APPENDIX K
An Architecture for Corridor-Wide Traveler Information Systems

In 1994, the I-95 Corridor Coalition (CC) initiated the Traveler Information Services (TIS) Project to develop an implementation plan for a Corridor-Wide traveler Information System (CTIS) using state-of-the-art and cost-effective technologies. This system provides a platform to design and develop methods for innovative traveler information collection, fusion and dissemination, while maximizing private-sector participation. The two major objectives of the TIS Project are: to develop a conceptual design for an Advanced Traveler Information System (ATIS) for the I-95 Corridor, and to develop a framework for TIS public/ private partnerships. The former focuses upon providing travel information in vehicles, homes, the workplace, public kiosks, and intermodal transfer points. The latter enables the individual members of the 1-95 CC to integrate and share information useful to the travelers. This information will form the basis of an open architecture that promotes organized public and private travel-information products and services.

To meet the project's objectives a comprehensive systems analysis and design process was used which included the following steps:

- Conduct a survey of existing public and private sector TIS providers
- Worked with the 1-95 CC member agencies to identify and obtain consensus on goals and objectives of the system
- Derive a complete set of functional, performance, and system requirements based on the goals and objectives
- Develop a conceptual design responsive to the requirements
- Refine the conceptual design based on technology availability, operational concept (including various roles of the public and private sectors in providing traveler information services), and implications of system's life cycle costs.

Grasso et all, summarize a few key aspects of the TIS project are summarized, including an overview of the CTIS goals, a vision for CTIS deployment with multiple phases; and the CTIS architecture with a description of its context, systems structure and design concept.

CTIS GOALS

A survey (telephone interviews and questionnaires) of each Coalition's member agency was conducted to identify the CTIS goals and objectives. The survey provided a set of candidate goals and objectives for the respondents to rate and/or modify. This set was designed to address the following areas:

- TIS high-level functions and services
- TIS users.
- TIS challenges.

CTIS VISION

The vision of the I-95 CTLS was defined for the near, medium, and long term. This vision is seen from the perspectives of an end-user and an operational user as described below.

END-USER VIEW

This end-user view presumes that the 1-95 Conidor Traveler Information Service will evolve over a period of years, going through three identifiable stages, each with its level of technology, relationship between public and private funding, and level of traveler behavior modification and interjurisdictional collaboration. This end-user view divides the evolution of CTIS into three phases: Phase I (O to 2 years); Phase 11 (2 to 5 years); and Phase III (5 to 10 years).

Phase I of the CTIS is focused on rapidly deployable, baseline information dissemination to the broadest possible public, at little or no charge. In addition, through its comprehensive data collection system and database management, the Phase I system is capable of rapid communication about incidents and traffic and transit trends to all affected public agencies, playing a critical role in enhanced incident management. Distinguishing characteristics of the Phase I system are:

a) Baseline Information Dissemination:

- Designed to accomplish near-tenn public-policy objectives by reducing congestion and vehicle emissions, increasing mobility, and enhancing public safety.
- Designed to build confidence in potential users and public-policy decision-makers.
- Based on proven technologies-there is no room for experimentation.
- Designed to modify traveler behavior so that they learn to use traveler information systems in general, CTIS in particular.
- Probably relies heavily on telephony (both wirehne and cellular), as the telephone remains the most ubiquitous communications medium with a real-time interactive capacity. In addition, other existing, low-risk, proven technology are likely to be employed, including dial-in bulletin boards, faxes, and pagers.
- Enhanced multimodal information to encourage modal shifts from singlc-occupancy to high-occupancy.
- Probably subsidized substantially by the public sector, as private-sector investment and consumer dollars would not be drawn to low-cost dissemination nor to promotion of multimodality.
- Includes information that serves key functional areas, including mode choice, route choice, and early stage “real-time” rerouting.

- Includes high priority information elements: real-time traffic conditions and incidents, construction activities, special events, weather conditions, and where available infor mation on transit conditions and schedules, multimodal options and travel time comparisons, traveler and tourist facilities, traffic diversion and speed advisories. and emergency services.

b) Incident Management Support:

- Designed to enhance the traffic recovery function by broad dissemination of advice to avoid incidents and of advice to return to sites of incidents when they're cleared.

- Includes emergency notification via pager of all key public-agency personnel.

- Includes comprehensive database compilation of incident management data, includ ing incident occurrences, traffic impacts, clearance times, etc., for the purpose of FHWA-required congestion management reports.

Phase II of the Corridor TIS looks significantly different to the end-user. Induced in part by the widespread dissemination and utilization of baseline information in Phase 1, more sophisticated private-sector information disseniination media proliferates. Trained by the public sector's aggressive promotion of the baseline system in Phase I, the traveling public sees increasing value in the purchase and use of more sophisticated traveler information services, which is delivered over private media at the expense of either the individual consumer or the wholesaler (such as paging companies or cable TV operators). The individual traveler end-user begins to see in Phase II the availability of interactive multimedia traveler information services over telephone, TV, online services, Personal Digital Assistants (PDA), etc. In addition to the baseline information as in Phase 1, Phase 11 begins to see new, more sophisticated kinds of information, including predictions and estimation of traffic conditions; traffic demand patterns and trends; detailed, dynamic trip planning and routing information and guidance; and dynamic multimodal trip planning and connectivity. We expect that these new multimedia, interactive information dissemination media offered by the private sector to individual travelers and fleet operators will make extensive use of the traveler information database maintained by the CTIS, perhaps at a fee, which could reduce the level of public subsidy. In addition, dispatchers and fleet managers will be able to make use of similar interactive multimedia information dissemination devices. Phase II will begin to provide services to "passive" users, those who are not required to actively take steps to obtain the desired information. Passive users subscribe to the service to receive personalized traveler information on an exception basis only. The system will know the subscriber's travel profile and only transmit information to the subscriber as needed (e.g., when there is an incident on subscriber's route and during the subscriber's travel period).

Public agency end-users in Phase 11 expand the deployment and sophistication of on-road demand management devices such as variable message signs, highway advisory radio and possibly kiosks at public places (e.g., parking garages, shopping malls, rest stops, or intermodal transfer points).

In Phase III, heavy emphasis in CTIS shifts to widespread deployment of in-vehicle navigational devices, displaying real-time, multimodal navigational information. Such in-vehicle devices will also likely serve as mobile probes, recording real-time traffic conditions on an anonymous basis and providing CTIS with largely automated, quantitative real-time data. Optimal pre-trip planning, which has the ability to have maximum impact on route, time, and mode of travel, is serviced through increasingly sophisticated multimedia interactive devices in the home or office. But the preponderance of consumer expenditures and commercial vehicle end-user expenditures will flow to in-vehicle navigational devices and their servicing with realtime information.

OPERATIONAL USER VIEW

The perspective of the people operating the RTICS, as described below, is divided into three phases similar to those of the end-users.

The RTIC operator receives and coordinates many disparate pieces of information about travel conditions within the Corridor. The operator communicates with local traffic operations centers within the RTIC's region as well as control centers for bus, rail, air, subway, and ferry information. In addition, the operator collects information from commercial traffic reporting services, and possibly commercial vehicle operations to help fill the information gaps. The data acquisition and fusion process initially is likely to be a manually intensive task. As the system evolves, however, more automated interfaces will be developed to more efficiently interface and exchange information with public and private data sources.

The operator collects information from other entities (e.g., the regional weather services) whenever necessary. The RTIC then fuses and forrnats the data, and disseminates the information to the "wholesalers." This data fusion and formatting step may be a public or private enterprise, while dissemination is almost certainly a private function (except for Variable Message Signs, VMS, and Highway Advisory Radio, HAR, dissemination). The operator also provides information to other public agencies their operational management (e.g., incident information to agencies responsible for clearance, and real-time traffic information to transit agencies).

During Phase II of the TIS evolution, the operator's view from the RTIC does not differ greatly from Phase 1. He or she still receives information from multiple, disparate sources and fuses those data for use as they come in. As more and more public Traffic Operation Centers (TOC) come on line, the operator may have less need for reliance on information from commercial vehicle operations for filling the information gaps, but will still rely on private-sector entities for some information gathering. In addition, more automated interfaces will be developed to existing TOCs to reduce the manually intensive data acquisition and fusion tasks.

The big changes in Phase 11 are in the dissemination media. The operator feeds the collected information to a much more sophisticated network of dissemination devices. The RTIC operator also does more with the collected information to enhance its value. The Corridor RTIC database is used in predictive as well as descriptive ways.

As the sophistication of the dissemination media increases, so too does the complexity of the operator's daily routine. In Phase 1, for instance, the operator may deal with one type of dissemination (e.g., an audiotext system) while Phase II has varied and more complex systems.

PROPOSED SYSTEM ARCHITECTURE

A well designed CTIS architecture is one that fully This longer time frame promises the greatest changes complies with all agency and end-user needs and which for the operational user. Technologies for data collection provides interfaces for existing and planned systems. CTIS will accommodate various electronic interfaces to data sources, including TOCS, Transit Dispatch Centers (TDCs), commercial traffic reporting firms (e.g., Metro Traffic Networks), and many types of extemal databases. Similar interfaces will be provided to data sinks, including end-users, and private sector disseminators, such as Information Service Providers (ISP), Communication Service Providers (CSP), or Value-Added Resellers (VARs). The interface between the end-users and these private entities are not considered as a part of the CTIS. However, it is recognize that there are important issues (e.g., ATIS standards) that are being examined by the National ITS Architecture Project and other organizations.

The key goal of the physical architecture is to generate a critical mass of traveler information that third-party disseminators-public, public/private, or private entities-find easy and attractive to disseminate, and that is therefore more valuable than disaggregated inputs from many public- and private-sector sources.

PHYSICAL ARCHITECTURE

Since the I-95 Corridor consists of several large regions, a distributed architecture was proposed. This proposed architecture encompasses five major regions of the Corridor, including:

- Boston (including Hartford, Providence, and northern New England)
- New York (including southern Connecticut, northern New Jersey, and northeastern Pennsylvania)
- Philadelphia (including Camden, Chester, Wilmington, and central and southern New Jersey)
- Baltimore-Washington (including northern Virginia)
- Richmond-Norfolk (including Hampton Roads)

These regions (also called travelsheds) correspond to the three consolidated metropolitan statistical areas, plus aggregations of the Baltimore and Washington, and Richmond and Norfolk metropolitan statistical areas.

Each of these five regions will house a traveler information center, which will act as a clearinghouse for transportation information within its region. It is the job of each center to acquire, fuse, validate, organize, and make available information to end-users and ISPS. The clearinghouse function will use database management servers to manage data. These data servers will communicate through the Coalition Information Exchange Network (IEN). Each of these regional data servers will collect and maintain data within its region in order to satisfy the needs of intra-urban, interurban, and inter-regional travelers. The regional data servers will also disseminate information to other regional data servers and to the other nodes on the IEN. The hardware architecture supporting these regional servers is based on the maximum use of commercial-off-the-shelf technology (COTS). In addition, to support an open architecture each of regional servers must comply with various established and de facto standards and practices such as: POSIX Compliant Operating Systems and TCP/IP; ANSI C/ C++; OSF Motif; Object-Modeling Technique; ANSI SQL, RDBMS; Client-Server/RISC Platforms; etc.

RTIC COMMUNICATION ARCHITECTURE

Each RTIC will provide a communication architecture capable of accommodating interfaces to other RTICS, agencies, users and the private sector. Each RTIC will support interfaces for local networks, Wide Area Networks, and switch elements which connect to public phone lines. The RTIC exchanges data with TOCs/TMCs (even if the RTIC is co-located within the TOC/TMC building) via a local gateway. This network interface allows for the exchange of data between the RTIC data processing equipment and the TOC/TMC. The TOC/ TMC network(s) are isolated from the other CTIS elements since the data exchange is controlled by the local gateway. This interface can be a network, such as Ethernet, using compatible communications equipment connected to a subnetwork. This subnetwork allows for the distribution of RTIC network information among the various data processing equipment within the center.

Inter-regional data networks are configured using the same gateway approach to allow the exchange of data to be controlled by the RTIC. Again these networks can be Wide Area Networks (WAN) using a compatible protocol such as DSI. The equipment used may include network modems (to connect to the public switch or the landline network) and bridges (to modify the WAN fortnat to a local network protocol). The RTIC's data processing equipment will have the capability of monitoring the WAN for operational functionality.

At the local level an ISP or commercial media member enters through a dedicated interface or through a dialup modem. This interface allows the service provider controlled access to the CTIS's data and satisfies the specialized data requirement of the ISP/partner. The typical equipment used here is analog and digital video/voice equipment, specialized modems, and network switch components. The traveler has access to the CTIS via the RTICs leased lines. Queries enter the CTIS via commercial modem, or audiotext equipment connected to the RTIC's data processing equipment.

RTIC FUNCTIONS

The primary goal of each regional traveler infonna'tion center is to compile, integrate, format, and manage data to be distributed to end-users and ISPS. To meet this goal, four major functions are required: data gathering; data fusion and processing; data delivery; and end-user device processing. In addition, subsystem functions in communications, data management, and data distribution are also needed; and support functions for trip-planning, system security, data fusion, ad-hoc user query, user-interface, data broadcast, map/GIS processing, and data exchange between RTICs required. The four major RTIC functions are described below.

Data Gathering. To appear seamless to the user, traveler information must be collected locally and integrated regionally, since travelers do not recognize imaginary boundaries such as state, county or city borders. Seldom do end-users require information only for a given city or county jurisdiction. This implies that transportation information must be collected and integrated from multiple public agencies and private organizations.

Since most traffic surveillance data is collected locally, regional data gathering activities require many system interfaces to information sources. RTIC system interfaces supporting center-to-center (e.g., TOC to RTIC, Transit Dispatch to RTIC, etc.) information exchange of voice and digital data are required. This information exchange capability is being developed by the I-95 CC through the Information Exchange Network (IEN) Project. The IEN effort includes the deployment of a uniform network backbone which will host over 67 IEN nodes strategically located at various Coalition member agencies to obtain local traffic data from each TOC. Since the local data will be in a unique format native to the host system, they are translated into a canonical IEN format and made available to other IEN nodes and RTIC data servers. The TOC-to-IEN interface initially will be manual but automated in the future as the system evolves.

Data Fusion and Processing. Once traffic and travel data are acquired, they must be fused, formatted, and/or further processed before dissemination to end-users, Data fusion includes consolidating and correlating data from multiple sources about the same point or area in the transportation network. For example, consolidating incident reports from commercial traffic reporting firms (acquired via aerial surveillance or motorist call-in) and public agencies (acquired via instrumented links and detection algorithms) is typically required. Not all data coming into the system need to be fused; sometimes they are just are simply acquired and stored (e.g., transit schedules). The acquired data must be validated and put together into formats to be used by other CTIS applications (e.g., trip planning). This may involve calculations combining one type of data with another, or aggregating the same kind of data together. To support route or modal travel time comparisons, for instance, data must typically be aggregated. For example, to determine travel times between cities, low-level link data (typically obtained at half-a-mile intervals) must be combined together to form a route travel time estimate. Finally, acquired, fused and formatted data must be spatially attached using geo-referencing to a base map or spatial model.

Data Delivery. To disseminate traveler information effectively and to provide ubiquitous access to all types of users, public/private partnerships comprising Coalition member agencies and various private-sector sponsors are required. Commercial endeavors by ISPS, VARS, CSPS, and various other types of repackages, distributors, and other providers of traveler information products and services are envisioned. These private-sector entities are expected to add information, package traveler information with other types of information, and disseminate information directly to end- users to enhance the effectiveness of the regional traveler information center. Actionable, real-time traffic and travel information will be collected and disseminated (by both the public and private sectors) on all modes, including private vehicles, and public and commercial transportation.

Dissemination of traveler information will likely occur in phases (as previously discussed), progressively adding more services and incorporating sophisticated technology over time. In the short-term phase (Years 0-2), the CTIS will disseminate primarily via proven communication media: commercial radio stations, VMS/ HAR, faxes, pagers and telephone. During the mid-term phase (Years 2-5), more sophisticated private-sector information dissemination proliferates. Information will contain more multimedia components, and from the user's point of view will be more interactive and personalized. Dissemination technologies and devices will include regular, cable and interactive TV; dial-up on-fine services; public kiosks; Intemet-accessed services; and various types of hand-held devices such as two-way pagers, personal digital assistants (PDAs), and personal communication systems (PCSs). In the final phase (Years 5-1 0). heavy emphasis will be placed on widespread deployment of in-vehicle navigational devices displaying real-time, location-specific, multi-modal navigational information. In addition, the use of intelligent agent processing will begin to be used. This technology will be employed to automate the information retrieval and delivery processes (i.e., from the user's point of view), and to increase the amount of personalized information, thereby facilitating more passive users who receive information only on an as-needed basis.

Since it is envisioned that the bulk of traveler information (especially personalized information) will be disseminated by the private-sector, the CTIS must provide sufficient external database access. Access to CTIS data by the private sector will be supported by two mechanisms: 1) dedicated communication channels where CTIS data (e.g., link, incident) is "pushed" out on a synchronous (i.e., periodic) basis or asynchronous basis; and 2) dedicated or dialup communication channels where CTIS data is "pulled" out on an as-needed basis by private-sector ISPS.

End-User Device Processing. This is potentially the most important component of the CTIS system, in that it is responsible for directly interfacing to end-users. @le most end-user device processing is likely to be a private-sector function, several end-user devices are likely to provided by public agencies. These include, VMS/HAR, kiosks, and telephone. Regardless of the device and the provider, all end-user device processing begins with acquiring travel information. Then, depending on the device and vendor, device specific processing occurs. These functions include, formatting, user-specific filtering, data presentation and display. In addition, for devices supporting two-way communications (Computers, PDAS, two-way pagers, kiosks, etc.), support for the construction, retrieval, and display of ad-hoc and fixed queries is also required.

Adapted from An Architecture for a Corridor-Wide Traveler Information System, by Barry A. Grasso, Gardiner A. Hall, Manzur Elahi, Tissa De Silva, Altman Thompson, and William V. Twomey, Proceedings of the 1996 Annual meeting of ITS America.

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