

PROJECT # 8 (95008)
Traveler Information Services (TIS)

Executive Summary

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PROJECT OVERVIEW

In 1994, the Coalition 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 TIS project was initiated to satisfy two major objectives - to develop a conceptual design for an Advanced Traveler Information System (ATIS) for the I-95 Corridor and to develop a framework for ITS public/private partnerships. The conceptual design focuses upon providing travel information in vehicles, homes, the workplace, public kiosks, and intermodal transfer points. The partnership framework enables the individual members of the I-95 Corridor Coalition to integrate and share information useful to travelers. This information will form the basis of an open architecture that promotes public and private product and service providers access to the jointly developed information.

Meeting the project's objectives required a comprehensive system's analysis and design. The first step in the analysis was to conduct a survey of existing public and private sector TIS. Next, the project worked with the I-95 CC to identify and obtain consensus on goals and objectives that the system will satisfy. Based on these goals and objectives, a complete set of functional, performance, and system requirements was derived. A conceptual design responsive to the requirements was then developed. Key considerations during the design process were technology availability, an operations concept that identifies the roles of the public and private sectors in providing traveler information services, and the system's life cycle costs.

CTIS GOALS

As part of the TIS project, a goal setting task was completed to identify end-user and agency requirements for the CTIS. Each agency of the Coalition was interviewed and asked to complete a survey to obtain consensus on system goals.

Table 1 identifies specific traveler user service goals and objectives that were a result of this process. These are the specific goals and objectives for the ultimate TIS system, that served as the baseline for developing the system requirements and the high-level conceptual design. The goals and objectives were designed to address the following areas:

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

It is important to note that goals do not address the specific technologies or the specific functions/requirements that will be implemented by the ultimate system.

CTIS VISION

The vision of the I-95 Corridor Traveler Information System (CTIS) was defined for the near, medium, and long term. This vision is seen from the perspectives of an end-user and an operational user.

End-user View

This end-user view presumes that the I-95 Corridor 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 (0 to 2 years); phase II (2 to 5 years); and phase III (5 to 10 years).

Table 1. Specific User-Service Goals

Goals	Objectives
<p>1. Enhance urban and interurban corridor road travel or various roadway users:</p> <ul style="list-style-type: none"> + business travelers + tourists + commuters + CVO/dispatchers + transit/paratransit operators 	<p>Provide timely and accurate information on the following, to both pretrip (home, workplace, transit stops, rest stops, public locations, etc.) and enroute (in-vehicle) users:</p> <ol style="list-style-type: none"> 1. Real-time incident/congestion summaries. 2. Traveler advisories. 3. Road weather conditions. 4. Construction summaries. 5. Alternate routes and modes. 6. Real-time link status. 7. Route guidance information. 8. Parking availability. 9. Parking locations. 10. Intermodal transfer points. 10. Trip planning capability. 11. Road environmental conditions.
<p>2. Enhance modal and intermodal travel for various urban and inter-city mass transit users:</p> <ul style="list-style-type: none"> + Bus, Subway Travelers + Air Travelers + Rail Travelers + Ferry Travelers 	<p>Provide timely and accurate information on the following, to both pretrip and enroute users:</p> <ol style="list-style-type: none"> 1. Schedule, route, and fare information on all transit modes (bus, train, subway, air, ferry). 2. Real-time status location information on transit modes (bus, train, air, subway, ferry). 3. Paratransit services. 4. Ride-matching services. 5. Trip plans. 6. Modal travel time comparisons.
<p>3. Enhance the safety of travelers.</p>	<p>Provide timely and accurate information on the following, to both pretrip and enroute users:</p> <ol style="list-style-type: none"> 1. Locations of hospitals. 2. Locations of emergency telephones. 3. Locations of repair shops. 4. Locations of police.
<p>4. Increase the availability of traveler information.</p>	<p>Provide timely and accurate information on the following, to both pretrip and enroute users:</p> <ol style="list-style-type: none"> 1. Regional weather conditions. 2. Food/dining and gas information. 3. Lodging. 4. Regional environmental conditions.
<p>5. Increase tourism.</p>	<p>Provide timely and accurate information on the following, to both pretrip and enroute users:</p> <ol style="list-style-type: none"> 1. Special events. 2. Attractions. 3. Historic sites. 4. Festivals. 5. Parks and recreational facilities. 6. Cultural and arts activities. 7. Educational institutions, 8. Resorts,

Phase I of CTIS is focused on rapidly deployable, baseline information dissemination to the broadest possible audience, 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:

+ Baseline Information Dissemination:

- Designed to accomplish near-term 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, tested and evaluated 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 wireline 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. This includes, the use of dial-in bulletin boards, faxes, and pagers.
- Enhanced multimodal information to encourage modal shifts.
- Probably subsidized substantially by the public sector, as private-sector investment and consumer dollars will 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, including real-time traffic conditions and incidents, construction activities, special events, weather conditions, and where available information on transit conditions and schedules, multimodal options and travel time comparisons, traveler and tourist facilities, traffic diversion and speed advisories, and emergency services.

+ Incident Management Support:

- Designed to enhance the traffic recovery function, by broad dissemination of advice to avoid incidents, and advises when normal levels of service are resumed.
- Includes emergency notification via pager of all key public-agency personnel.
- Includes comprehensive database compilation of incident management data, including 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 I, more sophisticated private-sector information dissemination 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, delivered over private media at the expense of either the individual consumer or the wholesaler (such as paging companies or cable TV operators) who see their media enhanced by the delivery of advanced traveler information. 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 disseminated in Phase I, Phase II 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 begin to be able to make use of similar interactive multimedia information dissemination devices serviced by CTIS. As identified in Figure 1, Phase II will begin to provide support for "passive" users. Passive users are not required to actively take steps to obtain information. These types of users subscribe to receive personalized traveler information on an exception basis only. The system will have knowledge of

their travel profile and will only transmit information on an as needed basis (e.g., when there is an incident on their route, during their travel times).

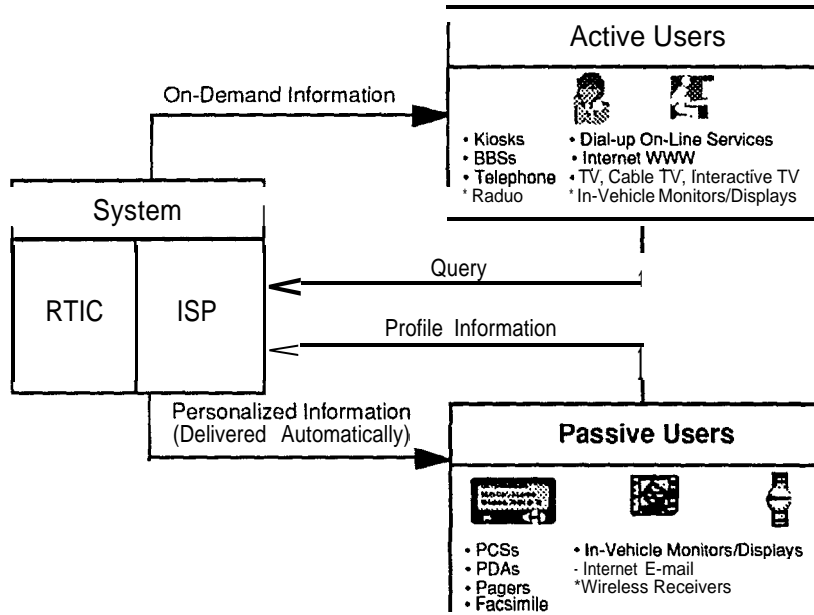


Figure 1. CTIS Provides Support for Both Active and Passive Users

Public agency end-users in Phase II expand the deployment and sophistication of on-road demand management devices such as variable message signs, highway advisory radio and possibly highly visible public place kiosks (for such facilities as parking garages, shopping malls, rest stops, intermodal transfer points and other mass dealing locations).

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 likely also serve as mobile probes, recording real-time traffic conditions on an anonymous basis back to CTIS, providing CTIS (which also services real-time on-road dissemination media such as variable message signs and highway advisory radio) 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 real-time information.

Table 2, summarizes the deployment schedule and the service provider of various TIS technologies. This table does not preclude the opportunity for services transitioning from public to private operation.

Table 2. Service/Deployment Phasing

Service	Deployment					Service Provider			
	Baseline	Year 2+	Year 5+	Year 10+	RTIC	ISP	Transit	Media	TMS/TOC
On-line Computer Service		X			X	X			
In-vehicle Device				X		X			
HAR	X								X
Public Kiosks			X			X	X		
VMS	X								X
Cable TV		X						X	
Network TV		X						X	
Telephone Menu	X				X	X			
Pagers		X				X			
Hand Held Devices			X			X			

Operational User View

Just as the view of the end-user will change over time as the CTIS develops, so will the perspective of those operating the RTICs.

In Phase I-Baseline Information Dissemination-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 gaps in information which is available from public agencies. 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.

Finally, the operator collects information from other entities, such as the regional weather services, whenever necessary. The RTIC then fuses and formats the data, and disseminates useful information to the wholesalers of traveler information. This data fusion and formatting step may be a public or private enterprise, while dissemination is almost certainly a private function with the exception of Variable Message Signs (VMS) and Highway Advisory Radio (HAR) operation.

The operator also communicates information to public agencies within the Corridor, such as incident information to agencies responsible for clearance, and real-time traffic information to transit agencies for improved operational management of their services.

During Phase II of the TIS evolution, the operator's view from the RTIC does not differ greatly from Phase I. 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 (TOG) come on line, the operator may have less need for 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 II 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 I, 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.

This longer time frame of Phase III promises the greatest changes for the operational user. Technologies for data collection are shifting from road-based to vehicle-based systems. For instance, a current Field Operational Test in the Washington, D.C. area is assessing the viability of measuring traffic speeds and link times by tracking cellular telephones. Also, as mentioned above, the proliferation of in-vehicle devices may provide another means of automated data collection based upon the vehicle.

While this shift radically changes the role of the operator in data collection, perhaps transforming her or him from an active participant in data collection to an interested overseer of an automated data collection system, it does not have similar effects on the fusion and dissemination elements. Indeed, while in-vehicle devices for tracking traffic condition hold substantial potential for improving the quality and quantity of data collected in the RTIC, they further complicate the fusion and dissemination elements by introducing additional dissemination outputs to serve these devices.

CONCEPTUAL SYSTEM ARCHITECTURE

The conceptual design for the system is presented from two perspectives: a logical architecture and a physical architecture. The logical architecture presents the organization of the system from the perspective of its functionality. The physical architectures allocates that functionality to physical regions.

A well designed CTIS architecture is one that fully complies with all agency and end-user needs and which provides interfaces for existing and planned systems. To understand the various types of external interfaces with CTIS, a context diagram was developed. This diagram, illustrated in Figure 2, forms the basis of the logical architecture and identifies the various external entities that will interact with the system. As shown, CTIS will accommodate various electronic interfaces to data sources, including Traffic Operations Centers (TOCs), Transit Dispatch Centers (TDCs), commercial traffic reporting firms (e.g., Metro Traffic Networks), and many types of external

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).

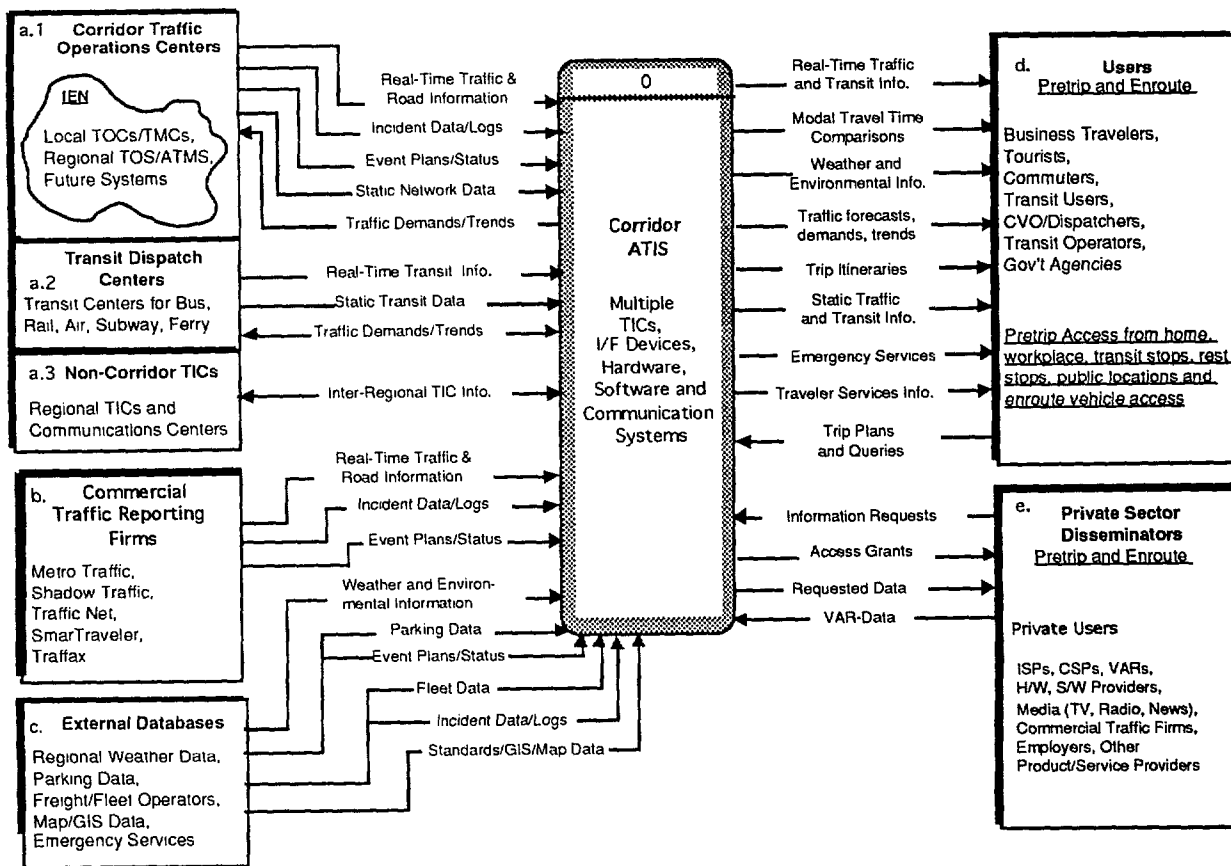


Figure 2. CTIS System Context

Based on this logical context diagram, a physical architecture was derived. 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.

Since the I-95 Corridor consists of several regions, and hosts over 20% of the total U.S. population, a distributed architecture, illustrated in Figure 3, was developed. Note that the proposed architecture identifies five major regions as identified below:

- ◆ 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)

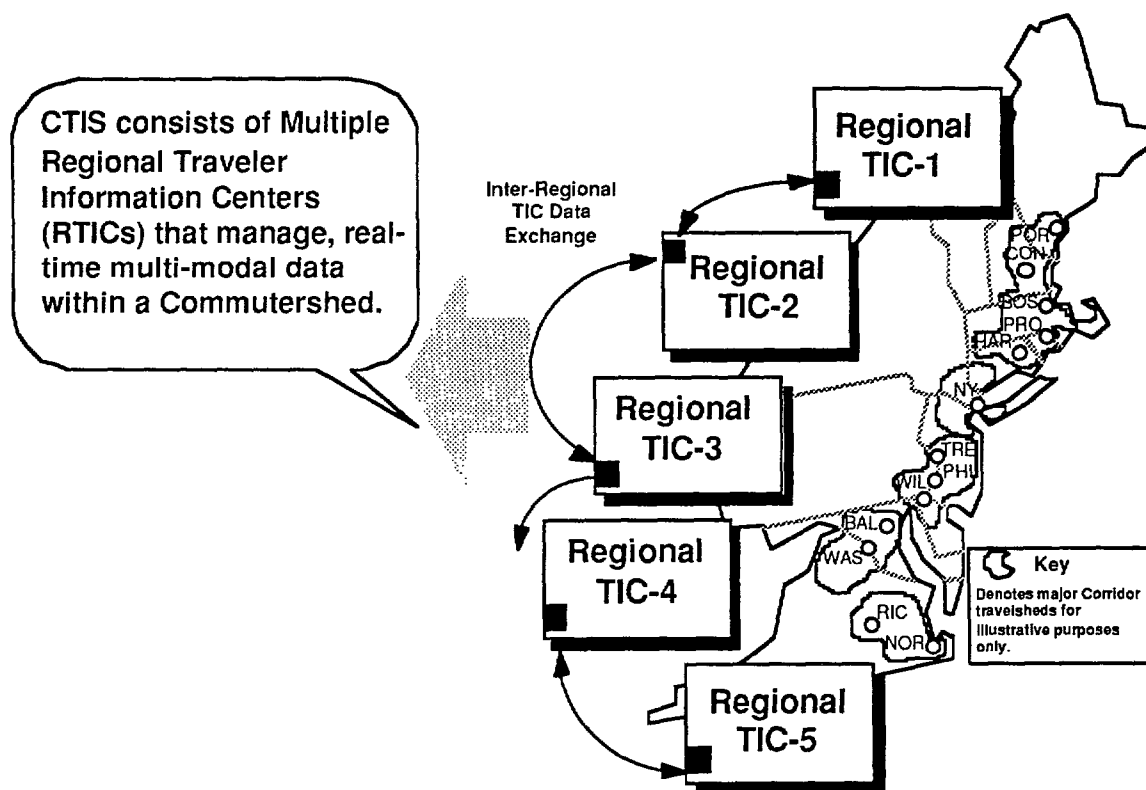


Figure 3. High-level CTIS Block Diagram Illustrating Candidate Corridor Regions

These regions (also identified as travelsheds) correspond to the three consolidated metropolitan statistical areas identified by the U.S. Bureau of the Census in the Corridor, plus aggregations of the Baltimore and Washington, and Richmond and Norfolk metropolitan statistical areas.

As illustrated, 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 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 intraurban, interurban, and interregional 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 are 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 as identified in Table 3.

*Table 3. Architecture Strictly Conforms
to Open Systems*

Requirement	Recommended Standard-Approach
Unix/NT	POSIX Compliant Unix & TCP/IP
c/c++	ANSI C/C++
X-Windows	OSF Motif
Object-Oriented	Rumbaugh's Object-Modeling Technique (OMT)
Relational Database	ANSI SQL, RDBMS
User-Friendliness	FHWA Human Factors Compliance Demonstrated through Simulation & Prototyping
GIS	SL-GMS, ArcView II or GDS
Expert Systems	Rule-Based and Case-Base Solutions
Client Satisfaction	Customer Acceptance Plans
Scaleability	Client-Server/RISC Platforms

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. Figure 4 shows how a typical RTIC will interact with the various communication elements. 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.

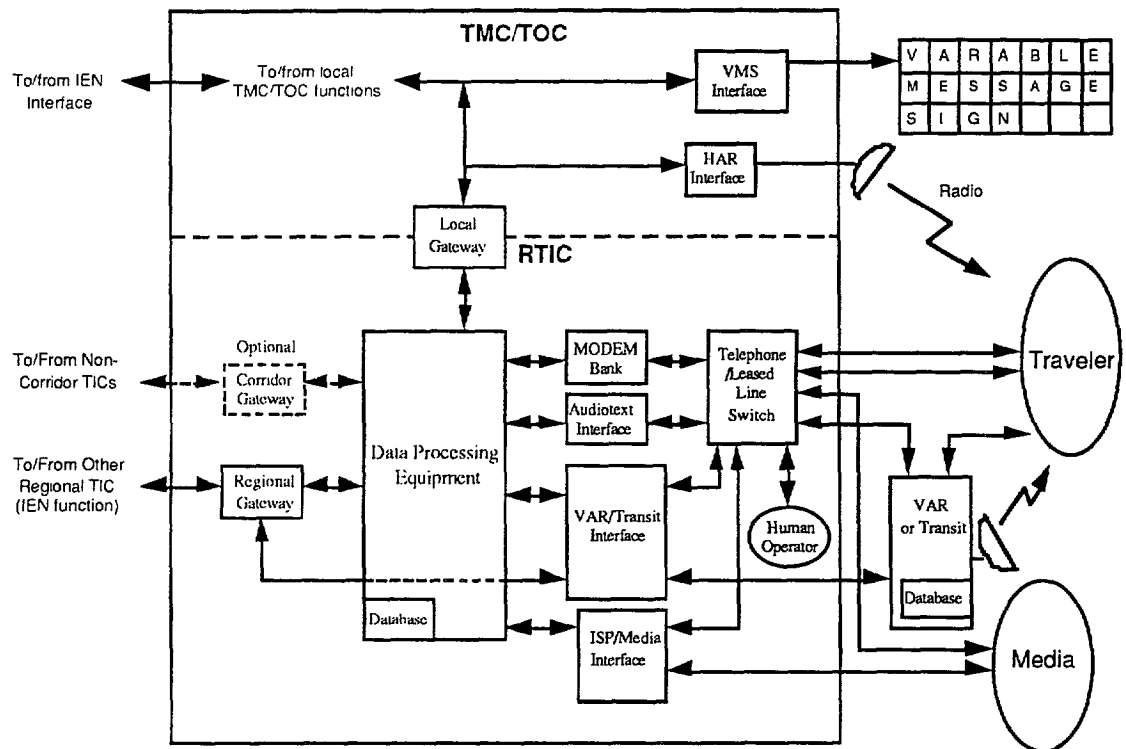


Figure 4. Typical RTIC Communication Architecture

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 DS1. The equipment used here may include the following:

- + Network modem(s) - Used to connect to the public switch or the landline network

- + Bridge(s) - Used to modify the WAN format 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 media enters through a dedicated interface or through a dial-up 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.

The primary goal of each regional traveler information center is to compile, integrate, format, and manage data to be distributed to end-users and ISPs; thus, the regional centers are the engines for the traveler information marketplace. To meet this goal, four major functions are required:

- + data gathering

- + data fusion and processing

- + data delivery

- + end-user device processing

Each of these RTIC functions will be discussed below. In addition to these functions, it is important to note that subsystems will be required in communications, data management, and data distribution. Moreover, to support various user and system needs, subsystem components are required for trip-planning, system security, data fusion, ad-hoc user query, user-interface, data broadcast, map/GIS, and exchange of data between regional traveler information centers.

Providing seamless access to regional traveler information begins with the task of 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. Seldomly do end-users require information only for a given city or county jurisdiction. This is partly due to the pervasiveness of suburb-to-suburb travel in the transportation network, and the fact that employees no longer reside close to their place of employment. The implication of appearing seamless is that traffic/transit surveillance and condition information must be collected and integrated from multiple public and private agencies. Figure 5 identifies the various CTIS sources of information and illustrates the relationship between RTICs, Traffic Operation Centers (TOCs) and IEN interfaces. Note that the figure is for illustration purposes and does not preclude the scenario of a joint RTIC/TCC operation.

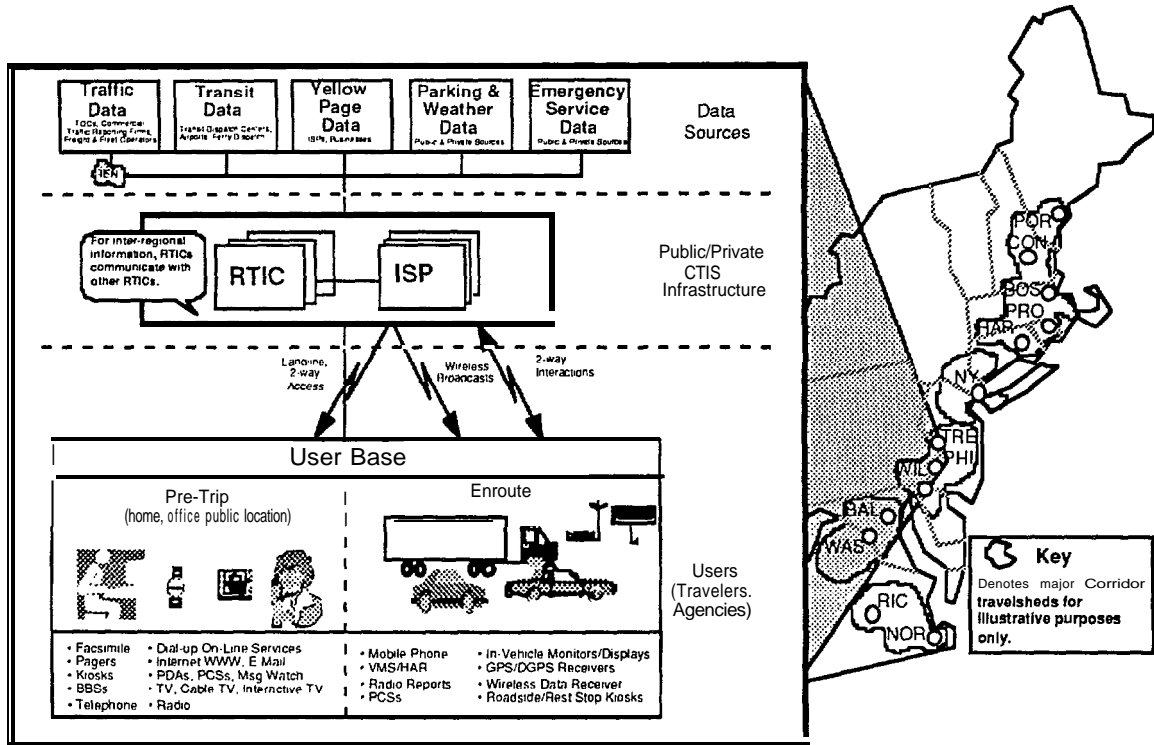


Figure 5. CTIS Block Diagram (illustrating coupling between RTICs and regions, and private-sector involvement through ISPs)

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 (i.e., TOC to RTIC, Transit Dispatch to RTIC, etc.) information exchange of voice and digital data are required.

Once information is acquired, and prior to it being delivered to end-users, data must be fused, formatted, and further processed. Fusion includes consolidating and correlating data about the same point or area in the transportation network, from multiple sources. 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. It is important to note that not all data coming into the system is fused. For example, transit schedules are simply acquired and stored. Once data is acquired it must be validated and put together into formats to be used by other CTIS applications --for example, trip planning. This may involve calculations combining one type of data with another, or aggregating the same kind of data together. In order to support route or modal travel time comparisons, for instance, data must typically be aggregated. For example, to determine travel times between cities (e.g., Baltimore-Washington) low-level link data, typically obtained at 0.5 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.

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 repackagers, 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. As illustrated in Figure 5, 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.

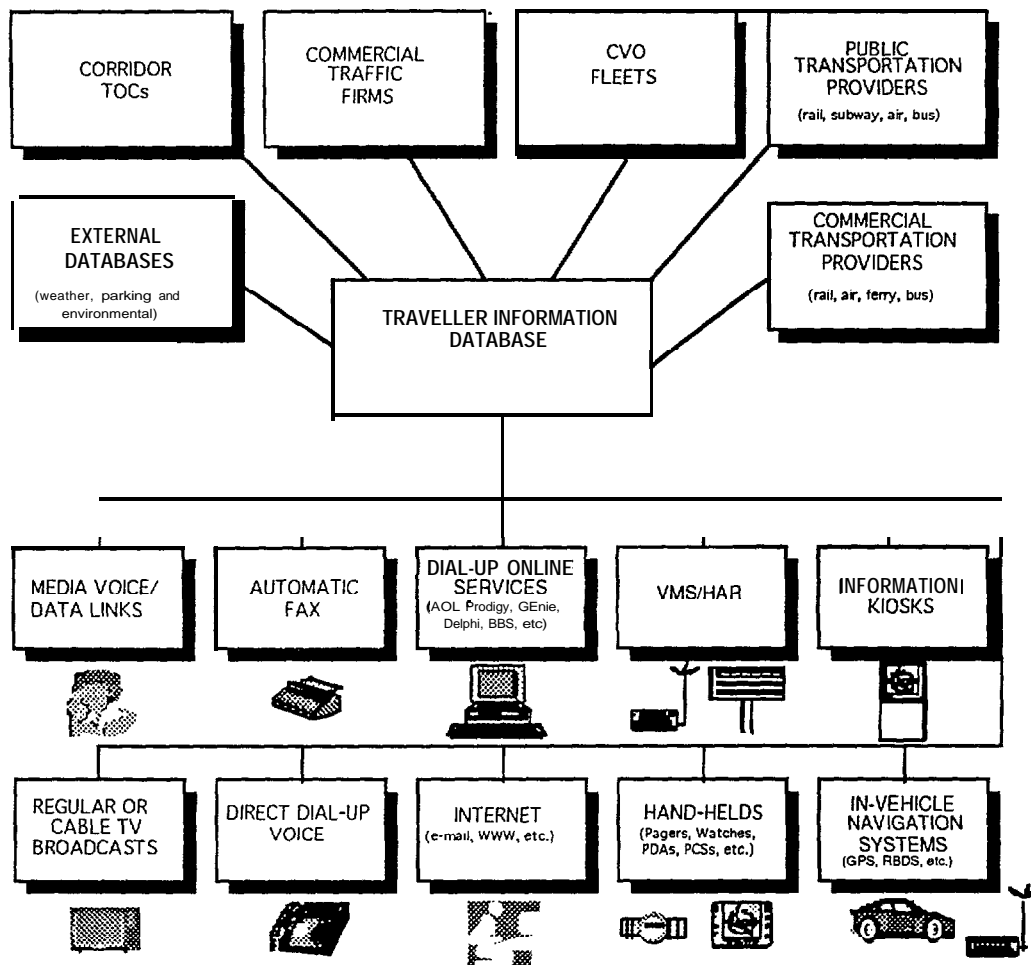


Figure 6. CTIS Data Sources and Sinks

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 baseline phase (years 0-2), TIS 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/devices will include regular, cable and interactive TV; dial-up on-line services; public kiosks; Internet accessed services; and various types of hand-held devices including, two-way pagers, personal digital assistants (PDAs), and personal communication systems (PCSs). In the final phase (years 5-10), 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. As depicted in Figure 6, CTIS will acquire information from many sources and will use various communication media to disseminate traveler information.

End-user device processing is potentially the most important component of the CTIS system, in that it is responsible for directly interfacing to end-users. While most end-user device processing is likely to be a private-sector function, several end-user devices are likely to be 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 traveler 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, next-generation pagers, kiosks, etc.), support for the construction, retrieval, and display of ad-hoc and fixed queries is required.

CONCLUSION

This project has presented a candidate architecture for a Corridor-wide Traveler Information System. The proposed architecture is distributed and identifies several Regional Traveler Information Centers to support the I-95 Corridor's concept of inter-regional traveler information. The design, development and operations of each center will require a public-private partnership to provide travelers in the congested I-95 Corridor with enhanced, actionable, real-time, multi-modal traveler information used for making informed travel decisions. The RTIC, using an open architecture and standard DBMS technology, will provide a testbed for the private-sector to provide or obtain traveler information and to experiment with various types of dissemination channels and devices.

The supporting analysis and documentation is contained within the Project's final report. The final report summarizes the findings of each of the Project's tasks. Appended to the report are the working papers containing the detailed analysis that led to the conceptual design for the Corridor-

wide Traveler Information System. Table 4 provides a listing of each of the Project's tasks and the corresponding section of the final report and the appropriate working paper.

Table 4 - Final Report Organization

Task	Final Report Section	Working Paper #
1-Inventory of Traveler Information Services and Commercial Opportunities in the I-95 Corridor	Section Z-Defining Traveler Information Services	1
2-A definition of Goals for the I-95 Corridor TIS System	Section 3-Agencies Goals Section I-The CTIS Vision	2
3-Requirements Analysis	Section 5-Requirements	3
4-Evaluation of Available TIS Technology	Section 6-Applicable Technology	4
5-TIS Conceptual Design	Section 7-CTIS Architecture	5
6-Scenarios for Private Sector Partnership TIS Opportunities	Section & Opportunities for Public/Private Partnerships	6