.3 The receiving monitor, receiver power supply and camera remote console shall be installed in the Control Center of the Gulf Freeway Surveillance Project Office at 6333 Gulf Freeway, Houston, Texas.

2.3.4 The bidder shall furnish the purchaser with two (2) copies of Instructional Manual, suitably bound, which will include schematics, parts list, and operating and maintenance instructions.

2.3.5 The equipment shall be warranted for two (2) years from date of acceptance against any inperfections in workmanship or material.

2.3.6 All items furnished shall be brand new.

2.4 Delivery

Delivery shall be to the Texas Highway Department warehouse as specified on the purchase order.

2.5 Measurement

Measurement of an acceptable Closed Circuit Television System using Microwave Transmission will be made on the basis of its physical appearance and its ability to function as described in this specification and as determined by the Engineer. In any event, the decision of the Engineer will be final and binding.

2.6 Payment

The "Closed Circuit Television System using Microwave Transmission," measured as provided under "Measurement," will be paid for at the unit price bid, which price shall be full compensation for furnishing all materials, installing and connecting all parts including enclosures, breakers, conduit, fittings, conductors, brackets, bolts, hangers, hardware and all manipulation, labor, tools, hauling, equipment and incidentals necessary to complete and provide a Closed Circuit Television System using Microwave Transmission.

APPENDIX C

SPECIFICATIONS FOR
PORTABLE VIDEO TAPE RECORDER

1.0 General

This specification details the requirements of a portable Helical-Scan Video Tape Recorder-Playback Unit to be used for recording of television video signals. The unit shall be portable, completely transistorized except for the kinescope of the built-in monitor, shall utilize 1" tape, and shall include all features herein specified.

2.0 Operational Features

2.1 The Recorder shall include all of the operational features as hereinafter specified.

2.1.1 In addition to the standard speed playback, the unit shall have the capability of providing variable speed slow motion in both forward and reverse directions. The slow motion speed shall be continuously variable over the range of approximately 0 to 12 fields per second.

2.1.2 Stop frame (still pictures) shall be provided. It shall be possible to stop the tape in any position for periods in excess of one hour without damage to either tape or heads for stop motion studies.

2.1.3 For convenient editing purposes, an illuminated tape counter calibrated in minutes and tenths shall be provided.

2.1.4 For further ease of editing, two fast forward and two rewind speeds shall be provided. At the slower of the fast forward and rewind speeds, it shall be possible to view the picture on a standard monitor to permit precise esiting.

2.1.5 The unit shall be supplied complete with built-in transistorized video monitor of not less than 4-1/2" picture diagonal. This monitor shall include pulse-cross capability to permit precise and easy adjustment of tracking and skew without the need for a separate oscilloscope. The video monitor shall be an integral part of and built into the Video Tape Recorder.

2.1.6 The portable Video Tape Recorder shall include a built-in transistorized VHF television tuner to permit recording of R.F. (broadcast or closed circuit) television programs on any standard VHF Channel 2 through 13. The tuner shall provide line level audio output through the recorder (0 db, 600 ohms unbalanced) and composite video (75 ohms unbalanced). The tuner shall be an integral part of and built into the Video Tape Recorder.

2.1.7 The Recorder shall include complete self-contained audio facilities with aural and visual monitoring of the audio channel. Aural monitoring shall be provided for both record and playback modes of operation. Input connectors shall provide for a balanced, 250 ohm low impedance microphone as well as a high impedance, 0 db level unbalanced source.

2.1.8 It shall be possible to record audio separately from video to permit addition of audio at a later date, or to replace the audio without affecting the associated video.

2.1.9 The unit shall include a sensing device to permit automatic pre-programmed tape stops. It shall be necessary only to attach sensing tape to the rear side of the 1" video tape at the proper point to permit automatic tape stoppage.

2.1.10 The Recorder shall include automatic brake operation to stop the machine in event of tape breakage or tape run-out at the end of a reel.

2.1.11 A remote control unit and cable assembly shall be available as an accessory to permit remote control of Record, Play, Stop, Fast, Forward, Rewind, Slow Motion, Still Frame and Power On-Off. A remote/local switch shall be provided as standard on the machine.

2.1.12 A meter shall be provided on the unit, with selector switch to permit monitoring of at least the following: Video Record Level; Audio Record Level; AC Line Voltage, FM Record Channel 1 Level; FM Record Channel 2 Level; Servo; Motor Drive Amplifier.

2.1.13 Indicator Lamps shall be provided to indicate the following minimum modes of operation: Record; Play; Power-On.

3.0 Technical Specifications

3.1 Electrical. The portable Video Tape Recorder shall meet or exceed all of the following electrical specifications:

3.1.1 Video bandwidth shall be at least ± 1.5 db from 10 cps to 3.9 mc.

3.1.2 Video input shall be 0.5 to 1.5 volts p-p (75 ohms unbalanced, internally terminated, composite video, sync negative).

3.1.3 Video output shall be 0.5 to 1.5 volts p-p (75 ohms unbalanced, composite video, sync negative).

3.1.4 Input power shall be maximum 470 watts at 117 volts ± 10%, 50/60 cps, single phase.

3.1.5 The Recorder shall be capable of resolving not less than 280 television lines horizontally and 350 lines vertically.

3.1.6 Video signal-to-noise ratio shall be not less than 38 db on interchanged tapes.

3.1.7 The audio channel shall feature a low impedance microphone input (-55 db, 250 ohms balanced) and a separate line level input (0 to -10 db, 10,000 ohms unbalanced). Audio frequency response shall be not less than ± 2 db 100 cps to 8 kc. Audio signal-to-noise ratio shall be not less than 40 db. Flutter and wow shall be not greater than 0.2% rms.

3.1.8 The Recorder shall utilize 1" video magnetic recording tape and linear tape speed shall not exceed 6 inches per second. Recording time shall be not less than 60 minutes on one 1800 ft. (7" reel) of tape.

3.1.9 The unit shall be fully transistorized except for the built-in Kinescope tube. The electronics shall be contained in enclosed plug-in modules except for record Amplifier, Full Track Erase, Playback Preamplifier and Head Drive Power Amplifier. All module test points shall appear on the face of the modules along with all associated alignment controls. Modules shall be accessible behind a hinged door, requiring no tools for access.

3.1.10 All signal relays shall be of the totally enclosed type for optimum reliability.

4.0 Mechanical Specifications

4.1 The portable Video Tape Recorder shall meet or exceed all of the following mechanical specifications:

4.1.1 The recorder shall utilize video recording tape of 1" width and shall not use more than 6 square inches per second.

4.1.2 Recording time shall be not less than 60 minutes on an 1800 ft. (7" minimum diameter) reel.

4.1.3 Overall weight, including monitor and tuner, shall not exceed 150 lbs.

4.1.4 Overall size shall not exceed 26" wide, 13" high, and 16" deep.

4.1.5 A hinged, transparent, heavy gauge plastic cover shall be provided covering the entire transport mechanism to protect tape and heads from dust and/or other foreign particles.

4.1.6 A heavy gauge cloth impregnated plastic cover shall be provided to cover the entire unit during transport or when not in use.

4.1.7 A built-in retractable carrying handle shall be provided on each end of the machine.

4.1.8 Video recording heads shall be guaranteed for a minimum of 2500 hours, or one year, whichever shall occur first. Heads shall be field replaceable.

4.1.9 The unit shall be capable of operation over the minimum temperature range of 0 to 40°C.

4.1.10 Side and front panels shall be easily removable for servicing by means of not more than two 1/4 turn screws on each panel.

5.0 General

5.1 The unit shall be supplied complete with operation and maintenance manual covering proper set-up, operation and maintenance of the machine.

5.2 The Recorder shall be supplied complete with one mating connector for each input/output connector on the unit.

5.3 The manufacturer and/or supplier of the equipment shall maintain complete spare parts or repair service on the unit and advise the purchaser in the bid of locations where such parts and service are available.

APPENDIX D

SPECIFICATIONS FOR
PORTABLE VIDEO TAPE RECORDER

1.0 General

This specification details the requirements of a portable Helical-Scan Video Tape Recorder-Playback Unit to be used for recording of television video signals. The unit shall be portable, completely transistorized, and shall utilize one-half inch tape, and shall include all features herein specified.

2.0 Operational Features

2.1 The Recorder shall include all of the operational features as hereinafter specified.

2.1.1 In addition to the standard speed playback, the unit shall have the capability of providing variable speed slow motion in both forward and reverse directions. The slow motion speed shall be fixed within a range of approximately 0 to 12 fields per second.

2.1.2 Stop frame (still pictures) shall be provided. It shall be possible to stop the tape in any position for periods in excess of one hour without damage to either tape or heads for stop motion studies.

2.1.3 For convenient editing purposes, an illuminated tape counter calibrated in revolutions of the supply reel shall be provided.

2.1.4 For further ease of editing, one fast forward and one rewind speeds shall be provided.

2.1.5 The unit shall use a standard video monitor to permit precise and easy adjustment of tracking and skew.

2.1.6 The portable Video Tape Recorder shall be capable of recording R.F. (broadcast or closed circuit) television programs on any standard VHF Channel 2 through 13 when connected to a VHF television tuner that provides line level audio output through the recorder (0 db, 600 ohms unbalanced) and composite video (75 ohms unbalanced).

2.1.7 The Recorder shall include complete self-contained audio facilities with aural monitoring of the audio channel. Aural monitoring shall be provided for both record and playback modes of operation. Connectors shall provide for a balanced, 600 ohm low impedance microphone.

2.1.8 It shall be possible to record audio separately from video to permit addition of audio at a later date, or to replace the audio without affecting the associated video.

0 Technical Specifications

3.1 Electrical. The portable Video Tape Recorder shall meet or exceed all of the following electrical specifications:

3.1.1 Video bandwith shall be at least 3.0 MHz.

3.1.2 Video input shall be 0.5 to 1.5 volts p-p (75 ohms unbalanced, composite video, sync negative).

3.1.3 Video output shall be 0.5 to 1.5 volts p-p (75 ohms unbalanced, composite video, sync negative).

3.1.4 Input power shall be maximum 470 watts at 117 volts ± 10%, 50/60 cps, single phase.

3.1.5 The Recorder shall be capable of resolving not less than 200 television lines horizontally.

3.1.6 Video signal-to-noise ratio shall be not less than 40 db.

3.1.7 The audio channel shall feature a low impedance microphone input (-60 db, 600 ohms balanced). Audio frequency response shall not be less than 80 to 10,000 Hz. Audio signal-to-noise ratio shall be not less than 40 db.

3.1.8 The Recorder shall utilize one-half inch video magnetic recording tape and linear tape speed shall not exceed 7½ inches per second. Recording time shall be not less than 60 minutes on one 2370 feet. (7" reel) of tape.

4.0 Mechanical Specifications

4.1 The portable Video Tape Recorder shall meet or exceed all of the following mechanical specifications:

4.1.1 The Recorder shall utilize video recording tape of one-half inch width and shall not use more than 3.75 square inches per second.

4.1.2 Recording time shall be not less than 60 minutes on a 2370 feet (7" minimum diameter) reel.

4.1.3 Overall weight shall not exceed 75 lbs.

4.1.4 Overall size shall not exceed 20" wide, 12" high, and 18" deep.

4.1.5 A transparent, heavy gauge plastic cover shall be provided covering the entire transport mechanism to protect tape and heads from dust and/or other foreign particles.

4.1.6 A heavy gauge cloth impregnated plastic cover shall be provided to cover the entire unit during transport or when not in use.

4.1.7 A carrying handle shall be provided on one end of the machine.

4.1.8 The Recorder may use a Rotary 2 or Rotary 4 head helical scanning system.

4.1.9 The unit shall be capable of operation over the minimum temperature range of 0 to 40°C.

5.0 General

5.1 The unit shall be supplied complete with operation and maintenance manual covering proper set-up, operation and maintenance of the machine.

5.2 The Recorder shall be supplied complete with one mating connector for each input/output connector on the unit.

5.3 The manufacturer and/or supplier of the equipment shall maintain complete spare parts or repair service on the unit and advise the purchaser in the bid of locations where such parts and service are available.

APPENDIX E

LIST OF CCTV SYSTEMS FOR TRAFFIC SURVEILLANCE

1. Gulf Freeway - Houston
2. Central Expressway - Dallas
3. Baytown-La Porte Tunnel - Texas
4. Lodge Freeway - Detroit
5. Interstate Highway 5 - Seattle
6. City Street System - Tokyo
7. Station WNYC - Police Department - New York City
8. Tunnel System - Port New York Authority - New York City
9. Freeway Surveillance Office - Chicago (Slow Scan)
10. Oakland - Bay Bridge - California