CHAPTER 8
Integration of Systems

Individual metropolitan intelligent transportation infrastructure elements are usually independently developed by a variety of agencies within a metropolitan area. However, the movement of goods and people occurs on the total transportation system within an area. In order to manage the entire transportation system within a metropolitan area in a coordinated fashion, individual elements are usually integrated. Therefore, integration is considered a key aspect of the metropolitan intelligent transportation infrastructure deployment. It is important to note that the metropolitan intelligent transportation infrastructure demands are unique for different areas. Each community should implement only the appropriate intelligent transportation infrastructure element(s) that match its particular needs. It is not effective to simply copy a successful system from one community to another and expect it to work.

Many metropolitan areas and communities already have several intelligent transportation infrastructure elements in place. The importance and benefits will be realized fully by linking them in areas that do not have integrated systems. This integration will maximize the value of investments and service to the traveler. In addition, buying smarter is the key when the existing technologies and equipment need to be replaced or upgraded.

The steps toward attaining integration include identification of the data that need to be transferred (including the timeliness of the data transfer), the establishment of methods for transferring data between systems, and the use of the data by the receiving systems. Integration of systems consists of data transfer and control. Data transfer is the physical exchange of data from one system to another, where the recipient system can use the data to structure its response to changing travel conditions more efficiently. Data sharing can occur among computer systems, operators, designers, and the public. Control is the processing and use of the data that have been transferred.

Both data transfer and control can be measured by varying levels of sophistication in the systems constructed to handle them. For example, lane closures on a freeway due to either planned (construction) or unplanned (incidents) events may cause traffic to divert to alternate arterial routes. This diversion may be directed by the provision of traveler information or may naturally occur as travelers avoid standing queues on the freeway. In an integrated system, traffic data on the freeway are transferred from the freeway-management system to the traffic-signal control system. If these systems are embodied in a comprehensive Traffic-Management Center, the transfer is automatic. In systems where they are physically separate, communications techniques must be used, sometimes with operator intervention. Regardless of the method to communicate, the transfer must be made as close as possible to real-time, so as to be useful. After the data are transferred, a decision of how to use the data must be made (the control function). This can range from implementing pre-determined signal-timing plans based on the severity of freeway conditions (e.g., low speeds over varying distances) to dynamically determining what the appropriate response should be through predictive models.

8.1 FREEWAY-MANAGEMENT SYSTEMS

Information collected by the freeway-management system can also be used by other metropolitan intelligent transportation infrastructure systems. Relevant information can be made available to support incident-management and emergency-management services, traffic-signal control, and regional multimodal traveler information. Information links to incident-management and emergency-management services may be used to transfer data concerning the location, severity, and duration of incidents on the freeway system. Traffic data measuring the demand and performance of the freeway system can be linked to the traffic-signal control system to coordinate the operation of the surface street system with the freeway system. Freeway traffic data can be linked to a regional multimodal traveler information center to provide travelers with information concerning the performance of the freeway system. A link to provide relevant information to transit management may also be included.

8.2 TRAFFIC-SIGNAL CONTROL

Traffic-signal control data on arterial travel speeds and conditions may be shared with the freeway-management, incident-management, and transit-management systems. The traffic-signal control system may also provide data to the regional multimodal traveler information system. Traffic-signal control may incorporate peripheral techniques/technologies not essential to the task of traffic control per se, which may enhance overall traffic-management capabilities in the area. These techniques/technologies may include closed-circuit television surveillance; motorist information systems (e.g., DMSs); a database management system to support analysis and development of management strategies; a data exchange with other traffic-management systems including freeway management and incident management. Offline simulation may be included to project near-term traffic trends for selection of signal-timing strategies to optimize throughput.

8.3 INCIDENT MANAGEMENT

Incident management relies on traffic data provided by the freeway-management system as well as the traffic-signal control system (surface arterial system) to detect and verify incidents. In addition, the system continues to monitor traffic conditions during the entire duration of an incident and to implement various control strategies to mitigate its impact. The freeway-management strategies may be coordinated with the traffic-signal control system to provide a balance of demand and capacity during congested periods. Incident location, severity, and duration data are shared with the emergency-management services to develop an appropriate incident response and to monitor the progress of incident clearance. Travelers may be provided with information concerning the incident location, duration, and severity, as well as incident clearance activities through the traveler information devices operated by the freeway-management and regional multimodal traveler information systems. Incident data may also be relayed to the transit-management system so that transit vehicles can adjust their routing. The incident-management system is frequently located with the freeway-management system, and both may be part of a single freeway-management center.

8.4 ELECTRONIC TOLL COLLECTION

Roadside readers mounted at various points along the freeway and arterial roadway system can be used to detect the presence and passage of vehicles equipped with toll tags to provide data to calculate roadway performance. These probe data can be used by the freeway-management and traffic-signal control systems to measure roadway conditions. Electronic toll collection can also be integrated with electronic fare payment through the use of a common fare media as a “smart” card.

8.5 TRANSIT AND EMERGENCY MANAGEMENT SYSTEMS

Information links from the transit and emergency-management systems to freeway management and traffic-signal control can provide for priority treatment of transit and emergency vehicles to improve on-time performance. Transit management can also provide freeway management and traffic-signal control with probe information for highway travel time determination. Transit location and schedule data as well as data on real-time schedule adherence can be transferred to the regional multimodal traveler information system, to distribute traveler information concerning transit service performance. In addition, there may be coordination with the traffic-signal control system for signal preemption and with the incident-management system for improved route guidance. Signal priority provides capability to preempt traffic signals on an emergency vehicle’s route so that the emergency vehicle is nearly always presented with a green signal. It includes the capability to warn drivers of affected vehicles that an emergency vehicle is approaching. Links with 911 and/or Federal/State or local emergency-management centers would be beneficial. These linkages would be especially helpful during inclement weather and potential evacuation situations.

8.6 REGIONAL MULTIMODAL TRAVELER INFORMATION SYSTEMS

As with other elements of the metropolitan intelligent transportation infrastructure, integration is essential to the deployment of an effective regional multimodal traveler information system. It is the aggregation of data from many sources, and the presentation of these data integrated in a common, easily assimilated format, that makes regional multimodal traveler information such a valuable element in influencing mode selection, route selection, and travel-time scheduling. Regional multimodal traveler information relies upon the other elements and technologies to provide current travel conditions in a metropolitan area. It receives incident, traffic, and transit data from the other elements.

8.7 CASE STUDIES

8.7.1 SMART CORRIDOR

The Smart Corridor project, in Los Angeles, is located along 12.3 miles of the Santa Monica freeway corridor. The objectives of the Smart Corridor are to provide congestion relief, reduce accidents, reduce fuel consumption, and improve air quality. This will be accomplished using advanced technologies to advise travelers of current traffic conditions and alternate routes (using strategies such as highway advisory radio, dynamic message signs, kiosks, teletext, etc.), improving emergency response, and providing coordinated interagency traffic management. The freeway systems will be operated by the State of California (Caltrans) and the arterial streets by the city of Los Angeles, with coordination provided via voice communications and electronic data sharing. The coordination and shared responsibility of the city and State transportation agencies will enable them to allocate their resources better, provide expanded coverage of the surface transportation system, and enable the control and management of the freeway and arterial systems to be a unified effort.

The heart of the project is a scenario/rules-based expert system that offers reactive guidance to freeway and arterial control. The Smart Corridor software is not a replacement for existing traffic control and information systems, but an umbrella system that incorporates new and existing systems into a single coordinated management system that can be accessed by any agency operator.

8.7.2 PENNSYLVANIA I-476

The I-476 project in Pennsylvania incorporates a system architecture that utilizes several intelligent transportation infrastructure elements communicating over a variety of communication technologies. The system allows expansion and growth for accommodating future elements and other technologies to be integrated. It includes: CCTV, ramp metering, incident detection, advanced vehicle detection, and a test-bed for evaluating the performance of overhead-mounted vehicle detectors. Operations will utilize a range of communication technologies to link field elements and the existing Traffic Control Center, including leased T-1, dial-up and Type 3002 telephone lines, fiber optics, and spread spectrum radio (Ramesh Gangisetty and Karl Ziemer, August/September 1996).

8.7.3 ARIZONA DOT TRAFFIC INTERCHANGE MANAGEMENT SYSTEM

The purpose of the Arizona Department of Transportation (ADOT) Traffic Interchange Management System (TIMS) is to facilitate coordination among the ADOT Trailmaster Freeway-Management System and city and county Traffic-Management Centers (TMCs), which will assist in reducing motorist delays. The TIMS provides the means for ADOT operators and city of Phoenix TMC operators to exchange and coordinate timing plan information and changes. The TIMS software at the ADOT TOC acts as a server for this information exchange, communicating with a client computer located at a city traffic-management site. This client computer runs the Remote Freeway-Management System User Interface, configured with only the options necessary for TIMS functionality.

At the TOC, the TIMS automatically detects a freeway-management system timing plan change and informs the appropriate city traffic control centers. The TIMS also provides the city control center with suggestions to indicate which city timing patterns should be used to achieve a desired or optimum traffic progression. The data that specifies which cities are affected by an ADOT traffic interchange and the suggestions will be maintained in the ADOT Freeway-Management System database at the TOC and consist of predefined sets of timing patterns designed to synchronize freeway-management systems and city signals.

The suggestion of timing-pattern change to the city TMC will be informational only. Any actual change in a city timing plan will be at the discretion of city traffic-management personnel. In the future, functionality will be developed to fully automate timing-pattern changes. When changes in a city timing pattern are implemented at the city traffic-control center, the city can inform the ADOT operators at the TOC of the change through the TIMS. The TIMS will provide the ADOT operators with suggestions of which freeway-management system timing patterns need to be used to achieve the desired traffic progression (http://www.azfms.com/About/System/tims.html).

8.7.4 MARYLAND CHESAPEAKE HIGHWAY ADVISORIES ROUTING TRAFFIC (CHART)

Maryland's Chesapeake Highway Advisories Routing Traffic (CHART), established in 1989, includes four major elements:

1. Surveillance;
2. Incident Response;
3. Traveler's Information; and
4. Traffic Management.

The CHART system is an integrated traffic-management system that includes incident management, traffic control, and traveler information for freeways and surface streets throughout the State of Maryland. It interfaces with several external systems such as the Econolite system that controls intersections throughout the State; the Montgomery County Signal System, providing information on surface streets in Montgomery County as well as sharing information about incidents; the DMS system, the traveler advisory radio system maintained by the State Highway Administration and Montgomery County; CCTV systems currently maintained by Montgomery County and the State-run tunnels; and a winter storm advisory system available from the State of Maryland Geographical Information System (GIS).

CHART uses electronic equipment to detect traffic incidents, inform motorists of highway conditions, and provide assistance during traffic incidents. A discussion of this equipment follows.

- Closed-Circuit Television (CCTV) - The CCTVs are used for verification of traffic conditions detected by CHART devices including overhead traffic detectors, #77 cellular phone calls (to report disabled vehicles), and Emergency Traffic Patrols (ETPs) /Emergency Response Units (ERUs).
- Bi-directional Traffic Detectors - These detectors monitor average speed across a given section of highway and notify state operations center operators when average speed falls below a preset threshold. The detectors enhance the operator's ability to quickly evaluate traffic incidents and dispatch appropriate resources.
- Dynamic Message Signs (DMS)
- Traveler Advisory Radio (TAR) - TAR station frequencies include: 530 AM along the I-70 corridor from Baltimore to Cumberland; 1290 AM along the Capital Beltway and I-270 in the Washington metropolitan area; 1610 AM along the Baltimore Beltway, I-95 and I-83 in the Baltimore metropolitan area, as well as along U.S. 50 from Annapolis to Ocean City; and 1040 AM at the BWI Airport.

- Emergency Traffic Patrols - ETPs are tow trucks that carry equipment to perform minor vehicle repairs and clear vehicles or debris from the roadway. ETPs are staffed by State Highway Administration (SHA) maintenance personnel and operate during peak travel hours on major Maryland highways, including I-95, I-495 and I-695.

- Emergency Response Units - ERUs are vans that carry equipment to perform minor repairs, and provide a higher level of service, including the establishment of proper traffic control and assistance in coordination of emergency activities upon arrival at an incident scene. ERUs also relay information to SHA's TOCs regarding lane closures and backups. ERUs are staffed by trained and certified CHART personnel and operate weekdays from 5 a.m. to 9 p.m. in the Baltimore and Washington areas.

- Road Pavement Sensors - Road pavement sensors use the latest computer technology to record road surface temperatures, information about snow, ice and winter chemicals on the roads, and whether a road is wet or dry. Information collected by road sensors is sent via telephone lines to a remote processing unit and then to a central computer at the emergency operations center. The data is helpful in determining when and where to send plows and de-icing equipment. (http://www.inform.umd.edu/UMS+State/MD_Resources/MDOT/sha/chart/chart.htm)

8.7.5 SILICON VALLEY SMART CORRIDOR

Oakland, CA, is implementing the Silicon Valley Smart Corridor in northern California. The project will coordinate freeway and selected surface-street traffic operations along 15 miles of the I-880/Route 17 corridor. The California Department of Transportation, the cities of San Jose, Milpitas, Santa Clara, and Campbell, the town of Los Gatos, and Santa Clara county will all be able to monitor and control the system as peers. The system will allow real-time data exchange and control such as adjustment of traffic signals, electronic signs, and other devices to respond to traffic volume changes and incidents. Each agency will have its own real-time status display map of the corridor to provide a common frame of reference for all traffic management. The system will also offer information to travelers, including a link to TravInfo, the San Francisco Bay Area's regional traveler information system (http://www.itsworld.com/techno.htm).

8.8 STANDARDS

The National Transportation Communications for ITS Protocol (NTCIP) will support integration of ITS technologies through the use of a standard communications protocol. Vendors can produce hardware and software products that will be able to effectively communicate with other NTCIP compliant devices in the system.

SOURCES:

- *Interstate-476: Networking for the Future*, August/September 1996, by Ramesh Gangisetty and Karl Ziemer, COMtrans.

- *An Integrated Intelligent Transportation Infrastructure for Your Area*, January 1996, US DOT Publication No. FHWA-JPO-96-005, prepared by FHWA and FTA.