CHAPTER 6
CONCEPTUAL SYSTEM DESIGN

The conceptual system design is viewed as an extension of the logical design of the system defined by the requirements in Chapter 5 of this report. While the logical design is technology independent, this conceptual system design considers the technologies (based on today's knowledge) that are relevant for accomplishing the system functional requirements. The conceptual system design described in this chapter focuses primarily at the field equipment level and the operations center level. The intent of this chapter is to provide an understanding of what type of surveillance equipment is needed to meet the functional requirements of the system. Additionally, this chapter discusses the conceptual design considerations (e.g., sensor spacing) for developing a preliminary system cost estimate detailed in Chapter 7. It should be noted that the information discussed herein is not intended to serve as specific recommendations, but rather provide the concept of what the surveillance system design would include in order to meet the Coalition's goals and objectives as stated in Chapter 2.

The presentation of the conceptual design of the Corridor-wide Surveillance System is organized into five sections. Section 6.1 provides the major considerations and assumptions for the conceptual design. Section 6.2 describes the surveillance design concept for the urban transportation system, while that of the rural transportation system is presented in Section 6.3. Based on these concepts, a detailed communications design concept is discussed in Section 6.4. Finally, Section 6.5 provides a summary of some improvements needed for the existing surveillance system to evolve into the envisioned system.

6.1 DESIGN CONSIDERATIONS AND ASSUMPTIONS

6.1.1 Surveillance Applications

Traffic incidents are a major contributor to congestion along the Corridor's highway system. Vehicle breakdowns along the roadway are often as troublesome as an accident. The blockage of lanes or the mere presence of a stalled vehicle can cause significant traffic delays. It is, therefore, important that the surveillance system provide adequate accident and incident information to effectively support traffic incident management. In fact, this functional goal of the surveillance system was rated as the highest priority by the Coalition member agencies in the goals and objectives survey detailed in Chapter 2.

As the freeway system becomes more and more congested, the possible use of parallel arterial streets to handle a portion of the traffic demand in the freeway corridor, at least during periods of incident management, becomes of increasing interest. However, many of these arterial streets have limited capacity to provide this type of relief because of their physical design features (e.g., geometric) or their inability to effectively control a large influx of traffic demand. If the arterial streets are to be used as alternate routes during incident management periods, more advanced traffic control systems must be used and adequate surveillance information provided.

The application of vehicle location and tracking in surveillance is another consideration. The probe data gathered from such a system is an additional source of surveillance data. The rationale is that an efficient surveillance system should have the ability to utilize existing resources to the maximum extent possible. Since vehicle location and tracking technologies are usually employed by public and private fleet operators, the conceptual design focuses on the information exchange aspect of the system.

Other surveillance applications considered include the collection of traffic and environmental data to support TIS, TDM, snow removal operations, and transportation facility planning.

6.1.2 Road Geographic Location

Since the Corridor's roadway network covers both urban and rural areas, the characteristics of these operational environments must be considered in the conceptual system design. To provide a basis for urban and rural roadway classification, the criteria defined by AASHTO (1990) were used. The roadway classifications adopted for this conceptual design are as follows.

The freeway is a divided roadway with a minimum of two lanes in each direction. The median between the opposing traffic flows has either a barrier or a clear area of approximately 150 feet or more. Each traffic direction has a paved shoulder on the right side of 10 feet or more, and a paved shoulder on the left of 4 to 8 feet. The right side of the roadway is a vehicle recovery area and must be kept clear of obstructions such as cabinets, although some States permit cabinets in this area if they are of break-away construction. All access to and from the freeway is controlled and only permitted at designated interchanges. The frequency of overpasses and ramps is controlled, and they are generally several miles apart.

The urban freeway follows most of the requirements for a freeway, but some elements may have been restricted or reduced because of physical constraints imposed by the surrounding land use. Urban freeways may be depressed or elevated, and both conditions can impose serious restrictions on shoulder and median widths. The access to and from the freeway is restricted to interchanges, but the number and frequency of interchanges may be considerably greater than those of the rural freeway, as close as one or two miles in roadside developed areas. Traffic volumes on the urban freeway are also generally higher for longer periods of the day than those experienced on the rural freeway.

The rural freeway follows all of the requirements of the freeway as previously described with some additions. The median area is generally grass of at least 150 feet, and the spacing of the interchanges is usually five miles or more. Although traffic flow problems do occur on rural freeways, the average traffic flow during off peak travel periods is generally lower than that on urban freeways. Electric power and communications facilities are generally available only at interchanges along rural freeways.

Both rural and urban areas occasionally have parallel arterials that can act as collector roadways and are, therefore, useful as alternate routes for sections of the freeway. In rural areas, the parallel arterials would probably have been built as collector roadways: whereas, in urban areas the parallel arterials are generally existing surface streets that either still function as urban streets or were redesigned to function as collector roadways. In both areas, there will be arterials that are not directly parallel to the freeways but may be used during freeway incident management.

6.1.3 Surveillance Technologies

Based on the detailed assessment of various surveillance technologies performed in Task 3 of this Project and documented in Chapter 4 of this report, the following sensor categories were selected for the conceptual system design.

- Vehicle Detectors.

+ Vehicle Probe.
+ CCTV Surveillance.
+ Aerial Surveillance.
+ Human Surveillance.
+ Weigh-in-Motion.
+ Environmental Sensors,

Within each category, there are various candidate products that can be used depending upon the specific needs and constraints of each local jurisdiction. Since ITS surveillance technology is a very fast-growing area, changes and additions in technologies can significantly influence the conceptual system design. Thus, the system design concepts presented below only represent the state of technology at the present time. Dynamic changes in surveillance technology and other ITS technologies should be monitored carefully and incorporated into the physical system design and implementation in the future.

6.2 URBAN SURVEILLANCE DESIGN CONCEPT

The primary focus of the surveillance concept in the Corridor's urban areas is to acquire data for traffic incident management, TDM, intermodal transportation, traveler advisory information, and transportation facility planning. The concept is based on a number of existing and emerging technologies, as shown in Figure 6-1. The theme for the conceptual system design is to collect and fuse traffic surveillance information from multiple sources to maximize system effectiveness and efficiency, as described by the following paragraphs.

To effectively collect data for traffic incident detection and management, additional point detection systems should be installed to fill in the existing surveillance coverage gaps. Overhead or roadside-mounted radar detectors were selected for the conceptual design because of their high ranking in the performance-versus-cost assessment. In addition, other emerging, viable technologies, such as ultrasonic and infrared, may be used alternately because of their similar communication interface requirements. It is assumed that new sensor installations will be integrated with existing roadway inductive loop detectors to provide automated incident detection capability at the local operations level.

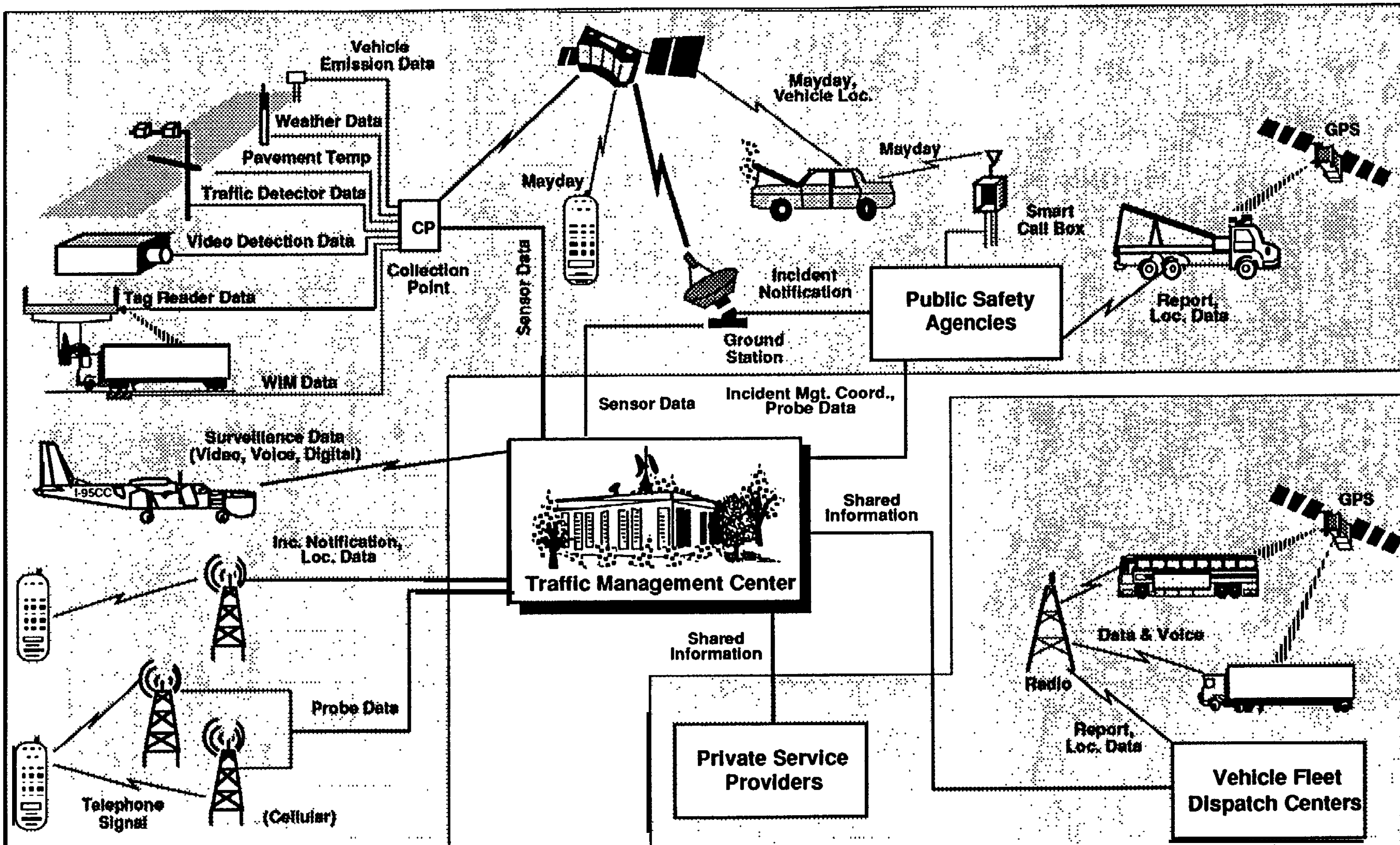


Figure 6-1 Conceptual System Design for Urban Areas

Stand-alone incident detection systems, such as the emerging WDS, should be installed at locations with a high potential for traffic accidents. Remote incident verification is performed primarily by CCTVs in this design concept. However, to enhance the ability to quickly verify (and possibly detect) incidents, the use of a multi-sensor surveillance aircraft is incorporated. This aircraft should be equipped with a long-range (20 to 30 nautical miles) air-to-ground radar and Forward-Looking Infrared (FLIR) sensors, and should have the capability to maintain an area-wide traffic situational awareness while focusing on acquiring detailed data of an incident. An ability to cue the FLIR based on the radar detection information is essential to this envisioned capability. The aircraft should also have the capability to communicate with multiple traffic operations centers and public safety vehicles on the ground, as well as other aerial surveillance assets in the surveillance area. Although adverse weather conditions may affect the mission availability of an aircraft, its ability to detect potential incidents and quickly verify the detection within a large range is appealing. An analysis is needed to assess the life-cycle costs and benefits of this concept.

Human surveillance continues to play a major role in incident detection. The design concept calls for the ability to receive cellular telephone calls from motorists, and incident notifications from public safety personnel (e.g., police and freeway service patrol vehicle drivers), public transit system operators, and commercial fleet operators. It is important to note that traffic incident management functions are allocated to Public Safety agencies (i.e., police, fire, and EMS) and are shown separately in Figure 6-1. In actual implementation, these functions may be housed in the same facilities as that of the TMC. Incident notifications may also be generated by an automated or semi-automated in-vehicle Mayday system. This type of technology has been mentioned in the literature and is expected to be available within the planning horizon of the Corridor-wide surveillance system. This design concept assumes that the Mayday signal would be received by "Smart Call Boxes" installed along the Corridor's urban freeways.

A final source of surveillance information in this conceptual design is vehicle probe data. These sources include vehicle tracking data acquired by public fleet operators (e.g., transit, service patrol, and police vehicles) and commercial fleet operators. Vehicle tracking data may also be acquired through the monitoring of cellular telephone signals (as currently being investigated in the Washington Metropolitan Area) and the use of electronic license plate readers. In addition to these sources, vehicle tracking data may also be obtained through the use of Electronic Toll and Traffic Management (ETTM) technologies. Several major programs are underway throughout the Corridor, with the largest of these being the EZ-Pass Project. EZ-Pass consists of seven transportation authorities in the New York metropolitan area, New Jersey, and Pennsylvania. The use of ETTM technology also provides opportunities for collecting probe data beyond the toll roadways, given that standards are established for this technobgy throughout the Corridor.

One of the concern in collecting probe data using on-board vehicle transponders is the number of transponder-equipped vehicles in the operating area, especially areas that do not have toll facilities. This concern should be examined to appropriately select the type of technology for probe data collection, including toll tag reader, commercial vehicle electronic data interchange equipment, cellular telephone, and vehicle's license plate reader. For example, electronic toll tag reader may be appropriate if a sufficient number of vehicles using the roadway are equipped with "standardized" toll tags (even if many of these vehicles may be from other states). Another concern is the issues related to organizational and personal privacy. These issues are being studied at the national level and expected to be resolved before such probe data collection concepts are implemented.

Tracking transit vehicles will not only provide probe data to the surveillance system, but will supply information for intermodal coordination (transit-to-transit and transit-to-automobile). This conceptual design accounts for the information exchange needed to enhance intermodal operations.

In addition to acquiring traffic surveillance data, the acquisition of pavement conditions, weather, and environmental data is incorporated into the design concept.

In the following paragraphs, a more detailed discussion of the implementation concept for urban freeways and arterial streets is provided.

6.2.1 Urban Freeways

The surveillance implementation concept for urban freeways addresses various considerations for mounting and spacing sensor devices. Assumptions for device spacing are required to develop the cost estimate, as discussed in Chapter 7. This section also briefly addresses the relevant communication aspects of the conceptual design.

For sensor mounting, depressed highway sections will usually have more over-the-roadway structures, providing more mount locations for traffic flow sensors. CCTV surveillance installation may be more difficult to locate on depressed roadways. Elevated highway sections usually have a minimum number of over-the-roadway structures; therefore, additional structures will be required for mounting overhead sensors. If additional structures are not preferred, side-mounted traffic detectors could be mounted on elevated roadways to avoid the need for over-the-roadway structures. Full use should be made of existing structures to minimize implementation costs.

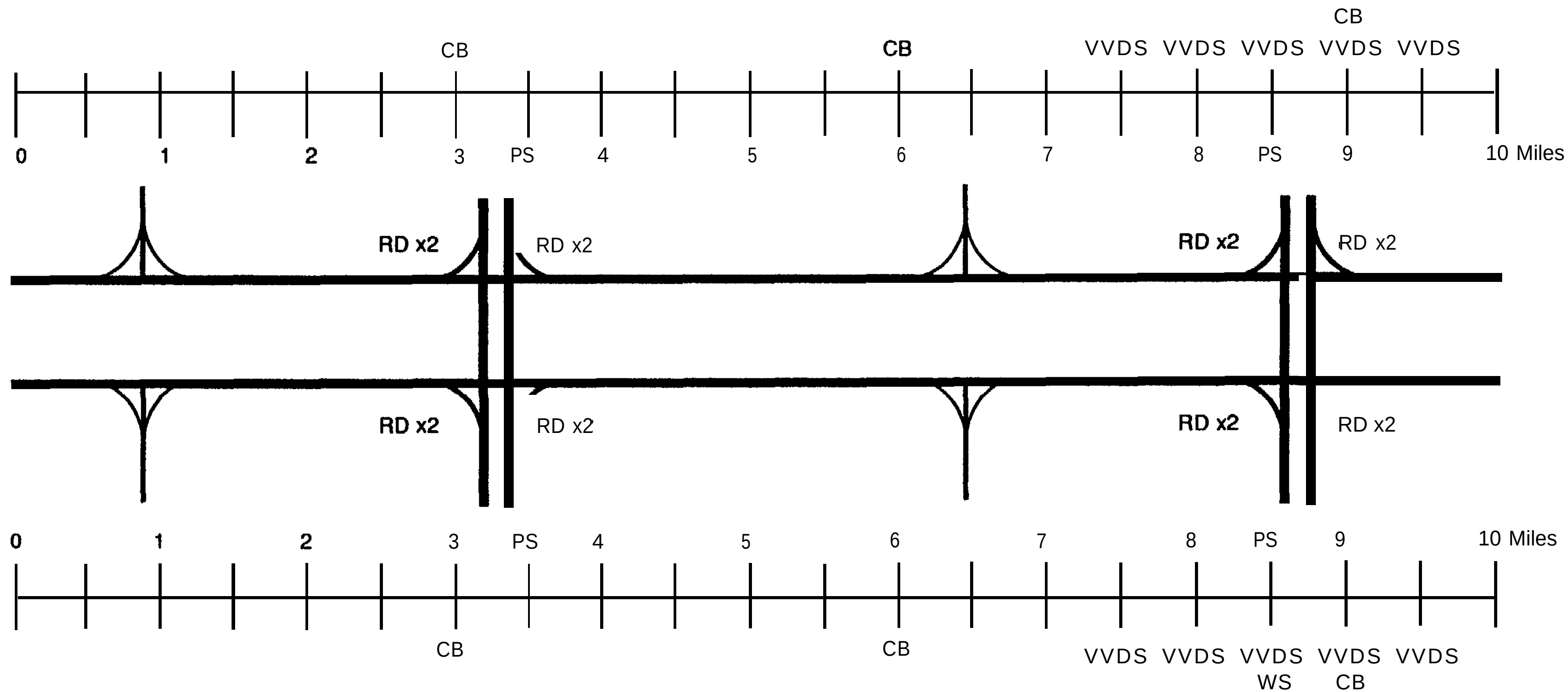
The assumed sensor spacing for this conceptual design in urban areas is summarized in Table 6-1. The rationale for these assumptions is described in the following paragraphs.

Table 6-1. Typical Placement of Surveillance Devices Along Urban Freeways

Types of Surveillance	Placement and/or Use
Traffic Sensor (Overhead Mount)	1/2 mile nominal; 3/4 mile maximum; and major ramps
Traffic Sensor (Side Mount)	Minor ramps
AVI	3 to 5 mile nominal; 5 miles maximum: and major ramps
VVDS	1 mile nominal: 2 miles maximum; and upstream of major ramps
Pavement Condition	As needed on bridges
Fog/Environmental	As required or needed
WIM	10 miles nominal; 20 miles maximum
CCTV	2 to 3 miles nominal
Aerial	Incident management
Human	Incident detection using cellular phone

6.2.2 Urban Freeways – Baseline

Figure 6-2 presents the baseline surveillance equipment layout for a typical urban section. For the design of a typical I-95 Corridor urban surveillance section, an urban section of a local freeway in New Jersey was used to determine the average number of major interchanges, on and off ramps, and overpass bridges. Although the exact locations of those items must be specified for the actual implementation of a surveillance system, the conceptual system design contains only typical sensor spacings for illustration and preliminary, Corridor-wide cost estimation purposes. The equipment spacings used in this report, therefore, should not be taken as recommendations at this time because they can vary significantly depending on the level of system implementation and the desired system functionalities by each Coalition member agency.



PS - Pavement Sensor
RD - Radar Detector
WS -Weather Station
WIM -Weigh-In-Motion

VVDS - Video Vehicle Detection System
CCTV - Closed Circuit Television
AVI - Automated Vehicle Identification
CB - Call Box

Figure 6-2. Typical Urban Freeway Section – Baseline Approach

The conceptual surveillance system is designed primarily for incident detection using radar sensors located at every half mile on each side of the roadway. Every two miles, a VVDS is assumed to be installed instead of a radar detector (every fourth sensor unit is a VVDS). VVDS installations enhance the radar detection system by providing a partial video image. For more complete video coverage, CCTV cameras may be used at major interchanges in a typical section. This design will provide roadway video coverage for a major section of the affected roadway.

Three AVI systems are placed between major interchanges. The intention is to put AVI and WDS in the same locations so that the video signal from VVDS can be used for multiple purposes, such as vehicle detection or toll enforcement.

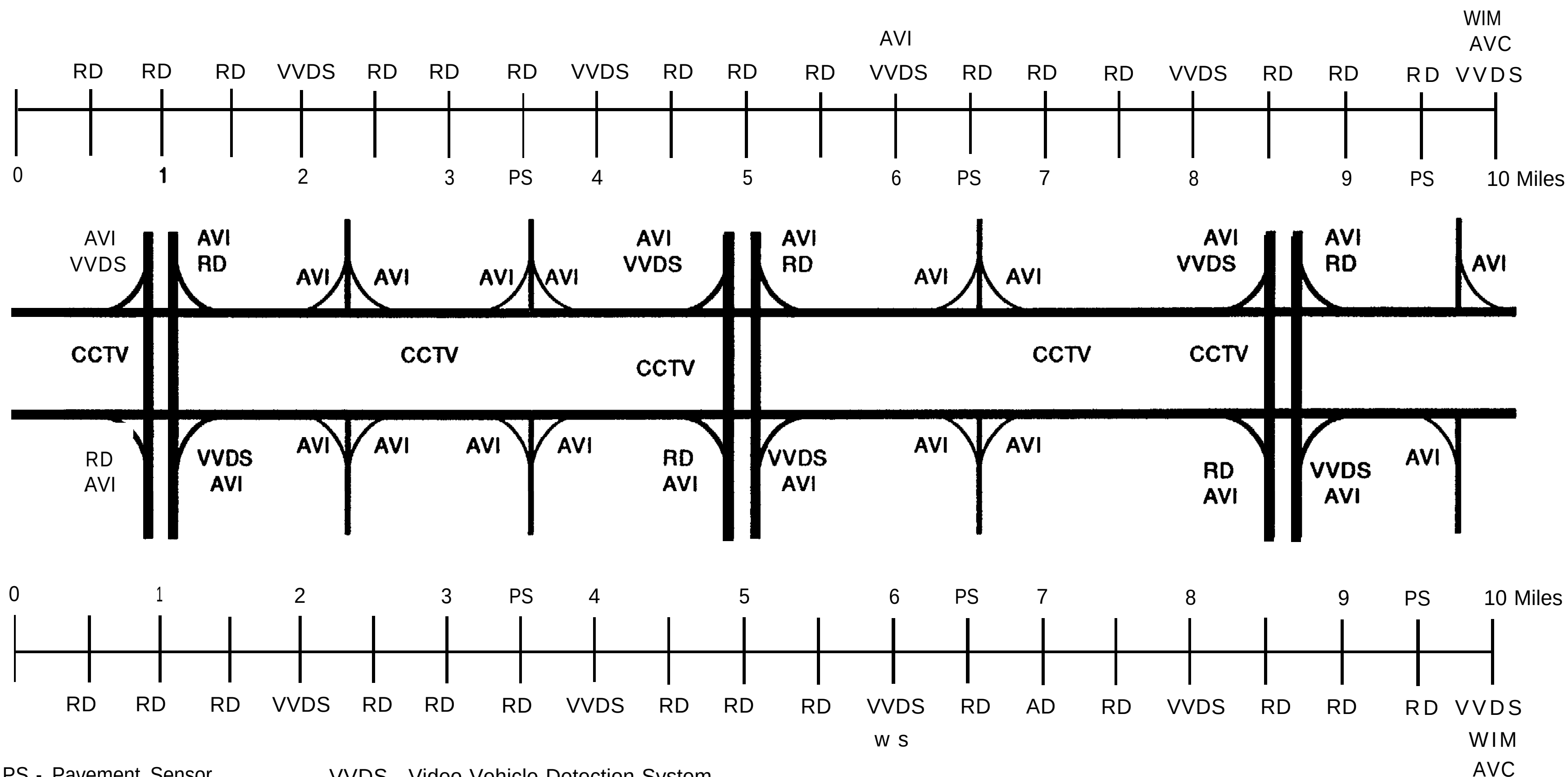
Radar detectors are placed at off-ramps of major interchanges. It is assumed that a typical section will have six major off-ramps for both directions, therefore, six radar detectors will be necessary. It is also assumed that there will be the same number of major off- and on-ramps. Although the installation cost for on-ramp surveillance favors loop detectors, maintenance cost and availability of a video signal makes the installation of VVDS attractive for on-ramp surveillance. Another advantage of VVDS is that with proper placing of VVDS, in many cases, one camera will be able to cover the main roadway and an on-ramp. By utilizing this option, one radar detector could be eliminated for each location.

Each typical section will have one full weather station. In addition, six pavement sensors at three locations (two sensors per location, one for each traveling direction) will provide the necessary pavement condition data.

It is assumed that WIM sensors will be placed every twenty miles in all traveled lanes. It is also assumed that WIM will be located with the AVI designated for toll collection and the VVDS designated for vehicle detection. This way, significant savings could be achieved by utilizing AVI and VVDS capabilities to enhance WIM.

6.2.3 Urban Freeways – Comprehensive Approach

Figure 6-3 shows the recommended equipment layout for a typical surveillance section with a comprehensive approach. This approach includes a few changes in surveillance installations when compared to the baseline. One of those changes is that the AVI system would cover each



PS - Pavement Sensor
RD - Radar Detector
WS - Weather Station
WIM - Weigh-In-Motion

VVDS - Video Vehicle Detection System
CCTV - Closed Circuit Television
AVI - Automated Vehicle Identification
AVC - Automated Vehicle Classification

Figure 6-3. Typical Urban Freeway Section – Comprehensive Approach

ramp, instead of the three locations on the main line in the baseline. This full AVI system will generate significantly more information for traffic management, such as origin-destination data. The second change includes WIM installations every ten miles. WIM installations will cover all traveling lanes in both directions and will be accompanied by Automatic Vehicle Classification (AVC). The third change will increase the number of CCTV installations from three to five. In most instances, five CCTVs would be sufficient, together with VVDS to provide total video coverage. CCTV cameras should be strategically positioned between two VVDS locations so that the farthest area covered by CCTV would be overlapped by WDS. Therefore, the conceptual design places one CCTV camera between two adjacent WDS locations two miles apart.

6.2.4 Urban Arterials

Typical urban arterial streets of special interest are the collector streets because these streets usually parallel the freeway. It is assumed that the I-95 Corridor traffic surveillance and control system would use the collector street network to bypass incidents on the freeway. It should also be noted that detector mounting should make full use of existing structures to minimize implementation costs.

It is reasonable to assume that the Real-Time, Traffic Adaptive Control System (RT-TRACS) being developed for the FHWA will be implemented along the Corridor's major arterial streets. This system usually requires queue length information and signal priority request information to optimize the signal timing and phasing. Therefore, VVDS-type technology, in combination with signal priority receivers, are needed at intersection approaches and at some mid-block locations.

The conceptual design for urban arterials also assumes that pavement and weather condition sensors will be installed at known or suspected problem areas, such as ramps between the arterial street and the freeway.

6.3 RURAL SURVEILLANCE DESIGN CONCEPT

Because of the lack of and the high cost to install an adequate surveillance communication infrastructure in the rural areas, the focus of the design concept is to rely on aerial surveillance, human surveillance, and in-vehicle Mayday notification capability for incident detection, The differences between the rural and urban design concepts (refer to Figure 6-4) area as follows:

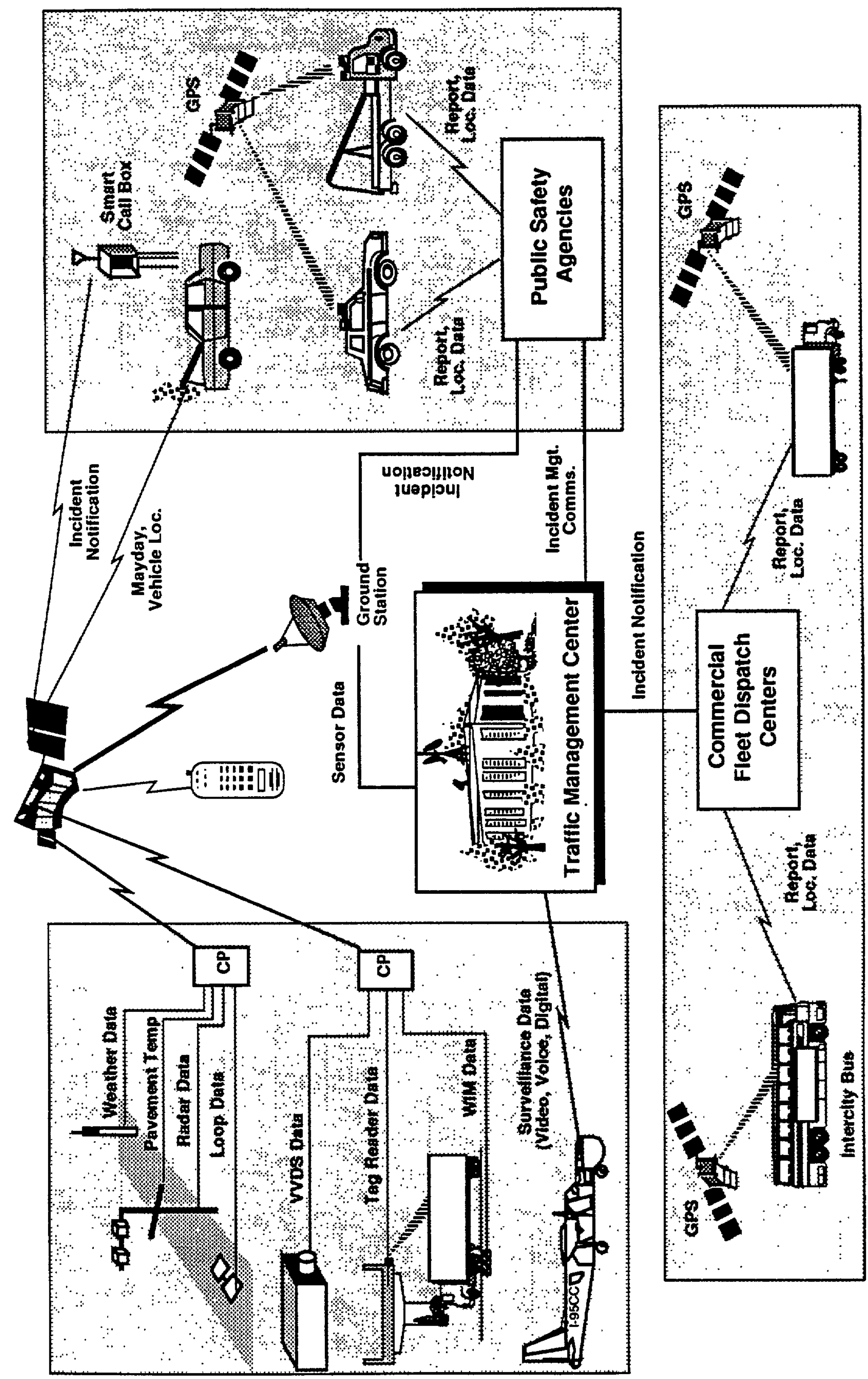


Figure 6-4 Conceptual System Design for Rural Areas

+ A satellite communication link is possible for connecting the field equipment with the land-line communication network leading to the TMC or public safety agencies. This link would be useful because of the lack and potential cost of land lines in rural areas. Cellular communication may be a viable candidate but its availability in rural areas in not clear at this time. Satellite communication services in rural areas are expected to be available in the near future.

+ The use of traffic detectors for automated incident detection is limited to sections of the roadway with high accident potential. Autonomous incident detection systems such as WDS are also recommended for such areas.

+ The role of the multi-sensor aircraft in the rural environment is more significant to provide surveillance coverage.

+ Vehicle tracking data may not be available because of the low vehicle location update frequency for long-distance trips. However, one can argue that because of the significant commercial traffic volume in the rural area, the collection of probe data may still be viable. Although the commercial vehicle volume may be high, these vehicles would probably be tracked by different organizations, making the fusion of the tracking data much more difficult, if not impossible.

+ The use of CCTV camera for incident verification is not considered viable because of the high communication costs.

6.3.1 Rural Freeways

A rural freeway surveillance section is presented in Figure 6-5. The placement of sensors for rural applications, are similar to those of the urban freeways and arterial streets. For the rural section, the same principles apply as for the urban section to determine the number of major interchanges. After studying rural sections of local freeways, it was found that an average lo-mile section has two major interchanges. The design assumption is that one interchange has a high incident potential. This interchange should be covered by VVDS-based surveillance with a total of five stations, two of which should be upstream, one at, and two downstream of the interchange. For the conceptual design, detector stations are placed be one-half mile apart.

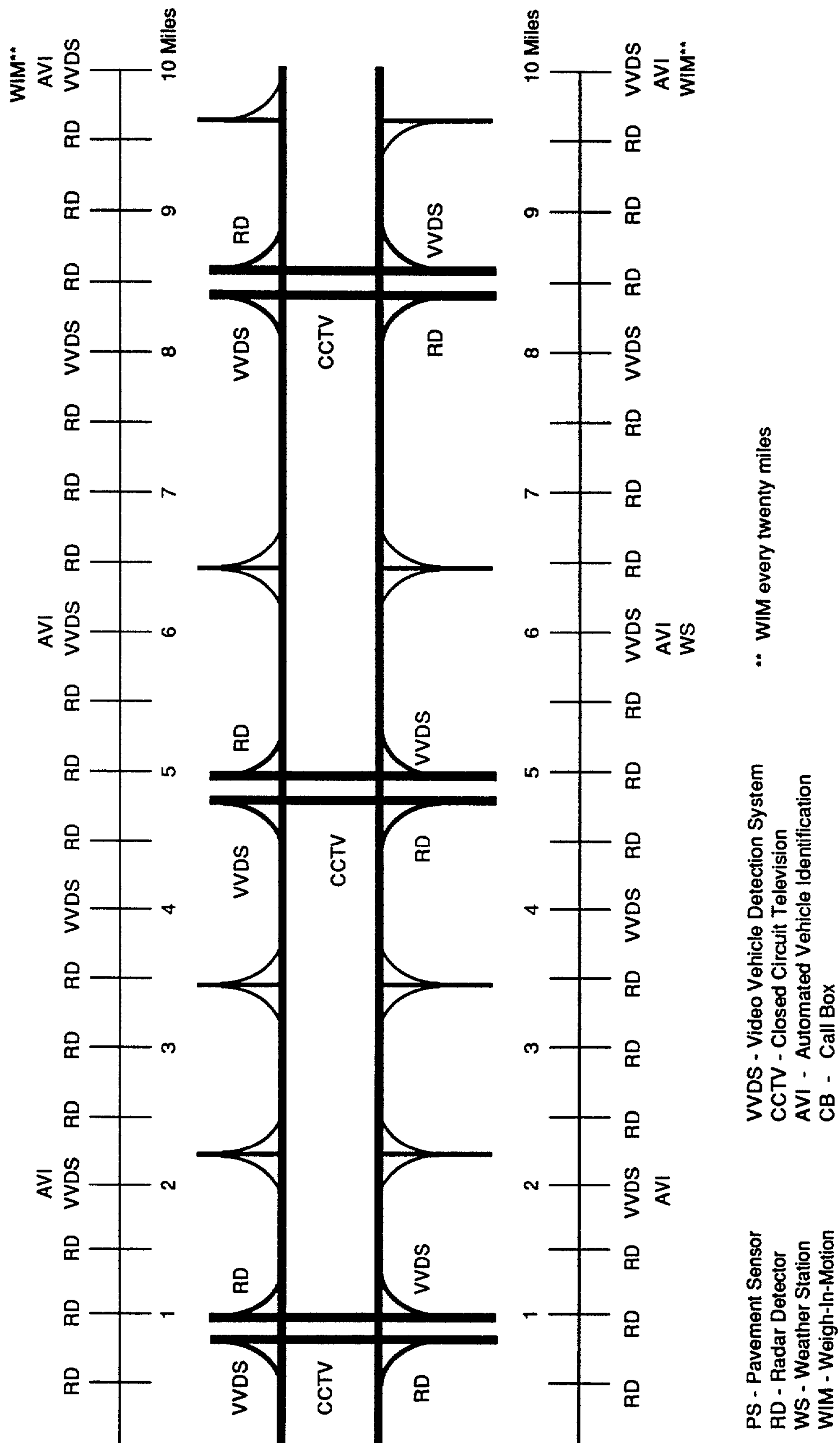


Figure 6-5. Typical Rural Freeway Section

It is assumed that both major interchange ramps will be covered by radar detectors. In rural areas, land availability is not as much of a concern as it is in urban areas, and traffic volumes are not as high. Therefore, it is assumed that major interchanges are full-cloverleaf interchanges with a total of eight on- and off-ramps. Therefore, each major interchange would require eight radar detectors. In addition, major interchanges (within the typical section) with expected lower incident probability, would need one radar detection station upstream, and one downstream.

Two road pavement sensors will be located in the proximity of the major interchanges, together with one full weather station. It is assumed that the weather station will be located such that it will minimize communication cost. To reduce system cost, a WIM installation is located in the proximity of major interchanges. Call boxes will be installed on both sides of the freeway at 3-mile intervals.

6.3.2 Rural Arterials

Since most of the surveillance requirements for rural arterials are related to intersection operation, the rural arterial conceptual design is based on principles the same as for urban arterials. The major difference is that some rural intersections should use radar detectors instead of VVDS. In addition, rural arterials should have call boxes installed every 3 miles.

6.4 COMMUNICATION CONCEPTUAL DESIGN

This conceptual design for surveillance communications focuses on the links that connect the surveillance equipment to the local TMC. Communication for the local TMC to other local TMCs, to the regional TMC, and to Corridor-level information centers is handled by the Information Exchange Network Project, and therefore, is not addressed here. The communications conceptual design covers the communication network both external to and within the local TMC as described in the following paragraphs.

6.4.1 External TMC Communication Network

Connected to the local TMC via land-based trunk line is a distributed network of controllers and sensors/detectors (see Figure 6-6). Although coaxial cable will suffice for meeting the communication needs, it would be more cost effective to switch to fiber-optics if new land lines are to be installed. This is particularly true if leased lines are used as data trunk lines; because by utilizing a faster medium, the leased line will be engaged for a shorter time, reducing the cost.

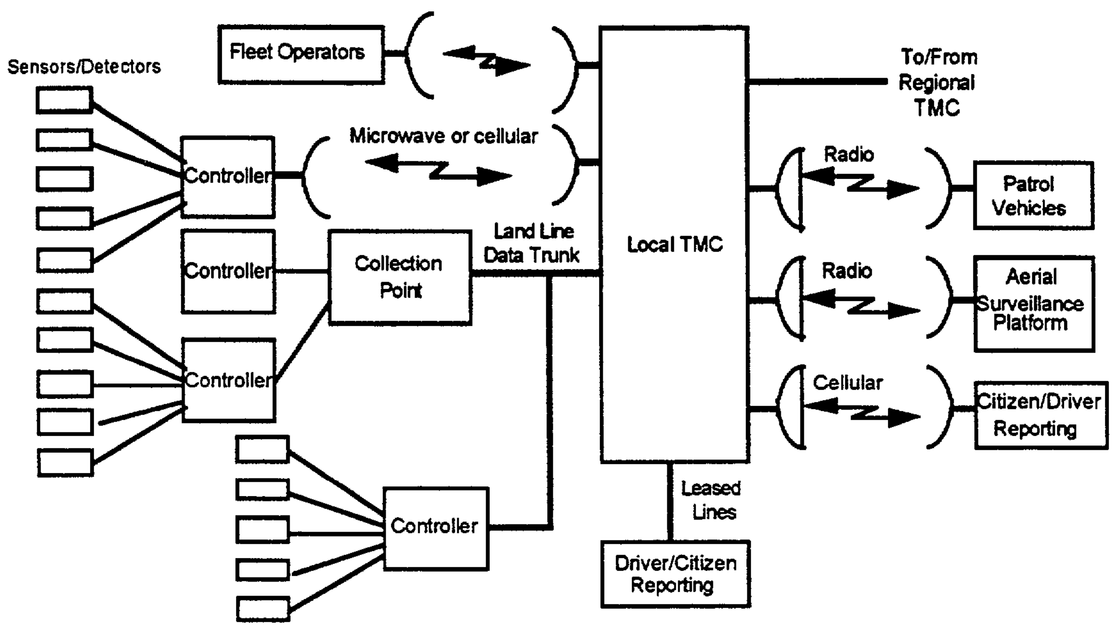


Figure 6-6. External TMC Surveillance Communication Network

Provisions have also been made to receive surveillance data via radio and cellular telephone (where available). These wireless media are necessary to support surveillance equipment located in rural areas where land lines are not available or too expensive to be installed. Wireless communications are also needed to connect the local TMC with mobile surveillance assets, such as patrol vehicles or aerial surveillance platforms (aircraft or balloon).

The above conceptual communication network was tailored to meet urban and rural conditions of the Corridor. For the urban conditions, a conceptual communication design using an assumed worst case of a 10-lane freeway was developed as shown in Figure 6-7. In this situation, it is more practical and cost effective to use land lines for both trunk and interconnections between field equipment. The media used must have the capability of transmitting up to 350 MHz (i.e., coaxial cable or fiber optics) for the broadband field network. If more communication nodes are desired on a single broadband network, four DS1 data links can be time-division multiplexed onto a DS2 (T2) compatible link. However, if more video information is required, either multiple coaxial cables or a fiber-optic cable will be required (since the bandwidth is greater than 350 MHz).

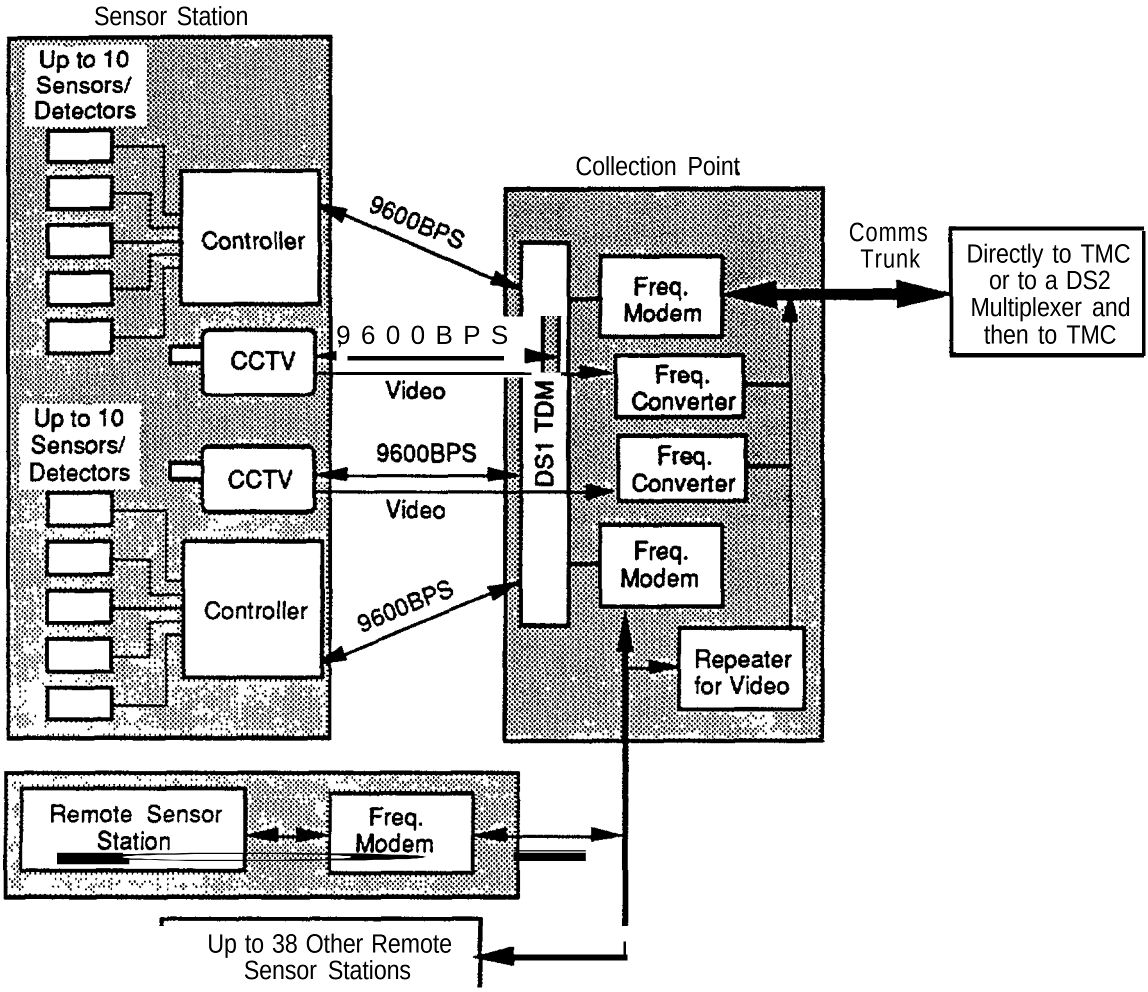


Figure 6-7. Conceptual Design for an Urban Surveillance Communication Network

For rural areas where land lines are not practical, or where there is a long distance between the local TMC and its communication nodes, the conceptual design shown in Figure 6-6 is more appropriate.

Here the communication links between the communication nodes and the local TMC use a combination of wireless services (such as cellular phone or radio) from a collection point to a satellite service (such as a cellular phone link) or microwave relay link.For short line of sight distances (within one mile) a collection point can poll other communication nodes using a radio link which may be daisy chained to a more remote controller by way of a repeater radio link. With this technique, a rural field network can be established using wireless communication. Of course, if practical, it is preferable to use land lines as much as possible to improve reliability. These radio

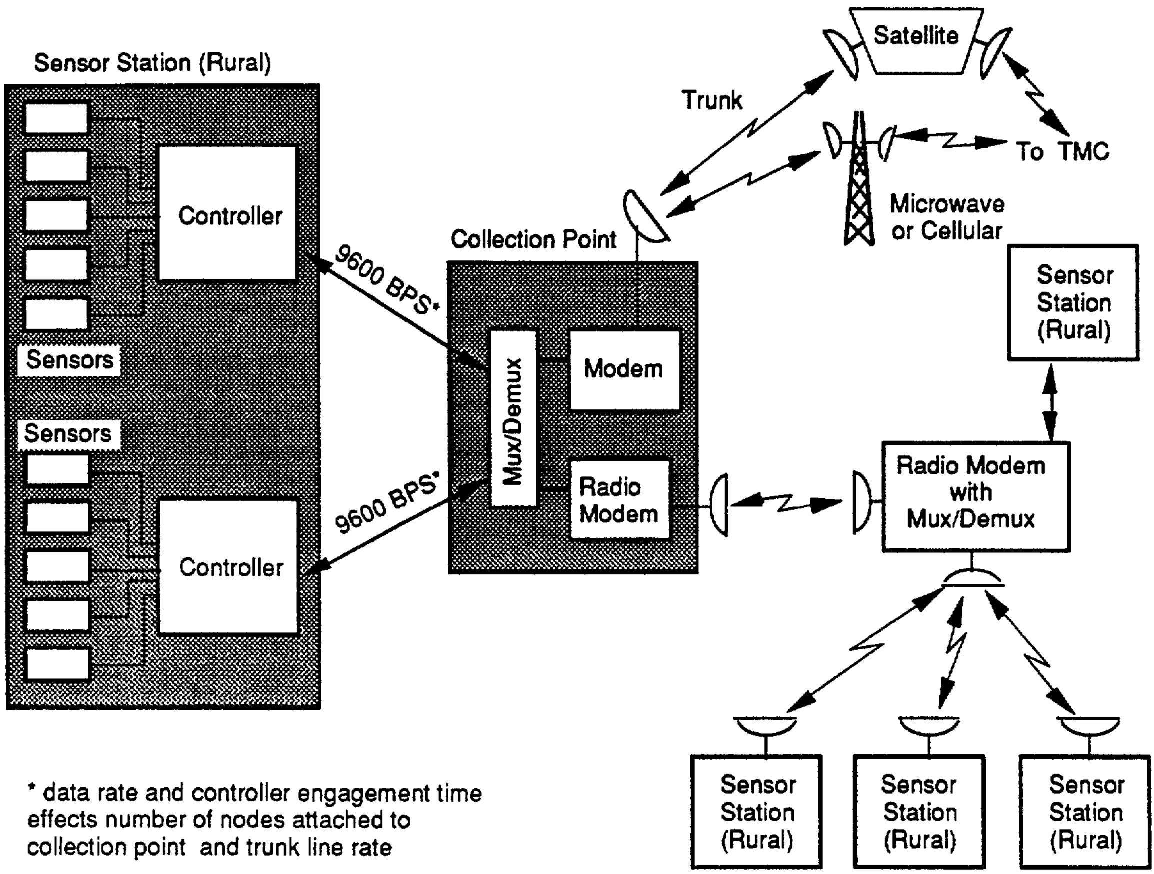


Figure 6-8. Conceptual Design for a Rural Surveillance Communication Network

links may use the 902 to 928 MHz spectrum (which sometimes can be unreliable). The data can enter the local TMC directly or through leased lines. Video links can be installed for rural surveillance by superimposing the video information on a RF carrier, and broadcasting the resulting signal using a wireless radio to a satellite or microwave relay point. Again, the information can be sent to the local TMC by way of direct link or through leased lines.

6.4.2 Internal TMC Communication Network

To accommodate the various communication media and data formats of the external TMC network, the communication network within the TMC must have the proper interfaces and communication links (see Figure 6-9).

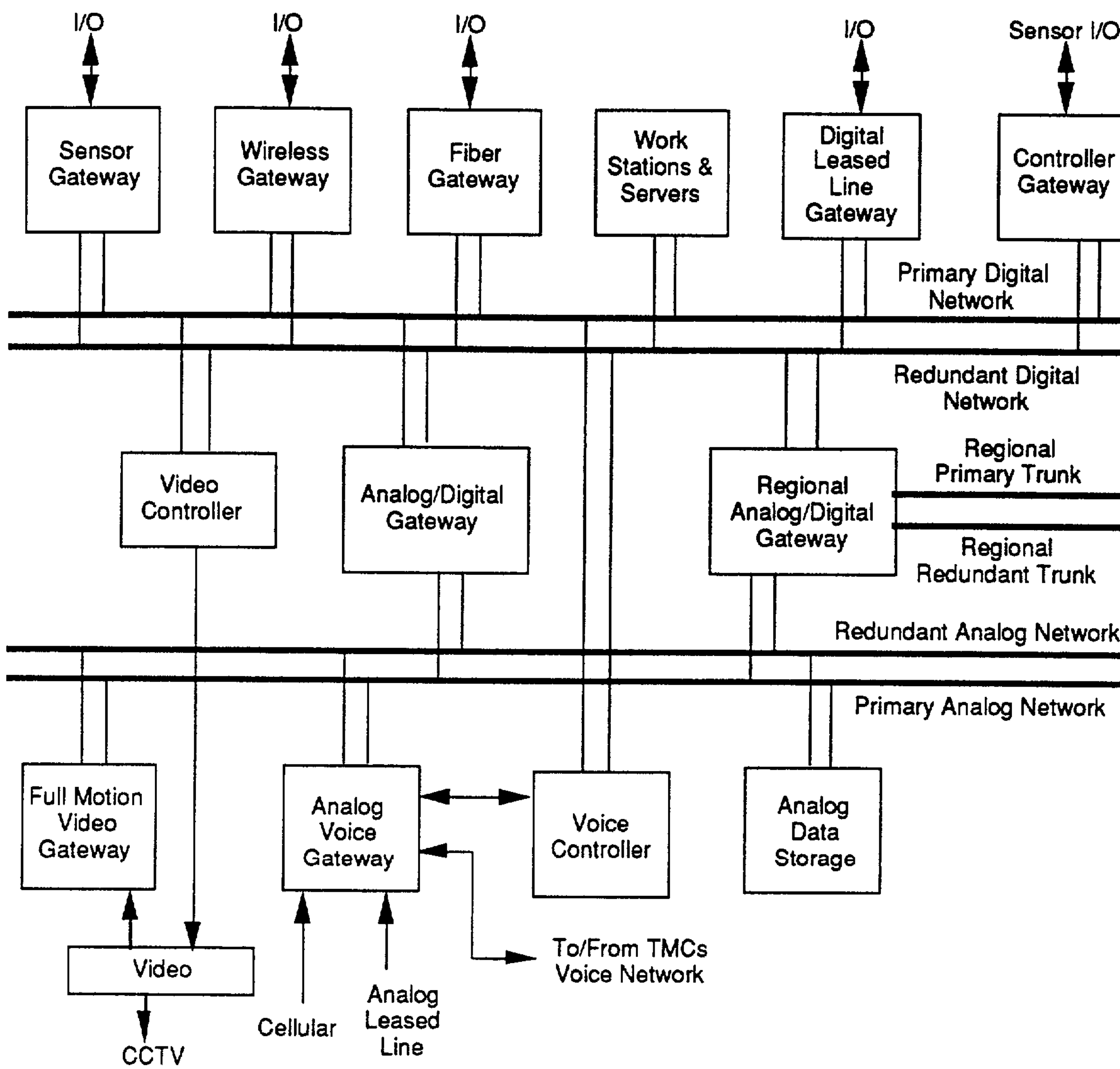


Figure 6-9. Internal Local TMC Communication Network

The interfaces utilize gateways to interface the external TMC media/data format with the internal TMC network format. Note that the equipment interfaces will accommodate all anticipated communication media, extant or planned.

For communication links, redundant digital and analog networks are needed to enhance reliability. The digital network handles digital, compressed video, and digitized analog data. The analog network handles video, voice, and other analog data. The ability to convert analog to digital and vice versa, is also possible using the analog/digital gateway.

The medium for a digital network throughput less than 10 Mbps shall be, at a minimum, a broadband coaxial cable and shall be compatible with a standard network interface, such as Ethernet (IEEE 802.3) using a TCP/IP format. For data throughput greater than 10 Mbps, the network shall be a broadband-compatible, single-mode fiber using (at a minimum) the SONET OCl format. The medium for an analog network throughput of less than 350 MHz shall be, at a minimum, a broadband coaxial cable with an FDM-compatible format. The medium for an analog network throughput greater than 350 MHz shall be, at a minimum, a broadband-compatible, single-mode fiber with an FDM-compatible format.

6.5 IMPROVEMENTS

6.5.1 Necessary Modifications

The current uses of existing detector systems by the other systems are generally compatible with the conceptual Corridor surveillance system; therefore, integration of the local systems into the Corridor should not pose a significant problem from a detector point of view. The conceptual Corridor surveillance system can accept and use the inductive loop information. Some of the other existing systems are using WIM, pressure plate, and other technology for detection. These systems are generally not compatible with the conceptual Corridor system for detection because of the lack of some traffic flow parameters: but these systems are acceptable for enforcement or use by the existing system.

Other types of sensors, such as VVDS, environmental, and AVI (ETTM), will have to be added to the existing systems where those and other types of Corridor-level sensors are proposed, but not extant. The installation of additional sensors and controller cabinets raises the questions of construction cost. Installation of additional sensors will also require communication interconnect between the sensors and the existing system control center. It is assumed that, unless a Corridor-level center, such as a local or regional TMC, is available, the additional sensors required for the corridor will have to be routed through the existing system control center. The existing system center will then reroute the sensor information to the Corridor system. There is the possibility that the local system can use the new data, and this added benefit may prompt the existing systems to install the additional field and central components.

Any surveillance and control systems in place on the freeway sections of the Corridor should be integrated into the TMC with a minimum of effort, because existing systems should be able to communicate with each other. This communication is standardized using standards such as SONET for fiber-optic systems. The computer systems may be proprietary, but their abilities to disseminate data to users implies that there must be access systems available to users. The establishment of a communication network along the freeway will provide the physical link between different systems. It is recognized that some existing system operators, such as toll road authorities, may be reluctant to accept a fully open interchange of control; but the interchange of data should not pose a jurisdictional problem. Interactive programs for the dissemination of data between systems must be developed.

Telephone and coaxial cable are the predominant communication systems currently used to transport information. Although the Corridor communication system should use fiber optics, telephone systems are compatible at the destination points. In the Existing Systems Survey, many of the member agencies stated that they plan to convert to fiber-optic communication systems, therefore, as the Corridor system is installed and the existing systems are replaced through planned replacement and normal upgrade, the communication systems should be switched to fiber-optic systems. The most expensive aspect of a fiber-optic system is the initial construction cost whereas for a leased telephone system, the primary expense is the operating cost. In the interim period, when both telephone and fiber-optic communication systems are used, telephone and fiber-optic communication can coexist at the roadside and control center.

The hardware at local and central levels of each existing system will have to be evaluated separately: but in general, the local existing hardware can remain, as long as the field system reports to its own center. The existing central system hardware will have to be sufficiently compatible with the Corridor system to transmit useful data to the Corridor system. This compatibility is generally on the software level and entails altering protocol parameters in the local system.

Other improvements related to communications are:

+ Establish a suitable network(s) for analog and digital communication within the TMC. This network(s) shall have the ability to manipulate voice, video, and data, and shall use either broadband coaxial cable or single-mode fiber optics.

+ At a minimum, broadband networks within the local TMC shall contain physical redundancy to prevent service shutdown due to any disruption in the primary network.

+ Provide gateways from existing data services to the local TMC broadband network.

+ Establish sub-networks within the local TMC to accommodate digital, analog, and video data types. The sub-networks shall be fault tolerant so that if the sub-network is off-line (for any reason), the main network still can be active.

+ Provide the capability for including security for data elements used within the local TMC. This will reduce the probability of inadvertent or intentional disruption of critical data services.

+ Ensure that the local TMC facility has ample growth potential for new leased lines and sub-networks (both cables and fixtures).

+ Establish a distributed field network to accommodate additional field equipment.

+ The trunk lines should be, at a minimum coaxial cables, but preferably fiber optics.

+ For RF, microwave, and other wireless media, a survey shall be conducted to determine issues such as interference, frequency, channel allocation, bandwidth, and environmental issues.

+ For aerial surveillance, establish a communication link to the aircraft, either directly or through a relay link.

6.5.2 Logical Migration Path

The existing surveillance systems comprise a significant portion of the proposed Corridor surveillance system. These existing systems must be integrated and connected to the TMC as soon as possible for two reasons. First, the surveillance data from the existing systems will permit an early startup of the Corridor system before the additional, Corridor-level sensors are installed.

Second, the connection of the existing systems will permit a full evaluation of the existing data and communication needs and will permit a realistic appraisal of the additional work required for full Corridor implementation.

The surveillance system implementation will require installation of both freeway and surface street sensors for new surveillance areas and existing systems with insufficient detectors. As an initial step, equipment should be installed to permit full freeway traffic surveillance and control. During this first phase, surveillance equipment will permit the system to recognize problems and incidents on the freeway, and to dispatch remedial measures in a timely manner.

The rerouting of traffic to parallel surface streets should not be done until the surface streets have adequate surveillance assets to permit, as a minimum, traffic condition assessment of the alternate routes. Once the surface streets are equipped with surveillance devices, the control of surface streets should be coordinated with the freeway system in the Corridor.

The recommended surveillance detector systems for the Corridor are based on existing technology and the extension of that technology. Therefore, as new detection devices are introduced, they must be evaluated. If those devices have been previously planned for inclusion in the system, they should be installed. If they are totally new, they must be evaluated for use as additional systems or as replacement systems for existing detection systems.