TRW

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The Cross Westchester Expressway Intelligent Transportation System

Concept of Operations Document

Prepared For:

THE NEW YORK STATE

DEPARTMENT OF TRANSPORTATION

REGION #8 ITS UNIT

By

TRW INC.

with HNTB

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EXECUTIVE SUMMARY

OVERVIEW

This document provides high-level insight into the Hudson Valley Intelligent Transportation System's (ITS) Concept of Operations. Also identified are the system's key elements and services, and multiple scenarios of how the system will work in various sample situations. With this as a baseline, more detailed engineering efforts towards the system's Final Design and Implementation can logically commence.

To these ends; it is very important that the Hudson Valley ITS's planners and stakeholders carefully review this document and provide their feedback to the system's designers regarding any areas of concern – e.g., stakeholders' preferences, priorities, and/or any desired changes. This will enable designers to have necessary guidance such that the Hudson Valley ITS can be properly developed into the operating traffic & incident management system that most appropriately meets the expressed and validated needs of Hudson Valley stakeholders.

PURPOSE

The Hudson Valley ITS is a logical continuation of the intelligent transportation system development initiated by the New York State Department of Transportation's formal ITS needs study, titled the *Lower Hudson Valley Early Deployment Planning Study*.

The ITS system for the Hudson Valley will be used to detect, verify, and respond to traffic congestion on the major highways and parkways throughout the entire Hudson Valley. In achieving this goal, the Hudson Valley ITS will provide an integrated incident management and emergency notification system within a single Transportation Management Center (TMC); thus, optimizing both of these critical services through enhanced cooperation and the sharing of a common database of incident information. The Hudson Valley ITS is also being developed to accommodate the expansion of ITS services to include advanced traffic control and traveler & transit information services.

This document provides the technical approach to implementing the Hudson Valley ITS and explains how the system will detect, verify and respond to congestion in a timely and efficient manner. It also provides an overview of the Hudson Valley ITS's functional architecture and how it fits into the National ITS Architecture Program, which enables more standardized means of synergistically interfacing with other critical ITS projects that already exist throughout the New York area, the northeast region, and nationally.

In short, this document defines the vision of the Hudson Valley ITS, based upon inputs from its planners and stakeholders, and as perceived by the system's designers. It defines the ITS concept by defining the integration approach to achieve the program's goals, the logical and physical architectures, and the intended software operations. It also the system's use through multiple sample operational scenarios. Finally, this document presents the planned phased deployment of the Hudson Valley ITS from an initial system deployment at the Interim TMC (located at 244 Westchester Blvd, White Plains, NY) to the final system deployment with the TMC to be co-located at the present site of the NYSPD barracks in Hawthorne, NY.

RESULTS

The culmination of developing the Hudson Valley ITS will result in traffic management operations 24 hours a day and 7 days a week from the final traffic management center located in Hawthorne, New York. Over one hundred highway and parkway miles of roadway throughout the Hudson Valley will be under constant surveillance through traffic flow sensors and closed circuit television cameras. Accordingly the Hudson Valley ITS will enable the NYSDOT and the NYSTA to more rapidly identify and respond to traffic incidents with appropriate emergency and support personnel; thus, increasing the safety of motorists and reducing traffic congestion via new abilities to more quickly open traffic lanes that may have been blocked, and via enhanced abilities to disseminate timely, relevant, and accurate traffic information directly to motorists. Studies have quantified associated regional economic enhancements via cost savings in reduced lost productivity, fuel consumption, and pollution such that the proposed system can pay for itself within a few short years.

SECTION A

INTRODUCTION

SUBSECTION A-1

OVERVIEW

The primary mission of the Hudson Valley Intelligent Transportation System (ITS) is to improve the safety of the traveling community in the Hudson Valley. Improved safety will be realized through efficient use of the major highways with timely and accurate information being made available to the traveling public for making their transportation decisions.

This document provides a high level perspective of the Hudson Valley ITS, a definition of key elements and services of the system, and sample scenarios of how the system will work. With this understanding as a baseline, engineering efforts for evolving to a Final Design and Implementation may commence.

The Hudson Valley ITS is a logical continuation of the intelligent transportation system development initiated by the New York State Department of Transportation with the *Lower Hudson Valley Early Deployment Planning Study* (LHV EDP), which was completed by HNTB in January 1996. As a result of the LHV EDP, HNTB developed a preliminary Intelligent Transportation System design for the Cross Westchester Expressway from the New York State Thruway (NYSTA) to the Hutchinson River Parkway to identify and document the near term ITS efforts planned by the NYSDOT for the Lower Hudson Valley. This effort was published in the *Intelligent Transportation System (ITS) Preliminary Design Report* by HNTB in October 1998. The Hudson Valley ITS project focuses on the development of a comprehensive incident management system and communication backbone on which to fully develop the ITS for the Hudson Valley with important communication links to NYSTA; NYSDOT Regions 1, 10, and 11; North Jersey operations center; and the Bridgeport, Connecticut operations center.

As stated in the *Intelligent Transportation System (ITS) Preliminary Design Report* "The ITS system for the Hudson Valley will be used to detect, verify, and respond to congestion." While achieving this goal the Hudson Valley ITS will provide an integrated incident management and emergency notification system in a single Transportation Management Center (TMC) to optimize both of these critical services through sharing a common database on incident information. The Hudson Valley ITS is also being developed to accommodate the expansion of ITS services to include advanced traffic control, and traveler and transit information services. This document, *The Hudson Valley ITS Concept of Operations*, provides the technical approach to implementing the Hudson Valley ITS and explains how the system will detect, verify and respond to congestion in a timely and efficient manner. It also provides an overview of the Hudson Valley ITS architecture and how it fits into the *National ITS Architecture*; providing the means to interface to the other critical ITS projects in the Southern New York area and nationally.

This document communicates the vision of the ITS to the planners and stakeholders in this effort, as it has been perceived by the designers. It is very important that the planners and stakeholders review this document carefully & provide their feedback concerning preferences, priorities, or changes desired to the designers. Your feedback ensures that the designers understand your needs, enabling them to make necessary changes to meet those needs.

SUBSECTION A-2

SUMMARY OF UPCOMING SECTIONS

Upon conclusion of this introductory *Section A*, the following sections document the Hudson Valley ITS Concept of Operations as derived from the *Lower Hudson Valley Early Deployment Planning Study,* the *Intelligent Transportation System (ITS) Preliminary Design Report*, and technical discussions with the New York State Department of Transportation (NYSDOT), NYS Police, New York State Thruway Authority (NYSTA), and Westchester County officials. More specifically, upcoming items include:

- *Section B* – a detailed approach to integration of the Hudson Valley ITS to develop a foundation for the growing ITS capabilities in the Lower Hudson Valley, including delineation of the functional needs for the Hudson Valley ITS.
- *Section C* – a high-level description of the Hudson Valley ITS's recommended integration logical architecture, including an overview and a list of data-, video-, voice-, and external interface major functional elements;
- *Section D* – a presentation of the software framework for providing the "glue" for integrating the physical subsystems of System Control, Automatic Traffic Recording, Video Surveillance, Variable Message Signs, and Voice Communications;
- *Section E* – a presentation of the Hudson Valley ITS recommended hardware architecture, including an overview and a detailed description of its recommended hardware framework for data collection, surveillance, and communications.
- *Section F* – a presentation of a sample operational scenario to demonstrate the use of the Hudson Valley ITS in a realistic environment.

SECTION B

APPROACH TO HUDSON VALLEY ITS INTEGRATION

SUBSECTION B-1

OVERVIEW

Systems integration is the key to developing an efficiently operating Intelligent Transportation System. Each ITS deployment consists of a variety of systems and functions that must inter-operate in a synergistic manner to provide the performance required. Data is collected through roadway sensors, video provides surveillance, computer algorithms process the data, and people execute response plans based on all of the inputs. None of this can occur effectively without a cohesively integrated ITS.

System integration begins with a solid, systems engineering process. All developments begin with people developing an idea to make something better. Then the engineering process can take the idea and develop it into reality. However, the idea must first be clearly defined by identifying the requirements – i.e., defining precisely what the system must do. Then, alternative approaches are explored for meeting those requirements – i.e., exploring how the system will achieve/perform its defined required functionality. Afterwards, the best options are chosen and further defined with interface and functionality descriptions. Finally, the functions and interfaces are then integrated into a cohesive system that fulfils the idea that started the process.

The Hudson Valley ITS began as an idea of the NYSDOT. The idea has been partially expanded by previous studies. The systems engineering process continues in this effort by clearly defining the concept of operation for the Hudson Valley ITS. This section of the document discusses key operational elements of the Hudson Valley ITS in order to further define what the system must do.

The Hudson Valley ITS is envisioned as an integrated communication, video, and data information management system. The design should provide the capability to collect information about the roadway network's transportation conditions, perform analysis, and support management decision making based upon this information. Furthermore, the Hudson Valley ITS should include appropriate elements necessary to provide timely traveler information based on the collected/processed/analyzed data such that travelers and would-be travelers can make informed decisions about their route-, timing-, and modal-related travel options within the Hudson Valley.

SUBSECTION B-2

KEY OPERATIONAL ELEMENTS

In approaching the issue of developing an Intelligent Transportation System, a customer-specific *Concept of Operations* is a powerful tool for enabling system designers to gain valuable insight into both the day-to-day needs of a system's users, and the ways in which the users envision the system will be used. To fully understand the operational needs of this system we must first understand who the users are. The classes of users have been defined to include motorists, media, transportation agencies, external agencies, and TMC operators. Each user class's interaction with the ITS is further defined as follows:

Motorists

Motorists will receive both regulatory and advisory information from the Hudson Valley ITS via Variable Message Signs (VMS), Highway Advisory Radio, (HAR), and AM and FM broadcasts. Their vehicles passing over and through the Hudson Valley ITS sensor fields generate the data for Traffic Management processing. With the widespread use of cellular phones, the motorists provide additional input for the identification and verification of highway incidents.

Travelers

Travelers or pre-trip planners make travel decisions based on information distributed by the Hudson Valley ITS regarding traffic conditions within the project limits. This information will normally be received through a Traveler Advisory Telephone System (TATS), commercial media, tuning to the HAR, or via the Internet.

External Agencies

External agencies such as individual county Departments of Transportation/Departments of Public Works, law enforcement agencies, and transit authorities will rely on the Hudson Valley ITS for highway information as well as access to VMS and HAR for communications to the motorists. External agencies who choose not to physically occupy the TMC can still be active partners in this project via dedicated, linked communications networks and remote workstations for input and output of transportation related data. Traffic engineers from the NYSDOT and public safety officials from various state and local jurisdictions will continually review response plans and results from response plan initiation. They will provide recommendations for enhancing and modifying system response plans.

Information Service Provider

An Information Service Provider (ISP) operating from the TMC will provide timely traffic information to interested radio and television stations along with the newspapers and potentially cable operators. The ISP will also provide a telephone/cell phone call-in service to provide information directly to interested motorists. This service will be consistent with the X-1-1 dedicated traffic information number currently being spearheaded by the Federal Government.

TMC Operators

The operators are responsible for the daily operations of Hudson Valley ITS which include:

- monitoring of traffic flow on the expressway and lateral connections via the vehicle detection system,
- verification of incidents through video surveillance system and audio communications,
- enactment of response plans consistent with regional/local policies and procedures, and
- documenting traffic/incident status and occurrences as necessary.

These operations are carried out from the TMC workstations with integrated computer and communications support during normal operational hours and during special events. The Hudson Valley ITS also provides for the on-line training of TMC operators using real-time field data and simulation data but without access to control of the remote field devices.

In addition to the expected traffic operators as described above the Hudson Valley TMC will include C911 Call Takers/Dispatchers, HELP Dispatchers, and other remote users. Management and support staff will also occupy the TMC and will have remote access to the same traffic information as the traffic operators through their own workstations.

Hudson Valley ITS Administrator

The Hudson Valley ITS Administrator is responsible for the quality of work of the TMC operators as well as normal administrative functions. The administrator will set responsibilities for TMC operators and define or limit the range of their monitoring and control of the TMC resources.

Hudson Valley ITS Support Personnel

The Hudson Valley ITS will be an integration of various technologies that include computers, communications, video, radio, telephone, and vehicle detection sensors. Hudson Valley ITS support personnel will coordinate the maintenance of field equipment and inventories of spares. Support personnel on site will also include hardware and software specialists to tune the computer system performance and to trouble-shoot any problems or "bugs" that may appear. Communications specialists will provide performance monitoring and troubleshooting of the communications, video and radio subsystems.

Based on the above definitions of the users, we may now define their needs as follows:

- …users need the system to detect, verify, and notify them of incidents or threatening weather conditions on the monitored highways
- …users need the system to provide timely and accurate information to enable them to make proper and timely decisions.
- …users need the system to collect, sufficiently, details on incidents to enable the timely and appropriate dispatch of emergency agencies and equipment.
- …users need the system to present events in order of priority, making sure that life safety events receive top priority.
- …users need the system to resolve conflicts between requests for information or control of devices received from several local and/or remote users.
- …users need a robust operating environment where system failures and/or resets cause minimal disruption in service.
- …users need the system to be flexible to incrementally add new services and scaleable to handle increased highway miles.
- …users need information to support effective planning by transportation administrators. For example, hourly volumes, directional splits, classification data, peak-hour speeds, and off-peak speeds.
- …users need the Control Center to be able to deliver multi-media information including video, computer graphics, and audio, either directly to kiosks at convenient locations (e.g., malls, park-and-rides, terminals, etc.) or through the various media agencies such as television, radio, and cable operators.

- …users need the system to effectively and efficiently execute traffic management algorithms on the traffic data being gathered. Also, based on the algorithm's state, users need the system to automatically implement traffic response plans, if required for a given event, that have been pre-approved by the operating agency.

- …users need timely and accurate access to real-time status of Hudson Valley ITS components upon request.

- …users need the system to maintain logs of maintenance events and schedules to optimize the availability of the whole system for operations.

- ...users need the system to provide a pager service for emergency notification of incidents and other specialized alerts as needed.

- ...users need the system to allow for "dial-in" connections by authorized remote users via standard telephone modem to allow remote users to input and receive data as well as allow authorized staff and technicians to interact with the system while out of the office

- ...users need the system to share CCTV video feeds with other TMCs and private agency partners

Based on experience from previously developed ITS projects and the National ITS Architecture, a number of key operational elements have been identified that help to define what the Hudson Valley ITS needs to do to meet these user needs. These key operational elements are defined by the following functions the ITS must perform:

<u>Traffic Management</u>:

- Monitor traffic flow on the Interstates and lateral connectors via a vehicle detection system,
- Verify incidents through a video surveillance system & audio communications.
- Enact response plans consistent with regional/local policies and procedures.
- Document traffic/incident status and occurrences as necessary.
- Control regional traffic as necessary to optimize movement of traffic.
- Control roadway traffic signals to support regional traffic flow.
- Disseminate traffic information.
- Monitor and evaluate the traffic network performance.
- Monitor system performance to optimize maintenance.

Emergency Management:

- Take emergency calls
- Dispatch emergency personnel and equipment
- Manage the emergency response based on predetermined protocols
- Coordinate responses with the traffic management element.

Planning:

- Collect and store data to support planning for the future (both traffic data and equipment operation/failure data)
- Develop diversion route plans in anticipation of incidents

Information Service Provider (Hudson Valley ITS provides support to this service):

- Provide a basic information broadcast
- Provide a means for traffic data retrieval interface to serve the ISP
- Provide a media system traffic data interface

Additional capabilities may be added to each of these services in the future as the community requires them and capital permits. These key elements provide a solid foundation of highly efficient ITS functions on which to build the system of the future – today.

The above requirements may be further derived to provide detailed descriptions of functions the ITS must provide as follows:

- …a centralized Transportation Management Center will house the processing capability for implementing traffic algorithms based on data collected by remote sensing devices. Data from the sensors, highway devices (i.e., VMS status), and video cameras will be aggregated in this TMC. The TMC will have video monitors to assist in incident verification and monitoring. Color graphics displays will portray the highway system status differentiating normal, increased, and critical congestion areas as well as incident locations. While not all of the area freeways will be instrumented with detectors, the system will display the entire highway system and will be capable of displaying manually-located incidents and events along those segments to provide operators with a comprehensive view of the freeway environment.

- …the communications network will encompass varying transmission technologies that include fiber optics, dedicated copper circuits, leased circuits, dial-up circuits, cellular telephone, spread spectrum radio, digitized video, and packet radio. Use of any technology, combination of technologies, or existing communications media will be based on a cost-performance analysis for meeting the requirements of Hudson Valley ITS.

In no case should the selection of a transmission media or the transition from one media to another adversely affect the application software.

- …The TMC will provide operating stations and dispatch centers for the NYSDOT, NYSTA, NYS Police, Westchester County, and other related agencies, such as the freeway service patrol (HELP), as required. Operators will work from integrated workstation consoles that are designed for functional traffic management operators who are not necessarily "technocrats". Key components of the workstation console are a computer system with color graphics displays, keyboard and mouse; video monitors with control panels for selecting cameras and monitors, and controlling the pan, tilt, and zoom (PTZ) of the cameras; and audio communications with headset and control panel for rapid connection to external agencies (e.g., police, fire, EPA, etc.)
- …software will support the generation of standard, predefined reports for daily, weekly, monthly, special events, and yearly reports on the operation of the Hudson Valley ITS and the associated traffic profiles. These reports would include incident summary reports, traffic volumes, vehicle types, system evaluation reports, and maintenance and operations reports. Data maintained in the database will be easily accessed to produce these reports. Ad hoc reports will also be supported such that The Hudson Valley ITS data can be accessed and formatted to meet the needs of Hudson Valley ITS administrators and associated public safety agencies.

Figure B-1 on the following page highlights the basic flow of information within the key subsystems of the Hudson Valley ITS as it is currently envisioned.

SUBSECTION B-3

FUNCTIONAL NEEDS

The key operational elements, mentioned above, help to describe what the system needs to do to meet the users needs. This section focuses on functional requirements for the system and the components of the Hudson Valley ITS to develop these key elements into an integrated and operating system.

SYSTEM CONTEXT

Every traffic management system requires a nerve center to operate and control the complex technologies in use. Based on the phasing of the CWE reconstruction, Hudson Valley ITS will first be controlled from the NYSDOT facility located at 244 Westchester Ave in the Interim Traffic Management Center. After completion of the TMC at Hawthorne the control center will move to the Hawthorne facility, initially using the communications medium established for the interim management center. Upon completion of the fiber optic back plane, all field assets will be connected to the TMC via the fiber.

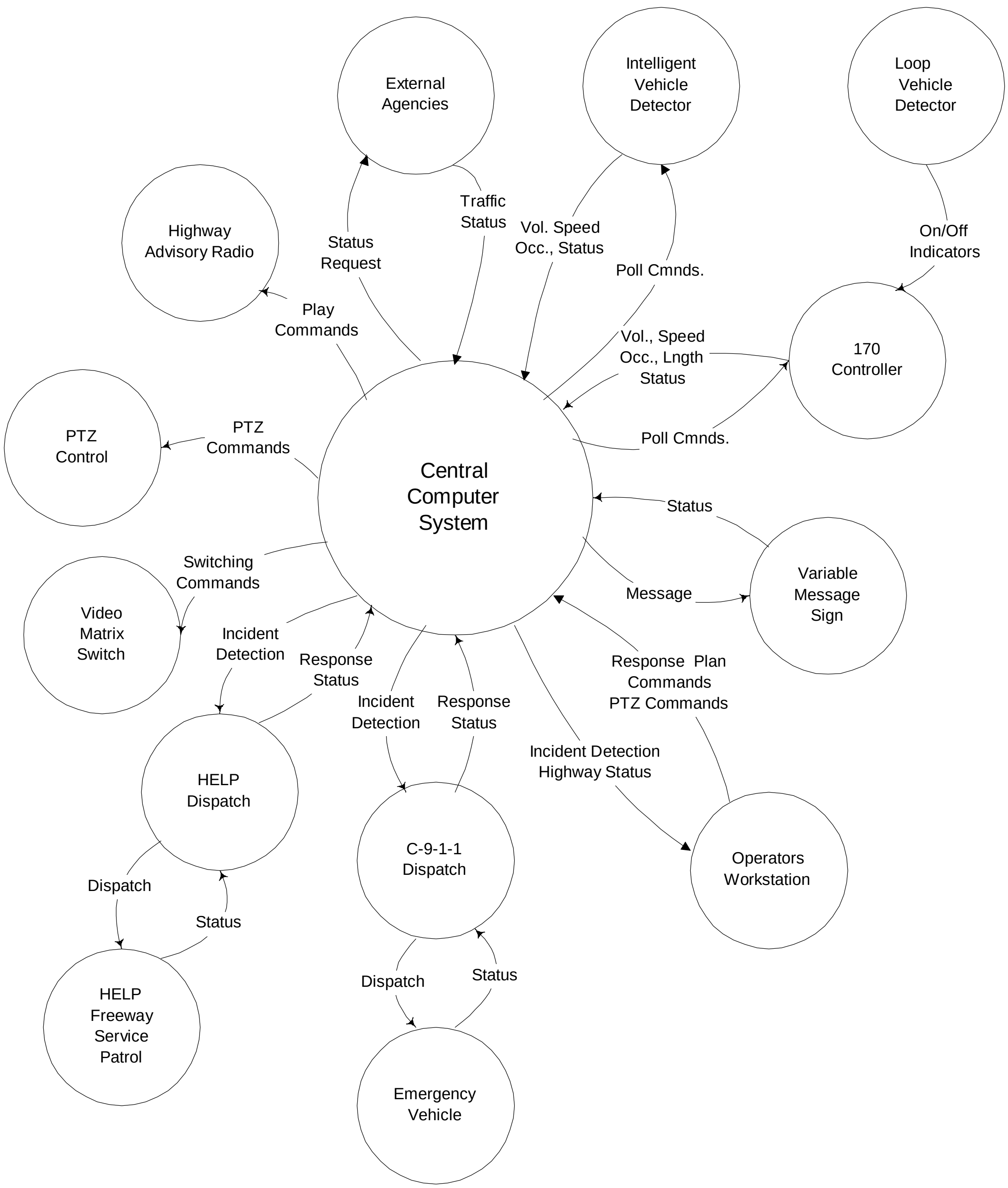


Figure B-1 Basic Data Flows

The Interim Traffic Management Center (ITMC), located at 244 Westchester Ave will provide capability to manage traffic flow along I-287 during its reconstruction. It is anticipated that the ITMC will consist of a server computer, operator workstations, and CCTV monitors. A UNIX based computer will provide central processing and server capabilities. The Windows NT based workstations and central computer will be linked via 100 Base T Ethernet LAN.

Since the Interim Traffic Management Center will be operating at a time when the Cross Westchester Expressway will be under reconstruction, fiber optic cabling will not be available because its installation is part of the reconstruction task. Therefore, the development and integration of the Hudson Valley ITS must be phased with the construction to provide incident management functions through different means of communications. Prior to completion of the fiber optic cabling, standard telephone connections or wireless technology will provide communications between ITS assets in the field and the ITMC at White Plains. Installation of the fiber optic backbone will include connections for each detector, CCTV, and VMS. Once the fiber optic cabling is completed to Hawthorne, the field assets will be connected to the fiber and their former communications service will be terminated.

The NYSDOT and the NYSPD are currently in the process of acquiring a computer aided dispatch capability (CAD) for the HELP highway service patrols. The CAD system will also reside in the management center located at White Plains. Integration of the CAD and the traffic management software will begin at White Plains to prepare them as a totally integrated system for installation in the TMC. The traffic management software and the CAD will be integrated to allow the exchange of data and alarms. NYSDOT and NYSPD will determine the data that needs to be exchanged between the two systems and an interface will be developed between the two systems in a manner that prevents unauthorized access and ensures that sensitive data pertinent to law enforcement will be properly protected.

The final Hudson Valley ITS will be controlled and operated from the Hudson Valley TMC located in Hawthorne, NY. The facility at Hawthorne is being designed under a separate contract to house the TMC and the local barracks for the NYS Police. The control center will accommodate operators from the NYSDOT, NYS Police, NYSTA, and other agencies as required. The NYSDOT and NYSTA operators will be responsible for monitoring and managing traffic on the roadways for which they are responsible. The NYS Police personnel will operate a Cellular-911 answering center and will be located in the command center with the NYSDOT and NYSTA operators. The Hudson Valley ITS functions will be integrated with the NYS Police CAD functions to provide a seamless exchange of data and information among the operating organizations. Information received via cellular telephone will be passed to the ITS operators for their use in notifying the public and managing traffic flow. Upon detection and verification of roadway incidents, ITS operators will transfer information to the NYS Police dispatchers to assist them in dispatching appropriate agencies and equipment, including the HELP Freeway Service Patrol. Data from each operator is stored in a shared database with password security for cells with sensitive data. This database and comprehensive audio system within the TMC will link all users together whenever necessary to coordinate responses.

All sensor & surveillance data including video, traffic counts, weather data, cellular reports, etc. will be routed to the TMC. Video monitors at the operator's workstation provide surveillance and incident verification capabilities. A video wall in the front of the TMC provides a large, dynamic map of the region that identifies incident locations and traffic flow rate information. The video wall provides a "Big Picture" understanding of the traffic conditions for operators (see Figure B-2), and observers looking in from an overlook above the main control room.

Figure B-2 Workstation example from ARTIMIS in Cincinnati/ Northern Kentucky TMC.

The TMC contains the central computer for detecting incidents and for controlling the technologies in the TMC and the field. The following subsections describe the functionality that must be provided by each major component of the Hudson Valley ITS.

SYSTEM CONTROL

The Hudson Valley ITS will provide appropriate equipment & personnel required to perform continuous day-to-day (24/7) management of the highways and roadways within the Hudson Valley. It is anticipated that as a minimum, NYSDOT, NYSTA, and NYS Police will provide, or contract for, trained personnel to operate and maintain the LHV TMC and its associated ITS. The TMC should, as a minimum, be capable of performing the following functions:

- Provide monitoring features of system field components including controllers, detectors, communication, and other equipment;
- Provide for the collection, analysis, and summation of traffic data gathered by various surveillance technologies;
- Provide capabilities for displaying system area map information and to modify graphical data overlaid on this map data;

- Provide capabilities for displaying and modifying intersection operations and graphical user interfaces;
- Provide status displays of current roadway and field equipment conditions;
- Interface with other transportation management systems to support effective system management and effective movement of people and goods; and
- Provide information collected and calculated by the system to other control centers, the media, and other government agencies.

A sub-element, but very important control function of the TMC is the TMC's integration with the New York State Thruway Authority's existing traffic management technologies. The NYSTA currently monitors traffic conditions on the Thruway highways and bridges from within the Traffic Information Center located in Tarrytown. Data from TRANSMIT readers and video feeds from CCTV along the NYSTA bridges in the area are routed to two workstations in a Traffic Information Center. The TIC operators use the data and videos to identify incidents and then notify motorists through a system of local Highway Advisory Radios (HAR) and Variable Message Signs (VMS) owned by the NYSTA. The system of sensors and computers are linked through an OC-3 SONET network. Videos are routed via analog transmission on fiber optic cable separate from the SONET. (Note: The NYSTA is investigating the viability of converting the CCTV videos to an IP digital format in the near future).

The local NYSTA primarily operates the TIC for information purposes only. That is, they identify incidents and inform the motorists of the incident. Dispatching of Thruway Police and other services is normally performed by the NYSTA TMC located in Albany. The TMC is notified of an identified incident by the local TIC, and dispatching functions are then performed by the Albany TMC.

The NYSTA TIC will continue to operate from the Tarrytown facility until the NYSDOT Region 8 TMC in Hawthorne is completed. At that time, NYSTA wants to be able to work out of the Hawthorne TMC in the same manner that they are operating from the Tarrytown facility. The Hawthorne TMC shall be designed to integrate the operation and control of the existing NYSTA traffic monitoring into the Hawthorne TMC. The NYSTA operators will be responsible for monitoring and controlling traffic on both their future-instrumented as well as their existing NYSTA instrumented routes.

VIDEO SURVEILLANCE

The video surveillance camera subsystem should provide the capability to monitor traffic headway and to verify incidents relative to their operational locations. Video equipment must be remotely controllable and generate standard video signals for routing to the TMC.

More specifically, the video functional element should as a minimum include:

- Video information collected through a surveillance closed-circuit television (CCTV) network;
- Selectable presentation of video information to ATMS personnel to support validation of congestion conditions, monitoring of overall traffic flow, confirmation of potential incident detections, and status of incident removal;
- Capability to monitor commercial and public television and cable channels for incident information and weather conditions;
- Management and control of all cameras; and
- Video input and output ports for internal and external organizations, including IRVN, and the NYSTA CCTV's.

DATA COLLECTION

The Hudson Valley ITS, in performing its primary traffic-related functions, should collect and process real-time information; including, digital and analog data from a variety of sensors. Data collection and dissemination of control signals should be accomplished over a network that consists of public telephone, cable television, fiber-optics, and radio technologies as available and appropriate within technological, budgetary, and integration/institutional constraints. The system should not be limited to the type of detectors used to gather traffic data; however, it may be necessary to develop new software modules to interface to the detectors if they are based on proprietary standards.

More specifically, the data collection functional element should include:

- A network on which the data moves throughout the areawide ITS;
- Digital and analog data collected from a variety of field sensors and transmitted to the TMC computer system for processing and operator analysis;
- The capability to accept digital data from other computer systems, such as other transportation management centers, transportation control centers, etc.;
- Data resulting from various internal processing elements; and
- A system database to include signalization plans, historical data, system configuration, system status, etc.

TRAVELER INFORMATION

The Hudson Valley ITS should provide current traffic condition data in support of associated pre-trip and en-route information dissemination for travelers and would-be travelers throughout the Hudson Valley Region. Since said traveler information data shall target travelers who are planning a trip and those whose trips are already underway, this subsystem should be able to provide various degrees of information from route-specific to the more generic needs of travelers just entering into or within the Hudson Valley. Furthermore, the traveler information system should be in a distributed-type software framework such that transportation-related data can be provided to a wide variety of traveler interface units and services. More specifically, these units should include public access dial-up servers, mobile and stationary Variable Message Signs, Highway Advisory Radio (HAR), and Traveler Information Kiosks. Overall, informational data associated with this subsystem shall help travelers select their most efficient path from origin to destination.

VARIABLE MESSAGE SIGNS

The Hudson Valley ITS should provide data such that Variable Message Signs (VMS) can disseminate information advising motorists of traffic conditions ahead (e.g. incidents, construction, congestion, etc.). In addition, the VMSs should provide periodic feedback as to operational status, diagnostic messages, and displayed messages.

More specifically, the VMS element should as a minimum provide the following functionality:

- Accept control data from central TMC facility;
- Advise motorists of traffic conditions as they enter the Hudson Valley region;
- Facilitate diversion from one highway to another and provide directional information to motorists;
- Facilitate diversions from a freeway to an arterial (designated arterial roadways must have adequate capacity to accommodate diverted traffic and some level of surveillance coverage);
- Facilitate early warning to motorists of dangerous conditions; and
- Provide information to aid in efficiently managing and alleviating traffic incidents and associated recurring and/or non-recurring traffic congestion.

VOICE COMMUNICATIONS

The voice functional element should include all voice data associated with the following:

- Telephone communication;
- Voice communication between TMC personnel and resources such as public safety personnel, public transit personnel and agencies; highway maintenance crews; radio and television traffic information reporters; freeway service patrols; emergency dispatch centers; and various radio systems;
- A voice switching capability that should support connecting telephone and radio communication between networks, and between control centers (Hudson Valley ITS TMC, NYSTA Center at Tarrytown, and NYSTA at Albany)
- Internal communications for the TMC facility including direct communications between operators stations.

Finally, the Hudson Valley ITS should allow for the entry of verified incoming voice information into a database to support the application of algorithms for incident management and/or operator action (e.g., pre-defined messages for automatic selection and activation/dissemination via appropriate HAR-, dial-in-, and Web-Based – "RealAudio™"-type – digital message systems, etc.).

REGIONAL ARCHITECTURE

In addition to the Hudson Valley ITS and existing NYSTA assets, a number of other ITS and information services exist in the Lower Hudson Valley. Many of these services are provided through the TRANSCOM organization. TRANSCOM is a consortium of 15 agencies from New York, New Jersey, and Connecticut. They provide the service of exchanging traffic information among the consortium members. Some of these services, such as IRVN, which provides video exchanges, have been mentioned in passing in previous sections. They also provide kiosks through their SATIN network, and incident detection through the TRANSMIT program. These services are important to the smooth operation of the Hudson Valley TMC. Likewise, the information to be collected by the Hudson Valley TMC is important to TRANSCOM.

The Hudson Valley TMC at Hawthorne will interface to TRANSCOM to provide the needed exchange of traffic speed, volume, and occupancy data, and traffic videos with this regionally significant consortium. Due to the diverse forms of information within TRANSCOM, they have developed a communications network known as the TRANSCOM Regional Architecture, which is based on the ITS National Architecture Program's Center-to-Center protocol. The Hudson Valley TMC will integrate this interface into its overall communications network and provide data and videos from the information collected in the Hudson Valley, while receiving similar information that TRANSCOM collects from other TMCs and information services in the area.

In addition to the communications with TRANSCOM, communication between the Hudson Valley TMC and other TMCs and DOT facilities is extremely important. To enhance system reliability and avoid total dependency on TRANSCOM, direct communications will be established between the Hudson Valley TMC and TMCs from Regions 1, 10 and 11of the NYSDOT, and similar TMCs in Northern New Jersey and Bridgeport, Connecticut. These communications links are planned to exchange information on traffic incidents that may affect each TMC as well as the direct exchange of video when required. Direct communications with highway and Thruway maintenance facilities and other supporting activities are also planned. These links facilitate the response of support crews to clear incidents quickly, to repair the transportation systems to avoid incidents, and to clear snow and ice from the roadways in a timely manner. A communications system to support these efforts of the entire Hudson Valley area in supporting the transportation infrastructure will be also be developed, with the Hudson Valley TMC serving as its primary hub.

SECTION C

INTEGRATION ARCHITECTURE

SUBSECTION C-1

OVERVIEW

Having identified functions to be performed by the Hudson Valley ITS, the engineering process continues by developing a plan for integrating the identified key elements into a cohesive system. This process develops the architecture, or framework, on which the Hudson Valley ITS will be developed. The Federal Government recognized the importance of this process several years ago & sponsored a program resulting in the National ITS Architecture. The National ITS Architecture defines the total ITS system in terms of user services, a logical architecture, a physical architecture, equipment packages, and market packages.

The user services represent what the system will do from the user's perspective. They are defined in bundles such as *Travel and Transportation Management*, *Travel Demand Management*, *Public Transportation Operations*, and *Emergency Management*. These bundles are broken into smaller groupings and then requirements assigned to define the user's needs. Section B is an overview of the efforts performed for the Hudson Valley ITS that go into identifying applicable user services of the National ITS Architecture Program.

The logical architecture is actually a tool that helps to define and organize complex entities and the relationships between them. It is the functional view of the system. The definition of the logical architecture begins at the highest level, Manage ITS, with a data flow diagram and decomposes each entity into more and more detailed data flow diagrams until no further decomposition is possible. Each function is defined in a data flow diagram consisting of process specifications and the data flows required for the entity to function properly.

The physical architecture is the physical (versus functional) view of the system. It better describes *how* the system should provide the required functionality. The physical architecture assigns the processes defined in the logical architecture to physical subsystems. The data flows of the logical architecture become data transfers in the physical world and all data flows for a given subsystem combine to define the subsystem interfaces. The locations of these subsystems are not defined, providing flexibility for the system designer to optimize a system to local needs.

The equipment package and market package definitions provide a differently bundled view of the architecture packages for planning purposes. They are logically grouped based on the synergism of the functions to be performed and the groupings necessary to deliver a given transportation service.

The Hudson Valley ITS will be developed to meet the National ITS Architecture. Details on the compatibility of the Hudson Valley ITS architecture with the National ITS Architecture is provided in chapters of a separate report – the *Hudson Valley TMC Software Requirements Document*. This section provides an overview of the Hudson Valley ITS physical architecture and how it corresponds to the National ITS Architecture.

Figure C-1 illustrates the general physical architecture defined by the National ITS Architecture. This drawing depicts the various subsystems of the architecture and illustrates the communication connectivity, or conceptual data flows between them. The physical architecture also includes textual descriptions of the subsystems and their data flows.

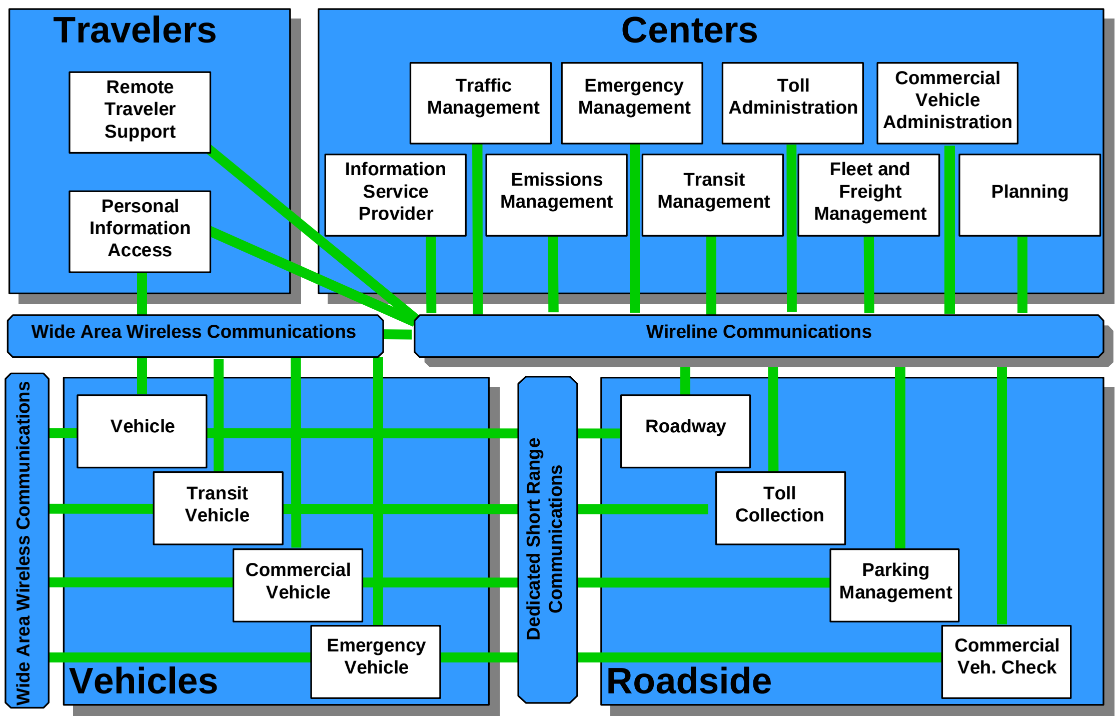


Figure C-1: National ITS Physical Architecture

This diagram depicts the *entire* physical architecture as defined in the National ITS Architecture. Practicality and limited capital restricts the Hudson Valley ITS, or any ITS project, from implementing the entire architecture in one project. Planners and developers must begin to implement a system which meets their near term needs and plan for future needs. Therefore, as illustrated in Figure C-2, the Hudson Valley ITS implements a carefully selected subset of the architecture. This figure also illustrates the location of each subsystem for the Hudson Valley ITS. Subsystems may exist in multiple sites such as the Traffic Management subsystem that may have elements of its functions in the TMC at Hawthorne, in the NYSTA in Tarrytown, and in the NYSTA in Albany.

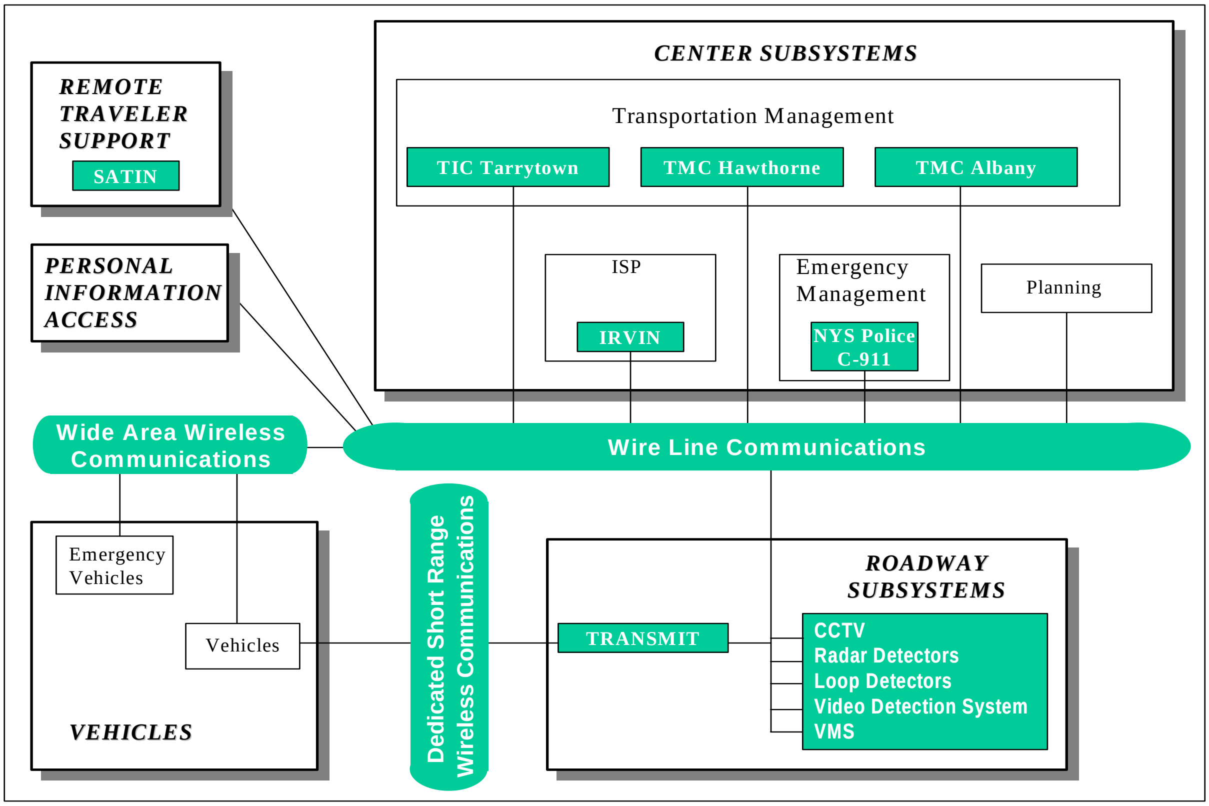


Figure C-2: The Hudson Valley ITS Initial Physical Architecture

SUBSECTION C-2

TMC MAJOR FUNCTIONAL ELEMENTS

As shown in Figure C-3, TMC requirements can be categorized into four broad areas:

- Information Gathering / Collection
- Information Management
- Traffic Control
- System Administration

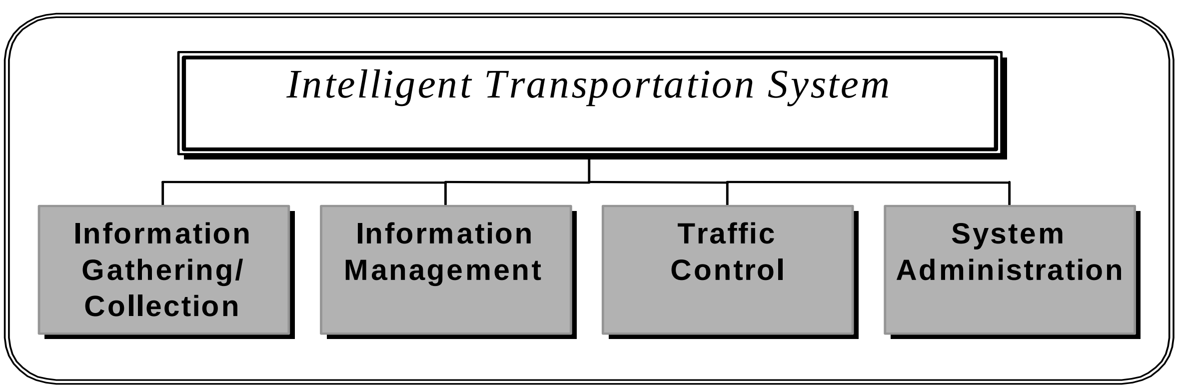


Figure C-3. Hudson Valley Intelligent Transportation System TMC Functional Elements

Accordingly, each of these areas may consist of one or more of the following elements:

- Data Functional Element
- Video Functional Element
- Voice Functional Element

For example, *Information Gathering / Collection* associated with the TMC's series of CCTV cameras consists of both a *Data Element* for sending pan/tilt/zoom and/or auxiliary functional control commands, & a *Video Element* for receiving (at multiple locations) images associated with each camera. Details regarding the physical interfaces and hardware/software necessary to enable control of these cameras from a "common-look-and-feel" interface at multiple locations will be forthcoming in Section D. However, it is first appropriate in the following paragraphs to present these elements (e.g., *Data*, *Video*, and *Voice*) in more detail such that it can provide the basis for a series of upcoming design-/vision-/discussion-type questions and answers regarding ITS-related data and video communications architecture/design issues.

DATA ELEMENTS

The data functional element provides capability to move data throughout the Hudson Valley ITS area of coverage. Major components of this element (as shown in Figure C-4) are:

- **Traveler Information**, which includes the Highway Advisory Radio (HAR), Traffic Advisory Telephone System, variable message signs, media, and interfaces to public access servers (Internet) and future traffic information kiosks;
- **Traffic Control**, which includes intersection-based vehicle detection, mid-block / system-type Automated Traffic Recording (ATR) devices, traffic signal controllers, and if desired, ramp metering systems (future);
- **Information Management**, which includes database management and requested reports, graphical display of queried information, network management and device alarms, and TMC security functions;
- **Traffic Management Strategies**, which integrates all top-level functions of the TMC and provides for coordinated implementation of desired traffic management strategies (e.g., incident detection algorithms and associated pre-defined response plans for congestion-, incident-, and special event management).

VIDEO ELEMENTS

The video functional element provides the capability to:

- Collect information via dedicated surveillance CCTV network;
- Monitor commercial, public and cable channels for incident information and weather conditions;
- Monitor overall traffic flow;
- Confirm incident detection and status of incident removal;

- Transmit video throughout the TMC and partner facilities (e.g., IRVN), including surveillance camera monitor and control capabilities;
- Provide video to outside agencies, including television stations, Emergency 911 (E911) services, and public safety organizations not included above.

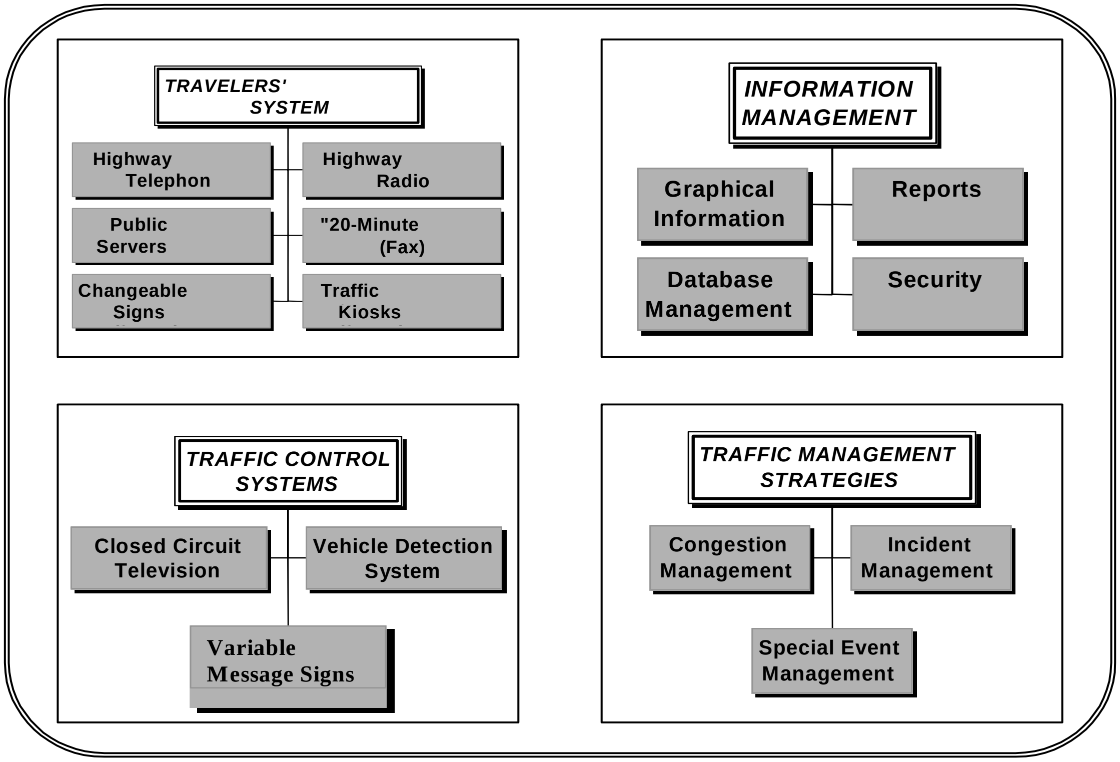


Figure C-4. Data Functional Element

Figure C-5 shows the major components of the Video Functional Element, which are the CCTV camera system; operator workstations, including video monitors and video function controls; large screen projection system; video switch; video multiplexor (mux); video recorders; and provisions for public and cable television video inputs.

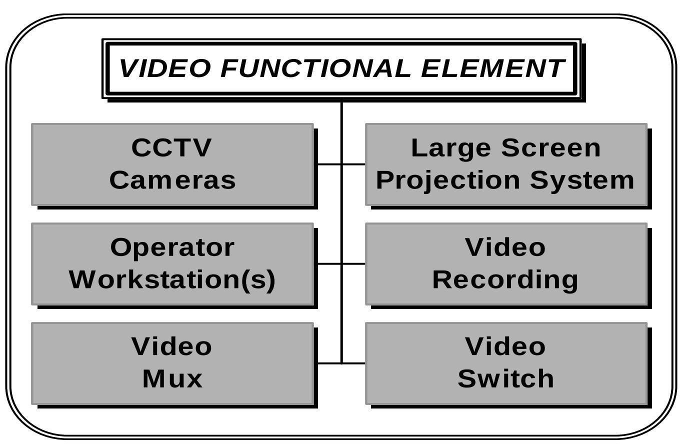


Figure C-5. Video Functional Element

VOICE ELEMENTS

This functional element provides the capability for telephone and voice communication between TMC personnel, public safety, transit personnel, highway maintenance crews, radio and television traffic information reporters, freeway service patrols, emergency dispatch centers, and various radio systems. This element also provides intra- and intercommunication voice for the TMC facilities.

The major components of the Voice Functional Element (as shown in Figure D-5) are:

- Operator workstation controls for voice circuit switching;
- Interfaces to a public or a Private Area Branch Exchange (PBX) telephone system;
- Interfaces to the Highway Advisory Telephone (HAT) system; and
- Radio systems

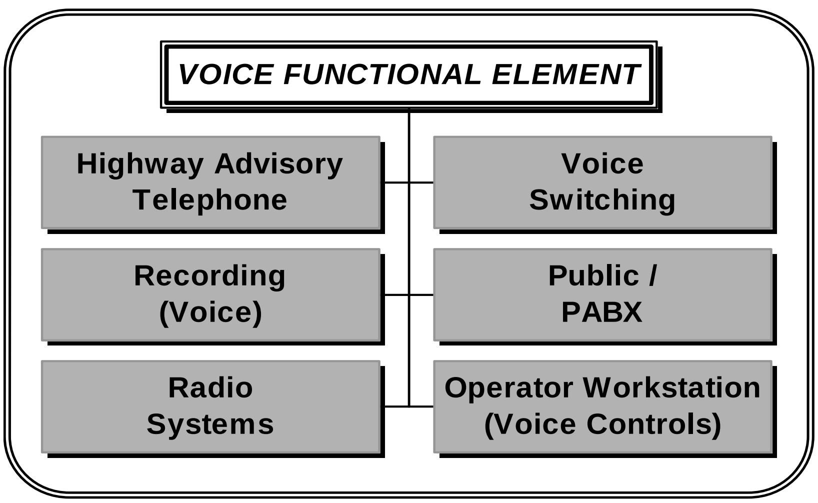


Figure C-6. Voice Functional Element

EXTERNAL INTERFACES

The final TMC design should also incorporate features that allow the basic system to be expanded to provide additional functional capability and/or to cover a larger region. This inherent expansion capability should also provide a means for interfacing with other independent systems, such as are being deployed in Region 10 and Region 11, in order that information of inter-regional significance can be shared. Anticipated external interfaces to the TMC include NYSDOT Regions 1, 10, 11: ConnDOT's Bridgeport Operations Center; NJDOT's North Jersey Operations Center; NYS Bridge Authority; TRANSCOM; I-95 Corridor Coalition; and various ISP's. External interfaces to the City of White Plains, Westchester County, BeeLine bus lines and other local transportation institutions are anticipated for the future. To the extent such external system interfaces are currently defined or their TMC interface requirements are known, planning for these interfaces should be accomplished at the final / detailed design stage. The National ITS Architecture Program's standards setting process has published a report for guiding these efforts. Entitled, *Center-to Center Communications Requirements and Issues*, this report should be referenced by system designers during the Hudson Valley ITS final / detailed design.

SUBSECTION C-3

CAD DATABASE INTEGRATION

One of the unique approaches of the Hudson Valley ITS is the dispatching of highway service patrols, known as HELP, using a computer aided dispatch (CAD) system that is integrated with the traffic management system. A project is currently underway to acquire a totally computerized dispatch system to facilitate the dispatching of service trucks to motorists in need and to incidents where they can be of assistance. The Hudson Valley ITS will integrate the HELP CAD system with the traffic management system by sharing data and alarms for notifying each system of incidents detected by the other system. As an incident is detected by the ITS and a report is being generated, data from the ITS operator's report will be transmitted to the CAD system to notify the dispatcher of the incident and any pertinent data that may be of assistance to the HELP driver. Conversely, incidents discovered by a HELP driver and reported to the HELP dispatcher will be transmitted to the ITS operator to facilitate their management of the incident.

As an incident as detected by the ITS, an alarm is triggered and a window is opened on the operator's workstation to allow the operator to begin generating a report. Data that has been designated to be transmitted to the HELP dispatcher is automatically packaged for use and transmitted to the CAD system connected to the same local area network (LAN). The data transfer triggers a window to pop-up on the CAD dispatcher's workstation, providing notification of the incident and of any pertinent details. A similar process in reverse, notifies the ITS dispatcher of any incidents of which the HELP dispatcher is aware. The HELP dispatcher will operate from the same room in the TMC as the ITS operator and will be able to see video feeds for monitoring the incident as it is serviced.

In addition to the integration of the data processing function of the HELP CAD and the ITS, dispatchers and ITS operators will have the ability to communicate directly to each other through the TMC telephone/audio system. Rather than yelling across the large room, the dispatcher may call an ITS operator directly at their workstation to more efficiently permit effective coordination of the incident management.

Regional coordination of HELP dispatch points will also be a major thrust of integrating the HELP CAD system into the Hudson Valley ITS. Communications channels for voice, data and video will be established between current HELP dispatch points located at NYSP Hawthorne, NYSP Somers, NYSP Monroe, Westchester County Department of Public Safety in Hawthorne, NYSTA dispatch in Albany, and the Interim TMC in White Plains.

SECTION D

SOFTWARE FRAMEWORK

SUBSECTION D-1

OVERVIEW

Quality software is the critical "glue" for enabling any successful integration of multiple related subsystems. Accordingly, it is significantly important to utilize a software framework that enables conformance to accepted standards while still maintaining appropriate flexibility to facilitate system growth in area, service and types of devices. It should also allow easy migration to newer hardware platforms and operating systems with minimal impact. In short, quality software will be the most visible manifestation of an operational Hudson Valley Intelligent Transportation System.

With this in mind, it is appropriate to recommend a framework based on the standard CORBA (Common Object Request Broker Architecture)-type software architecture, which advocates object oriented solutions that separate the network/communications functions of an application from the application itself. This environment provides the means of adding devices to an ITS without having to recompile software source code. Also, when used in conjunction with a concept that TRW calls *agents*, this environment enables one to use devices of a given class (e.g., CCTV camera, traffic detector, etc.) from multiple vendors, while still maintaining a "common-look-and-feel" for the user. For ease of discussion, the following sections will refer to this framework as the ATMS Toolbox.

The software used for the Hudson Valley ITS will be based on the ATMS Toolbox core software and may differ somewhat between the initial management center development and the final TMC software. For purposes of providing a means of bringing the initial Hudson Valley ITS on-line quickly with proven software, it is planned that an initial system based upon software currently managing incidents for the Louisville – Southern Indiana *TRIMARC* ITS program will be utilized. This is because the initial TMC corresponds well with the ITS developed for Louisville, KY in size and structure. Both the initial Hudson Valley ITS and the Louisville ITS manage approximately 12 miles of highway. The Louisville ITS communicates with field devices via telephone and wireless technology, as the initial Hudson Valley ITS is anticipated. The core software from the Louisville ITS will provide automatic incident detection, camera PTZ control, detection sensor operation, and video control. Since it is anticipated that some field sensors, VMSs, and cameras will be different from Louisville's system; new device driver agents will need to be written for these devices. This approach minimizes the need for developing all brand new software for the initial ITS deployment.

The final structure of the software for the Hudson Valley ITS will depend on the results of the definition of the software functional requirements and the systems engineering process. It is anticipated that most of the core software from Cincinnati's ARTIMIS system will be applicable to the final Hudson Valley ITS system. The ARTIMIS uses a SONET communication network and currently manages nearly 90 miles of highway in Southwest Ohio and Northern Kentucky. The Louisville and Cincinnati software is very similar, with differences being primarily in the communications technologies. The length of highway is not very important, but the size of the ARTIMIS ITS system demonstrates the expandability of the core software to provide regional traffic management as is planned for the Hudson Valley.

SUBSECTION D-2

APPLICATION ARCHITECTURE

The ATMS Toolbox software architecture is based on an architecture originally developed for intelligent network management concepts coupled with device diagnostics and device control methodologies applied to the domain of Transportation Management. It has evolved through the Expert Traffic Management System (ETMS) and Intelligent Traffic Management System (ITMS) Independent Research and Development (IR&D) projects of TRW Inc., and has matured via appropriate modifications/adaptations into the ARTIMIS (Advanced Regional Traffic Interactive Management & Information System) freeway traffic management system in Metropolitan Cincinnati / Northern Kentucky.

In short, this architecture was developed to better address:

1. The complexity, diversity, and lack of comprehensive standards for transportation-oriented monitoring and control devices and software systems;
2. Evolving standards for algorithms, operational concepts, and device and system integration requirements;
3. The extremely high cost of developing customized and integrated transportation management sub-components; and
4. The ever increasing demand for fully integrated and intelligent systems.

As illustrated in Figure D-1, this architecture is a collection of distributed object modules that are easily expandable and that model the transportation domain -- a software representation of how devices are logically connected and where they are physically located. Thus, this framework can provide a fully standard interface between defined devices and the ARTIMIS-evolved / ATMS Toolbox environment. What this means for the Hudson Valley ITS is that as additional communications capacity becomes available and/or as a variety of vendors might be used when purchasing future devices, TMC operators will not have to constantly re-learn new software. Instead, from the perspective of the user, this type of software architecture will enable them to work with a single "common-look-and-feel" graphical user interface (GUI) irrespective of the communications media being used or the manufacturers' protocol of a particular device being communicated with.

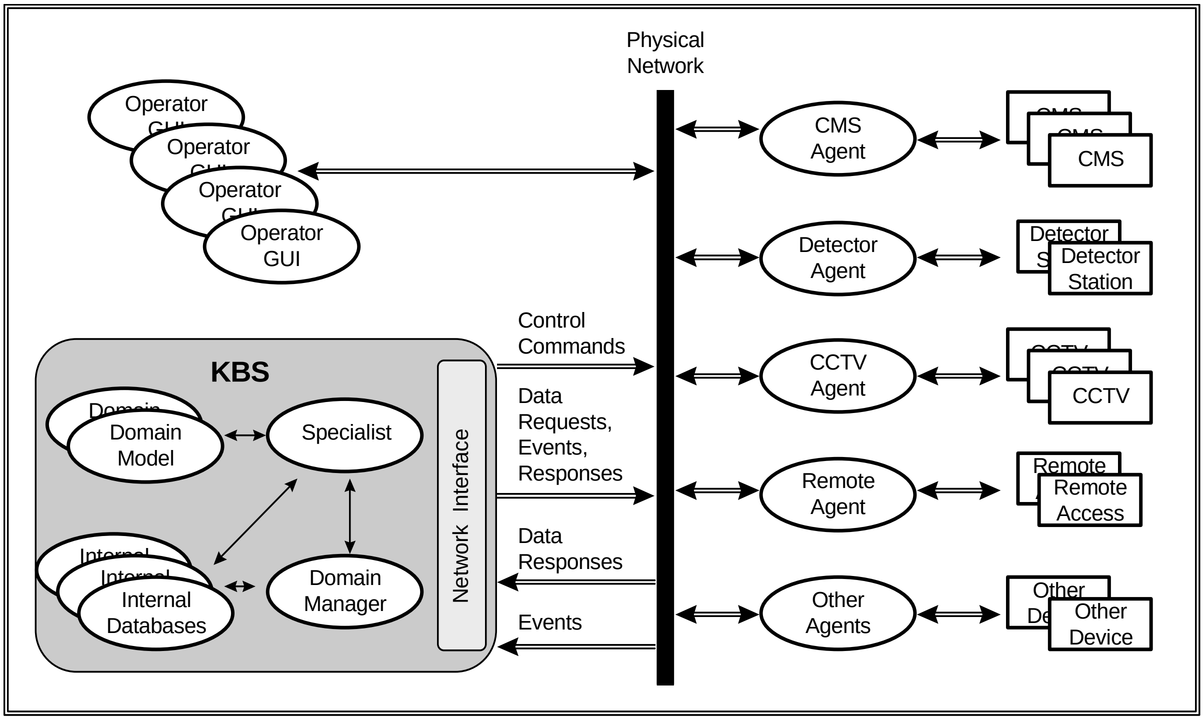


Figure D-1. Recommended Hudson Valley ITS Software Framework / Architecture

For example, standardized user interface screens associated with an object class such as *CCTV Control* will send a standardized message such as "Pan_Left" to an associated class-specific agent (see Figure D-2). Then, upon auto-linkage of the appropriate API (Application Program Interface) module via associations contained in the application's included Knowledge Base, said agent's vendor-specific poller / command implementor module sends vendor-specific commands such as "Open_Port, Start_Pan, Stop_Pan, Close_Port, etc." to the appropriate CCTV camera.

Similarly, this environment also standardizes the message protocol between a GUI application and each device agent (e.g., CCTV Camera, VMS, etc.). This enables one vendor's protocol for a given type of device to be simultaneously used (on a different communications channel) with a different vendors' protocol for a similar type of device. In fact said "agents" created within this framework are designed such that 90% of the interface code is reusable regardless of device type, and only 10% of the code may require future changes in order to integrate a proprietary protocol.

For example, the ATMS Toolbox architecture currently uses a message protocol that is based on a subset of the standard Simple Network Management Protocol (SNMP). Since the evolving National Transportation Communications for ITS Protocol (NTCIP) is also based on a subset of the SNMP, any agent modifications required to integrate future NTCIP-compliant transportation devices will be minimal. They are already nearly compatible as an inherent nature of this architecture – SNMP –, which is a superset of NTCIP.

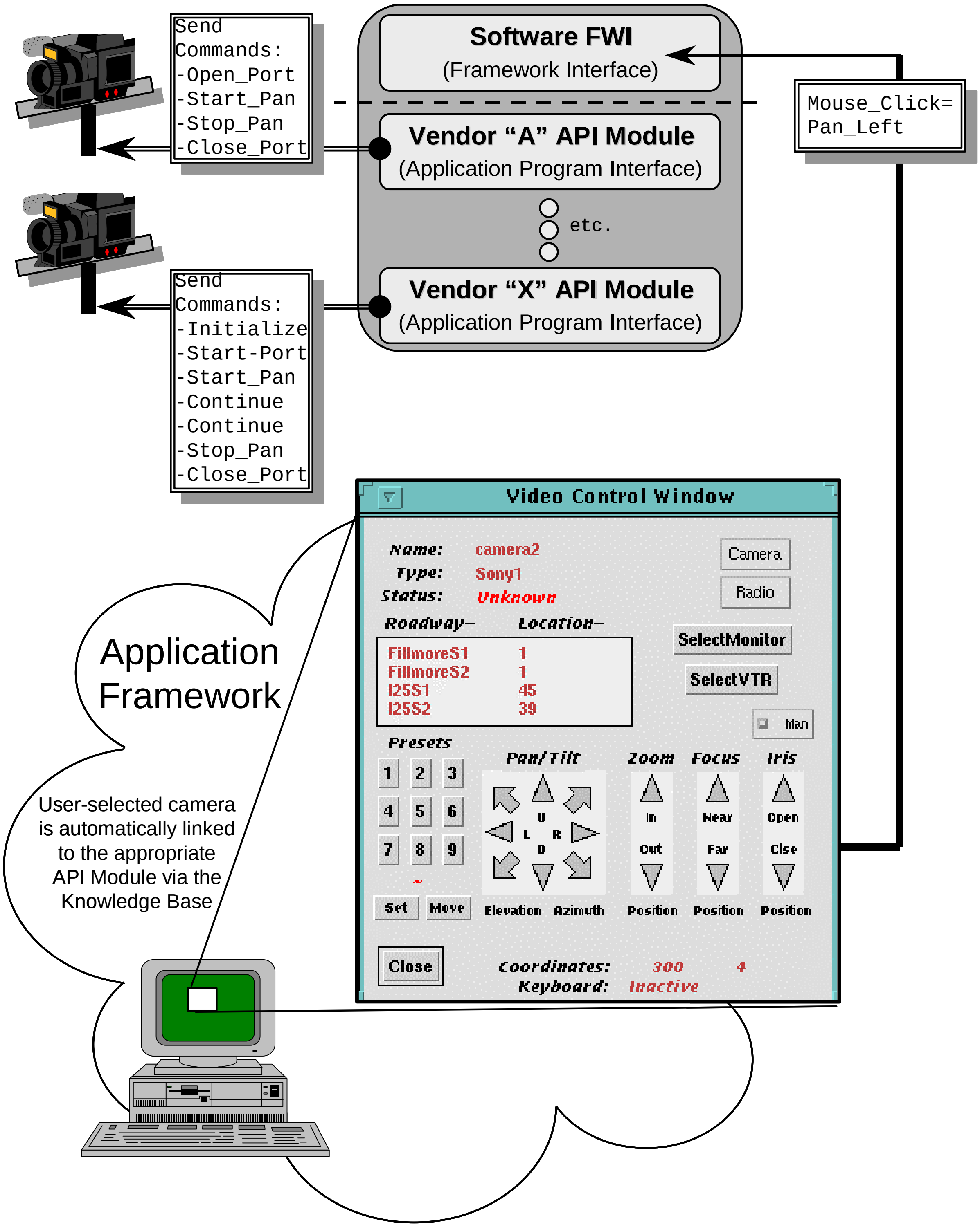


Figure D-2. Universal CCTV Control via Software Agents

As a further benefit to the Hudson Valley ITS, this environment enables a user to interactively add devices to the system by placing an icon representing the new device on the map display. Then, the user defines the new device on a map graphic and by entering details about the device, such as its name, type, etc. through a graphical-user-interface (see Figure D-3). From the location of the icon and the information entered onto the screen, the system automatically populates the traffic domain model at a low level with objects representing the traffic devices placed on the map, complete with their inherited attributes and associations to other objects.

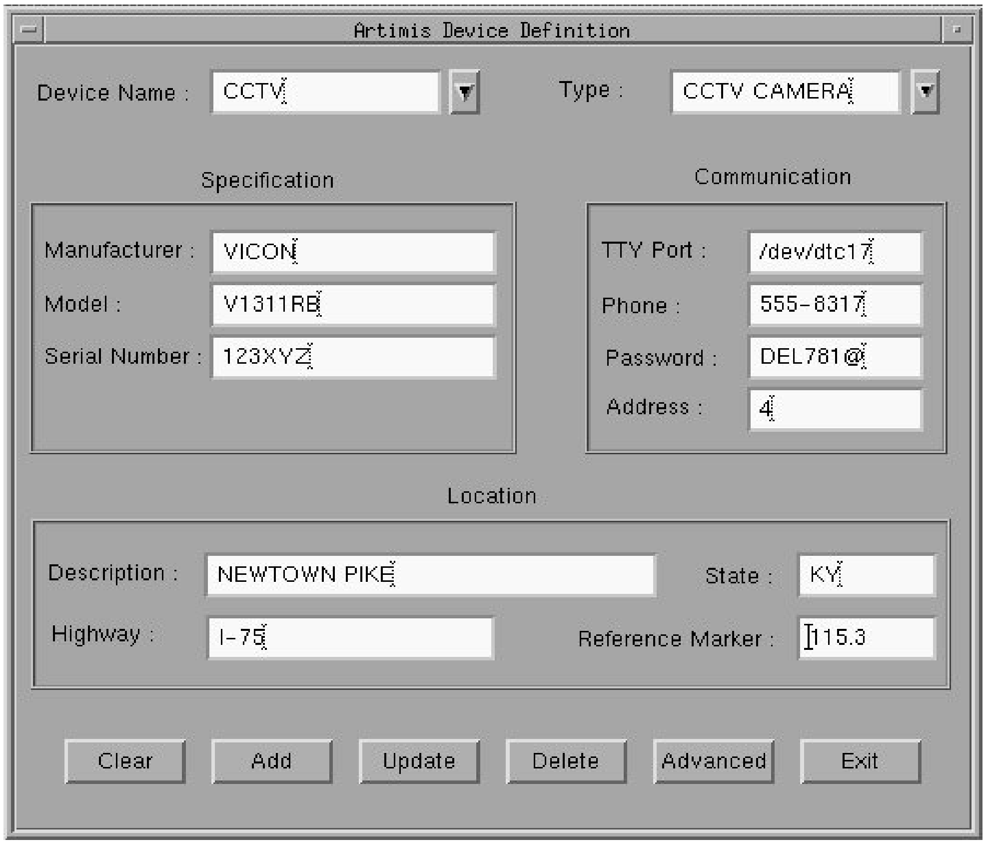


Figure D-3. Sample Device Definition Screen

For example, if a municipality installs a new detector along a freeway, the Knowledge-Base Builder enables a user to connect the new detector to the system by dragging and dropping a detector icon to the appropriate location on the map graphic. The user then completes the definition by entering information about the detector through a graphical-user-interface screen. From the location of the detector icon and the information provided through a screen, the application automatically connects the detector to all other transportation components and devices controlled by the transportation center, such as pollers and message signs. From then on, the system "knows" that there is a new detector providing traffic data, and the detector is placed on-line almost immediately. It is then able to receive and output data without any software development or system integration effort performed by a human. An interface for controlling the detector is also automatically created by the system the first time an operator selects the detector for control.

SUBSECTION D-3

TOP-LEVEL OPERATIONAL CHARACTERISTICS

BACKGROUND

As indicated above, the ARTIMIS-evolved / ATMS Toolbox framework was created as an alternative to archaic, expensive, proprietary, and hard-to-modify transportation systems. It addresses the increasing needs of state and local transportation managers to maintain their own systems. It also provides a user interface that is intuitive and easy to use; relying on point-and-click mouse operations and built-in help. This approach to software also provides the capability to modify transportation systems in a fraction of the time it takes to update and modify conventional systems. This is accomplished by providing the templates, patterns, and traffic domain models already defined and ready for population, thus reducing the amount of time required for new system development. Furthermore, prior creation of objects reduces the amount of newly developed code required for each system implementation. As such, custom software development is minimal because the object-oriented design replaces much of the burden of custom software design. The following builds upon this technical framework and highlights examples of some of the more frequently used types of graphical-user-interface screens.

SAMPLE USER INTERFACE SCREENS

As depicted in Figure D-4 from the ARTIMIS freeway incident management system, the software environment is based on a graphical user interface that has as its highest levels a fully zoomable areawide map depicting items such as CCTV camera sites, Variable Message Sign locations, construction work zones, etc. In addition, these top-level screens also have Windows®-type drop-down menu bars and "shortcut" buttons for selecting a variety of system reports, monitoring actions, and device control functionalities.

For example, whenever an operator wishes to control a particular CCTV camera, they simply use their "mouse" to "click" the map icon corresponding to the location of the desired camera. Then, the software automatically makes necessary connections to the chosen camera (including the "turning-off" of any conflicting cameras on shared channels), and display the software's CCTV control window in a manner appropriately configured for the camera (see Figure D-5). Alternatively, if a particular camera had special vendor-specific functionalities, then the software would display a similar GUI that included all additional options (see Figure D-6).

In a similar manner, TMC operators can bring-up video control functions for automatically performing functions such as:

- Selecting which video image is to be displayed on a particular TV monitor, large-screen display, and/or in a multiplexed (quad-combined) format (see Figure D-7);
- Controlling which video images to be recorded onto any connected video cassette recorders (see Figure D-8); and
- Determining how often multiple cameras are sequenced such that their images are displayed on a single TV monitor, when desired (see Figure D-9).

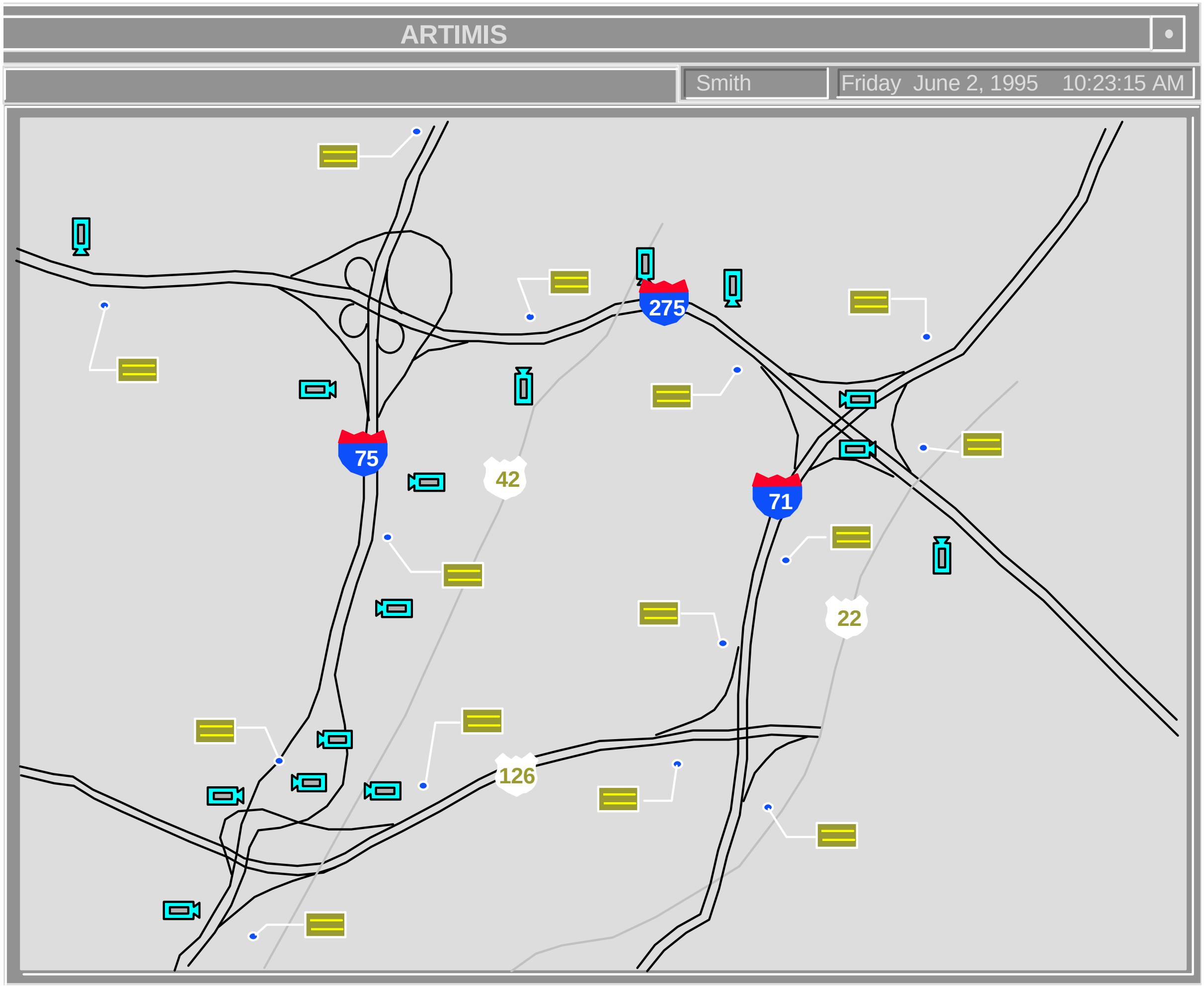


Figure D-4. Sample Top Level Graphical View of Connected Devices

Figure D-5. Sample TMC Operator CCTV Camera Control Interface

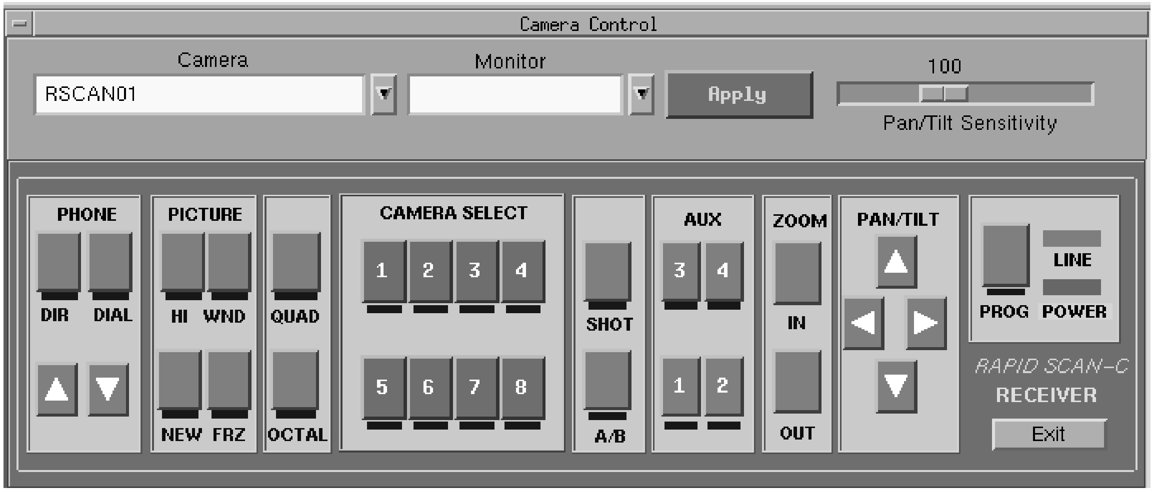


Figure D-6. Sample CCTV Interface for Cameras with Additional Capabilities

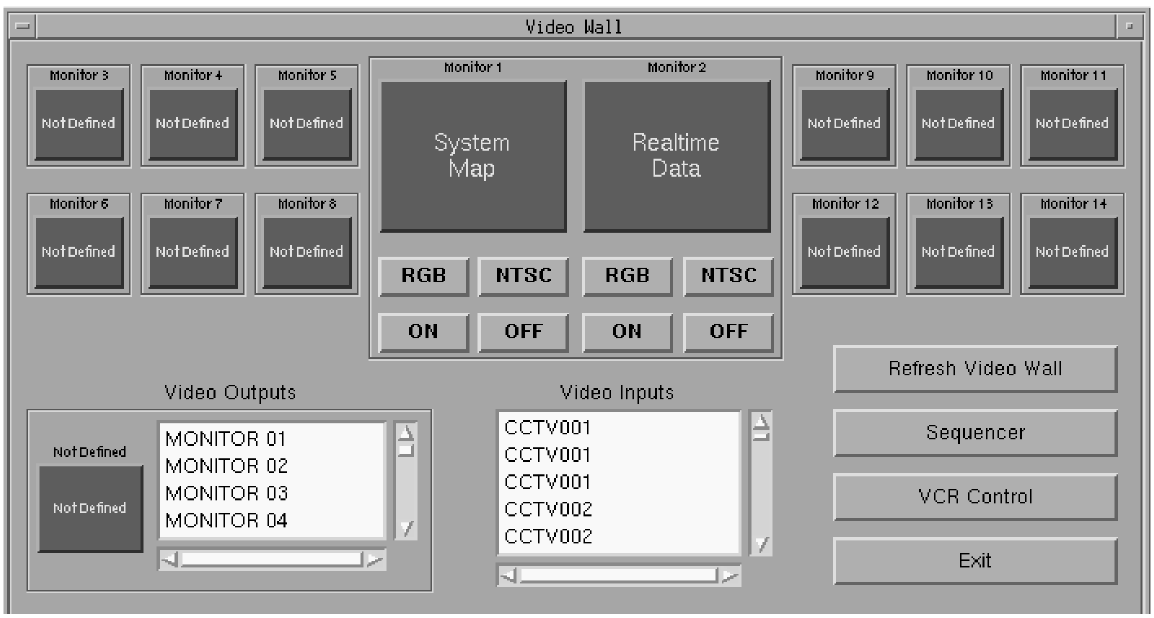


Figure D-7. Sample User Interface for Video Monitor Selection and Control

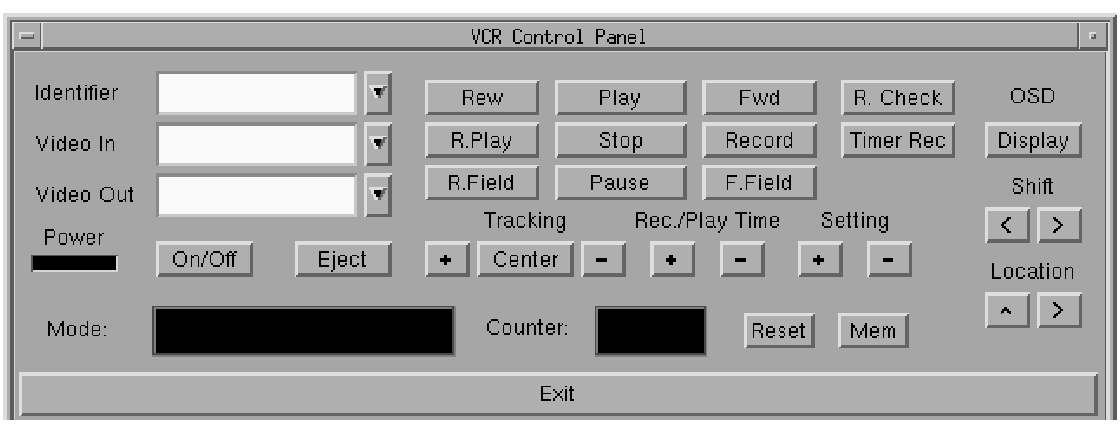


Figure D-8. Sample User Interface Screen for VCR Control

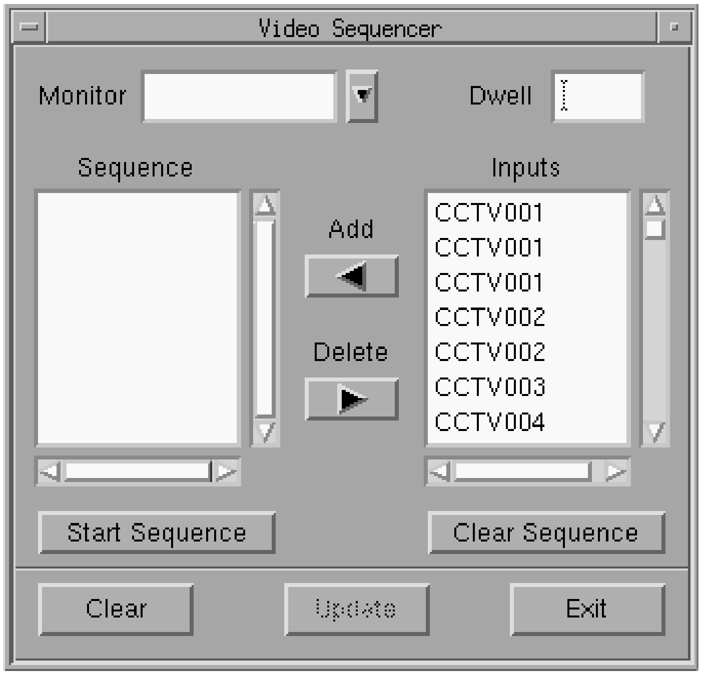


Figure D-9. Sample CCTV Camera Sequencer User Interface

This simplified control method, based upon system operators "pointing" and "clicking" desired devices shown on a system map, is also used for organizing and monitoring information that is placed on variable message signs (see Figure D-10 and Figure D-11). It is also used for keeping track of lane closures such as those associated with construction projects, etc. (see Figure D-12).

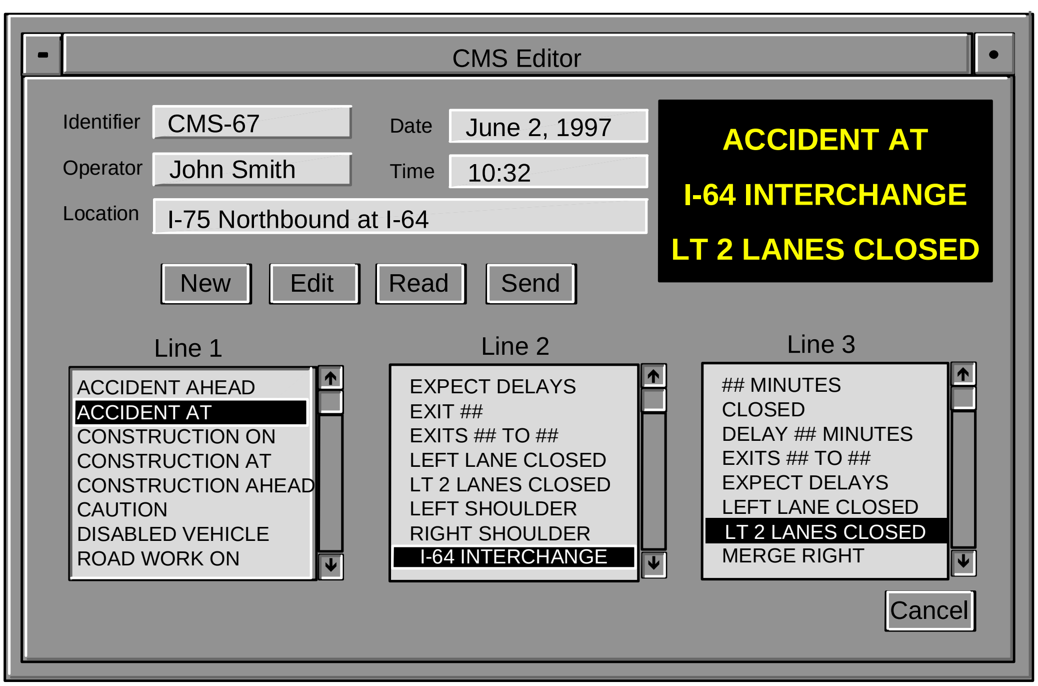


Figure D-10. Sample Editor for Controlling Variable Message Signs

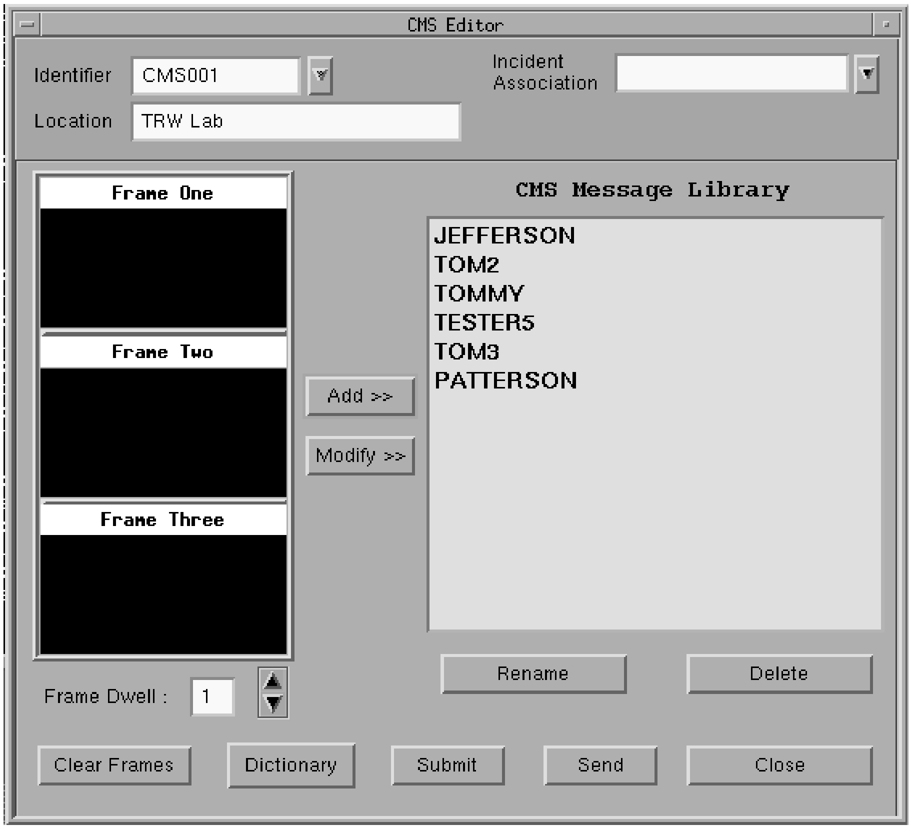


Figure D-11. Sample Editor for Linking Pre-Selected Variable Message Sign

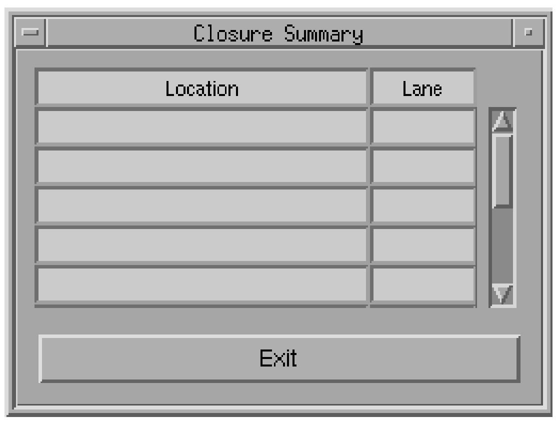


Figure D-12. Sample User Interface for Tracking Roadway Lane Closures

Finally, in illustrating how operators could more easily send traffic FAX reports from their word processors directly to a networked FAX server in a manner similar to printing to a printer, Figure D-13 presents a sample Microsoft Word® "Print" window that has been configured for printing to a FAX server. Likewise, Figure D-14 illustrates a sample FAX recipient group configuration screen. This type of screen could also be used for sending traffic reports via the Internet (e-mail addresses would replace phone numbers on the screen) so that traffic information could be distributed to multiple registered recipients all at the same time.

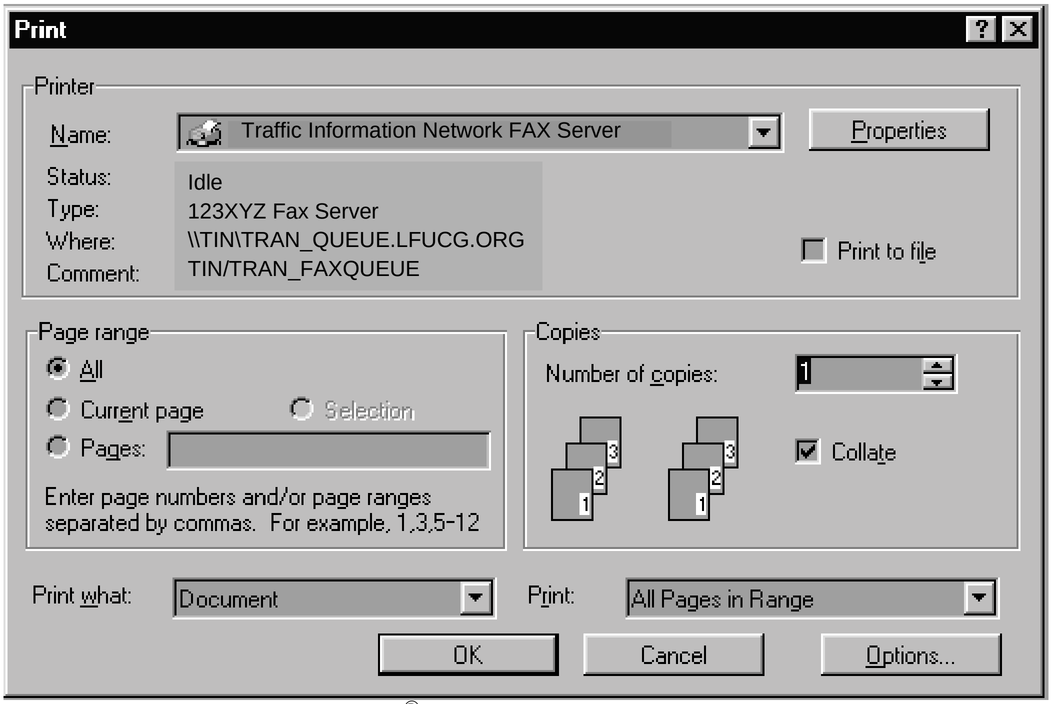


Figure D-13. Sample Microsoft Word® Print Window Configured for A Networked FAX Server

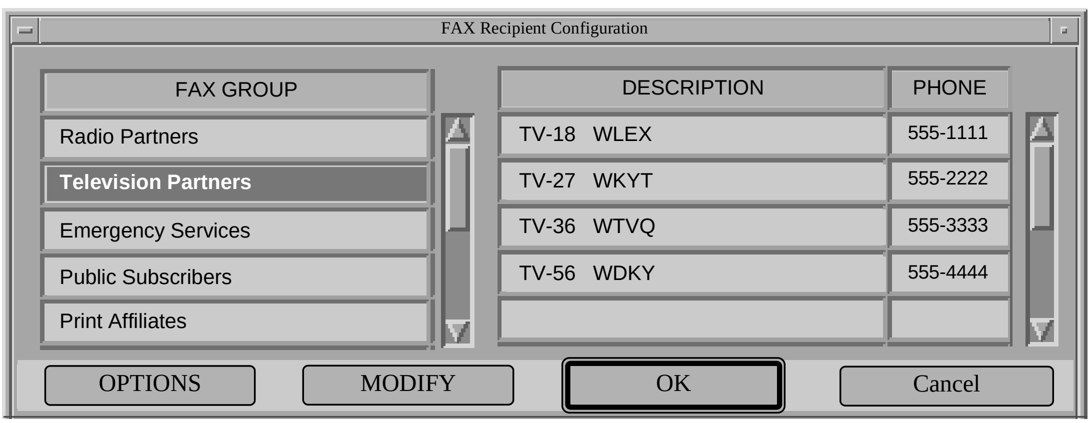


Figure D-14. Sample FAX Recipient Group Configuration Screen

A number of other functions found to be useful, have also been programmed into the TMC software framework. This includes items such as an integration of real-time data from traffic flow detectors, automated incident detection, consolidated real-time incident reporting / response initiation. It also provides the ability to pre-program various special events into an integrated database for more automated distribution of relevant information during those hours that the TMC might not be regularly staffed. To this end, the following paragraphs and associated figures illustrate how the ARTIMIS-evolved/ATMS toolbox software framework can also integrate these features within the same context as the earlier presented common-look-and-feel screens of a PC-based graphical user interface. For example, Figure D-15 on the following page illustrates how real-time data from connected traffic detectors may be viewed as associated trend-lines within the ATMS toolbox software environment.

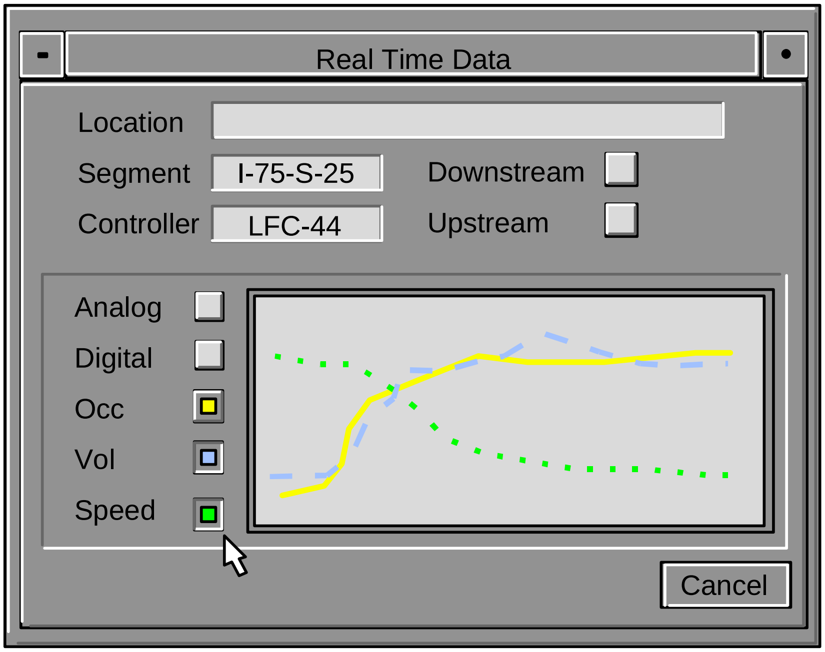


Figure D-15. Sample Detail View of Real-Time Data from A Connected Traffic Detector

Similarly, it might be desired that the data from multiple detectors be summarized and displayed on a zoomable map. Figure D-16 illustrates a way in which this information may be viewed such that different colors would represent the intensity of associated real-time traffic congestion for a particular segment or for a larger geographic area that system operators might be monitoring

If the thresholds that associate each of the map colors of Figure D-16 were desired to be modified such that they displayed different degrees of traffic operational efficiency (e.g., speed, volume, occupancy, level of service, etc.), a user interface similar to what is illustrated in Figure D-17 can meet the need. The operator establishes the threshold level at which it is desired for each map color to change. For example, in D-17, the map roadway in this sector will remain green as long as the average traffic speed remains above 35 MPH. The roadway of that sector turns yellow when the average speed falls to less than 35 MPH but is greater than 25 MPH. The roadway turns red for average speeds below 25 MPH. In fact, screens similar to these can also be used to help calibrate automated incident detection algorithms and to link their output with color-coded maps.

For incidents, an operator interface such as is shown in Figure D-18 provides a means of inputting, maintaining, and managing desired information as it occurs. This allows engineers and planners to have much more comprehensive information when performing routine traffic analysis or when evaluating and prioritizing projects as part of proposed future geometric safety improvements. A similar form may also be used for queuing the database for purposes of tracking all active incidents.

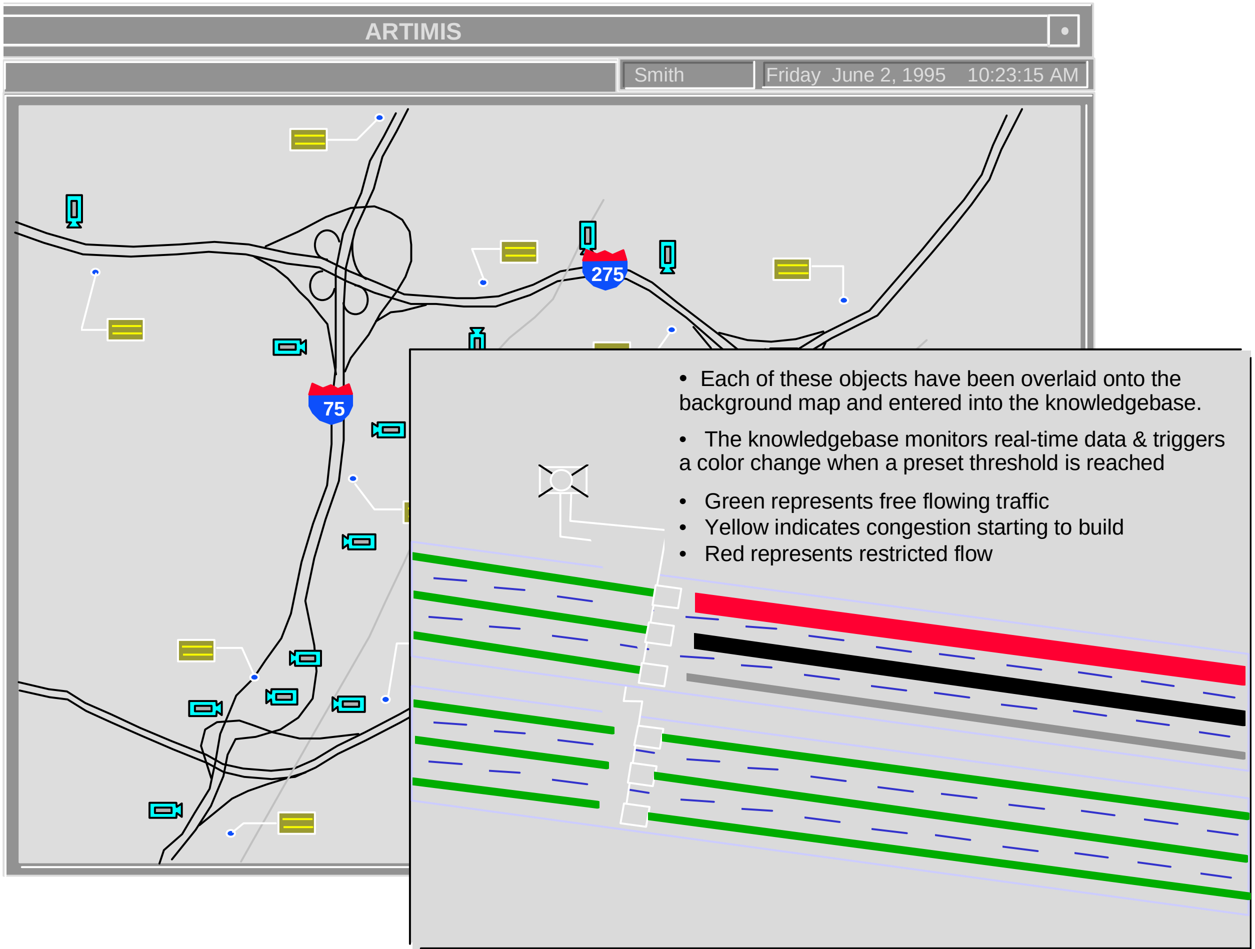


Figure D-16. Sample Screens Displaying Color-Coded Maps of Real-Time Traffic Congestion

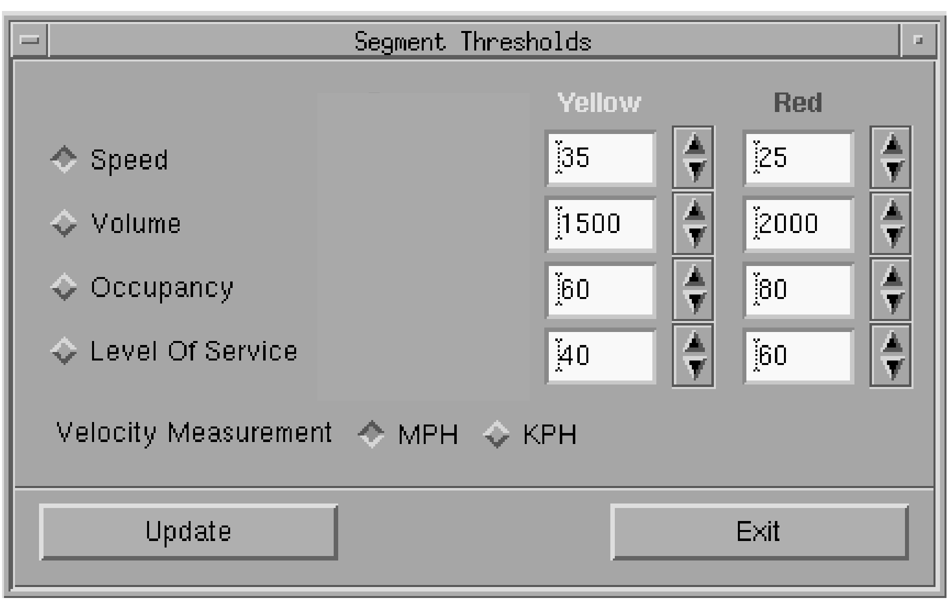


Figure D-17. Sample Screen for Editing Thresholds When Displaying Color-Coded Maps

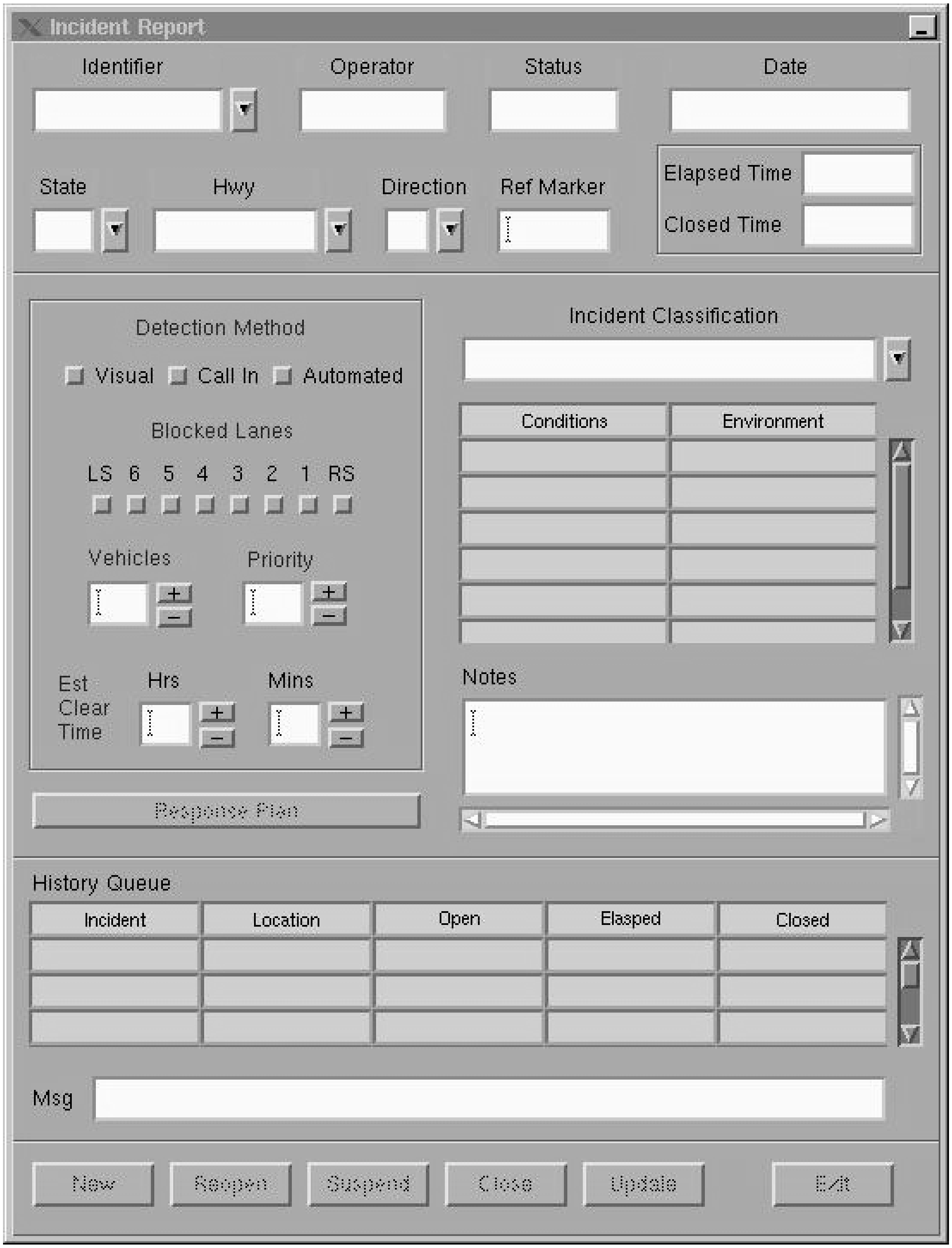


Figure D-18. Sample User Interface for Reporting and Managing Active Incidents

Having detected an incident through the automatic detection algorithms, an "intelligent" response plan screen (see Figure D-19) may be made to "pop-up" providing a checklist of tasks for the operator to perform. Then, the operators can more efficiently and effectively perform predefined responses (e.g., notify proper ambulance, notify proper police office, etc.)

based upon where, when, and of what level of severity described the given incident. As an additional feature, "time stamps" may also be automatically entered into appropriate data fields each time an applicable response element is completed by a TMC operator and/or whenever relevant information is automatically transmitted to a TMC operator via software links from the computer aided dispatch (CAD) system to the core ATMS software. With this precise and consolidated information, system management may utilize the resultant database for purposes of more easily quantifying the system's benefits (e.g., faster emergency response times and potential lives saved, quicker re-opening of blocked lanes, etc.) and for more comprehensively justifying operational costs and capital expenditures for any necessary future system expansions.

Figure D-19. Sample "Intelligent" Response Plan User Interface Screen

Finally, as illustrated in the sample screen of Figure D-20, system operators may desire to have similar-type interface screens for more easily pre-programming a variety of automatic response scripts for use during scheduled special events and/or scheduled construction closures in the area being managed. This is an especially beneficial feature for improved traffic operations during those times that events or construction has been scheduled to take place outside of the TMC's normal operating hours.

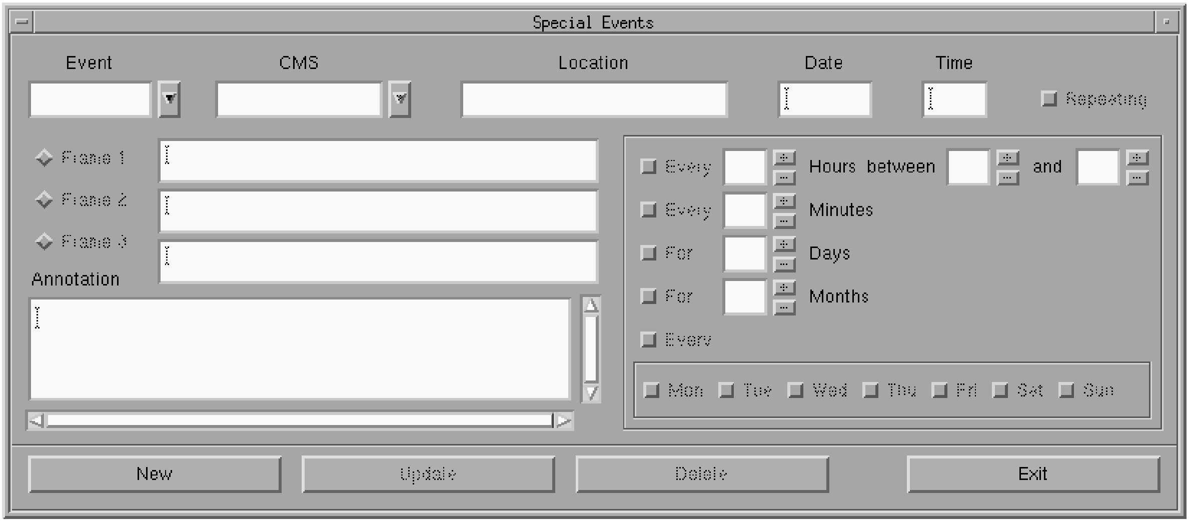


Figure D-20. Sample User Interface for Pre-Programming Responses To Special Events

Plans for the Hudson Valley ITS also include integration with predictive-type dynamic traffic assignment simulation software for enhanced VMS control, and integration with areawide computerized traffic signal system software for TMC-based traffic signal control of predefined routes along the area's highways to facilitate diversion of traffic to arterials when required. Software will be added to the core ATMS software as described above to allow the operators to select an appropriate route and timing plan based on the time of day, state of traffic, and condition of the arterials at the time of the needed traffic diversion. The Hudson Valley ITS, through coordination with the Westchester County and cities involved in the diversion routes, would initiate control of the traffic control signal timing plan, based on predefined plans, until the incident creating the diversion is cleared.

SUBSECTION D-4

SUMMARY

The software framework described for the Hudson Valley ITS provides a mature/proven means for integrating all desired subsystems and eliminates the need to otherwise have multiple workstations – each dedicated to one subsystem. Instead, multiple workstations may be added, each with the same capability and not dependent on manual input from a differing workstation. In addition, control and monitor capabilities for the VMS, Video Surveillance, and system data collection stations are available simultaneously at multiple remote locations (if desired) with proper access authorizations. Furthermore, the framework's object-oriented and knowledge base approach to generating responses to observed events (e.g., exceeding data thresholds, changes in operational status, or loss of communications, etc.) enables the system to automatically execute all associated services. Similarly, device commands and control for both proprietary and NTCIP-compliant devices (as well as SNMP-compliant communications devices) is readily available and inherent in this intelligent software infrastructure and basic systems architecture.

In short, the TRW ATMS Toolbox software application envisioned for the Hudson Valley ITS provides:

1. Device integration using standard interfaces fully compatible with SNMP, NTCIP, and other protocols that may be provided;
2. Device monitoring and control under one common graphical users' interface using a standard set of control windows, pull-down menus, push-buttons, mouse activated icons, and a configurable knowledge-base;
3. A fully functional and distributable object-oriented knowledge-based system that associates devices, device locations, device data, device control, roadways, roadway attributes, and analysis and response methodologies with observed events; and
4. A systems approach that can contain an intelligent infrastructure capable of implementing response strategies automatically, or by operator request and approval.

SECTION E

HARDWARE FRAMEWORK

SUBSECTION E-1

OVERVIEW

This section describes the hardware framework for the final Hudson Valley ITS. The architecture for the interim system will be very similar, but will not include a fiber optic communications system in the field. Section B provides more details on the Interim System and the phasing of installing the Interim and Final systems based on the reconstruction of the Cross Westchester Expressway and the installation of ITS equipment on other routes.

The Hudson Valley ITS architecture is comprised of multiple subsystems that in most cases are tightly integrated. Figure E-1 depicts a simplified System Block Diagram showing the basic functions of the system with interfaces between the subsystems. Details of the system will be developed in the preliminary and final design documents. Towards this goal, the following subsections provide highlights of the primary subsystems of the Hudson Valley ITS.

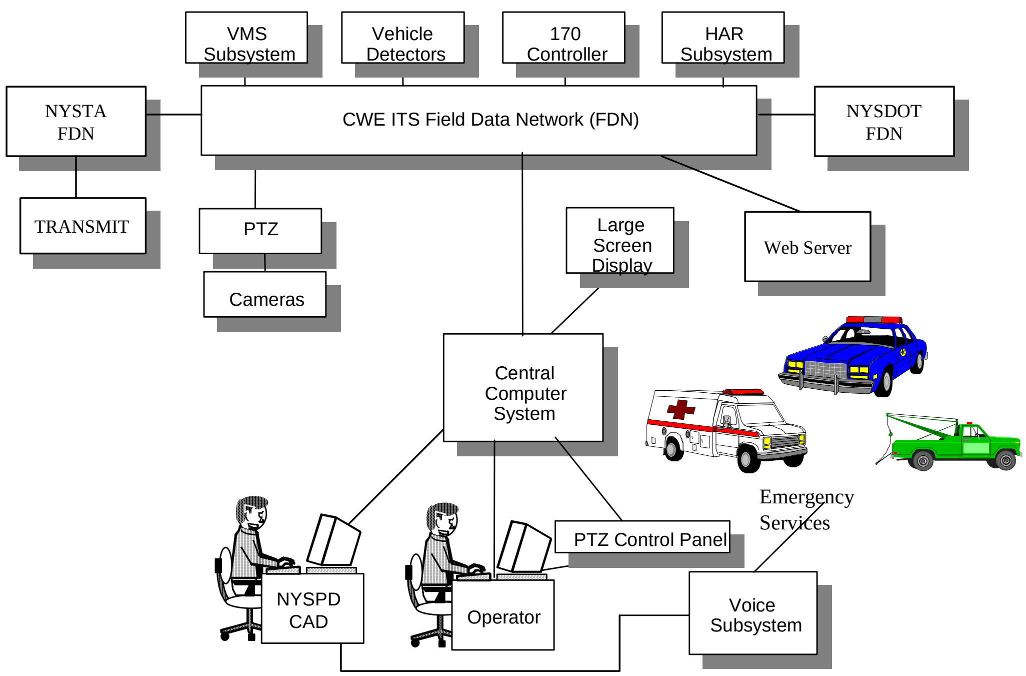


Figure E-1. Hudson Valley ITS Hardware Framework Overview

SUBSECTION E-2

CENTRAL COMPUTER NETWORK

The Central Computer Network, which includes the central computer server and its peripheral devices (e.g. system console & printers) is the heart of the freeway incident management system. Of primary importance, is the central computer server, which hosts the application software that analyzes data from the field data sensors for detecting and alerting the TMC operators of traffic events. It also hosts associated databases for storing desired information. The server also allows TMC operators to send commands to various TMC devices such as the video matrix switch, as well as to electronically linked "other" TMCs.

Figure E-2 illustrates the conceptual Interim TMC central computer network, which is structured to meet the needs of an initial field environment that will not yet have fiber optic communications installed. Incorporated is a central processor working as a server, with networked links to client workstations for operator interface to the system. An Ethernet 100 Base-T will provide communications within the initial TMC, whereas a communications server provides the interface to the field sensors and VMS via a wireless Cellular Digital Packet Data (CDPD) network. It must be emphasized that the above should be only be considered a conceptual plan, since further design tradeoffs must still be performed as part of later more detailed design phases, prior to finalizing this initial approach and/or purchasing specific equipment.

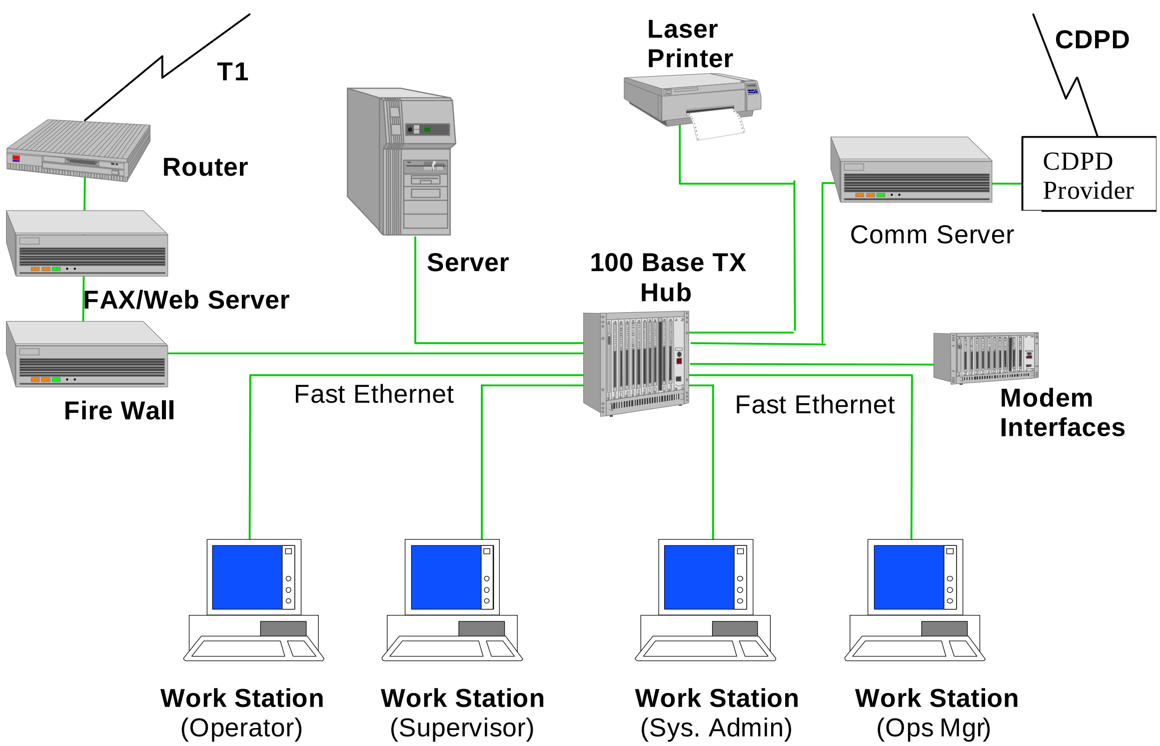


Figure E-2. Initial Hudson Valley ITS Central Computer System Concept

As alluded to above, the central computer network is planned flexibility, since the final Hudson Valley ITS will need to accommodate expansion to the system as well as the higher speed fiber-optic communications system from field sensors. It should be noted, though, that operation of the final system will be the same as the operation of the Interim TMC due to the flexible software framework of the core ATMS software (see Section D). This enhances operator competency by allows them to train and become familiar with the ITS operations that they will be using in the final TMC, prior to actually moving into the final TMC. True, planned utilization of fiber optic communications will require additional skills for the system administrator, but this technology will remain transparent to the traffic operations personnel.

In short, customer functional requirements for the ITS will greatly affect design & development of the central computer network – a key element of the total ITS. As such, careful analysis of the customer's needs and operational preferences in the Interim TMC will be performed to evolve this hardware framework for the final Hudson Valley ITS. This will also help mitigate the rapid progression & obsolescence in technologies for computer systems; thus ensuring that up-to-date systems are always installed in the TMCs. Accordingly, all computer systems for the Hudson Valley ITS will be specified to provide the most technologically advanced processors and accessories available at the time of the acquisition.

SUBSECTION E-3

OPERATOR WORKSTATION CONSOLE

TMC operators will perform their daily tasks of managing the highway environment from an Operator's Workstation Console. It is anticipated that workstation positions for the initial & the final system will contain the same hardware, with additions as necessary to meet expanding roles of the final TMC. Each console will be equipped with a high performance computer workstation for the analysis & display of highway traffic data. Two high resolution color graphics monitors will display highway representations detailing the location of sensors, cameras, communication equipment, and VMSs, and in a manner that enables the operational state of the devices to be color coded. Portions of the highway system that are not currently being monitored by detectors will also be displayed to facilitate the marking of incidents and construction activities. Information regarding these roadway segments will be integrated with the advisory system (HAR & VMSs). The operator can display detail data for monitored highway lane segments, which includes vehicle volumes, speed, & occupancy for selected time periods. Through the use of pop-up work areas the operator will be able to input data relating to incidents (i.e. detection method, type of incident, projected resolution time, actual resolution time, etc.). Approved response plans will be presented to the operator for action. The console will support automatic on-screen viewing of video feeds from the field upon incident detection, or on-demand by selecting the camera icon that is to be viewed. The operator will also be able to control the selection of cameras & monitors from the console video panel as well as control camera pan, tilt, & zoom. Communications with other operators & various external agencies will be through the headsets and communications control panel at each console. The control panel will facilitate rapid linking of the operator with the appropriate agency or HAR transmitter.

Display ergonomics of each operator’s console will also allow multiple incidents to be more easily managed concurrently through the Incident Queue. The Incident Queue is displayed on one of the monitors at an operator's console and on the large screen displays. The operator's queue contains entries for all incidents that are currently active and for which the operator has responsibility. Those incidents which have been routed to the operator's incident queue, but which the operator has not yet performed incident classification on, are displayed first in the queue, followed by other active incidents that have already been confirmed by the operator. The incidents in each category (unconfirmed and active) will be listed in order of severity and priority. When an operator terminates an incident, the incident is removed from the queue. An operator may select any incident off of the incident queue list. If the operator selects a previously unconfirmed incident, the operator will be placed into the incident classification operation. If the operator selects an active incident, the operator will be placed into the incident management operation. Incidents that remain unattended in the queue will automatically increase in priority to assure visibility to both the operator and the TMC supervisor.

SUBSECTION E-4

CONTROL CENTER COMMUNICATIONS

As indicated in Figure E-2, communications among TMC devices within the Control Center, both at the initial and at the final TMC, will be provided by a local area network (LAN) operating at a minimum of 100 MBPS. Furthermore, though the initial system will interface to field devices via a CDPD network, it is anticipated that the final ITS system will use a communications server to interface between the internal TMC network and the fiber optic network, which will be utilized to provide communications to/from field devices. Finally, in addition to the LAN supporting communications between the Central Computer Server, Operator Workstations, Control Center Large Screen Display, system peripherals, and the video matrix switch, the LAN will also support realization of other communication-related elements, which are detailed in the following paragraphs.

NETWORKED FAX CAPABILITIES

In enabling TMC operators to send traffic condition and incident FAX reports without having to first print a copy and then manually feed it into a traditional FAX machine, the envisioned Hardware Control System Design (see Figure E-2) includes a FAX Server Device that is connected directly to the TMC LAN. In doing so, this device becomes an addressable port with an associated “fax queue” (similar to a “print queue” on a networked laser printer). This allows the control center operators to send a fax by a “print to fax” from existing software (e.g., Microsoft® Word) instead of printing to a printer. Furthermore, to enable operators to send said faxes to multiple recipients at once, appropriate software will also be included for purposes of easily setting-up calling groups such that one fax can be automatically distributed to multiple radio and TV stations, etc.

INTERNET ACCESS

The envisioned Hardware Control System in Figure E-1 also illustrates existing connectivity for the Hudson Valley ITS Web Server. Similar to the earlier described addressability of a "fax queue", TMC operators can connect to the Hudson Valley ITS Web server from their workstation via the TMC's Local Area Network. They can then send automated e-mail traffic updates to multiple recipients and/or place desired information on appropriately linked Traffic Engineering / Hudson Valley ITS Internet "Web Pages".

FILE SHARING

The Hudson Valley ITS Hardware Control System provides for the TMC operators and associated control center personnel to have password controlled access to each others' common use data files and/or network software without having to physically work from another person's PC-workstation. The envisioned Hardware Control System in Figure E-2 also includes a TMC-dedicated network file server on the Hudson Valley ITS' LAN. Furthermore, upon integration of system loop detectors and/or other similar devices, this file server can also act as a central data repository for such planning/analysis-related information.

SUBSECTION E-5

TRAFFIC SURVEILLANCE AND CONTROL

Traffic Surveillance and Control elements are comprised of multiple subsystems that include video and sensors for surveillance, and highway advisory radio and variable message signs for control. It is anticipated that traffic surveillance and control for both the initial and final system will be essentially identical, with the exception of their communication network. As mentioned previously, the initial system will use telephone or wireless communications interfaces to the devices in the field; whereas, the final system will communicate with these devices via the fiber optic communications network. As the fiber optic system is completed, each device will be interfaced to the fiber optic system and the communications service used initially will be terminated. For completeness, the following paragraphs briefly describe the functions and characteristics of each associated subsystem.

VIDEO SUBSYSTEM

The Hudson Valley ITS Video Subsystem consists of remotely controlled cameras located along the roadway with pan, tilt, and zoom (PTZ) receivers, video monitors primarily housed at the Hawthorne TMC facility, a video matrix switch, and PTZ controllers mounted at the operator's console. The video system will utilize installed fiber optic for full motion video, or leased telephone system services for compressed video transmission and other wireless transmission technology services that may be appropriate to deliver video images from the field to the control center. A video matrix switch will also be included to allow any camera to be displayed on any monitor, combination of monitors, or area of large screen displays. The switch will be modular to facilitate growth in the number of field cameras and facility security cameras.. The switch will also be able to rotate through a predefined sequence of cameras to defined monitors during normal operation, and will control the video feeds to the various external agencies and the media. Finally, as this will be a microprocessor-controlled switch, the Central Computer System will be able to issue commands to the switch to automatically focus cameras to the general location of suspected incidents detected by the field sensors. TMC operators will then be able to "fine-tune" control the PTZ from their local control panels.

VARIABLE MESSAGE SIGN CONTROL

As indicated in Figure E-1, the envisioned Hardware Control System will enable LAN-connected and appropriately password-authorized control center personnel to access and control existing (and future) variable message signs (VMS) such as those that are currently used by NYSTA to notify motorists of traffic incidents and weather conditions. This is accomplished via installation of appropriate software on each control centers' PC-workstation that allows the operator to choose a sign or group of signs, and to specify either a predefined message for display, or to generate a new message for proper approval and ensuing display. Each selected approved message is then routed to the proper VMS(s) over the ITS LAN to each signs' field controller hardware device, which issues the proper commands for the sign to display the desired message to the public. The VMS control software will also include access to, and control of portable VMS assets so that control of the portable VMS units will maintain a "common look and feel" user interface as those used by operators for the stationary VMS.

HIGHWAY ADVISORY RADIO

Highway Advisory Radio (HAR), owned and operated by the NYSTA, will provide traffic information, highway construction advisories, on-site disaster incident management, and local emergency notification. Multiple HAR stations are strategically located in such a way as to allow synchronized messages to be broadcast throughout the Lower Hudson Valley. The HAR system will provide near-real time information on the state of the Hudson Valley and its feeder routes during operational hours. When the TMC is unattended, other valuable traveler information will be broadcast such as on-going construction activities or special events that may impact traffic during these off-hours. Advisory signs with attached flasher devices will be placed throughout the system. The flashers local to an incident will be activated to notify motorists of a current HAR message providing pertinent information. Since operating frequencies for the HAR service are strictly regulated by the Federal Communications Commission, any new HAR stations added to the area network will likely need to transmit on the same frequency as the existing HAR stations. Supplemental portable HAR stations will also be integrated into the Hudson Valley ITS to allow quick HAR set-up and operation in the area as required. The TMC will communicate with the portable HARs via wireless technology, either cellular modems or CDPD. Operation screens on the workstations in the TMC will have a same look-and-feel as the control screens for the permanent location HARs.

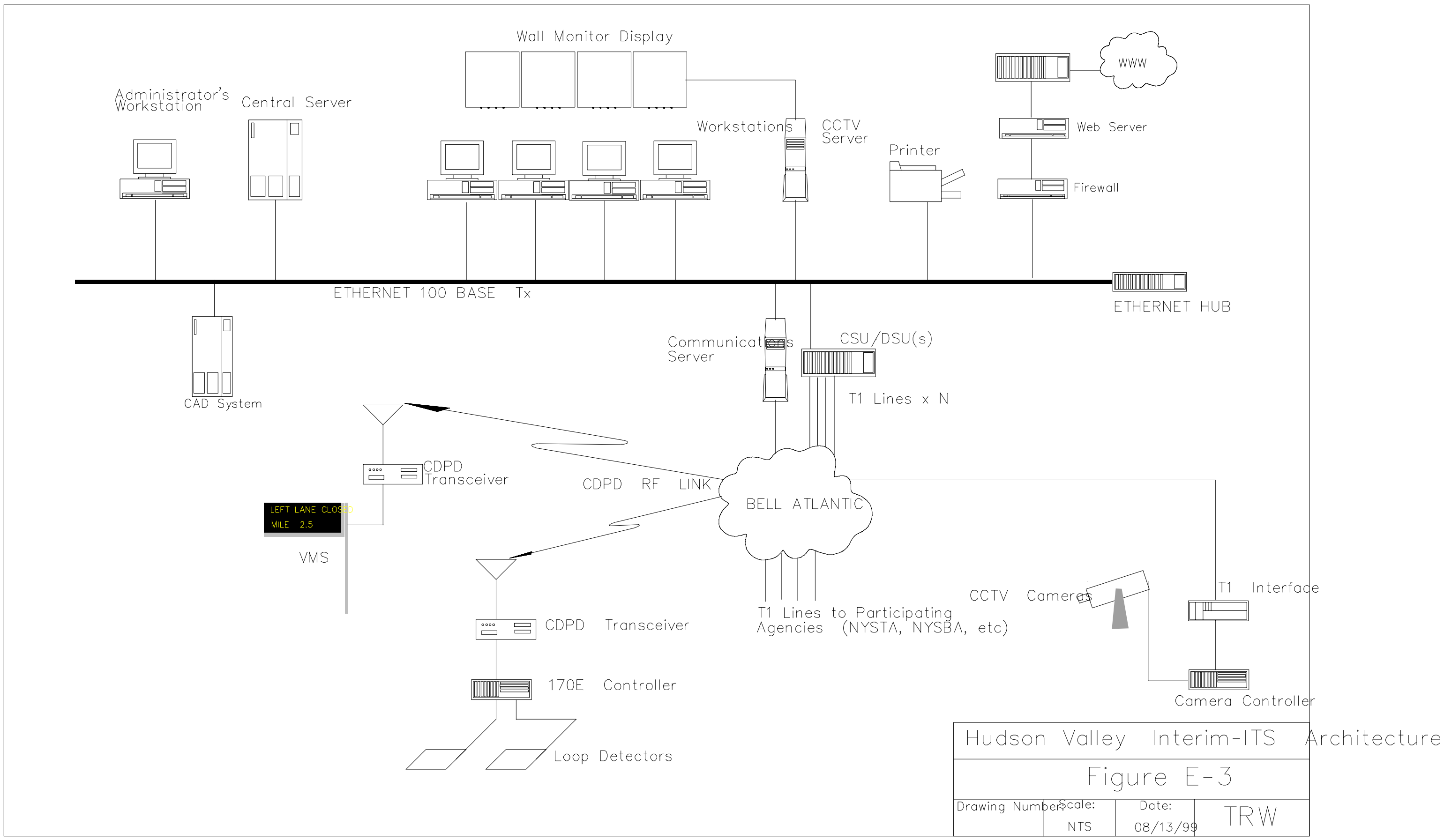
TRAFFIC FLOW SENSORS

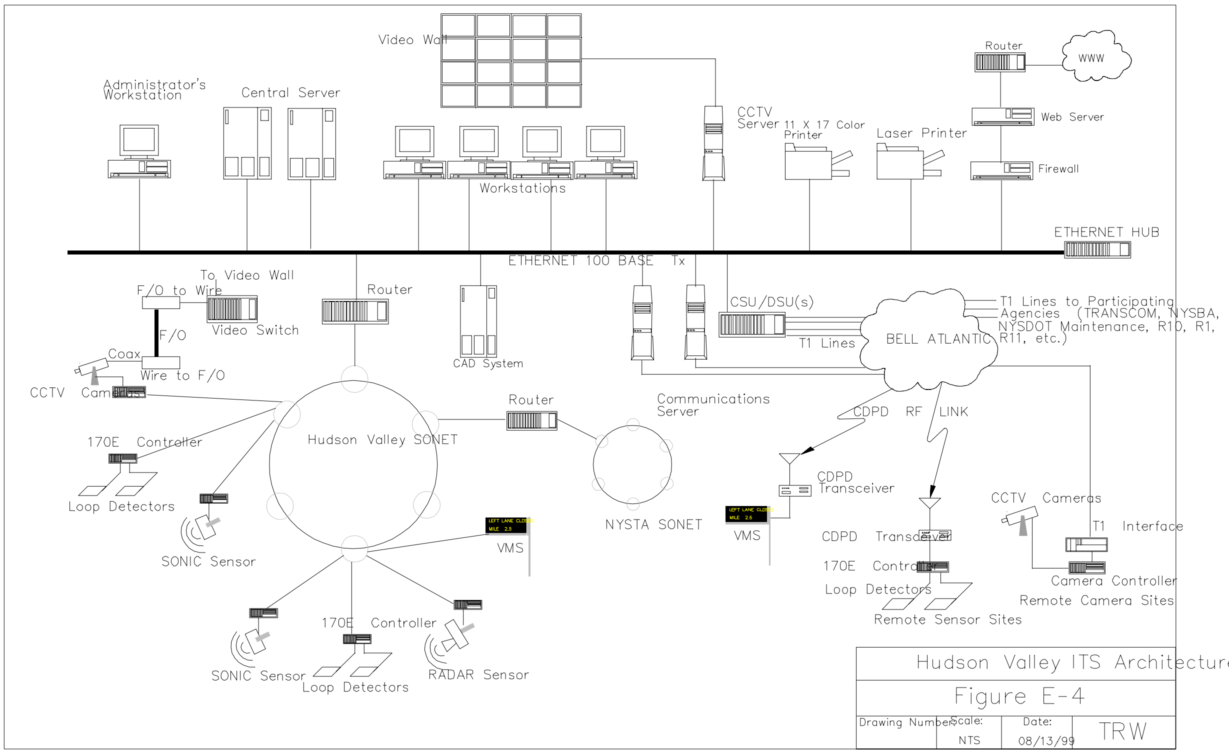
Traffic flow sensors deployed along the roadways form a detection subsystem for gathering aggregate traffic flow data such as volume, speed, & occupancy, and vehicle length for vehicle classification purposes. The devices may come in different technologies based on the data needed to be collected and the cost of installation in the various locations. These detectors can range from the traditional loop detectors & associated 170 controllers, to magnetometers, to more recent technologies such as video vehicle detection, acoustic detectors, & microwave detectors, etc. Many of these new detectors are microprocessor based and can calculate traffic flow data without the need of a 170 controller and cabinet, and also have their own communications interfaces. Many of these devices also can be installed above or to the side of the road surface to mitigate installation costs, pavement degradation for post-construction installations, and disruption to normal traffic along a roadway. The detection subsystem also provides necessary data to the control center, which is used by the center to perform analysis for determining unusual traffic patterns, congestion, and operating automated incident detection algorithms along managed highway segments. By having a view of the status of the entire system, traffic control and incident management operators can more efficiently and effectively formulate and implement appropriate diversion plan actions or associated traffic information messages to be disseminated through other subsystems (i.e. VMS's and HAR). Data from the detection subsystem will also be archived for off-line analysis, future planning and traffic modeling/simulation activities, and for generating any needed management reports. For the final Hudson Valley ITS, emphasis will be placed on the utilization of non-intrusive "above-the-roadway" technologies for detection.

SUBSECTION E-6

SUMMARY

This section of the document has provided an overview of the Hudson Valley ITS' envisioned hardware architecture. Figure E-3 summarizes this hardware framework connectivity for the Interim TMC. However, its purpose is only to convey the current ideas of the designers, and as such, it does not imply final design selections or that the details of the final design have been worked. As with any systems engineering process, it is very important to always discuss the ideas presented here with the customer and to work-out any issues on these "higher level" design concepts prior to starting any more detailed design efforts. Nevertheless, as illustrated in Figure E-4, since this framework is based on a flexible and scaleable architecture, expansions in both functionality and geographic scope can be enabled in a manner that allows for more harmonious coexistence between reuse of Interim TMC equipment and the incorporation of new additional equipment for the larger-envisioned final Hudson Valley ITS.


Wall Monitor Display
Administrator's Workstation
Central Server
Workstations
CCTV Server
Printer
WWW
Web Server
Firewall
ETHERNET 100 BASE Tx
ETHERNET HUB
CAD System
Communications Server
CSU/DSU(s)
T1 Lines x N
CDPD Transceiver
CDPD RF LINK
BELL ATLANTIC
LEFT LANE CLOSED
MILE 2.5
VMS
CDPD Transceiver
170E Controller
Loop Detectors
T1 Lines to Participating Agencies (NYSTA, NYSBA, etc)
CCTV Cameras
T1 Interface
Camera Controller
Hudson Valley Interim-ITS Architecture
Figure E-3
Drawing Number:
Scale:
NTS
Date:
08/13/99
TRW


Video Wall
Router
WWW
Administrator's Workstation
Central Server
CCTV Server
11 X 17 Color Printer
Laser Printer
Web Server
Firewall
Workstations
ETHERNET HUB
ETHERNET 100 BASE Tx
To Video Wall
F/O to Wire
Router
Video Switch
F/O
CAD System
CSU/DSU(s)
T1 Lines to Participating Agencies (TRANSCOM, NYSBA, NYSDOT Maintenance, R10, R1, R11, etc.)
T1 Lines
BELL ATLANTIC
Coax
Wire to F/O
CCTV Cameras
Router
Communications Server
CDPD RF LINK
170E Controller
Hudson Valley SONET
Loop Detectors
CDPD Transceiver
NYSTA SONET
VMS
CCTV Cameras
SONIC Sensor
VMS
CDPD Transceiver
T1 Interface
170E Controller
Loop Detectors
Camera Controller
Remote Camera Sites
Remote Sensor Sites
170E Controller
SONIC Sensor
Loop Detectors
RADAR Sensor
Hudson Valley ITS Architecture
Figure E-4
Drawing Number
Scale:
NTS
Date:
08/13/99
TRW

SECTION F

SAMPLE OPERATIONAL SCENARIOS

SUBSECTION F-1

OVERVIEW

This section is provided to highlight key operational states of the Hudson Valley ITS via a series of three realistic situations that may be faced by ITS operators. In each case, a situation description is provided, followed by a detailed operational scenario to help illustrate how the Hudson Valley ITS is envisioned to mitigate each situation. For example, information is provided that illustrates the general flow of data inputs, outputs, and associated human interactions among the important hardware and software configuration items that have been identified in the Hudson Valley ITS's functional system architecture. To add further realism to each situation; especially, since they appear in this document as printed text only, a companion set of computer disks that contain a series of annotated interactive computer screens are provided in order that readers can view each scenario as the operators would see it on their workstations. These screens, which are saved as Microsoft PowerPoint slides, can be viewed in PowerPoint's "slide presentation mode". Each slide also includes a series of explanatory notes to assist in the understanding of the information being conveyed & to impart awareness of the necessary operator activities that can occur. It must be noted, however, that each operational scenario highlights incident-related operator directed activities and not the daily system support or "housekeeping" tasks that the ATMS core software will also be capable of handling. Finally, please also note that though the initial Hudson Valley ITS and the final system have several identified areas where the two systems likely differ in software architecture and hardware configuration, it must be remembered that the robust design of the ATMS core software enables user interfaces in both cases to maintain a "common look-and-feel" – i.e., operators will be able to interact with the ITS in a similar manner for each deployment phase.

SUBSECTION F-2

TRUCK ROLLOVER-RELATED ROAD CLOSURE

This scenario describes likely actions in response to an incident detected automatically by the Hudson Valley ITS along the I-287 corridor. The scenario given here is based on a large semi-tractor trailer jackknifing on eastbound I-287 near Mile Marker 1.6 in Westchester County (just west of the Knollwood Road off-ramp), which results in the blockage of all eastbound lanes at that location.

INCIDENT DETECTION

The ITS incident detection algorithms compare the volumes, speeds, and occupancy data between pairs of upstream and downstream sensing locations every 30 seconds. Because of the truck jackknifing on eastbound I-287, traffic flowing past the sensor installation at Mile Marker 1.4 is impacted and differences are noted when compared to the sensor installation at Mile Marker 1.8. Sensor location 1.8 is showing a decrease in volume from the last polling period and significantly lower volume readings than at sensor location 1.4, yet speed-readings at location 1.8 are quite normal. Speed for eastbound traffic at location 1.4 is declining and occupancy is increasing from previous polls and shows a significant change from the downstream location. These attributes of the highway segment as automatically analyzed by the Central Computer System, automatically generate a possible incident alert to the operator responsible for the I-287 corridor. The operator then receives an audible alarm; the graphic display for that segment of highway flashes yellow indicating a possible incident; and a window work area pops up on the operator's display with the data on location, lane(s) that triggered the alert, and the current volume, speed, and occupancy at that location.

INCIDENT VERIFICATION

Since the alert is for the I-287 corridor, the Central Computer System will issue a command to the video matrix switch to display both the camera nearest the incident detection station and the camera downstream from the incident station onto the operator's video monitors. At this point, the operator may now use the integrated video control panel to pan, tilt, and zoom each camera to locate the incident. When the operator locates the jackknifed truck, it can be seen that all eastbound lanes are blocked. On the workstation display, the operator opens and fills-in an incident report, which is automatically assigned a unique incident report number and electronically time tagged with the time the incident started. The operator then provides more location details and other “as observed” information such as type of incident (i.e., truck jackknifed), type of verification (i.e., visual, camera), identity of lanes blocked, and estimated time to clear. As the queue expands after the initial incident, alarms will be triggered upstream from the incident. Then, the operator visually inspects the sector of the alarm and determines if a separate incident has occurred. If so, the operator confirms the new incident and a unique number is assigned to it. Otherwise, additional details, as appropriate, can be added to the first incident report that was opened and assigned the original incident number.

Also upon verification, notification of the incident is automatically routed to the NYSPD dispatchers that are residing within the TMC, as well as to all participating agencies whom desire to subscribe to an incident notification transmission (or some subset of all incidents) such as NYSDOT Maintenance, NYSTA, and WCDPW, among others who may decide to participate. The NYSPD dispatchers and other agency operators may then select to view the incident on their workstation displays via the networked CCTV video feeds. The data on the incident is transmitted from the TMC central server to the NYSPD CAD server where it is loaded into the CAD database. Being automatically entered into the CAD database, the NYSPD dispatcher is not required to write a separate report but may instead use the data obtained from the traffic operator to dispatch HELP vehicles and NYSPD troopers.

INCIDENT RESPONSE / DISPATCH

With the incident now confirmed and the critical information regarding the incident input by the operator, the incident management system now compares the entered incident data with the set of available predefined/pre-approved response plans. Accordingly, the operator will be presented a pop-up work area that has the recommended actions (response plan) to be initiated, given the inputted described incident. This work area will also provide a "check-off" box as each action is accomplished. The response plan will include, but is not limited to the following:

- Responsible Public Safety Agencies for this area
  - -- Police
  - -- Fire
  - -- Ambulance/Rescue Squad
  - -- HAZMAT Response Team
  - -- Towing Service
- HAR stations to be activated
- Recommended HAR Message
- VMS Locations to be activated
- Recommended VMS Message
- Activate Video Recording
- Priority Notification List (if necessary)
  - -- Transportation Officials
  - -- Media (for additional traveler advisory broadcasts)

The operator will step through this response plan that has been authored and coordinated with transportation & safety agencies within the incident management systems' jurisdictions. Utilizing the integrated telephone panel at the console, the operator will select the button(s) for the appropriate public safety agency to notify. With the cameras viewing both the upstream and downstream traffic from the incident, the operator can provide some guidance for the easiest route to the incident (e.g., westbound in the eastbound lanes from the Knollwood Rd exit to the incident). If a fire or spill is seen at the incident, the operator can alert these agencies for quick response. If towing is going to be necessary, the operator can free the on-scene officer of this routine task & initiate the alert to the responsible servicing agency to clear the incident.

The operator will be given an appropriate HAR message to be activated at the relevant HAR stations associated with mitigating incidents at this location. This message may be preprogrammed such as "Eastbound I-287 closed at Knollwood Road" or the situation may require a special message composed on the spot and approved by the TMC supervisor (e.g., if a HAZMAT fire, possibly "I-287 closed eastbound. Please keep windows closed."). For this fire example, the operator selects the message in the work area, the Central Computer System will connect through the telephone system to the HAR stations in the incident area, and those to the east of the incident (assuming a westerly wind), and issue the command to play the HAR message.

This same process is also followed for the VMS's in that the recommended message(s) – messages may vary for the different highway VMS locations and street level VMS's – will be displayed for the operator to activate or for new message(s) to be composed and approved by the authorized supervisor. In all cases, the information conveyed is that eastbound I-287 is closed at Knollwood Rd. and that motorists should tune to the HAR station for more details. For example, in order that travelers can avoid the eastbound I-287 corridor; thus minimizing traffic congestion and secondary incidents, it may be appropriate to send these messages to the eastbound VMS's west of the incident, and to VMS's on Sprain Brook Parkway and I-87.

Finally, with the integration of the HELP CAD system and the core ATMS software, pertinent data for the HELP dispatchers and drivers is automatically packaged in the appropriate format for the CAD system and transmitted over the TMC LAN to the CAD central computer. Such a transfer of data triggers a pop-up window, notifying HELP dispatchers of the incident & the actions taken. HELP dispatchers, sitting in the same room as the ITS operators can also visually verify the incident as the ITS operator does on the video monitors. With this, they become better equipped to dispatch the proper service vehicle to the incident and to prepare the driver for actions that need to be taken arrival. Anyone authorized to use the TMC telephone/ audio system may initiate direct communication between dispatchers and the operators. Similarly, if the HELP dispatcher should be informed of an incident before it is detected by the ITS, similar pop-up windows notify ITS operators of said incident detected by a HELP driver.

INCIDENT MONITORING

Once the above actions have been taken, the operator may now transition to monitoring the incident or attending to new incidents that might occur. To help in this, the core ATMS software automatically monitors the time that an incident has been detected and verified, and queues the operator every five minutes to confirm that the incident is still active. Data from the upstream and downstream detectors can be constantly displayed so that the operator can see the decrease in volume along the corridor. If the congestion should expand into additional detector areas as upstream vehicles slow, the cameras upstream and downstream will again be activated based on the location of the end of the queue. The operator need only to view the scene to confirm continued activity at the incident. If a higher priority incident should occur, the supervisor may allocate this incident (truck jackknife) to another operator for control and monitoring, and then the five minute "reminders" will instead appear at that operator's display.

INCIDENT CLOSURE

Once an incident has been cleared from the roadway, the operator will enter the clearance time and any related special comments into the incident's workspace screen, which is accumulated into a database for daily/monthly/yearly reports and analysis. The closure of the incident will also cause changes to the HAR messages and VMS's. However, since the road had been closed for some period, causing congestion to be built up eastbound between the incident and the I-87 exit, there will be a continued slow down. Thus, until such time as queues dissipate, the HAR and VMS message will now display a message such as "Expect

Delays through Knollwood exit." The graphic displays will again transition from red to yellow, showing congestion but no incident; and again, every five minutes, a reminder message "pops-up" on the operator's screen to assess the traffic conditions based on the sensor stations at Mile Markers 1.4 and 1.8. The time at which the roadway returns to the "non-congested" state will be automatically noted in the database for analysis of incident impacts on the highway system. Once the congestion finally clears, VMS displays revert to their default display of expected travel times between exits or other messages as determined necessary by the TMC Manager.

SUBSECTION F-3

ROADWAY DEBRIS REPORT

A traveler has called the TMC facility to report that some debris has fallen onto the westbound exit ramp of I-287 at Hillside Avenue. The operator brings up the display map for this exit ramp segment and selects the CCTV button on the screen to identify the nearest camera to that location. With the camera icon displayed at the interchange, the operator clicks on the icon to have the video matrix switch bring that image to the operator's console. Then, using the integrated control panel, the operator pans the camera along the westbound exit ramp looking for the reported debris. Once located, the operator zooms in to identify the material. Since it is causing vehicles to swerve and slow down, the operator composes a message – “CAUTION! Debris on Hillside Exit Ramp" – for display on VMS #9 facing westbound I-287 at Mile Marker 3.4. In short, this is but one use of the video subsystem. In addition to other primary uses of the video system for items such as providing a rapid means of verifying and monitoring incidents, and providing additional information as needed to public safety agencies, a secondary function of the video system is also its interface with the TMC’s own facility security system for purposes of monitoring for building access safety.

SUBSECTION F-4

OPERATIONS SUPPORT REQUEST

In this situation, it has been anecdotally observed by the NYSTA that there has been an increase in incidents at around 4:00 P.M. during weekdays. To confirm this, NYSTA requests the TMC Supervisor to research this topic. The Supervisor selects the “Reports” option from the workstation menu, and a form appears in which desired Incident Reports can be requested via a variety of user-selectable “Key Field(s)” such as incident-time “> 3:55 P.M. and < 4:15 P.M.”, & incident-day “not Saturday or Sunday”. Then, by selecting the “Access” button, the core ATMS software is instructed to interrogate its relevant database(s) for all incident reports that match these criteria. Finally, the system responds with the number of reports found. The Supervisor can then decide to do a different query, or to select the “Print” option of the “Report” menu so that detailed copies can be distributed to others for review.

APPENDIX A

NATIONAL ITS ARCHITECTURE CONSISTENCY

SUBSECTION AA – 1

OVERVIEW

As per the National ITS Architecture's *Implementation Strategy* document, "Nationwide implementation of Intelligent Transportation System (ITS) services will result from a multitude of individual deployment decisions by public agencies and the private sector. The National ITS Architecture creates the opportunity for interoperability across these diverse ITS deployments while preserving flexibility and choice for the many implementers".

Furthermore, the National ITS Architecture's *Implementation Strategy* document states, "The architecture is implemented to achieve these benefits in three principal ways:

(1) Adaptation or development of consensus standards for transportation products based on architecture requirements,

(2) Development of regional architectures which interpret the national architecture and tailor it to support integrated regional ITS solutions, &

(3) Incremental deployment of architecture compatible systems".

SUBSECTION AA – 2

TOP-LEVEL CONSISTENCIES

Cognizant of the above, the development and deployment of the Hudson Valley ITS provides an excellent example of how the National ITS Architecture Program's (NITSAP) outputs have found a large-scale home to utilize, grow, and real-world test the NITSAP standards-setting activities such that this deployment can contribute to the eventual realization of the "single" interoperable ITS that is envisioned for across the nation. The State of New York & responsible organizations in the Hudson Valley area have accepted the challenge and the opportunity granted by the NITSAP to develop a stepping stone to this National goal of ITS compatibility and interoperability. Accordingly, Figure AA-1 illustrates in "architecture format" a top-level diagram expressing the interactions of included subsystems.

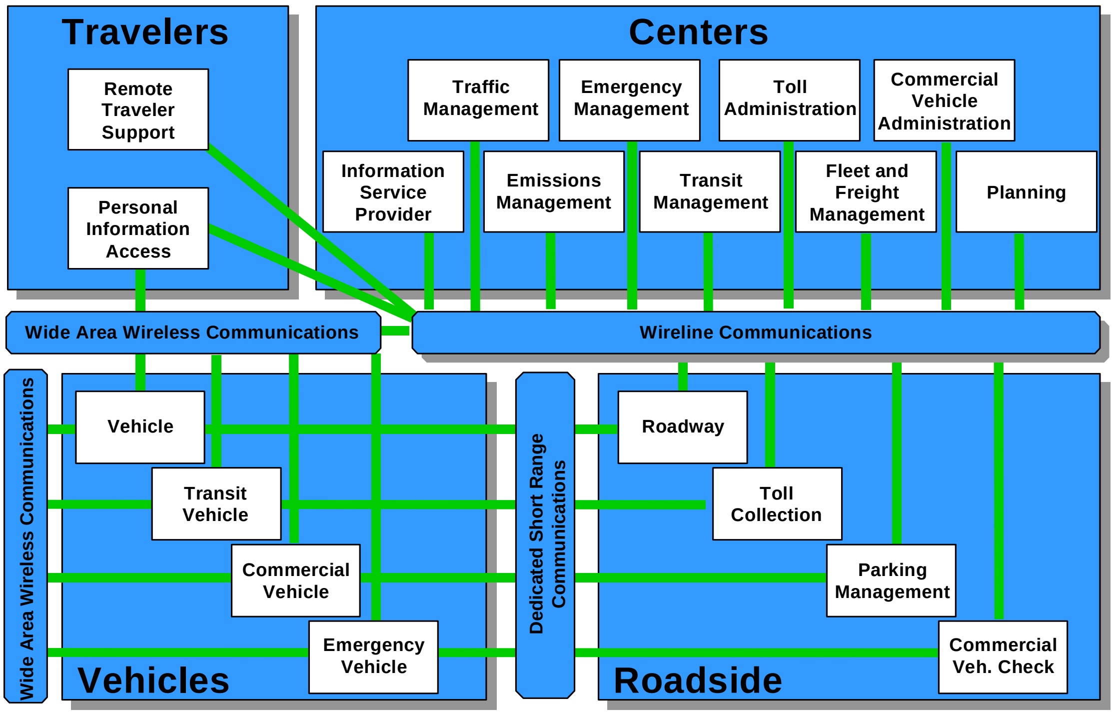


Figure AA-1. National ITS Physical Architecture Subsystems

With this as a starting point, the Hudson Valley ITS identified priority functions were isolated into the physical architecture as illustrated in Figure AA-2 (additional details can be found in the *Software Requirements* document).

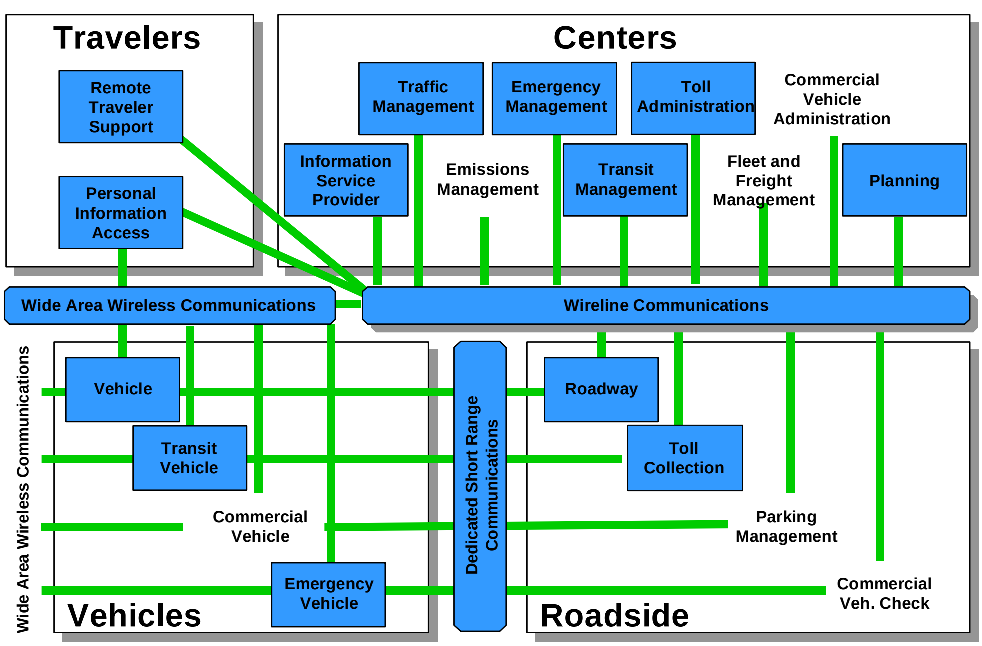


Figure AA-2. Hudson Valley ITS Regional Architecture Subsystems

Adding specificity, Figure AA-3 reformats the above such that participating agencies and deployed technologies are also included (additional and more complete details can be found in the *Software Requirements* document).

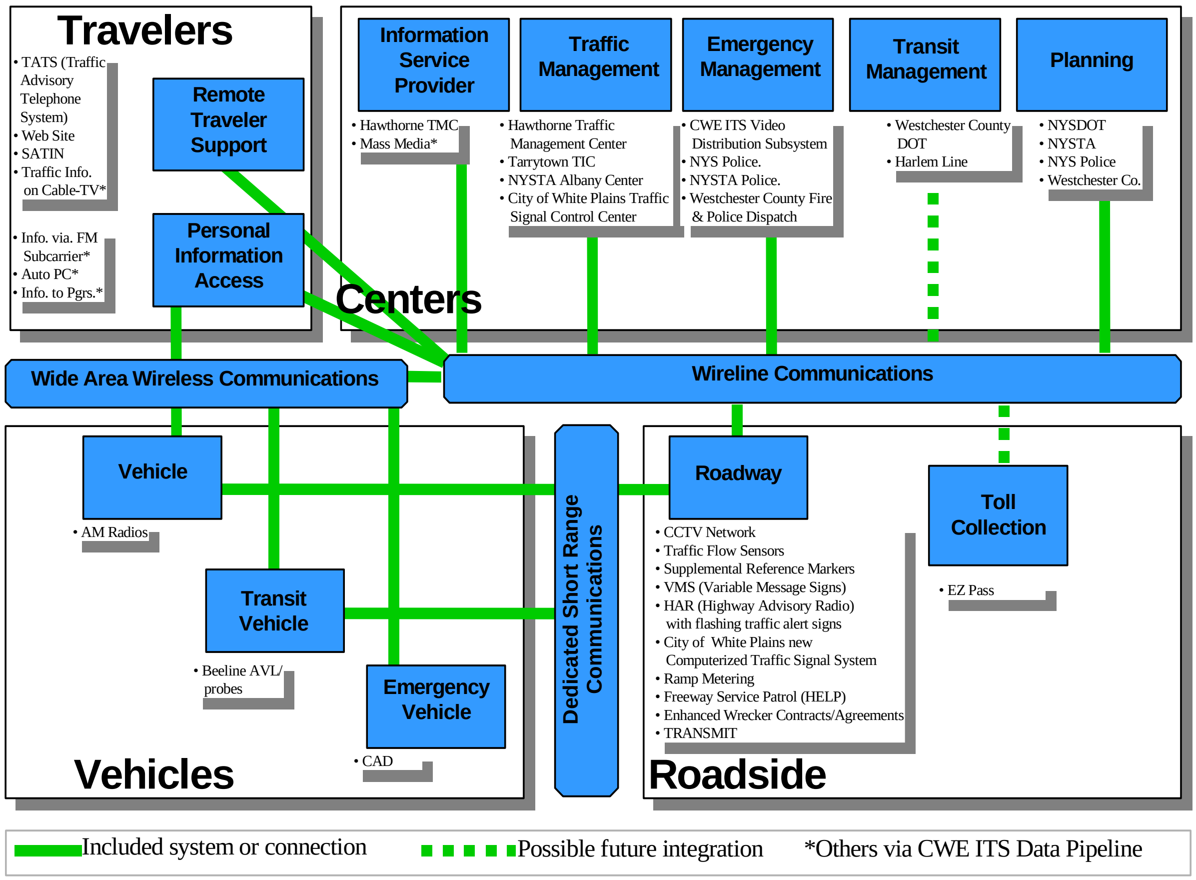


Figure AA-3. Hudson Valley ITS Physical Architecture Subsystem Entities

Finally, the Hudson Valley ITS system is being designed through careful selection of ITS Market Packages as defined by the National ITS Architecture. In short, each Market Package was explained in detail to agencies involved in the identification of Hudson Valley ITS requirements. Then, agencies prioritized the User Services / Market Packages that they believed would best fit the needs of the Hudson Valley area (for further details, please see the *Lower Hudson Valley Early Deployment Plan* document). Finally, each selected priority Market Package was developed into potential countermeasures and implementable designs by using the available National ITS Architecture documents as our guides for implementation and (where defined) our standard for technology insertion. In short, and as is detailed in the *Software Requirements* document, when projects identified in the *Intelligent Transportation System Preliminary Report* proceed towards their deployment, The Hudson Valley ITS team will continue to apply relevant concepts of the National ITS Architecture.

SUBSECTION AA – 3

CONSISTENCY DETAILS

As the National ITS Architecture Program has evolved itself from a program geared towards developing and educating the transportation community about compatible subsystems and User Services/Market Packages, to a program that is geared towards defining the necessary hardware-, software-, and communications protocol standards that enable more efficient and cost-effective deployments of said items, the Hudson Valley ITS development team has striven to incorporate all appropriate recommendations into our day-to-day systems integration activities as per defined requirements.

The Hudson Valley ITS development team is constantly reviewing the status of NTCIP standards for potential requirement in the Hudson Valley ITS equipment specifications. As the standards are adopted they will become requirements. If it is determined that a standard is near completion and that vendors can develop interfaces nearly compatible to the standard, that standard may also become a requirement.

For devices that do not yet have evolved NTCIP definitions, we will specify that they are computer-controllable (e.g., standard RS-232) such that they could eventually be converted to an NTCIP protocol when the device vendors implement these standards. Overall, the Hudson Valley ITS team will continue to monitor the development of the National ITS Architecture and associated standards for opportunities to derive benefits via implementing these standards within Hudson Valley ITS as both this system and the National ITS Architecture mature.

SUBSECTION AA – 4

SUMMARY

The Hudson Valley ITS system is being planned and designed with National ITS Architecture compatibility strategies in mind. Though many of the standards identified in the National ITS Architecture are still evolving today, and therefore are not yet true standards, the Hudson Valley ITS system will be designed to allow insertion of technologies that are fully compatible with the National ITS Architecture as they become available. In short, through local support and careful coordination with the FHWA, the Hudson Valley ITS project is striving to not only be consistent with the National ITS Architecture, but to be a model of National ITS Architecture implementation.