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PROJECT # 8
Task 3 - Traveler Information Services (TIS)

Requirements Analysis Report

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1. INTRODUCTION

This Working Paper, the third in a series of six, summarizes the results of Task 3-Requirements Analysis-of the Traveler Information Services (TIS) Project. This paper is submitted to the Project's Technical Review Committee (TRC) for review and consensus. The TRC's comments, recommendations, and assigned action items with respect to this paper will be analyzed and substantively included in the Final Report for this Project.

1.1 PROJECT OBJECTIVES

The I-95 Traveler Information Services Project is an Advanced Traveler Information System (ATIS) implementation tailored to the unique needs of the Northeast Corridor. The project is designed to acquire and disseminate information on roadway traffic conditions, and other pertinent transportation information throughout the Corridor. The TIS will use a variety of static and dynamic information ranging from transit schedules and call-in reports to real-time traffic monitoring data and transit status information. TIS will ingest, aggregate, and fuse these data in a database architecture that supports dissemination through a variety of communications systems and services to help travelers in the I-95 Corridor choose the most efficient transportation modes and/or routes.

This Project's objectives are:

+ To present a conceptual design and requirements for a Corridor-wide TIS; and

+ To identify opportunities and principles for private/public partnering in providing Traveler Information Services.

1.2 TASK 3 OBJECTIVES AND APPROACH

The focus of Task 3 is the identification and development of a consistent, complete, and testable set of requirements that satisfy the goals and objectives identified in Task 2 of the effort. Contained within this set are requirements that describe:

+ Traveler Information Needs. Those requirements that describe the types of information that the system must provide.

+ Route and Modal Choice Criteria. An analysis of how travelers choose their current travel routes and modes and how a TIS can provide them with additional data to assist in their choices.

+ Communications. The purpose of these requirements is to outline the capabilities that the system will require for disseminating information from the perspective of both the end-user and within the TIS itself.

+ Database Format. These requirements define the standards and data structures that the system will use for manipulating information.

+ Map Database. The purpose of these requirements is to encapsulate those requirements for storing and manipulating map information.

+ TIS Interface. These requirements define the content of messages that are used for communicating with systems that are external to TIS.

+ System Requirements. These are the requirements that describe the technical features of the system, such as, modularity, information accuracy, standards, and maintainability.

These requirements are documented in this working paper for the Technical Review Committee's review and ratification. These agreed upon requirements will then be used as the platform upon which the system's conceptual design will be built.

1.2.1 Task 3 Approach

Developing requirements for TIS is an iterative process that involves consideration of many different facets. Using the system goals and objectives that were developed in Task 2, we first identified and defined the types of users that the system will serve. Once these users were identified, we then developed a list of the types of information that these users will require. After the information needs of the users was understood, we then examined the types of applications and technologies that will be required to support the processing and dissemination of user required information. Finally, we then developed the requirements that are needed for ensuring that the resulting system will be well engineered from the perspective of evolution and operability. The approach that was used for developing the system's requirements is shown in Figure I-l.

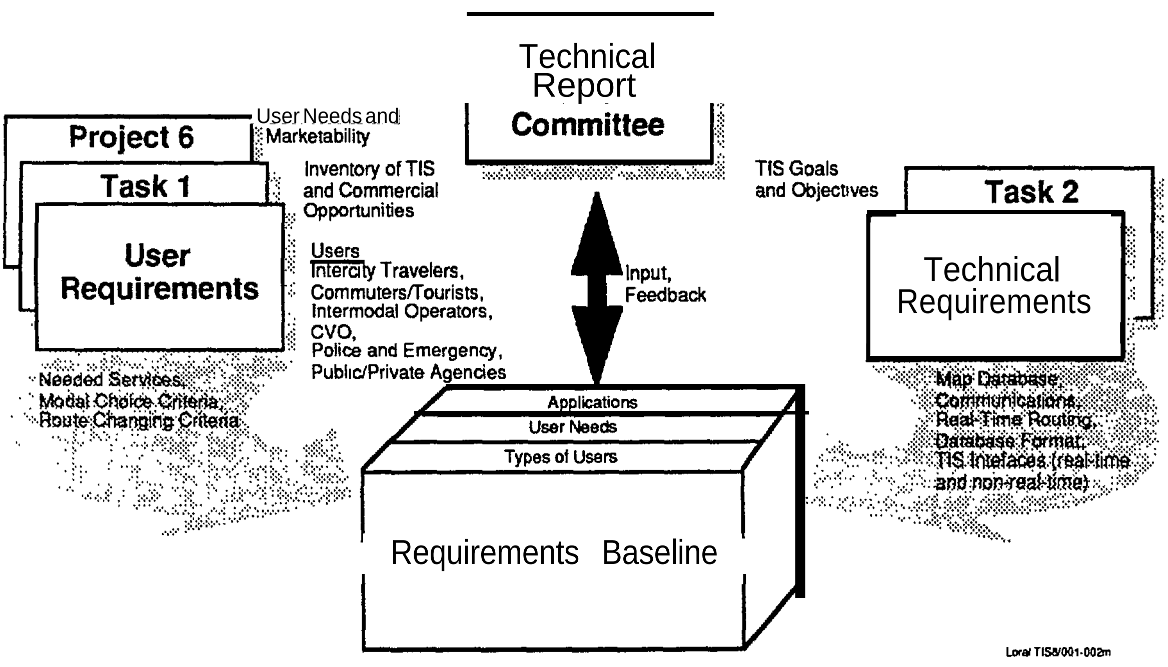

Figure 1-l. The Requirements Development Approach

As described previously, a comprehensive list of the system's users was first developed. For the purpose of this analysis users are divided into three broad categories. The first category is composed of the end-user, these are the people who will make travel decisions based upon the information that the TIS provides. First, in coordination with Project 6-User Needs and Marketability- we classified the types of end-users. Once the types of travelers were classified we then developed an assessment of their travel information needs. This assessment was approached in three ways. First, we reviewed the initial results of the Project 6 User Needs focus groups. Next, we developed operational scenarios that described the information that the various classifications of travelers would need and how that might use that information. Finally, we examined user needs with respect to the survey results of Task 1. This information provided the public and private sectors' perceptions of end-user needs. The next portion of the user needs analysis was to examine the TIS needs from the perspective of the public and private sectors. For this portion of the analysis we relied upon the results of Tasks 1 and 2 as input. All of this information was integrated to develop end-user needs requirements.

Once we developed a firm understanding of user needs, we next examined the applications and technologies that would support satisfying those needs. This aspect of the analysis was approached from three directions. First, we reviewed the results of Task 1 of this project to include the Corridor's planned technology deployments in the assessment. Next, we used the preliminary results from Task 4 — Technology Assessment -to develop application and technology requirements. Finally, we applied lessons learned from our team's experience in deploying TIS systems.

The final step in the requirements analysis and development process was the specification of the system's technical requirements. These are the requirements that specify the following characteristics of the system:

+ Modularity.
+ Information accuracy and timeliness.
+ Reliability.
+ User friendliness.
+ Robustness.
+ Maintainability.
+ Standards compliance.

The details of this analysis and the resulting requirements are the subject of the remainder of this working paper.

1.3 DOCUMENT ORGANIZATION

This document is organized into 9 major sections. This section provides an overview of the working paper and the approach used in the requirements analysis and development process. Section 2 presents the vision of TIS and its operational environment. The focus of Section 3 provides an analysis of the criteria that travelers use for making mode and route selections. Section 4 is the user needs analysis, this section describes the information needs that TIS must satisfy. Section 5 provides an analysis of communication technologies and their relevance to TIS. The analysis of database and map database requirements is presented in Section 6. In Section 7, there is an analysis of the requirements needed for TIS external interfaces. The topic of Section 8 is TIS System Level requirements, those requirements that govern the systems performance. This working paper concludes with Section 9, where a complete list of TIS requirements is presented.

2. THE I-95 TIS

"TIS is a traveler's decision support system that aids in making intelligent travel decisions at the time and location where these decisions are made."[1] TIS will operate in an information-rich environment and it will collect, process, and disseminate the Corridor's transportation information. This information will include a variety of static and dynamic data ranging from transit schedules and traffic network geometries to call-in motorist reports and real-time transportation network status data. This information will support travelers in forming both pretrip and en route travel plans. This data will be collected and disseminated through a wide variety of communication media that will provide access to the widest possible range of the traveling public.

An important aspect of this vision is the role that both the public and private sectors will play. Providing the services prescribed by this vision of TIS, will require the formation of new partnerships. These partners will provide the research & development, market analysis, infrastructure deployment capital, and day-to-day operations of TIS. These partnerships will encompass both the public and private sectors and individual segments of the system may be supported by any combination of these partnerships.

2.1 THE I-95 TIS VISION

As previously described, the operational environment for TIS is evolving. As TIS matures, its characteristics will evolve in three primary areas: public acceptance and use, technology, and service provider roles. One of the primary uses of TIS, from a public policy perspective, is that it will be one of the fundamental tools that the public sector will have for promoting intermodal transfer. Initial studies and operational tests have proven that providing travelers with accurate and timely information will influence travel plans. This is an important piece of knowledge that is leading to further research in determining precisely the information that travelers require and the most effective means for transmitting that information. Simply put, it is unknown who will use what information and what the effect of widely available travel information will be. Another perspective of this area is that the utility function for providing this information to travelers is unknown. What this means is that it is unclear what use will be made of this information and what value travelers will

[1] Working Paper 1, Paragraph 2.1

place on having that information. The effort of the Coalition’s Project 6 is directly aimed at making a preliminary estimate in this area. Essentially, understanding these effects is a learning process, as the experience base grows the system will evolve and operate more efficiently.

The second area affecting TIS evolution is technology. Technologies impact deployment by providing the means for achieving the TIS vision. As technology evolves, the capability for providing specific services is enhanced. This in turn affects the utility function previously described. The specific technology areas with the greatest impact upon TIS are communications and data processing. The impact of technology changes will be explored in greater detail in the Task 4-Technology Assessment- working paper.

The issue of service provider roles covers many different facets. It is envisioned that providing TIS will require a new series of public to public, public to private, and private to private partnerships. While there are existing examples of all of these types of partnerships, it is a certainty that these partnerships will change in fundamental ways, Specifically, the following issues will need to be addressed:

+ Developing the working agreements among agencies.

+ Becoming accustomed to different organizational dynamics.

+ Satisfying public objectives while meeting profit objectives.

The issues of organizational roles will be addressed in further detail during Task 6 of this project.

In the following paragraphs, this vision of TIS is developed further. This elaboration of the TIS vision is divided into three distinct phases. Phase I is the short term of 0 - 2 years, Phase II is the mid-term 2 - 5 years, and Phase III is the long-term 5 - 10 years. The discussion for each phase is presented from two perspectives. The first is from the perspective of the end-user, the other is from the perspective of a TIS operator.

2.2 THE TIS VISION

The objective of this Project is to develop the conceptual design of an information system that supports travelers in making travel decisions. At a high level, there are two types of travel to be considered, long and short range travel. Long range travel describes those trips where the traveler moves from metropolitan region to metropolitan region. This focus of this project is to provide traveler information that optimizes long range travel. While long range travel is the target, the travel information needs of short range travelers must also be considered in the development of the design. This is because of the fundamental reason that a long range trip is really a series of short range trips that are tied together. For this reason local travel information collection and dissemination will support a corridor-wide traveler information system.

This section sketches a vision of the I-95 Corridor Traveler Information Service (CTIS) in the near, medium, and long term. This vision is seen from the perspectives of an end-user and an operational user.

2.2.1 End-user View

The end-user view described in this section makes assumptions about what features are essential to the success of advanced traveler information systems in the foreseeable future:

+ Data collection for the Corridor Traveler Information System can be based on static and real-time data collected from public agencies, but will need to be augmented by privately collected quantitative and qualitative data for roads and transit routes not covered by automated public-agency systems (due to existing gaps in surveillance, reference Task 2, Project #3). Public-agency data is very uneven throughout the I-95 Corridor. Operating experience with working traveler information systems makes clear that detailed, up-to-the-minute event data is the first essential building block to generating usage of an ATIS.

+ Data collected from public and private sources for integration into the Corridor TIS will be ‘fused” and maintained in one or more regional travel information centers, in which the data will be interpreted and formatted for use in CTIS dissemination media.

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 stages as demonstrated by Figure 2-1.

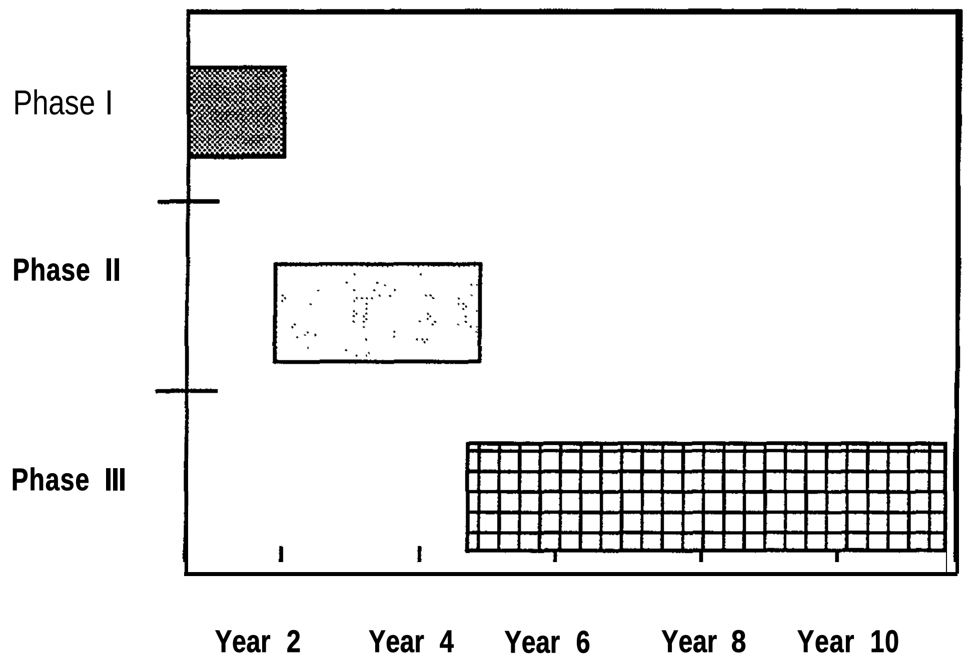

Figure 2- 1. Phased TIS Deployment

While this end-user view does make an attempt to put time frames on the stages of CTIS evolution, these time frames are imprecise and variable. Central to the view, however, is the division of CTIS' evolution into three phases, and the particulars of Phase I, which amount to a definitive action proposal for the Coalition.

2.2.1.1 Phase I-Baseline Information Dissemination

Phase I of 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:

+ 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.

- Aggressively multimodal and 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 and environmentally constructive travel.

- Includes information that serves key functional areas, including mode choice, route choice, and early stage “real-time” rerouting.

- Includes high priority information elements identified in Task 2 Working Paper, at least in their early stages-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 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, pemaps 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.

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).

2.2.1.3 Phase III-Real-time. In-vehicle Information Dissemination/Internally Contained

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.

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 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, including incident occurrences, traffic impacts, clearance times, etc., for the purpose of FHWA-required congestion management reports.

End-users, in the broad categories of individual travelers and public agencies, will have ready real-time access to the information and services described above from the Phase I CTIS. In addition, we assume that commercial vehicle operators will continue to develop their own systems, since Commercial Vehicle Operations (CVO) derives direct economic benefit from real-time traveler information. We further presume that the commercial vehicle operator will access the Phase I CTIS to enhance their own systems, perhaps for a fee paid to the operator of the CTIS; and that the commercial end-user of traditional radio and TV stations (and their end-users, the traveling public) will make use of this enhanced traveler information database to deliver more accurate radio and television traffic reports, and that the radio traffic reports will continue to be a critical component of the traveler information system, since radios will continue to be the principal in-vehicle communications device.

2.2.1.2 Phase II-Multimedia. Interactive Information Dissemination

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

2.2.2 Operational User View

Just as the view of the end-user will change over time as the Corridor ATIS develops, so too will the perspective of those operating the regional traffic operation centers. For this operational user's perspective, the same three phase developments of the TIS is contemplated.

2.2.2.1 Phase I-Baseline Information Disseminatlon

The Traveler Information Center (TIC) 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 TIC'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 TIC 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 [except for VMS and HAR dissemination].

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.

2.2.2.2 Phase II-MultimedIa. interactive Information Dissemination

During Phase II of the TIS evolution, the operator's view from the Traveler Information Center (TIC) 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 (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 II are in the dissemination media. The operator feeds the collected information to a much more sophisticated network of dissemination devices. The TIC operator also does more with the collected information to enhance its value. The Corridor TIC 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.

2.2.2.3 Phase III - Vehicle Information Real-Time Dissemination/Internally-Contained

This longer time frame 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 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 TIC, they further complicate the fusion and dissemination elements by introducing additional dissemination outputs to serve these devices.

2.3 ISSUES

This section addresses the issues facing the Corridor Traveler Information System. The first subsection discusses some of these issues. The second discusses how the Coalition can address several classes of issues.

2.3.1 Issues Facing CTIS

Most travelers on Corridor roadways get their traveler information from private-sector firms, such as Metro Traffic Control and Shadow Broadcast Services relayed through radio and TV stations (reference Task 1 Working Paper). These firms have developed pragmatic, ad hoc approaches to "surveillance", information gathering, fusion, and dissemination. They are potential partners in a Corridor Traveler Information System. The nature of this relationship, particularly where the boundaries will be drawn and how benefits are to be apportioned, will be contentious.

Our Working Paper 6 will address this issue specifically, but two models are already discernible, and are presented here for consideration.

A simple model will have CTIS gather and fuse data provided by public-sector devices, such as in-roadway detectors, and provide it to private-sector firms equally. CTIS would disseminate to public-sector output devices, such as variable message signs. CTIS would not otherwise disseminate information to travelers; all dissemination would be left to private-sector firms. Note that this model closely resembles how weather information is disseminated.

In the vision presented in Section 2.1, commercial firms provide their information to CTIS, which fuses it with public-sector information. This would lead to better data, but private firms may feel that they're contributing something proprietary, and, through CTIS, sharing it with their competitors. These problems can be dealt with, but it will be complex and delicate. Moreover, each state in the Corridor has its own policies and (as our survey for Tasks 1 and 2 showed) its own objectives for partnership with private-sector firms.

Another issue that the CTIS design must address is the probability of differing technical standards. All roadway operating agencies in the Corridor subscribe to consensual standards. To give a trivial example, stop signs are all octagonal, red, with a white reflective border. However, the agencies vary in various minor ways from these standards. Until a Corridor-wide, computer-based system is put in place, these variations are unimportant. A Corridor-wide system, however, looks for uniformity, even if it doesn't demand it; and a computer-based system demands precision. For example, how operating agencies refer to locations on their roadway networks varies; but CTIS will need to establish a single set of location referencing, if only for its own purposes. Will CTIS have to convert from a dozen or two systems to its own, and then disseminate back, reconverting into the dozen or two systems?

The key technical issue facing the development of CTIS is its "architecture", and how this architecture relates to the similar but not identical Information Exchange Network (IEN). Most documents and discussions assume that, in parallel to IEN, CTIS will have four regional centers. At this stage, however, it is not clear that the best number for CTIS is four or one or ten or zero, i.e., a virtual center.

2.3.2 Issue Resolution

The Loral TIS vision, as described in Sections 2. and 2.1, encompasses many components. From the multiple sources of raw data through the consolidation and reformatting of information, to the dissemination of specific information to a myriad of end-users. There are countless interfaces between equipment, organizations and individuals. These human and technological interfaces will literally be the links in the chain which can cause the project to succeed or fail. For, if the information is not timely, accurate and easily accessible, the public will not use the final product.

In order to make this multitude of interfaces work efficiently, a number of issues will need to be addressed in a direct and problem-solving fashion. The results from our survey of potential private sector partners for TIS underlined the importance of these issues. It is fair to say that the primary concern expressed by private sector companies is uncertainty about the ability of the public sector agencies and other entities to overcome institutional divisions, differentiated policies, and lengthy decision-making.

The I-95 Corridor Coalition is aware of this concern. Indeed its very existence as a multistate, multimodal group addressing the need to provide a consistent TIS along a corridor as extensive and complicated as I-95 indicates that a high degree of cooperation and communication already exists. Nonetheless, as the TIS project enters the conceptual design phase, many of these interface communication issues will appear at a finer grained level of detail, where they must be identified and solved.

The following is a list of interface issues which will arise as the TIS project moves through the conceptual design phase. Each identified issue will be accompanied by a suggested method to address it.

2.3.3 Institutional Issues and Policies

This is a broad topic and one which will have to be treated at several levels. Clearly the I-95 Corridor Coalition already has several mechanisms in place to handle cross-agency policy issues. The Executive Board is the prime policy making body, which oversees the Steering Committee comprised of technical and policy makers from member agencies. In addition, there are four working groups, each with a functional area to oversee. Under these working groups are a number of technical review committees; one for each project taking place under the umbrella of the coalition.

Thus, the coalition has already established a framework to deal with policies at the Executive Board and Steering Committee levels, and issues of increasing technical specificity as the work becomes more targeted towards particular products. This structure may have to develop even more fully as the conceptual and final product designs emerge. So, for example, as detailed questions regarding the integration and formatting of data need to be answered, a cross-agency structure needs to weigh recommendations and approve particular methods and formats for the corridor as a whole.

Decisions of this nature can perhaps be made through one of the existing technical review committees. It might be prudent, however, to consider establishing a public-private technical standards committee to deal with such issues. The advantages of a public/private committee would be:

+ To take advantage of the expertise of some of the companies engaged in the high tech aspects of TIS.

+ To establish a good working relationship between the public and private components of an ultimate TIS system.

+ To become aware of proprietary issues between private companies early in the process.

+ To develop a final technical product acceptable to the major parties who would be ultimately responsible for developing and using the TIS system.

+ To ensure early consensus on technical issues.

It may be desirable to form several of these public/private standards committees to deal with very specific areas of expertise. Examples might include communications protocols, data input formatting, system architecture, equipment specifications, data output specifications, and other similar topics.

2.3.4 Consensus Building

As the conceptual and final design develops, there will inevitably be areas of conflict. These areas can encompass public agencies, private companies, and combinations of the two. Proprietary, competitive, and jurisdictional issues will certainly arise among participants. It may be advisable to create a dispute resolution mechanism early in the process to address these issues before too much time and energy are expended without producing results acceptable to all parties.

Presumably, internal policy disputes among coalition members, if any should arise, would be handled by the Executive Committee and/or Steering Committee. However, disagreements may arise between agencies in technical and procedural areas which might not be appropriate for resolution at the Executive Committee level. For these issues, as well as for those which arise between private companies and public and private partners, a well-defined dispute resolution mechanism might be extremely helpful.

Options for dispute resolution mechanisms exist with increasing frequency along the corridor. Private companies provide these services, many court systems include referrals to individuals well versed in these areas, and arbitration experts are also available.

Alternately, the panel could include interested parties as long as all points of view were equally represented; e.g., public and private sectors, different transportation modes, and geographical distribution. No member would be allowed to serve as a mediator if his or her specific company or agency was a party to the dispute.

Whichever model is selected, it might be wise to designate both the dispute resolution method and a selection of individuals able to serve in advance of any fully developed dispute. Pre-designated panel members may be asked to help develop consensus as project development issues arise, but ideally before any real dispute develops. If differences of opinion appear to be slowing progress, a panel member with a specific area of expertise may be asked to intervene early to help achieve consensus at the product development level.

2.3.5 Establishing Public Awareness and Acceptance

The first step in achieving a successful TIS deployment is developing consumer awareness. Consumer awareness can be heightened through media outlets and advertisements. From lessons learned on the SmarTraveler project, however, consumer awareness is only the first hurdle to overcome. Users must first have their skepticism reduced by informing them of what types of technologies are used to acquire real-time data. These technologies need to be accurate and reliable so that confidence can be gained by the user community. Public sector sponsorship has also been an important element. Users are more willing and have greater confidence levels in using systems that are sponsored by public agencies. Finally, information on how to use various CTIS services needs to be strongly addressed.

As the TIS develops, it will be very important to keep the end-user in mind. Technical challenges, cross-agency coordination and public/private partnerships are complex and difficult prospects in themselves. But success in these areas cannot be fully realized without constant reference to the needs and proclivities of the traveling public.

Consequently, it will be important to check progress in product development with the consumer at several points along the line. This can be done in a variety of ways commonly used in market research. Among the standard methods are:

+ Focus groups.

+ Telephone surveys.

+ Written surveys.

+ Prototype testing.

The applicability of each of these methods will vary according to the nature of the information needed and the degree of product development. Focus groups are relatively inexpensive and easy to organize. They do not produce quantitative market data, but are very useful in assessing consumer acceptance for ideas in development. Thus, as TIS options become defined in sufficient detail to be described to potential users, a focus group or series of focus groups targeted at different types of users could demonstrate consumer reaction. The Coalition understands the value of focus groups and it is in the scope of Project 6-User Needs Marketability to conduct focus groups. The results of those focus groups are considered in this project.

Focus groups could highlight user understanding of a TIS in such areas as: ease of access, technical concerns and/or hurdles, best methods to reach audiences, cost sensitivities, and user flexibilityand habits. Focus groups could be conducted for auto commuters, commercial users, multimodal commuters, pleasure travelers and other specific groups.

Telephone and written surveys produce more quantitative market research data, but require more effort to conduct and analyze. Written surveys may be an effective option along the corridor, however, as a clear set of TIS products begins to emerge. Whereas phone surveys require a trained set of personnel to conduct them, written surveys could be handed out along the corridor at toll booths, rest areas, transit stations and other facilities. If produced in a self-mailer format, they would likely produce a significant number of returns, and it would be certain that those returning the forms would be interested in TIS. If a higher number of returns is desired, it may be possible to find a private sector sponsor who would offer a reward for each filled in response; e.g. a free soda at a concession chain along the corridor. This method would produce perhaps the first full fledged market research on public understanding and acceptance of TIS along I-95.

Finally, when a TIS prototype exists, it will be possible to give actual demonstrations to potential consumers. The first step will be the multimedia presentation on TIS, what it is and how it works, which will be a deliverable under this contract. The coalition can use this presentation in public meetings, on cable TV, at gatherings of business groups such as Chambers of Commerce and Rotary clubs along the corridor and at other forums where interest in TIS is developing.

Eventually, a full-fledged prototype should be available to demonstrate along the corridor. As the “information super highway” is such a well covered topic in the media, the merging of high tech information about the real super highway should be a topic of significant public interest. The media along the corridor would probably cover new TIS product prototypes if they are properly publicized. If each coalition member had access to a prototype for some period of time, no doubt a public relations program could be designed to familiarize the traveling public with the benefits of TIS along each section of the corridor.

3. MODE AND ROUTE CHOICE CRITERIA

This section provides an analysis of how users choose their travel modes and travel routes. Information on what criteria travelers user for changing their route or mode as a result of being given CTIS data and choices will be identified.

This section will set the context for the traveler information needs (a.k.a. high-level functional requirements) set forth in Section 4 and Section 9.

3.1 CHOICE OF MODE AND ROUTE

The traveler, both before leaving the destination and while en route, must make choices as to the mode of travel and the route. This choice is governed by:

+ The reason for the trip.
+ The destination of the trip.
+ Personal preferences.

There are also restrictions imposed on some travelers by their handicaps. In this analysis, the possible traveler information sources for pretrip and en route information are briefly examined. The advantages and disadvantages of each mode of transportation are discussed as a prelude to the selection of the modal and route criteria. The resulting criteria are the traveler's primary means for making an informed choice.

The choice of mode restricts the choice of route, and the choice of route restricts the choice of mode. These two factors, mode and route, depend on one another. It is the personal preferences of the traveler as to whether the mode or the route is chosen first. We assume that any selected mode or combination of modes can be used by the traveler. Physical handicaps enter into the analysis because a physical handicap is not a choice, but a restriction. Handicapped restrictions may become less important because all major forms of public and most forms of private transportation are likely to be barrier-free in the future.

Of the two related choices, mode can be defined as specific items independent of route decisions or destinations. The fact that not all routes provide accessibility to all modes at a specific location can be discounted in this analysis with no adverse effect to the result because the traveler can use a combination of modes. By contrast, a route can only be defined given a specific start and end point, and may be strictly limited by available modes.

Influencing travel decisions, such as mode and route, is not a well understood area and is currently a research topic. For example, the effect of posting a VMS message alerting drivers that there is congestion ahead is unknown. What is known is that some drivers do alter their route, but there is no evidence quantifying the effect of the action. Because of the uncertainties involved with understanding traveler behavior, this project is working under that assumption that each traveler has an individual cost function associated with every trip. The point of a traveler information system is to provide the traveler with accurate and timely information that will allow the traveler to assess the costs associated with each trip. It is then assumed that the traveler will minimize the cost function. From the perspective of the traveler potential costs may be:

+ Time.
+ Convenience.
+ Out-of-pocket Expenses.
+ Weather.
+ Aesthetics.
+ Length of Trip.
+ Urgency of the Trip.
+ Cost of Collecting Information.

Because each traveler has an independent cost function for each trip, the above list is merely representative of cost elements that travelers may consider. The goal of this project is to provide travelers with all of the information that is practically possible about all modes and potential routes to allow them to make effective travel decisions.

Pretrip information can be received at home or at work, and en route information can be received during a trip. This information aids travelers in making mode and route choices by providing travelers with timely and accurate static and real-time traffic or multimodal information on the following activities:

+ Construction activities.
+ Accidents or other incidents.
+ Adverse weather.
+ Seasonal Events.
+ Other transportation system delays.

Figure 3-1 shows some major sources for both pretrip and en route traveler information. All four sources for pretrip information are accessible to all three locations: home, office, and traveler information centers or kiosks. The en route information sources are accessed by both the driver of the vehicle and the passenger or passengers, but not all the sources are accessed by both.

Many travelers currently use only one mode due to 1) habit and 2) lack of usable and timely information that suggests alternate modes or routes. For this analysis, we assume that the traveler has a greater capacity in choice of mode and route than at present. This assumption is valid considering that the traveler in this analysis has access to all the information needed to make an informed decision.

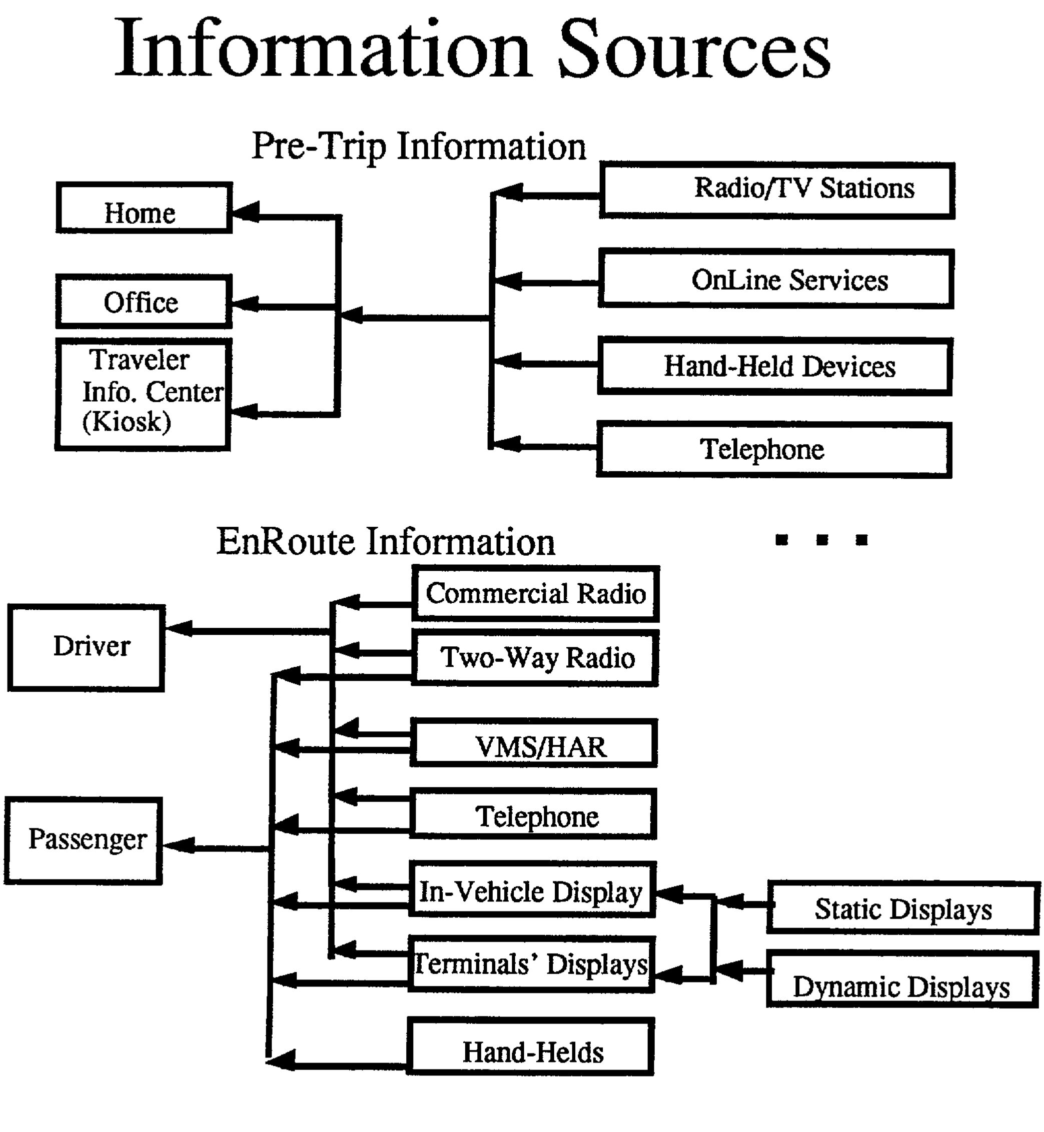

Figure 3-1. Traveler Information Data Sources

The traveler has the advantage of selecting from a number of different modes, both commercial and noncommercial:

- For the commuter, the available modes include: car, bus, bicycle, train, light rail, and plane.

+ The traveler who uses commercial transportation for business or recreation, but is not a regular commuter, has the added mode of commercial car or taxi, a mode seldom employed by the regular commuter.

+ The tourist can use any of the available modes, but the trip is usually not during peak travel periods. This off-peak travel provides the tourist with several benefits as discussed in the following paragraphs.

3.1.1 Pretrip Information

This section discusses how a traveler accesses information before he or she starts on a trip. The information can be accessed before the beginning of the trip or during the trip, either en route or at transit or intermodal transfer points. Before the trip begins, the traveler can receive information concerning available travel modes and routes by accessing transportation information:

+ At home.

+ At the office or place of employment.

+ At a traveler center or kiosk.

The traveler information services available to the traveler for prettip information include:

+ Commercial radio stations broadcasting regular travel information, mostly concerned with traffic and transit delays.

+ Commercial television stations broadcasting regular travel information, usually only during peak travel periods.

+ Newspapers for announcements of large-scale or long-duration disturbances such as major roadway construction.

+ In the future, traveler and traffic information obtained from traveler information centers by phone, computer link, or static or dynamic displays in terminals, kiosks, or other public areas.

3.1.2 En Route Information

A number of services either are now or will be available in the future to the traveler while the traveler is en route. The traveler, in many different modes of travel, can access this information. As a driver or passenger in a car or truck, the traveler can receive information from the following:

+ Highway Advisory Radio (HAR).

+ Variable Message Signs (VMS) along the highway.

+ Commercial Radio.

+ In-vehicle displays, a development that will be available to the general public in a few years. These units are also mostly for the highway user, but will probably also be useful in an urban environment. Static and dynamic information will be displayed. Dynamic information will be transmitted wirelessly [e.g., Cellular Digital Packet Data (CDPD), FM subcarrier] in real-time to in-vehicle processors.

+ Information is or will be available in transit and intermodal transfer terminals. The information should be available from both static displays showing route information, and dynamic displays of current traffic and transit information.

+ The driver of a bus can receive travel information from the same sources as the driver and passenger of a car or truck, as well as from a dispatcher.

+ The passengers of buses, trains, light rail, and planes can receive en route information from the driver or vehicle crew, such as the conductor on a train or light rail, as to transportation problems. These travelers can also receive information at the transit terminal via voice announcements, variable message signs, or static or dynamic routing information.

It is important to note that the accuracy and the reliability of disseminated information is critical to the success of a traveler information system. Technical issues such as providing accurate travel time comparisons through VMS and HAR must be resolved before the wide spread deployment of such capabilities.

3.1.3 Establishment of Criteria for Choice of Mode and Route

The traveler decides on travel mode and route based on personal criteria that depend, in part, on the type of travel and the time of day. For our analysis, we divide non-goods-carrying travelers into three types: commuter, business traveler, and tourist. Table 3-1 highlights the major criteria used by the three basic types of traveler, and the handicapped traveler; all of these criteria are addressed by the traveler information needs (a.k.a. high-level functional requirements) identified in Section 9. The handicapped traveler is actually included in each of the three basic types, but there are additional overriding concerns depending on the degree and type of handicap. In the future, all modes of public transportation may be barrier-free, but the present situation does present barriers to some of the handicapped and this condition must be considered.

Table 3-1. Criteria for Choosing Mode and Route

Criteria	Commuter	Business	Recreational	Handicapped
Static information-pre-trip information				
Expected delays (i.e., recurring)	Yes	Yes	Yes	
Expected travel time & distance	Yes	Yes	Yes	
Number of intermodal transfers	Yes	Yes	Yes	Yes
Transfer distance to/from transit or between modes	Yes	Yes	Yes	Yes
Urgency of trip		Yes		
Time of day			Yes	
Trip itineraries			Yes	
Traveler information services			Yes	
Perceived costs	Yes	Yes	Yes	
Modal Preferences	Yes	Yes	Yes	
Dynamic information-real time information				
Traffic/Transit delays (e.g.. accidents)	Yes	Yes	Yes	
Modal travel time comparisons	Yes	Yes		
Current weather and forecasts	Yes	Yes	Yes	

3.1.3.1 Commuter Criteria

The commuter will generally base mode and route decisions on both static and dynamic information. The static information includes:

+ Expected delays.

+ Expected travel time.

+ Number of intermodal transfers.

+ Transfer distance to/from transit or between modes.

+ Perceived cost.

+ Modal preferences.

The expected delays is an item that must be updated daily, while the expected travel time and cost are computed by the commuter only when changes occur to the selected mode or alternate modes. The number of transfers affects the travel time, and missed transfers could delay the trip. The commuter will attempt to minimize the transfer distance. Additional factors, such as the time to find parking, feed into this equation. The perceived cost is composed of both out-of-pocket trip costs such as transit tickets, tolls and parking, and other costs such as fuel, vehicle depreciation, and lost work or leisure time due to travel. Finally, when multiple modes are available, commuter modal preferences are also candidate criteria. Modal preferences not only identify what the preferred modes are, but also within each mode preferences may exist. For instance, within the vehicle mode, a user may specify that he or she does not wish to travel on freeways. Similarly, within the transit modes a user may specify a preference to not use bus.

The dynamic information useful to the commuter concerns possible delays with respect to the work trip:

+ Real-time traffic and transit information concerning delays.

+ Real-time modal travel times for comparison,

+ Real-time weather information and forecasts,

Although the commuter usually remains with the previously chosen travel mode, the traveler can alter the start time of the intended trip based on expected delays. If the reported delay is longer than the commuter can or will accept, the commuter then considers the possibility of changing to another mode. The decision, if for only one trip, will probably be based upon travel time. If the switch to another mode is for an extended time, the difference in cost will enter into the commuter's considerations.

3.1 .3.2 Business Traveler Criteria

The business traveler uses a similar set of criteria as the commuter on which to base choice of mode or route, except the urgency of the trip is generally weighted higher in priority. The urgency of the trip has a greater influence on the selection of the trip mode and route because the more urgent the trip, the more important the expected travel time. The number of expected delays directly influences the expected travel time. As with the commuter, the expected delays must be updated before the trip, although the traveler may start from an office rather than a home. The number of intermodal transfers is also a factor that is governed by the urgency of the trip, as is the transfer distance, generally between modes. The more urgent the trip the fewer transfers can be accepted because a missed transfer means a delayed or failed trip. The perceived cost is not as important for the business traveler as for the commuter because the costs are generally a one-time event instead of a daily occurrence. The business traveler does recognize that travel time during the work day is lost production time; and therefore this is a component of perceived cost. A number of transit systems provide the business traveler with a work area or, as one carrier states, "a moving office". The highway-related modes generally cannot provide this service because the traveler must either drive the vehicle, or the vehicle ride is not smooth enough, or the vehicle large enough to provide a suitable work area. Similar to the commuter, modal preferences are also criteria used when select route or mode changes.

The business traveler then considers the current condition of the selected mode and route. Similar to the commuter, the business traveler considers the following dynamic information items:

+ Real-time traffic and transit information concerning delays.

+ Real-time modal travel times for comparison.

+ Real-time weather information and forecasts.

The business traveler is more concerned with delays as explained above, but usually has more of an option as to the start time of the trip.

3.1 .3.3 Tourist Criteria

The tourist includes those traveling in the midday period and for reasons other than direct employment. These travelers have additional static information demands, but a similar set of dynamic criteria. The static criteria are:

+ Time of day.

+ Expected delays.

+ Expected travel time.

+ Intermodal transfers.

+ Transfer distance to/from transit or between modes.

+ Perceived travel costs.

+ Trip itineraries.

+ Traveler information services including trip plans.

The tourist usually has more flexibility to alter the start time of the trip to correspond to an improved travel time. The tourist also considers the expected delays and expected travel time, but rather than choosing a different mode or route, the traveler may just change the start time of the trip. Depending on the type and duration of the trip, and any extra baggage carried by the traveler, intermodal transfers and transfer distance may be of considerable importance. A traveler with several pieces of baggage will select a mode or route that offers direct travel; whereas a traveler without baggage may not consider the transfers or walking to be a concern. The perceived costs of the trip may be the governing factor because the traveler can alter the other factors by minor changes, but the mode will generally determine the cost of the trip. Again, similar to both the commuter and the business traveler, modal preferences are also criteria used when select route or mode changes.

The tourist usually has the time to set up a planned itinerary for the trip and this itinerary can be checked against the expected and current traffic and transit conditions. Before the trip, the traveler can reprogram the proposed trip after considering information obtained from the traveler information services. An example of this function is currently performed by the American Automobile Association (AAA). They organize a trip itinerary showing roads, stops, and points of interest. Their output is centered on car travel, but the proposed CTIS will disseminate information for all modes of travel.

The tourist then considers the current condition of the selected mode and route. Two of the same dynamic information considered by the commuter and business traveler are considered by the tourist:

+ Real-time traffic and transit information concerning delays.

+ Real-time weather information and forecasts.

The tourist does not usually cancel the intended trip because of a negative input from one of these dynamic items. Rather, the traveler reschedules the trip or its start time.

3.1 .3.4 Handicapped Traveler Criteria

There is a special concern for the handicapped traveler in all categories. The advantages and disadvantages mentioned the ability of a specific transportation system to accommodate the handicapped. Generally, the higher level transport systems such as trains and planes will always accommodate the handicapped in some manner, but the items of most concern are:

+ Intermodal transfers.

+ Transfer distance to/from transit or between modes.

These two items are static information that can be retrieved from the CTIS under the area of trip planning. The handicapped person must consider these two items before selecting a mode and route. Because these two items will present the most difficulty to the handicapped traveler, they are critical, and depending on the type and severity of the handicap, these two items may be the governing items in the selection of a travel mode.

After considering the above two items, the handicapped traveler will then consider the static and dynamic items that fall under the appropriate topics detailed above for the commuter, business traveler and tourist.

3.1.4 Alterina the Traveler's Modal Choice

There are reasons for attempting to change the traveler's selection of travel mode. Some of the reasons that may encourage an attempt to change modal use decisions include the following:

+ Environmental damage from one mode is less than from another mode.

+ One mode is causing considerable problems, such as traffic congestion on the highways.

+ The infrastructure supporting one mode is over stressed or over used.

The method often employed to encourage the traveler to use another mode of travel is cost. Generally, the government attempts to move the commuters from car travel to transit, either bus or rail or subway. This is done to reduce the traffic congestion on the highways and in the urban areas. One method of encouraging this change is to increase the costs to the car user by increasing tolls for vehicles entering the urban areas. Some cities, such as New York City, which has control of most major access points because they are over or under rivers, increase the tunnel and bridge tolls. Other cities, such as Hong Kong, are attempting to assess vehicles a differential tax based upon the section of the urban area used by the vehicle. The more congested sections would levy the higher taxes. These attempts have had only minor success. One reason for a lack of change could be the other factors involved in the choice of travel mode. Unless transit travel time is reduced or better methods of transporting the transit riders to their final destination is found, the change in travel costs will not have sufficient effect. Generally, cost difference alone is insufficient to prompt a large percentage of the travelers to change their preferred mode of travel.

Most of the attempts that have had some success in moving car users into bus and rail transit address more than just the cost factor. The largest area of success appears to be in the use of the “park and ride” lots. The car user parks the car in a lot, usually without parking cost, and uses a bus or train to complete the journey to work. A similar system is the “rideshare” lots where individuals park their cars and several commuters share one car for the remainder of the trip. The general success of these facilities appears to be because they address several of the modal choice factors. The park-and-ride and rideshare lots have accomplished this goal by maintaining an acceptable travel time while reducing individual travel costs.

4. TRAVELER INFORMATION NEEDS

This section analyses the information needs of travelers in the Corridor-the user requirements aspect of the I-95 Traveler Information System. To analyze these requirements, the Loral Team assessed three dimensions:

+ Types of users.
+ Their needs.
+ The full range of delivery possibilities.

The complete set of derived user requirements is shown in Section 9, with the prefix TI.

Working Paper 2-Definition of Goals for the I-95 Corridor TIS System-sets out Specific User-Service Goals (in Section 4.2). Each of the candidate objectives set out in that paper can be thought of as a highest-level user requirement. Where appropriate, lower-level requirements are identified, and the requirements are discussed.

4.1 TYPES OF USERS

The first step in requirements analysis is to identify various users of the system. The Loral Team recognizes the emphasis that the I-95 coalition is placing on determining requirements for all users, not just the traveling public.

For our analysis, we have divided users of a traveler information service into the following categories:

+ Travelers.

+ Employers.

+ Special-event generators.

+ Operators of public places.

+ Operating agencies.

+ Emergency services.

+ Private-sector disseminators.

We deal with each of these in turn.

4.1.1 Travelers

Travelers are the largest and most important component of CTIS's end-users. They are themselves a highly varied group. To be able to test our requirements against this very large group of users, we have divided travelers according both to their purpose and to the distance in which they travel.

For our analysis, we identify four **distances** for travelers:

+ Intraurban.

+ Suburb-to-city.

+ Intersuburban.

+ Interurban.

Intraurban travelers travel from one location to another within the built-up, central portion of an urban settlement. For the purposes of this analysis, "intraurban" does not respect municipal or even state boundaries. Someone traveling from Camden to Philadelphia or Arlington to Washington would be considered an intraurban traveler.

Intraurban travelers have rich mode choice and are likelier to use nonhighway means of passenger transport.

Suburb-to-city travelers travel from a city's suburban fringe into the more central, built-up area (or the reverse), e.g., the traveler from Silver Spring, Md., to Northwest Washington may well be considered intraurban; but someone traveling from Rockville, Md., to Northwest Washington would likely be considered suburb-to-city.

Intersuburban travelers travel from one suburb to another of the same city, e.g., from Stamford, Conn., to New City, N.Y; from Willingboro to Cherry Hill, N.J.; or from Greenbelt, Md., to Falls Church, Va.

There is, of course, considerable overlap.

For the purposes of this analysis, suburb-to-city travelers may also encompass travelers from outlying communities.

The distinction between this traveler and the intraurban traveler comes with respect to mode choice and information needs. A suburb-to-city traveler does not have the option of taking urban transit from origin to destination; even if the service is available, the low population density, circuitous routes, and ease of parking may encourage driving.

Finally, **interurban travelers** travel from one of the Corridor's major cities to another, for example, from Newark to Baltimore. For this analysis, it is largely irrelevant whether the traveler's origin or destination is one city's center or another's suburb.

For our analysis, we identify these purposes for a traveler:

+ Commuters.

+ Business travelers.

+ Goods carriers, fixed- or variable-route.

+ Tourists.

Our Working Paper 2 divided travelers into these groups:

+ Business travelers.

+ Tourists.

+ Commuters.

+ CVO/dispatchers.

+ Transit/paratransit users.

For our analysis, we changed *CVO/dispatchers* to *goods carriers* to make clear which kind of commercial vehicle we were discussing (for example, not inter-city buses, which are in many states classified as "commercial vehicles"). And we also wanted to take the emphasis away from the dispatch function, although we recognize that it is through this function that many CTIS services will be delivered to the truck on the road.

We also folded *transit/paratransit users* in with other travelers. We felt that the *mode* is less important than the purpose of the trip.

A commuter travels from his or her home to his or her place of work. The commute does not vary from day to day with respect to its origin and destination, though it may not be taken every day nor at exactly the same time every day. Nonetheless, for this analysis, we do assume that the commuter does not greatly vary his or her habits. Although for every traveler type, except the tourist, getting there is not half the fun, for the commuter it is far less than half. Furthermore, it is meeting commuters' information needs where the greatest impact is likely to be made on peak-period congestion.

A **business traveler** travels to, for example, a meeting site, that is, not the traveler's usual place of work. The key point here is that the business traveler is not commuting, that is, traveling a regular route, but is rather going somewhere he or she does not go very often, possibly never before.

A business traveler is not just a man in a suit. He or she may travel to a site to provide some service, such as repairing an appliance, exterminating pests, locksmithing, etc., etc. In general, a business traveler is likely to spend considerable time in his or her vehicle: and may well be going some place he or she has never been. The business traveler cares about parking, accessibility to destination, etc.

A **goods carrier** travels to a location to pick up or deliver nonhuman payload. Goods carriers may be divided further, into those that day-to-day travel the same streets or highways-such as a delivery or shuttle service-and those that make deliveries to new destinations every day-such as a firm that delivers furniture.

A **tourist,** of course, is a visitor to a location **who** (hopefully) derives much of his or her pleasure from the act of traveling. A tourist is likely to know very little of his or her surroundings, or to understand commonly used directional or locational references. A tourist taking I-95 from Boston to Florida may not know when he or she approaches Washington that I-951495 to Richmond is the right direction; or that a radio announcer's saying "the Inner Loop of the Beltway is closed at the Wilson Bridge" means big trouble, whereas "the Inner Loop of the Beltway is closed at the Legion Bridge" is irrelevant. Besides these confusions, a visitor to Washington will be further confused by major arterials that follow the Potomac, which flows in a north-to-south direction past Washington and Alexandria, being described as "east" and "west".

4.1.2 Employers

In many localities, employers of a certain size are required to contribute to their region's air quality by facilitating their employees' generating less pollution in their commutes or in their on-the-job traveling. Such employers would find TIS useful in advising their employees of less polluting modal and route choices. In addition, some employers are large enough that their employees arriving or leaving have a demonstrated effect on traffic congestion.

4.1.3 Special-Event Generators

Special-event generators generate "unusual" traffic: a sporting event, a parade, a local festival-in short, anything that disrupts usual traffic in an area.

A special-event generator cares about future events. For example, the planners of a marathon would not want to schedule their event (which requires road closures for five hours or more) past a sport facility holding a major championship--or vice *versa.*

A special-event generator may care about today's traffic; see the next section.

4.1.4 Operators of Public Places

For this analysis, a "public place" is one where many people gather. It may be a sport stadium, a shopping center, a college. The operator of a public place may wish to relay traveler information to its patrons, whether out of public-spiritedness or as a result of local government action.

If the public place dumps all its occupants into the transportation system at one time (like a sport facility), accurate and timely information about local traffic conditions relayed to the patrons could mitigate their effect on traffic.

4.1.5 Operating Agencies

Although the agencies that operate transportation facilities in the Corridor are the major sources of traveler information, the stream of fused traveler information echoed back could be very useful to an operating agency, particularly in an environment where different agencies operate adjacent and alternate routes.

4.1.6 Emergency Services

CTIS is not intended as a source of dispatch date for emergency services. Consequently, in general, emergency services are no different than other travelers; indeed, they fall pretty neatly into the category of business traveler: given this origin and that destination, what are traffic conditions etc. on the derived route? However, our analysis breaks them out into a separate category in order that their needs may be always considered.

4.1.7 Private Sector Disseminators

A private-sector disseminator is a firm or public-sector entity that takes traveler information and reprocesses it-whether by adding value to it and then reselling it, or by redistributing it, or otherwise. Loral Team member SmartRoute Systems is such an entity, likewise Metro Traffic Control and Shadow Broadcast Services.

4.2 USER NEEDS

User needs were derived from two sources: the prioritized user services as shown in Working Paper Z-A Definition of Goals for the I-95 Corridor TIS System, and from scenarios that the Loral Team developed, and which are shown in Appendix A.

To avoid duplication, these needs are not shown here, but are given in requirements format in Section 9.

4.3 DELIVERY

This leads to the third dimension of user requirements, delivery. Information may be delivered to the traveler in many different ways. In this section, we identify what information may be delivered to travelers, and how travelers' needs are affected by how the information is delivered.

We classify means of delivery by where and how, each of which is discussed further below. What you won't find is the technology. For example, en route-*personalized* delivery may be over subcarrier, cellular telephone, pager, or a new radio channel, but it doesn't matter in this document for two reasons:

+ Dissemination technology is largely irrelevant to the information and functional needs of the user.

+ Dissemination technology is more the property of operating agencies or private-sector disseminators than of CTIS itself.

In our analysis, traveler information can be delivered in any of three places:

+ En route.

+ At home or office.

+ In a public place.

In our analysis, traveler information can be delivered in one of three ways:

+ Personalized.

+ Specialized.

+ Broadcast.

Personalized traveler information is intended for the use of a single traveler. For example, a commuter may specify that she wishes to drive from 1234 Elm Street to the Elmvale light-rail station, take the train to Metro Center, and walk 1 block to her office in Smith Plaza, arriving between 8:40 and 8:50. If traveler information is personalized for her, it will apply only to this routing, highlighting congestion and alternate routes to the rail station: delays on the light-rail line: a closed sidewalk between Metro Center and Smith Plaza.

To receive specialized traveler information requires a special device. The information is not personalized to the recipient, however. The European Radio Data System-Traffic Management Center (RDS-TMC) devices are specialized traveler information devices.

Anyone can receive broadcast traveler information. It might come from a commercial radio station, a highway advisory radio that uses AM or FM, or a variable message sign. An AM/FM radio is not considered a specialized device.

5. COMMUNICATION CAPABILITIES

This section identifies high-level communication capabilities for the CTIS. Two areas of communication requirements are addressed: center-to-center communications, and center-to-dissemination devices. Center-to-center communications includes interfaces such as TIC to TIC, TIC to TOC/Traffic Management Center (TMC), TIC to Regional Communications/ Operations Centers, and TIC to private-sector disseminators. Center-todissemination device communications includes interfaces such as TIC to media outlets, TIC to online services, TIC to public kiosks, TIC to in-vehicle devices, and TIC to hand-helds.

The communication capabilities identified in this section identify high-level conceptual interfaces where a communication interface is required. The specific communication medium is a design and implementation detail subject to a number of constraints, including CTIS system design/architecture, message content, packet size, frequency of updates, data rates, duplexity, openness, availability, range of coverage, mobility, and capital and operating costs. Specific identified communications requirements are presented in Section 9 with the identifier COMM.

5.1 COMMUNICATIONS OVERVIEW

The CTIS requires a robust communications system to move data from center-to-center and to get timely and accurate traveler information to all types of pretrip and en route users (e.g., commuters, business travelers, CVO, private-sector disseminators, etc.).

The capabilities identified in the Project #1 IEN requirements document will support the movement of video, voice, and data from center-to-center. The IEN, however, does not handle center-to-dissemination devices or center-to-private-sector disseminators.

5.1.1 Communications Hierarchy

The CTIS communication hierarchy, shown in Figure 5-1, is envisioned to consist of a group of Regional TICs each reporting traveler information summaries to their respective Corridor Communications/Operations Centers. The exchange of data between regions is a function of the Corridor Communications/Operations Centers. The dissemination of data to end-users is a function of the Regional TIC and/or the Local TIC.

The purpose of this project is to develop a traveler information system that is corridor-wide in perspective. This presentation of the communications hierarchy is intended to illustrate the logical flow of information through the CTIS, it does not represent a physical system architecture. In this illustration travel information is bi-directional, the CTIS must provide adequate " hooks" for local systems. In order to further amplify the illustration it is helpful to map the hierarchy to actual facilities. A potential future instantiation of the hierarchy might be:

+ The Maryland SOC (representing the Baltimore, Washington, and northern Virginia) and TRANSCOM (representing metropolitan New York) are Corridor Communications/Operations Centers. These centers exchange travel information about their region with each other. To do this collect information about their respective metropolitan areas.

+ At the Baltimore/Washington/No. Virginia regional level each of the agencies Collect and share travel information. Information that is of interest to the Corridor is passed along to the appropriate Corridor Communications/Operations Center.

+ The lowest level of the hierarchy is the local level, where raw data collection and information dissemination occurs.

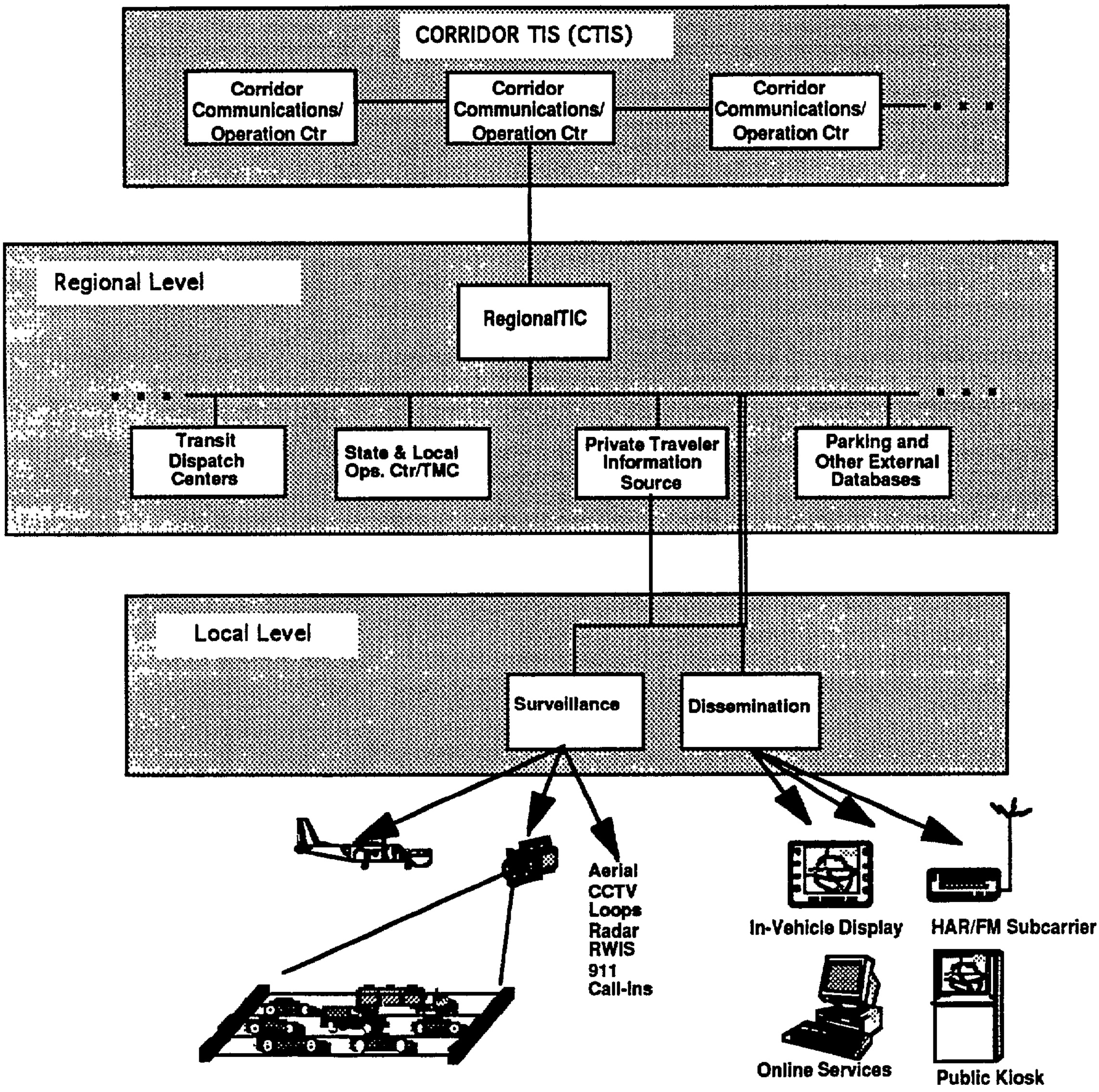

Figure 5-1. CTIS Communications

To obtain a more comprehensive understanding of all external interfaces and dataflows, reference the Level 0 Context Diagram discussed in Section 7.

5.1.2 Regional/Local TIC

Each Regional TIC is responsible for interfacing to and exchanging surveillance and traveler information with a number of external systems, including the following:

+ Transit Dispatch Centers - for example, light rail, subway, bus, airports, ferry.

+ State and Local Traffic Operations Centers or Traffic Management Centers.

+ Private Traveler Information Sources - for example, Metro Traffic Networks and Shadow Broadcaster Services,

+ External Databases and Systems - for example, parking garages, freight/fleet dispatch centers, and weather systems.

In addition, the Regional TIC[2] shall provide the appropriate communications interfaces for access to the following dissemination devices:

+ Computer Networks/Online Services (e.g., Internet, Prodigy, America Online).

+ In-vehicle Devices.

+ Variable Message Signs.

+ High Advisory Radio.

+ Public Kiosks.

+ Cable TV Networks.

+ Network TV Stations.

+ Telephone Menus.

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[2] The design of the system should accommodate jurisdictional preferences to have similar communication interfaces at the local level as well.

+ Hand-Held Devices.

The data flowing from the Regional TIC to the previously mentioned entities will consist of the following in both text and graphical form:

+ Real-Time Traffic and Transit Information.

+ Modal Travel Time Comparisons.

+ Weather and Environmental Information.

+ Traffic Forecasts, Demands, Trends.

+ Trip Itineraries.

+ Static Traffic and Transit Information.

+ Emergency Services.

+ Traveler Services Information.

For a more detailed understanding of the dataflows (and their composition) from the Local TIC to both users and private-section disseminators, see the Level 0 Context Diagram in Section 7 of this document.

5.1.3 Corridor Communications/Operations Center

This is the highest level of the system hierarchy. It is envisioned that it will consist of four information exchange nodes identified by Project 16 (Feasibility of Regional Communications Centers). Each Corridor Communications Center will serve a certain geographic region. Each center will have the capability to exchange information with both Metropolitan TICs within its region, and with other regional centers either inside or outside the Corridor. The I-95 Business Plan calls for the following four regional communications centers:

+ New York/New Jersey area.

+ Washington/Baltimore/Northern Virginia area.

+ Philadelphia/Camden/Wilmington area.

+ Boston/Providence area.

It is important to note that the system hierarchy described in this section is being presented only for discussion of communication capabilities. This hierarchy may not be the actual architecture developed in Task 5 of this report. The notion of four regional communication centers is just one of many solutions.

5.2 COMMUNICATION OPERATIONAL REQUIREMENTS

The operational requirements used in the defining the CTIS communication links are based on a flexible, adaptable, communications system which maintains a capability for long term growth.

Flexibility

Flexibility, as defined here, is the ability for the communication system to accommodate different communication standards without compromising the data flow of the system. The CTIS communication system shall be flexible so that a mixture of communications techniques may be used in the distribution and dissemination of data.

Communication standards shall be fully compatible with the existing de-facto or emerging standards where possible.

At a minimum, CTIS communications shall be compatible with the following communication standards.

Table 5-1. CTIS Communication Standards

RS232	SONET - Synchronous Optical Network
HDLC	FDDI - Fiber Distribution Data Interface
RS449	ISDN - Integrated Services Digital Network
RS485	ATM - Asynchronous Transfer Mode
NTSC Analog Video	H.261 Compressed Video
FM and PSK Radio	Cellular Radio
RS422	Ethernet (IEEE 802.3)
DS1	VSAT
RS530	X.25 Data Packetizing
TCP/IP	CSMA, CSMA/CD
CDPD	FM-SCA

To maintain flexibility, incompatible data formats are to be avoided when using a common media. The CTIS communications network shall preclude the use of a proprietary communication protocol which excludes the use of other communications protocols sharing the same transmitting media. Subnetworks using a particular communications protocol exclusively are allowed. However, if the data is to be shared on a broadband network, a communications gateway shall be used to convert the protocol to the broadband media-compatible protocol.

Adaptability

The first issue of adaptability is the ability of the communication system to accommodate unique jurisdictional requirements while being technologically contemporary. This implies that critical data services through the network shall not be interrupted due to the addition of these new equipment or changes in system topologies.

The second issue of adaptability is the CTIS communication system's compatibility with the needs of the local TICs (public or private). This allows for the differences in requirements for each local TIC. These differences may include the types and amount data (voice, image, data), and the available resources.

Long Term Growth

The long term growth of the CTIS communications environment is based on the factor of adaptability, flexibility, and scaleability. Provisions, therefore, shall be made within the communications link budget to accommodate future systems as they become available. Examples include, future or planned TMCs, TICs, Road Weather and Environmental Systems, Regional Weather and Environmental Systems, and AVI/AVL and cellular tracking systems.

5.3 COMMUNICATIONS ALTERNATIVES

There are a variety of options available for the center-to-center and center-to-dissemination device communication links. These include both wire and wireless options:

Wire	Wireless
Twisted pair cable	Microwave
Coaxial cable	Spread spectrum radio
Fiber optic	CDPD
Leased lines	AM/FM Subcarrier
Public lines	Radio Paging
	TV Subcarrier

5.3.1 Wire Communication Options

Twisted Pair Cable

The twisted pair cable option is only useful for low-speed data communications. There are generally two types of interfaces that are used with twisted wire pair cable in the Intelligent Transportation Systems (ITS) field, both of them are serial interfaces: RS-232 and RS-449.

The RS-232 interface is the older of the two types and has serious disadvantages considering the severe restrictions on both speed and distance. This interface permits the transmission of data at speeds up to 20 kbps (20 thousand bits of data per second), and is strictly limited in distance. The maximum transmission distance is 50 feet (15 meters). Three advantages of this interface is that the data flow is bi-directional, the interface is usually compatible with any computer or remote

computer type of data gathering or control device, and the interface equipment and software is inexpensive. This interface is generally used for connecting roadside sensors to trunk communication systems and for intracabinet connections.

The RS-449 option with a balanced interface, defined as RS-422, provides much the same service as the RS-232 interface except that the maximum speed and distance capabilities have been increased. The speed of the interface has been increased to 10 Mbps at a distance of 40 feet. The interface can transmit 1.2 kbps of data at distances up to 4000 feet. The data stream is bi-directional, as is the RS-232 interface, but it is not compatible with most computers or remote computer devices without a special Input/Output (I/O) port. Whereas most components come equipped with a RS-232 interface as standard equipment, the installation of a RS-449 interface is usually an additional cost. This interface is generally used for the transmission of field data when the destination is within a half mile (1 Km), and the data rate is sufficiently low enough to not warrant a more expensive communication system.

Coaxial Cable

Coaxial cable can accept data, both digital and analog, at speeds up to 10 Mbps (10 million bits of data per second), and data and video sufficient to service up to 20 cameras at one location. The high data and video transmission rates are achieved by Frequency Division Multiplexing (FDM) and Time Division Multiplexing (TDM) of the signals on coaxial cable. The transmission of video signals requires a far larger bandwidth than traffic flow data. The consideration of transmission needs for Closed Circuit Television (CCTV) surveillance cameras effectively precludes all options except coaxial cable, fiber optic, and microwave for the CCTV component of the system.

Fiber Optic

Coaxial cable systems have been effectively supplanted by fiber optics for long haul operations, that is for long distance transmissions, since fiber optic systems are more reliable and have a higher capacity. A Synchronous Optical Network (SONET) level fiber optic communications system operating at Optical Carrier (OC)-48 bandwidth, the fastest currently in general use, can send digital data at the rate of 2.4 Gbps (2.4 billion bits of data per second). The transmission distance of a fiber optic signal is governed by the signal loss. The general rule being that a clean signal can be transmitted approximately 20 to 30 miles without regeneration, and that digital signals can be regenerated almost indefinitely while analog signals decrease in quality with each regeneration. The SONET system can transmit both digital data and either compressed or full motion video signals.

The Bell System Standard digital transmission hierarchy is developed around ascending levels of bit rate. The fundamental rate is named Digital Signal Zero (DSO) which functions at a rate of 64 kbps. This is multiplexed into a signal containing 24 DSO signals and is referred to as DS1, which functions at a rate of 1.544 Mbps. It should be noted that a DSO channel can support one voice communication path, a data communication path of 56 kbps, or, in the instance of data communications, can be subdivided into multiple lower speed signals. From the DS1 level, the Bell System Standard provides for additional multiplexing of signals such that the DS2 rate becomes 6.312 Mbps and the DS3 rate becomes 45 Mbps.

A DS2 signal is capable of carrying the digital equivalent of 96 voice channels and the DS3 rate, approximately 45 Mbps, contains 28 of the basic DS1 signals, or a digital equivalent of 672 voice channels.

Bell System Standards for digital transmission have been in use for many years in almost all telephone systems in the USA. Great advances have been made in the last few years in high speed digital/optical transmission systems. Equipment is now available to support bit rates of 2.4 Gbps, which is equivalent to over 32,000 voice or data channels.

A few years ago transmission specialists recognized, however, that there were drawbacks to the existing digital and optical standards and systems. Therefore, a group of transmission specialists, representing many manufacturers and institutions, formed a committee to develop a standard to address and correct these drawbacks. This standard has been consolidated under the name SONET. The standard has been subdivided into various elements which are intended to address a number of network functions. Some of the standard elements are fully developed while others are still in various stages of development.

SONET standards include high-speed optical bit rates from approximately 50 Mbps (OC1) to approximately 2.4 Gbps (OC48). OC1 is an acronym for Optical Carrier Level One, meaning the ability to carry the equivalent of one DS3 (45 Mbps). Hence, OC48 can transport 48 DS3 signals.

The digital signals sent by the optical transmitters of different equipment manufacturers are being standardized in their electrical and optical properties as well as format. This makes it possible to install equipment from different vendors at opposite ends of a fiber optic cable.

One of the completed SONET standards provides for a digital architecture wherein an individual DS1 bitstream is clocked synchronously, making it possible to access individual DS1 channels without the expense of double multiplexing and demultiplexing at each access point. The SONET Standards Committee is completing work on the standard interfaces for certain overhead bits **which have been designated for use to support the operations, administration, and maintenance requirements of a network.**

A multimode fiber optic cable can be used for short distances, up to 2000 feet. The cost for the multimode cable and the electronics is less than for single-mode cable: therefore, it is advantageous to use this system for short distances. The common use of this system is to return CCTV camera signals to a controller cabinet.

Leased Line

Leased telephone lines have a data capacity of 1.544 Mbps, or a T-1 line. This capacity is sufficient for most data transmissions but can only accommodate compressed video. Disadvantages of using leased lines include access and cost. The CTIS system proposed for the I-95 corridor is centered on freeway/highway operation. Most of these roadways do not have easy access to telephone lines. The cost factor can be of considerable concern because a T-1 line could cost in the vicinity of $2,000 to $3,000 per month in rental/lease fees.

Public Telephone Lines

Public telephone lines, also known as standard voice-grade lines, can be used to transmit both analog and digital data at rates as high as 14.4 kbps.

5.3.1 Wireless Communication Options

Microwave

Microwave radio systems have a sufficient bandwidth to transmit data and video at speeds up to 40 Mbps for distances up to 50 miles. Although the microwave system can transmit long distances, the system has a disadvantage in that it is a line-of-sight operation. Microwave radio is not particularly desirable for short distance operations, as antennas would be required at each camera site.

Spread Spectrum Radio

Radio, specifically spread spectrum radio, is useful for relatively short distances and for remote sites, but has serious limitations. The data speed of approximately 256 kbps is sufficient for transmission of data, both digital and analog, and for transmission of compressed video. A limitation of the system is that the transmission distance is only 1 to 2 miles and is strictly line-of-sight. More powerful radio systems are available with transmission ranges up to 20 miles, but these systems require FCC licenses and specific transmission frequencies. In and around urban areas there may not be sufficient frequencies.

CDPD

CDPD is a technology that utilizes digital packet-switched networks through standard analog cellular channels. There is much optimism about the use of CDPD in the community since it is full-duplex and can transmit as high as 19.2 kbps. The technology utilizes the existing cellular telephone infrastructure and sends data in packets during idle times on voice channels.

AM/FM **Subcarrier**

AM and FM subcarrier technology allows the transmission of audio or digital information on all AM and FM stations. RDS format transmissions typically operate under the FM spectrum at 57 kHz and 1187.5 bps. Higher speed FM subcarriers are available that can operate as high as 92 kHz and can support transmission rates up to 19.2 kbps. AM subcarriers typically operate below 30 Hz, and are much lower in data rates, less than 100 bps.

Radio Paging

Radio paging is standard alphanumeric paging technology, where many different frequencies are used. Paging technology can be used to broadcast or multicast messages to low-cost receivers at 1.2 kbps transmission rates.

TV Subcarriers

Similar to AM and FM subcarriers, TV stations have the capability to transmit subcarriers on their aural carrier. The Second Audio Program (SAP) is the most popular TV subcarrier in use today, with transmission rates around 4.8 kbps.

6. CTIS DATABASE REQUIREMENTS

The CTIS database maintains the traveler information collected, fused, and disseminated by CTIS. Two classes of data are considered the primary responsibility of the CTIS database: general alphanumeric structured data (including text fields), and map/georeferenced data. The increase in the quantity, type, and complexity of data will require the integration of sophisticated, reliable, and mature technologies. The database requirements for CTIS addresses these techniques and technologies required to more effectively manage the information. CTIS database requirements are listed in Section 9 with the prefix DB.

6.1 GENERAL DATABASE REQUIREMENTS

The CTIS database plays a fundamental role in achieving the CTIS goals and objectives as defined in Task 2. The CTIS database must receive, fuse, and validate data efficiently and accurately. Timely, accurate multimodal information on traffic and travel conditions in the Corridor must be made available to both private travelers and commercial operators of passenger and freight transportation services. Highway traffic data relating to nonrecurring incidents will be maintained by the CTIS database and automatically distributed to the appropriate transportation agencies within the Corridor. The database is also responsible for maintaining nonhighway transit information in order to assist a traveler in choosing the most efficient mode(s) of transportation to utilize in order to reach his desired destination. In order to support these goals and objectives, it is required that the database fulfill the following requirements:

- The CTIS database shall support operations within a distributed, heterogeneous environment which will provide seamless collection and delivery of traffic and other travel information across jurisdictional and modal boundaries.

- Because of the expected level of utilization and the distribution of CTIS facilities throughout the corridor, the CTIS database shall provide access to multiple, simultaneous users/applications.

- The CTIS database will interface with the IEN for the receipt/dissemination of data from/to Corridor Traffic Operations Centers including local TOCs/TMCs Regional

Traffic Operation System/Advanced Traffic Management System (TOS/ATMS), and other future systems to be integrated with the IEN.

+ The CTIS database shall provide both direct access and application program interface access, and shall support predefined ("canned") and ad hoc queries. In addition, predefined ("canned") and ad hoc reports will also be supported. It is imperative that the user interface be intuitive and simple to use.

Another goal of the CTIS project is to gain and increase the private sector's participation in the design, development, operation, maintenance, and enhancement of the Corridor Traveler Information Service and system. The ability for a private sector participant to supply and retrieve data is included in this goal. To facilitate the achievement of this goal:

+ The CTIS database shall comply with industry standard Data Definition Language (DDL) and Data Manipulation Language (DML). An industry standard such as ANSI SQL will be utilized for DDL and DML development. Subsequent enhancements to the system by either the private or public sector will utilize this same requirement in order to easily integrate with the existing system.

Data such as real-time traffic and road information, incident data/logs, event plans/status, and static network data will be received and maintained by Commercial-Off-The-Shelf (COTS) products. Integration of COTS products has been specified in order to minimize development and maintenance costs, as well as maximize system interoperability and future scalability. The COTS database products will support the following requirements necessary to insure the integrity and security of the data:

+ The CTIS database shall maintain the integrity of the data including data element format checks (data type, field lengths, etc.), referential integrity between database structures, and valid value constraints (set membership and numeric/date range checking).

+ The CTIS database shall provide access control to the database and its functions. Access control includes the ability to add users and customize database privileges based on users and user groups/responsibilities.

+ **The CTIS database shall provide dictionary facilities for defining, maintaining, and updating TMC database structures. Capabilities supported will include the ability to add new structures, modify existing structures, and delete structures. Robust maintenance and performance features including the capability to store database files and structures across multiple disk volumes will also be provided.**

+ **The CTIS database shall provide automatic and procedural backup of data. These capabilities will insure data integrity in the event of a system (hardware or software) failure. The database shall also provide automatic and procedural recovery of the CTIS data following a system failure.**

The COTS products integrated in support of the CTIS database must be deployable on a variety of hardware platforms. A scalable architecture allowing a variety of configurations including multi-threaded processing, Symmetrical Multiprocessing (SMP), and client-sewer capabilities will be supported. Requiring a high level of portability and scalability will provide a continued migration path for future CTIS functionality.

6.2 MAP/GEOREFERENCED DATABASE REQUIREMENTS

The dissemination of information to travelers in support of multimodal regional and interregional travel will depend on the ability to associate the data to the specific geographic location within the I-95 Corridor. The communication of data such as trip plan alternatives, traffic and transit conditions, parking data, environmental and weather data, special event and tourism information, and traffic diversions are facilitated by tools and capabilities available from COTS map products and Geographic Information Systems (GIS). Several GIS products include network analyses and routing algorithms. In addition to the general requirements described above, the following high level requirements have been specified have been specified for map/georeferenced data:

+ **The CTIS database shall comply with applicable map and geographic data storage requirements.**

+ **The CTIS database shall provide access control to map/GIS data.**

+ **The CTIS database shall provide a user-friendly interface for creating new GIS coverages/layers.**

+ **The CTIS database shall maintain an integrated view of CTIS data. This integrated view will include the capability to reference structured alphanumeric data to digitized map data. Functionality supported will include dynamic segmentation.**

+ **The CTIS database shall provide automated and procedural support for the import and export of the following data formats: ARC, DIME, TIGER, Etak, ERDAS, LANDSAT, SPOT, DEM, DXF, CAD Nav Tech, Thomas Brothers, and Digital Orthophotography.**

A salient feature of a well-designed CTIS is to provide the tools necessary to effectively obtain traveler information. A key ingredient to fulfilling this requirement is the implementation of an effective GIS and Map-based user-interface. The GIS and Map-based user-interface shall be capable of fulfilling the following requirements.

+ **The base map display shall provide standard zoom and pan capabilities for the traffic network of interest; display of coordinates: and display of user selected features/attributes. This could include a surface street/arterial network, or a freeway network, or some combination thereof (city maps with superimposed freeway maps). The user-selected features/attributes will include, but not be limited to, link-based data (e.g. historic, real-time, and projected speed, volume, surface condition, and environmental data) and predefined GIS coverages/layers (e.g. counties, points of interests, street names, historic sites, recreation facilities, emergency locations, rest and repair shops, surveillance and control devices, etc.).**

+ **The map display shall provide tool-kit level Application Program Interfaces (API) or interfaces for a commercial GIS product to facilitate geocoding and referencing, map customization and color-coding, feature association, spatial queries, and the superimposing of images, icons and text on the display.**

+ **To support a heterogeneous map environment, a common link referencing scheme (or a common base map) must be used to address problems such as: the same link identifier being used for different links by different mapping tools, and different link identifiers being used for the same link by different mapping tools; and any given location's having many different ways of being described.**

7. INTERFACE REQUIREMENTS

This section describes the system-level interface requirements for CTIS. The system-level requirements addressed here examine the exchange of information with both existing and future systems that support traveler information services within the Corridor. Requirements are listed in Section 9 with the prefix IF.

Figure 7-1 illustrates CTIS's interfaces with its information sources and sinks.

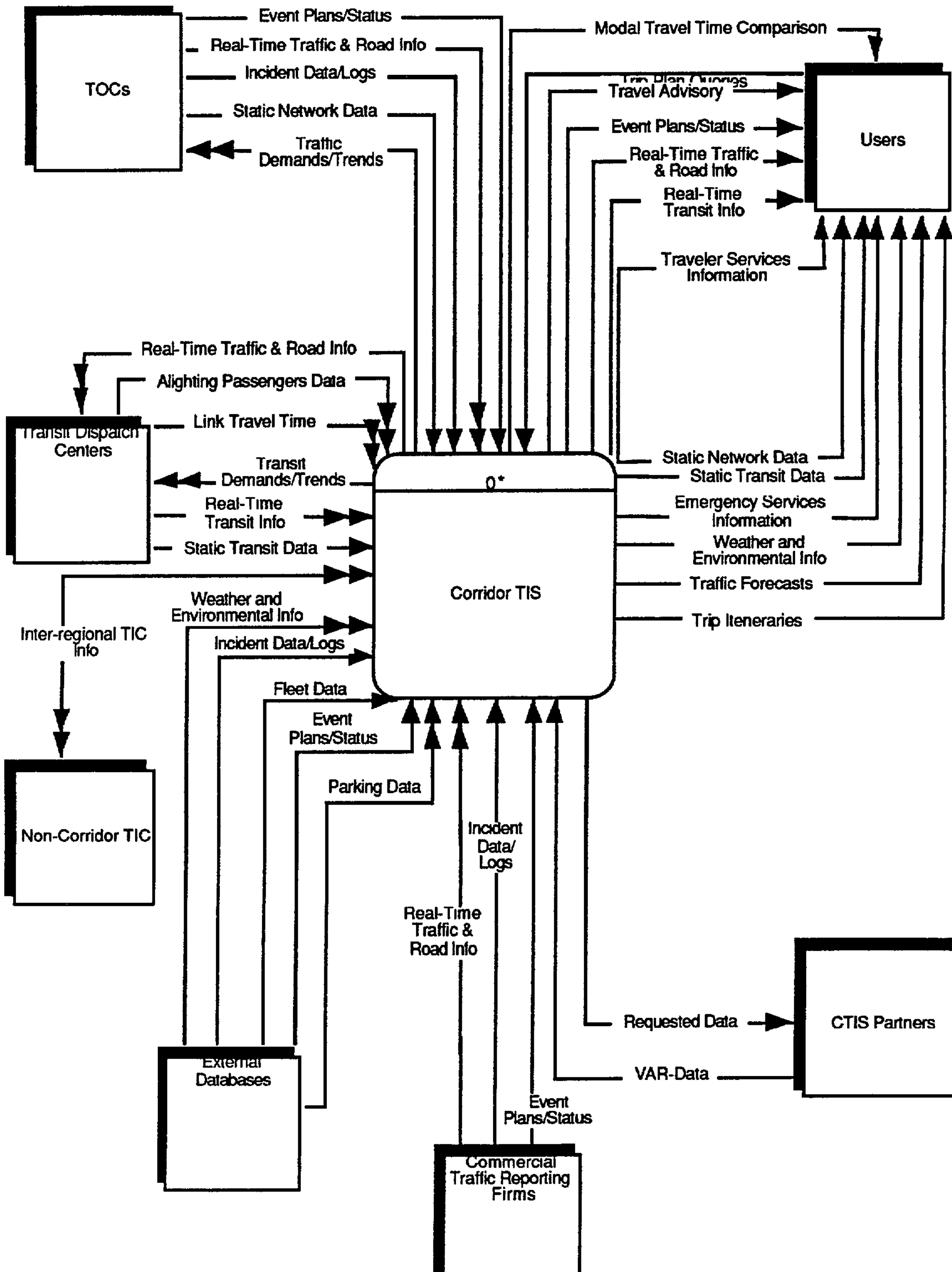

Figure 7-1. CTIS External Interfaces

7.1 CORRIDOR TRAFFIC OPERATIONS CENTERS (TOC)

A primary source of TIS data will be from Corridor traffic operations centers located throughout the I-95 Corridor. These centers can be local traffic operations centers or TMCs, regional TOSs, ATMSs, or other future systems. These systems within the Corridor will all supply data over the IEN; the IEN will network together the local and regional systems with CTIS, creating a seamless mechanism for exchanging TIS data within the Corridor.

The local and regional systems will gather local and regional information respectively, such as: real-time traffic and road information, incident data and logs, event plans and status, and static network data. This predominantly real-time information will be provided to CTIS which will, in turn, supply the local and regional systems with traffic demand and trends information. The information to be exchanged between these systems is shown in Table 7-l.

Table 7-1. Information Exchanged with Corridor TOCs

element	subelement	subsubelement
Real-time traffic and road information	link data	link ID
		link name
		street name
		link type
		length
		LOS
		number segments
		direction
		speed limit
		link times
		start latitude and longitude
		end latitude and longitude

Table 7-1. Information Exchanged with Corridor TOCs (Cont'd)

element	subelement	subsubelement
Real-time traffic and road information	link data	milepost
		link geometry
		speed
		volume
		occupancy
		surface temperature
		surface condition
		restrictions
	travel advisories	
	suggested routes	
	alternate routes	
	alternate modes	
Incident data and logs	location	
	name	
	ID	
	start time	
	end time	
	estimated duration	
	delay time	
	cause	
	description	
	incident classification	
	lanes blocked	
	severity	
	status	
Event plans and status	construction events	incident ID
		event name
		construction type
		location

Table 7-1. Information Exchanged with Corridor TOCs (Cont'd)

element	subelement	subsubelement
Event plans and status	construction events	start time
		end time
	special events	incident ID
		event name
		special event type
		location
		start time
		end time
		event characteristics
		traffic impact
		transit impact
		emergency services required
Static network data	road network topology	
	road geometry	
	raw map data	
	historical traffic data	
Traffic demands and trends data	currently loaded origin and destination matrix	
	historically loaded origin and destination matrix	

7.2 TRANSIT DISPATCH CENTERS

Transit dispatch centers will be the primary provider of transit-related information to CTIS. Transit dispatch centers will gather data and information for bus, rail, air, subway, and ferry. Typical information available at a transit dispatch center would include real-time transit information, static transit data, and traffic demands and trends. CTIS will then supply the transit dispatch centers with updates to the projected demands and trends, based on actual public user information and the

real-time transit information. Therefore, CTIS and the transit dispatch centers will work in accord to achieve maximum efficiency when exchanging transit-related information. When applicable, information exchanged between these two systems will use the IEN.

Table 7-2. Information Exchanged with Transit Control Centers

element	subelement	subsubelement
Real-time transit information	transit location data	
	transit arrival estimates	
	passenger loading estimates	
	park-and-ride lot status information	
Static transit	transit schedules	
	transit routes	
	transit fares	
	transit usage	
Traffic demands and trends	currently loaded origin and destination matrix	
	historically loaded origin and destination matrix	

7.3 NON-CORRIDOR TRAFFIC INFORMATION CENTERS (TIC)

Non-Corridor traffic information centers do not lie within the geographic boundaries of the I-95 Corridor. For example, a Non-Corridor TIC could be a TIC in Raleigh, N.C. These Non-Corridor TICs will have an interface to exchange interregional TIC information with CTIS. The IEN will not be the mechanism for exchanging data with non-Corrfdor systems.

Table 7-3. Information Exchanged with Non-Corridor TICs

element	subelement	subsubelement
Inter-regional TIC information	TIC ID	
	real-time traffic	
	road information	
	modal travel time comparisons	
	weather and environmental information	
	traffic demands	
	traffic trends	
	traffic forecasts	
	static traffic and transit information	
	emergency services	
	travelers services information.	

7.4 COMMERCIAL TRAFFIC REPORTING FIRMS

Commercial traffic reporting firms will be another source of relevant information for CTIS. Metro Traffic, Shadow Traffic, Traffic Net, SmarTraveler, and Traffax are all examples of the increasing presence of commercial traffic reporting firms. Although the actual operations of the firms varies substantially, the information required by CTIS is consistent: Real-time traffic information, incident data and logs, and event plans and status. Interfaces with these commercial traffic reporting firms could potentially use the IEN.

Real-time traffic information shall be comprised of two information types: real-time traffic and road information, and real-time transit information. For a brief discussion of real-time traffic and road' information, see Section 7.7. For a brief discussion of real-time transit information, see Section 7.2.

7.5 EXTERNAL DATABASES

External databases will be another source of TIS data for CTIS. There are several types of databases that will maintain information relevant to CTIS. Typical information expected to be available from external databases includes weather and environmental information, parking data, fleet probe data, and standards/GIS/maps data.

Table 7-4. ***Information Exchanged with External Databases***

element	subelement	subsubelement
Weather and environmental data	location	
	date	
	temperature	
	cloudy conditions	
	visibility	
	precipitation type	
	precipitation level	
	air quality	
Parking data	parking ID	
	name ID	
	location	
	capacity	
	occupancy	
Fleet probe data	vehicle ID	
	vehicle class	
	date	
	route ID	
	travel time.	

Table 7-4. Information Exchanged with External Databases (Cont'd)

element	subelement	subsubelement
Fleet probe data	location	
	speed	
	number stops	
	average delay	
	link travel times	
	weather data	
	incident data	
Standards/GIS/map data	GIS layers	jurisdictional coverage
		county zones
		state coverage
		population zones
		recurring congestion zones
		long-term construction zones
	corridor digital map data	

7.6 USERS

The users of the Corridor TIS will have a prominent role since they will ultimately help to determine the success of the Corridor TIS through their usage. The Corridor TIS will make available to end-users much of the information gathered from the external entities such as Corridor Traffic Operations Centers, Transit Dispatch Centers, Non-Corridor TICs, Commercial Traffic Reporting Firms, and External Databases. The end-users will have pretrip access from their homes, the workplace, transit stops, and at public locations. En route access will be accomplished through in-vehicle processors and wireless communication mechanisms.

Users can generally be segmented into the following groups: business travelers, tourists, commuters, transit users, CVO/dispatchers, transit operations, and government agencies. The

information available at the Corridor TIS for these users will include: Real-Time Traffic and Transit Information, Static Traffic and Transit Information, Modal Travel Time Comparisons, Weather and Environmental Information, Traffic Forecasts, Demands, and Trends, Trip Itineraries, Emergency Services, and Travel Services Information. Users will also be able to send Trip Plans and Queries to the Corridor TIS.

Table 7-5. Information Exchanged with Users

element	subelement	subsubelement
Real-time traffic and transit information	*see Tables 7-1 and -2*	
Modal travel time comparisons includes	origin	
	destination	
	modes	
	travel times	
Weather and environmental information (regional data only; road-specific data is real-time link based)	location	
	data	
	temperature	
	cloudy conditions	
	visibility	
	precipitation type	
	precipitation level	
	air quality	
Traffic forecasts, demands, and trends	current loaded origin and destination matrix	
	historical loaded origin and destination matrix	

Table 7-5. information Exchanged with Users (Con t'd)

element	subelement	subsubelement
Traffic forecasts, demands, and trends	forecast origin and destination matrix	
Trip itineraries	origin and destination	
	suggested routes	
	suggested modes	
	route guidance	
Static traffic and transit information	static traffic data	construction events
		special events
		road geometries
		road restrictions
	static transit data	transit schedules
		transit routes
		transit fares
		transit usage data
Emergency services	hospital locations	
	emergency telephone locations	
	repair shop locations	
	police locations	
Traveler services information	special events	
	attractions	
	historical sites	
	festivals	
	parks and recreational facilities	
	cultural and arts activities	
	educational institutions	
	resorts	

Table 7-5. Information Exchanged with Users (Cont'd)

element	subelement	subsubelement
Trip plans and queries	trip plan requests	origin and destination
		departure time
		arrival time
		modal preferences
		route preferences
		cost constraints
		transfer constraints
		special access requirements
	ad hoc queries	
Information requests	requester name	
	data set	
	frequency	
	access method	
	access times	
Access grants	user authentication key	
	access areas	
	access restrictions	

7.7 PRIVATE SECTOR DISSEMINATORS

Private sector disseminators will exchange data with the Corridor TIS on an as-needed basis. In general, the private sector disseminators may have their own subscribers, and may wish to augment their own information with information available from the Corridor TIS. The Corridor TIS will have provisions to accept information requests from and send access grants and requested data to the private disseminators. In addition, the Corridor TIS may receive data from the private disseminators.

Private sector disseminators encompass many ranges of information disseminators. Typical examples include information Service Providers (ISP), Communication Service Providers (CSP), Value Added Resellers (VAR), Hardware (H/W) and Software (S/W) providers, media (TV, radio, print), commercial traffic firms, and employers. These private disseminators would each have unique information needs and therefore would request relevant data as needed from the Corridor TIS.

8. SYSTEM-LEVEL REQUIREMENTS

This section describes the system-level requirements for the CTIS. The system-level requirements are those requirements that are applicable to the system as a whole, to which each subsystem shall be compliant.

System-level requirements are defined for the following categories:

- **Hardware.**
- **Software.**
- **Fault Tolerance.**
- **Performance.**

Each of these requirement categories will be discussed in detail in succeeding paragraphs.

8.1 SYSTEM-LEVEL HARDWARE REQUIREMENTS

The system-level requirements for the hardware to be used for the development of the CTIS conceptual design are presented in the following paragraphs. The requirements themselves are given in Section 9 with the prefix HW.

It is important to recognize that the actual number of workstations, communication links, and the characteristics of the hardware in general are subject to change based on the following:

- **Size of the Transportation Network (surveillance and control scope).**
- **System Performance Requirements.**

+ Functional Specifications.

+ Customer/Site Requirements (external interfaces, type and quantity of incoming and outgoing data at each site-e.g., data to commercial traffic reporting firms, required staffing profiles).

+ Size of the Region (e.g., number of participating nodes, communication load requirements).

+ Technological Advances (e.g., hardware performance).

+ Deployment Considerations.

  - Characteristics/Configuration of Existing System.

  - Upgrade/Migration Path.

  - Policies and Procedures.

  - Budgets.

  - Available Space.

These issues will be addressed during the design considerations of Task 5. This document provides requirements that describe the general hardware configuration.

8.2 SYSTEM-LEVEL SOFTWARE REQUIREMENTS

The system-level requirements for the software used in the development of the conceptual design are presented in Section 9 with the prefix *SW.* The system-level requirements for the software are driven by the need to perform the following:

+ Execute applications on any vendor's platform (hardware independence).

+ Produce a maintainable and modular system.

To accomplish this, CTIS software shall be compliant with established and mature open system standards. Two of the biggest requirements enforced will be the following:

- **POSIX-compliant operating systems with ANSI- and POSIX-compliant source code.**

- **SQL-compliant database and source code level APIs.**

These requirements are levied so that the functionality needed to provide interoperability, portability, and scalability of software across hardware platforms and networks of heterogeneous types is achieved. These standards and others identified in formal requirements in the following paragraphs will specify standard services, interfaces, data formats, and protocols that are available on a variety of hardware platforms and network configurations.

The CTIS software must be designed to be modular, maintainable, and flexible so that it is adaptable and flexible to accommodate new technologies as they become available.

8.3 SYSTEM-LEVEL OPERATOR INTERFACE REQUIREMENTS

The system-level Operator Interface Requirements for CTIS are presented in Section 9 with the prefix OI. The requirements are driven by the need to:

- **Establish a common, consistent interface between users and applications to reduce training and increase operator productivity and performance.**

- **Limit modifications to operator interface code when porting to a new hardware platform by adopting a common API that is stable for all or many platforms.**

The interface between the operator and applications is important since it provides the framework for interactions necessary for the effective and efficient operation of the system.

8.4 SYSTEM-LEVEL FAULT TOLERANT REQUIREMENTS

The system-level fault tolerance requirements are presented in Section 9 with the prefix FT.

8.5 SYSTEM-LEVEL PERFORMANCE REQUIREMENTS

The system level performance requirements are listed in Section 9 with the prefix PERF.

9. SUMMARY OF REQUIREMENTS

This section lists the individual requirements that the conceptual design must address. The requirements contained within this section are intended to describe a system that will be deployed over 10 years. It should be remembered that satisfying all of these requirements will require 2005 technology. These requirements are intended as a target, to be used by system developer as a model when they are developing system designs.

TRAVEL INFORMATION REQUIREMENTS

TI 1	**CTIS shall provide real-time incident/congestion summaries. A real-time incident/congestion summary describes: unscheduled incidents affecting the performance of a roadway; and unusual congestion on a roadway.**
TI 1.1	**CTIS shall provide only those incident/congestion summaries of interest to the user. See TI 12.**
TI 1.2	**CTIS shall provide information about incidents and congestion.**
TI 1.2.1	**CTIS shall give the lanes affected. E.g., two left lanes: center lane: lanes 1-3.**
TI 1.2.2	**CTIS shall give the cause of an incident or congestion, when it is available. E.g., accident, hazmat spill, emergency roadwork.**
TI 1.2.3	**CTIS shall provide free-form comments on an incident or congestion, when they are available. Comments would likely be entered (or ratified) by an operator in the traffic management center or traffic information center having jurisdiction.**
TI 1.2.4	**CTIS shall provide an indication of an incident or congestion's severity.**
TI 2	**CTIS shall provide traveler advisories. A travel advisory is a notice from an operating agency to all travelers on the agency's roadways in a certain area or on a certain route. An advisory notifies travelers of severely adverse traveling conditions or of major changes in traffic patterns.**
TI 2.1	**CTIS shall provide only those travel advisories of interest to the user. See TI 12.**
TI 3	**CTIS shall provide road weather conditions. Road weather conditions are specifically relevant to driving, such as the condition of the road surface (e.g., snow covering of a highway).**
TI 3.1	**CTIS shall provide only those road weather conditions of interest to the user. See TI 12.**

TRAVEL INFORMATION REQUIREMENTS -CONT.

TI 4	CTIS shall provide alternate routes and modes. When CTIS gives real-time incident/congestion summaries (see TI 1). CTIS shall also give information about how the user can avoid the incident or congestion. These alternate routes apply to all travelers on a particular roadway link, and are thus distinct from the alternate routes and modes that may be proffered by a personalized routing or trip-planning engine. Alternate routes for this requirement may be generated automatically by a traffic management system (as part of a response plan) or may be specified by an operator.
TI 5	CTIS shall provide real-time link status. Real-time link status is valuable for problem detection (by the operating agency) and for routing, but is of little value in its raw form to travelers and other users.
TI 5.1	For each instrumented lane in each instrumented link, CTIS shall provide: whether traffic is enqueued; speed of traffic; occupancy; density; volume; other items to be determined.
TI 5.2	CTIS shall provide video images of links.
TI 5.3	CTIS shall provide only real-time link status of interest to the user. See TI 12.
TI 6	CTIS shall provide route guidance information. I.e., specific instructions, once a route has been derived; for example, "turn left onto Route 850 northbound in 300 yards, at the white church."
TI 6.1	CTIS shall allow routes to be specified directly by the user (e.g., I-95 southbound to I-495 westbound to S.R.12 southbound, etc.) or indirectly, e.g., from a trip planning capability that addresses TI 33.
TI 6.2	CTIS shall decompose each route into a set of instructions.
TI 6.3	For each route-guidance instruction, CTIS shall provide: the maneuver (e.g., turn left); distance or time or both to the next maneuver; landmarks along the way and particularly at the point of maneuver.
TI 6.4	CTIS shall provide instructions vocally, in written form, graphically, or in combination.
TI 6.5	CTIS's route-guidance information shall include restrictions [e.g., no vehicles over 1 ton Gross Vehicle Weight (GVW); chains or 4-wheel drive required; etc.] as required by TI 13.
TI 7	CTIS shall provide road environmental conditions. Road environmental conditions are specifically relevant to driving, such as Nitrous Oxide ($N0_2$) levels at or near the roadway surface.
TI 7.1	CTIS shall provide only those road environmental conditions of interest to the user. See TI 12.
TI 8	CTIS shall provide information on road restrictions, such as weight, height, time-of-day turn restrictions, choke points, etc.
TI 8.1	CTIS shall provide only those road restrictions of interest to the user. See TI 12.
TI 9	CTIS shall provide travel condition forecasts.

TRAVEL INFORMATION REQUIREMENTS - CONT.

I-I 9.1	CTIS shall provide only those travel condition forecasts of interest to the user. See TI 12.
I-I 10	CTIS shall provide travel demand patterns and trends.
TI 11	CTIS shall provide scheduled-event summaries. Scheduled-event summaries include construction and all other scheduled events that will affect traffic on a roadway, such as traffic-pattern changes and parades.
TI 11.1	CTIS shall provide only those scheduled-event summaries of interest to the user. See TI 12.
TI 11.2	CTIS shall provide information about scheduled events.
TI 11.2.1	CTIS shall give the lanes affected. E.g., two left lanes; center lane; lanes 1-3, etc..
TI 11.2.2	CTIS shall give the cause of scheduled event, when it is available. E.g., construction, parade, sporting event.
TI 11.2.3	CTIS shall provide free-form comments on a scheduled event, when they are available. Comments would likely be entered (or ratified) by an operator in the traffic management center or traffic information center having jurisdiction.
TI 11.2.4	CTIS shall provide an indication of a scheduled event's severity.
TI 11.3	CTIS shall give information about the currency of individual items in the scheduled-event summary.
TI 11.3.1	CTIS shall give the prospective end date and time for each scheduled event.
TI 11.3.2	CTIS shall indicate whether the scheduled event is active or not at a given moment in real-time.
TI 11.3.3	CTIS shall, on user request, provide information about scheduled events in prospect. E.g., 6 or 6 or 12 or 24 hours in advance.
TI 12	CTIS shall provide only that information of interest to the user. This requirement covers: real-time incident/congestion summaries (TI 1); traveler advisories (TI 2); road weather conditions (TI 3); real-time link status (TI 5); road environmental conditions (TI 11); road restrictions (TI 13); and scheduled-event summaries (TI 17).
TI 12.1	CTIS shall allow the user to circumscribe the information he or she receives by area, government unit, road, "corridor", direction, or time of day. E.g., the area bounded by S.R. 101, I-97, I-93, and the Smith River; Delaware County, Bala Cynwyd; I-95, I-495, U.S. 1, Kenilworth Avenue; the northwest commuter corridor into/out of a city: eastbound in the morning, westbound in the evening.
i-I 12.2	CTIS shall allow high-impact information from outside the user's specified area of interest to be presented to the user, based on a weighting by severity and distance For example, the closure of a major freeway a mile from the user's specified corridor will be relayed to the user.

TRAVELER INFORMATION REQUIREMENTS - CONT.	
TI 13	CTIS shall provide information about parking.
TI 13.1	CTIS shall allow the user to circumscribe the information about parking by: area (e.g., Delaware County); within *n* feet of destination address; within *n* minutes of a destination address (by foot or transit); whether the parking location is accessible underground or through an attached building to the destination address.
TI 13.2	For each location with available parking, CTIS shall provide the number of available spaces and the cost to park there.
TI 13.3	CTIS shall aggregate information about available parking spaces by the area specified by the user. E.g., there are 450 parking spaces available for less than $10 within five minutes' walk of Memorial Stadium.
TI 14	CTIS shall provide schedule, route, and fare information on all transit modes.
TI 14.1	CTIS shall provide fare and general policy by property. For example, CTIS can provide fare and general operating policies and rules for each big-city transit service.
TI 14.2	CTIS shall allow the user to specify schedule, route and fare information.
TI 14.2.1	CTIS shall provide schedule, route, and fare information for the routes or branches of routes specified by the user.
TI 14.2.2	CTIS shall provide schedule, route, and fare information for all routes along a trip plan from TI 33.
TI 14.2.3	CTIS shall provide schedule, route, and fare information for a specific corridor specified by the user.
TI 14.2.4	CTIS shall provide schedule, route, and fare information for all routes and branches and modes accessible at a transit stop or station specified by the user.
TI 14.3	CTIS shall provide information about scheduled travel times from a specified origin to a specified destination.
TI 14.4	CTIS shall provide information about the likelihood of getting seating on a specified route or section of the route.
TI 15	CTIS shall provide real-time status location information on transit modes.
TI 15.1	CTIS shall provide real-time information on prospective arrivals of vehicles at a transit stop or station specified by the user.
TI 15.2.	CTIS shall provide real-time travel time information along a trip plan from TI 33.
TI 16	CTIS shall provide timely and accurate information on paratransit services.
TI 16.1	CTIS shall allow the user to circumscribe the information on paratransit services he or she receives.
TI 16.1.1	CTIS shall allow the user to specify paratransit services by category.
TI 16.1.2	CTIS shall allow the user to specify that he or she receive information about paratransit services in a specified area.

TRAVELER INFORMATION REQUIREMENTS - CONT.

TI 16.1.3	CTIS shall provide timely and accurate information on paratransit services along a trip plan from TI 33.
TI 16.1.4	CTIS shall provide timely and accurate information on paratransit services within an urban travel corridor.
TI 17	CTIS shall provide timely and accurate information on ride-matching services.
TI 17.1	CTIS shall provide timely and accurate information on ride-matching services from an origin specified by the user and within a radius to the origin of time or distance specified by the user.
TI 17.2	CTIS shall provide timely and accurate information on ride-matching services to destination specified by the user, within a radius to the destination of size and time or distance specified by the user, and within a timeframe specified by the user.
TI 17.3	CTIS shall provide information on the cost implications of a prospective ride match.
TI 18	CTIS shall provide timely and accurate information on the locations of hospitals. See TI 35.
TI 19	CTIS shall provide timely and accurate information on the locations of public telephones. See TI 35.
TI 20	CTIS shall provide timely and accurate information on the locations of repair shops. See TI 35. Because repair shops are not official, the origin of the list is likelier to come from value-added resellers than from the Coalition or a related agency.'
TI 20.1	CTIS shall provide AAA ratings or similar information the user might use to choose a particular repair shop.
TI 21	CTIS shall provide timely and accurate information on the locations of police. See TI 35.
TI 22	CTIS shall provide timely and accurate information on regional weather conditions, to both pretrip and en route users. See TI 35.
TI 23	CTIS shall provide timely and accurate information on food/dining and gas, to both pretrip and en route users. Because establishments offering food or fuel are not official, the origin of the list is likelier to come from value-added resellers than from the Coalition or a related agency.'
TI 23.1	CTIS shall provide AAA ratings or similar information the user might use to choose a particular restaurant or gas station.
TI 24	CTIS shall provide timely and accurate information on lodging, to both pretrip and en route users. See TI 35. Because lodging establishments are not official, the origin of the list is likelier to come from value-added resellers than from the Coalition or a related agency.

TRAVELER INFORMATION REQUIREMENTS - CONT.	
TI 24.1	CTIS shall provide AAA ratings or similar information the user might use to choose a particular lodging.
TI 25	CTIS shall provide timely and accurate information on regional environmental conditions, to both pretrip and en route users. See TI 35.
TI 26	CTIS shall provide timely and accurate information on special events, to both pretrip and en route users. See TI 35.
TI 27	CTIS shall provide timely and accurate information on attractions, to both pretrip and en route users. See TI 35.
TI 28	CTIS shall provide timely and accurate information on historic sites, to both pretrip and en route users. See TI 35.
TI 29	CTIS shall provide timely and accurate information on parks and recreational facilities, to both pretrip and en route users. See TI 35.
TI 30	CTIS shall provide timely and accurate information on cultural and arts activities, to both pretrip and en route users. See TI 35.
TI 31	CTIS shall provide timely and accurate information on educational institutions, to both pretrip and en route users. See TI 35.
TI 32	CTIS shall provide timely and accurate information on resorts, to both pretrip and en route users. See TI 35.
TI 33	CTIS shall provide a trip planning capability. Commuters, fixed-route goods carriers, and other travelers may use trip planning once, to get the best routes for regular trips.
TI 33.1	CTIS shall require the user to specify origin and destination.
TI 33.1.1	CTIS shall allow origin and destination to be specified by street address.
TI 33.1.2	CTIS shall allow origin and destination to be described. E.g., Greenbelt Road & Executive Place, or 300 yards west of Lanham-Severn Road on Greenbelt Road.
TI 33.1.3	CTIS shall allow origin or destination to be specified by landmark. E.g., St. Brigitte's Church, Memorial Stadium Gate 2.
TI 33.1.4	CTIS shall allow origin or destination to be specified as an area or location E.g., Sykesville to College Park.
TI 33.2	CTIS shall allow the user to specify the parameters for the trip plan, both globally and for a specific plan, and shall otherwise use default settings.
TI 33.2.1	CTIS shall allow the user to specify which modes he or she will accept, and to rank these modes.
TI 33.2.2	CTIS shall allow the user to identify whether time, distance, or fuel or energy consumption is the most important criterion for deriving and ranking trip plans.
TI 33.2.3	CTIS shall allow the user to rank time, distance, fuel or energy consumption, and cost as parameters for deriving and ranking trip plans.

TRAVELER INFORMATION REQUIREMENTS - CONT.	
TI 33.2.4	CTIS shall allow the user to specify whether offered trip plans are to be scenic or not.
TI 33.2.5	For trip plans incorporating driving, CTIS shall allow the user to specify preferred road types, e.g., no superhighways.
TI 33.2.6	For trip plans incorporating driving, CTIS shall rank offered trip plans by difficulty of driving.
TI 33.2.7	CTIS shall allow the user to specify that trip plans are to be ranked according to their nearness to amenities, e.g., lodging, food.
TI 33.2.8	For trip plans incorporating driving, CTIS shall allow the user to specify that offered trip plans are to be ranked according to the opportunities for ridesharing.
TI 33.2.9	CTIS shall allow the user to specify that offered trip plans are to be ranked according to the number of transfers.
TI 33.2.10	CTIS shall allow the user to specify that offered trip plans are to be ranked according to the likelihood of getting a seat.
TI 34	CTIS shall provide modal travel time comparisons. A modal time travel comparison may be forced to the user's attention if the difference in travel time is greater than n%.
TI35	CTIS shall provide only that safety, traveler, and tourism information of interest to the user. This requirement covers: locations of: hospitals (TI 18), public telephones (TI 19), repair shops (TI 20) and police (TI 21); regional weather conditions (TI 22); food/dining and gas (TI 23); lodging (TI 24); regional environmental conditions (TI 25); special events (TI 26); attractions (TI 27); historic sites (TI 28); parks and recreational facilities (TI 29); cultural and arts activities (TI 30); educational institutions (TI 31); and resorts (TI 32).
TI 35.1	CTIS shall provide the locations of the user-specified class(es) of safety, traveler, and tourism facilities or activities nearest to the vehicle.
TI 35.1.1	CTIS shall provide the locations of the user-specified class(es) of safety, traveler, and tourism facilities or activities nearest to x,y locations derived from the Global Positioning System.
I-I 35.1.2	CTIS shall provide the locations of the user-specified class(es) of safety, traveler, and tourism facilities or activities nearest a specified roadway link. E.g., I-495 between Interchanges 12 and 14.
TI 35.2	CTIS shall provide the locations of the user-specified class(es) of safety, traveler, and tourism facilities or activities nearest a specified route.
TI 35.3	CTIS shall allow the user to specify a distance or travel time from the vehicle's location or route more than which CTIS will not provide the locations of the user-specified class(es) of safety, traveler, and tourism facilities or activities.
TI35.3	CTIS shall allow the user to specify a distance or travel time from the vehicle's location or route more than which CTIS will not provide the locations of the user-specified class(es) of safety, traveler, and tourism facilities or activities.

TRAVELER INFORMATION REQUIREMENTS - CONT.

TI 35.4	**Where relevant, CTIS shall provide the locations of the user-specified class(es) of safety, traveler, and tourism facilities or activities within whose catchment area or jurisdiction the vehicle's location or route lies. This is particularly relevant to hospitals, which often have a specified catchment area, and especially police. CTIS must know for a given roadway or area which police force has primary jurisdiction (e.g., State Police on an Interstate, but county police on the arterial leading to it).**

COMMUNICATIONS REQUIREMENTS	
COMM 1	The CTIS communications subsystem shall have the capability to move data from center-to-center, from center-to-dissemination devices, and from center-to-private-sector-disseminators.
COMM 2	The CTIS communications subsystem shall have the capability to support both wire and wireless communication mechanisms. Wireless communications will mainly be required to support in-vehicle communications.
COMM 3	The CTIS communications subsystem shall have the capability for interfacing to and exchanging surveillance and traveler information with transit dispatch centers, state & local TOCs/TMCs, private traveler information sources, and future external databases and systems.
COMM 4	The CTIS communications subsystem shall have the capability for interfacing with various dissemination devices and outlets including computer networks, in-vehicle devices, VMS/HAR, public kiosks, cable and regular TV networks, automated telephone systems, and hand-held devices.
COMM 5	The CTIS communications subsystem shall have the capability for transmitting and receiving voice, image and data. Information to be exchanged will include real-time traffic and transit information, modal travel time comparisons, weather and environmental information, traffic forecasts/demands/trends, emergency service and other traveler information services in both graphical and text forms.
COMM 6	The CTIS communications subsystem shall be flexible, adaptable, and scaleable to support long-term growth.
COMM 6.1	The CTIS communications subsystem shall accommodate different communication standards without compromising the data flow of the system.
COMM 6.2	The CTIS communication subsystem shall be flexible so that a mixture of communication techniques may be used in the distribution and dissemination of the data.
COMM 6.3	The CTIS communication subsystem shall adhere to industry de-facto and established standards. This requirement precludes the use of proprietary communication protocols.
COMM 6.4	The CTIS communication subsystem shall not be interrupted due to the addition of new equipment or changes in system topologies.
COMM 6.5	The CTIS communication subsystem shall accommodate future systems as they become available. These include, future or planned TMCs/TICs, Road Weather Information Systems (RWIS), Regional Weather and Environmental Systems, and AVI/AVL and cellular tracking systems.

DATABASE REQUIREMENTS

DB 1	**The CTIS database shall provide access to all data necessary to improve the efficiency, safety, and comfort of intermodal travel. The range of data maintained wi include information such as transportation conditions and advisories, alternative routes and modes, emergency services, roadside service options. The CTIS database shall maintain all data necessary for the CTIS Traveler Information Needs defined above.**
DB 1.1	**The CTIS database shall provide both direct access and application program interface access.**
DB 1.1.1	**The CTIS database shall provide online direct user access to all data (alphanumeric, map, georeferenced) needed for CTIS operations.**
DB 1.1.2	**The CTIS database shall provide an application program interface to all data (alphanumeric, map, georeferenced) needed for CTIS operations.**
DB 1.2	**The CTIS database shall interface with the IEN to facilitate the exchange of data within an integrated Intelligent Transportation System.**
DB 1.2.1	**The CTIS database shall receive data from the IEN.**
DB 1.2.2	**The CTIS database shall send data to the IEN.**
DB 1.3	**The CTIS database shall provide access to multiple users/applications.**
DB 1.3.1	**TheCTIS database shall support concurrent control.**
DB 1.4.	**The CTIS database shall comply with industry standard DDL and DML.**
DB 1.4.1	**The CTIS database shall comply with industry standards for structured data.**
DB 1.4.2	**The CTIS database shall comply with applicable map and geographic data storage requirements.**
DB2	**The CTIS database shall provide a user-friendly GUI for System Administration (SA) functions.**
DB 2.1	**The CTIS database shall support the user in building custom reports and *ad hoc* queries.**
DB 2.2	**The CTIS database shall have the capability to store previously built custom reports and "canned queries."**
DB 2.3	**The CTIS database shall allow the user to access all Database Management System (DBMS) functions through a graphical interface.**
DB 2.4	**The CTIS database shall provide online help for database functions.**
DB 3	**The CTIS database shall provide access control to the database and its functions.**
DB 3.1	**The CTIS database shall allow the DBA to establish privileges on the database as a whole or on individual tables, views, or procedures.**
DB 3.2	**The CTIS database shall allow the granting of privileges to "authorization types," such as public, group, user, or role, corresponding to different job positions within the CTIS.**

DATABASE REQUIREMENTS

DB 3.3	The CTIS database shall provide access control to map/GIS data.
DB 3.4	The CTIS database shall provide access control procedures (login, passwords, etc.).
DB4	The CTIS database shall provide dictionary facilities for defining, maintaining, and updating TMC database structures, maps, and geographic data structures.
DB 4.1	The CTIS database shall provide a user-friendly interface for creating new database structures and GIS layers, and defining attributes.
DB 4.2	The CTIS database shall provide support for creating and modifying primary and secondary search indices on database attributes.
DB 4.3	The CTIS database shall permit the addition of new tables, GIS layers, and attributes to existing structures without requiring the shutdown of the database.
DB 4.4	The CTIS database shall provide the capability to store the various database files (data, journal, dump, etc.) on different disk volumes.
DB 4.5	The CTIS database shall provide all the storing of database tables across multiple disk volumes.
DB 4.6	The CTIS database shall maintain the integrity of the data.
DB 4.6.1	The CTIS database shall perform data element format checks (data type, field length, etc.).
DB 4.6.2	The CTIS database shall maintain the referential integrity of the database.
DB 4.6.3	The CTIS database shall have the facilities to define valid value constraints on table attributes.
DB 4.7	The CTIS database shall maintain an integrated view of all CTIS data.
DB 4.7.1	The CTIS database shall be capable of referencing alphanumeric data to digitized map data.
DB 4.7.2	The CTIS database shall support a network topology with connectivity so that streets have relationships with each other. Low-level support for maintaining links, nodes, and polygons shall be provided.
DB5	The CTIS database shall provide automated and procedural support for loading data.
DB 5.1	The CTIS database shall provide facilities to load structured data received from external sources.
DB 5.2	The CTIS database shall provide facilities to load map and GIS data received from external sources.
DB 5.2.1	The CTIS database shall support the import and export of the following data formats: ARC, DIME, TIGER, Etak, ERDAS, LANDSAT, SPOT, DEM, DXF, CAD Nav Tech, Thomas Brothers, and Digital Orthophotography.

DATABASE REQUIREMENTS- CONT.

DB6	The CTIS database shall provide automatic and procedural online backup of data.
DB 6.1	The CTIS database shall mirror the critical data necessary to support ongoing CTIS operations.
DB 6.2	The CTIS database shall provide automated capabilities and procedures for necessary to insure data integrity in the event of system (hardware or software) failure (e.g., checkpoints, journals, transaction logs, database backups, etc.).
DB 6.3	The CTIS database shall provide procedures for creating, storing, and maintaining database backups.
DB7	The CTIS database shall provide automatic and procedural recovery of the CTIS data in the event of failure.
DB8	The base map display shall provide zoom and pan capabilities for the traffic network of interest; display of coordinates; and display of user selected features/attributes; This could include a surface street/arterial network, or a freeway network, or some combination thereof (city maps with superimposed freeway maps). The user-selected features/attributes will include, but not be limited to, link-based data (e.g. historic, real-time, and projected speed, volume, surface condition, and environmental data) and predefined GIS coverages/layers (e.g. counties, points of interests, historic sites, recreation facilities, emergency locations, repair shops, surveillance and control devices etc.).
DB 8.1	The base map must be capable of supporting the real-time display and update of data and dynamic graphics.
DB 8.1	The base map shall support dynamic segmentation so that a link topology can be superimposed on top of the base map. This link topology must allow each link to be independently accessed by the users and independently updated via an API by the programmer.
DB 9	The map display shall provide tool-kit level APIs or interfaces for a commercial GIS product to facilitate geocoding and referencing, map customization and color-coding, feature association, spatial queries, and the superimposing of images, icons and text on the display.
DB 10	The map display shall provide the capability of displaying street maps for cities and freeways at the highest level and network geometries (e.g., number of lanes, intersection layouts) at the lowest level for the analysis network of interest. The lowest level is likely to require the use of imported CAD files.
DB 11	The map display must be able to display CAD, raster, and vector data.
DB 12	The map display must support the ability to annotate maps with transportation symbols and text.
DB 13	The DBMS, GIS, and map display components shall be compliant with the OSF/Motif style guide.
DB 14	The base map positional data must be accurate to within 50 feet and support coordinate transforms among: State Plane, Lat/Lon, UTM, and X/Y.

DATABASE REQUIREMENTS - CONT.	
DB 15	**The map display must be capable of supporting multiple simultaneous users.**
DB 16	**To support a heterogeneous map environment, a common link referencing scheme (or a common base map) must be able to accept input locations in and convert among at least: longitude and latitude; UTM; street addresses; state plane; operating agencies' linear referencing schemes; landmarks; descriptions; hierarchical link schemes (such as ITIS).**
INTERFACE REQUIREMENTS	
IF 1.1	**CTIS interface with the TOCs shall be flexible and expandable. This means that TOCs can be readily added or deleted as an interface and a data supplier to CTIS.**
IF 1.2	**The local TOCs in the Corridor shall make their collected information (e.g., real-time traffic and road information, etc.) available to CTIS.**
IF 1.3	**CTIS shall be capable of accepting the collected information from Corridor TOCs. This collected information can either be scheduled file transfers, periodic real-time updates, or event-driven data (e.g., incident information).**
IF 1.4	**The local TOCs in the Corridor shall be capable of accepting information from CTIS (e.g., traffic demands and trends data).**
IF 1.5	**When possible, the information exchanged between the Corridor TOCs and CTIS shall occur over the IEN.**
IF 2.1	**CTIS interface with the transit dispatch centers shall be flexible and expandable. This means that transit dispatch centers can be readily added or deleted as an interface and a data supplier to CTIS.**
IF 2.2	**Transit dispatch centers shall make their collected information (e.g., real-time transit information, etc.) available to CTIS through an interface.**
IF 2.3	**CTIS shall be capable of accepting the collected information from transit dispatch centers. This collected information can either be scheduled file transfers or periodic real-time updates (e.g., passenger loading estimates, etc.).**
IF 2.4	**Transit dispatch centers shall be capable of accepting information from CTIS (e.g., traffic demands and trends data).**
IF 2.5	**When possible, the information exchanged between the transit dispatch centers and CTIS shall occur over the IEN.**
IF 3.1	**CTIS interface with the non-Corridor TICs shall be flexible and expandable. This means that non-Corridor TICs can be readily added or deleted as an interface and a data supplier to CTIS.**
IF 3.2	**The non-Corridor TICs shall make their collected information (e.g., interregional TIC information) available to CTIS through an interface.**

INTERFACE REQUIREMENTS - CONT.

IF 3.3	CTIS shall be capable of accepting the collected information from non-Corridor TICs This collected information can either be scheduled file transfers, periodic real-time updates, or event-driven data (e.g., incident information).
IF 3.4	The non-Corridor TICs shall be capable of accepting information from CTIS.
IF 4.1	CTIS interface with commercial traffic reporting firms shall be flexible and expandable. This means that commercial traffic reporting firms can be readily added or deleted as an interface and a data supplier to CTIS.
IF 4.2	The commercial traffic reporting firms shall make their collected information (e.g., real-time traffic information) available to CTIS through an interface.
IF 4.3	CTIS shall be capable of accepting the collected information from commercial traffic reporting firms. This collected information can either be scheduled file transfers, periodic real-time updates, or event-driven data (e.g. incident information).
IF 5.1	The external databases interface with the TOCs shall be flexible and expandable. This means that external databases can be readily added or deleted as an interface and a data supplier to CTIS.
IF 5.2	The external databases shall make their collected information (e.g., real-time traffic and road information, etc.) available to CTIS through an interface.
IF 5.3	CTIS shall be capable of accepting the collected information from external databases. This collected information can either be scheduled file transfers or periodic real-time updates.
IF 5.4	When possible, the information exchanged between the external databases and CTIS shall occur over the IEN.
IF 5.5	If the IEN is not utilized, the performance of the mechanism for information exchanged between the external databases and CTIS shall meet or surpass that of the IEN.

HARDWARE REQUIREMENTS

HW1	The system shall use standard, commercially available hardware. This includes all computer-related hardware [Central Processing Units (CPU), peripherals, large screen displays, CCTV monitors, CCTV video import cards, etc.].
HW 2	The hardware platform shall be capable of meeting the software, facility, operator interface, and fault tolerance requirements for the CTIS.
HW3	The hardware for the operator workstations shall be capable of accommodating interfaces for video inputs.
HW 4	The hardware for the operator workstations shall be capable of allowing a configuration of multiple monitors, each controlled by a single keyboard.

HARDWARE REQUIREMENTS - CONT.	
HW5	**The hardware for video switching to TV monitors shall be capable of selecting any camera in the configuration and displaying its outputs.**
HW6	**The hardware for the front-end communications system shall be capable of interfacing with various types of communication links to receive both digital and analog information.**
SOFTWARE REQUIREMENTS	
SW1	**The operating system shall be multitasking and multiuser.**
SW2	**The operating system shall support distributed file systems, directory services, and remote procedure calls.**
SW3	**The operating system used shall be a POSIX-compliant Unix (FIBS PUB 151-2). POSIX 1003.1 [a.k.a. POSIX.1-System Application Program Interface (C Language)], POSIX 1003.2 (a.k.a. POSIX.2--Shell and Utility Interface), and POSIX 1003.4 (a.k.a. POSIX.4-Real-Time Services)[1] at minimum shall be met. No proprietary operating system shall be used.**
SW4	**The operating system shall provide real-time extensions (reference POSIX.4) for process priorities and preemptive scheduling.**
SW5	**The programming language for all newly developed source code shall be an ANSI-compliant higher order language. Utilization of extensions to programming languages provided by specific vendors is to be avoided.**
SW6	**The interprocess communication standard for point-to-point and broadcast communication shall be either POSIX message queues (specified in POSIX.4) or TCP/IP sockets/datagrams.**
SW7	**The CTIS software shall be modular. Modularity is characterized by the ability to add, change, or replace modules without affecting other modules. To achieve modularity, the interdependencies (coupling) between the applications will be minimized and the cohesion of functions within an application will be maximized. The extent to which applications can function as standalone entities will be maximized.**
SW8	**The CTIS software shall be maintainable. Maintainability will be supported through well-defined system interfaces, modularity (reference SW 14.1) high-level programming languages (reference SW 4), software layering, up-to-date system documentation, and through the mandatory use of industry standards (reference SW I-9).**

1 As of this date 1003.4 is in draft 12, however, implementations with major API functionality are now available on most commercially available operating systems.

SOFTWARE REQUIREMENTS - CONT.

SW9	The CTIS software shall be flexible. Flexibility is the ability to adapt the software for different environments and domains, while minimizing code changes and recompilations. Flexibility shall be supported through parameterization and data-driven approaches. Parameterfzation shall to the extent possible, capture possible variations in the system as input parameters, compilation parameters/instantiations (e.g., C++ templates or # DEFINEs), module parameters, and tables.
	Flexibility is also achieved by designing for interoperability and portability. Interoperability will be supported to minimize changes to software systems communicating with each other in a heterogeneous environment (i.e., data communications). Portability shall be supported by mandatory compliance of software to ANSI and POSIX standards.
SW10	All application software with access (both read and write) to a commercial DBMS sha contain ANSI-compliant SQL.
SW11	The extent to which software interfaces directly to map databases or GIS databases shall be limited. In cases where this is deemed necessary, a separate API (not provided by the vendor) shall be used to minimize the impact of porting to a new map/GIS database (reference "software layering").

OPERATOR INTERFACE REQUIREMENTS

OI 1	The User Interface shall use a graphical, direct manipulation icon, menu, and windows-based paradigm. The system will be mouse and keyboard driven.
OI 2	The GUI shall accommodate the input and display of all data, including system login, map displays, request for services (reports, application invocations/terminations, etc.), and all data obtained from the DBMS (real-time and historical traffic, failures, incidents, etc.).

FAULT TOLERANCE REQUIREMENTS

FT 1	The configuration of the software (including databases) shall not permit a single point of failure.
FT 2	The configuration of the hardware (including networks) shall not permit a single point of failure to the system.
FT 3	The database shall support mirroring for online recovery of database failures (reference paragraph 2.3.4). Mirroring will be used only for the critical part of the database; it is not currently envisioned that mirroring of the whole database will be necessary.
'T 4	The system shall not permit the user to start new applications on a node that will cause it to exceed peak utilization of available resources (CPU, Disk, I/O).

FAULT TOLERANCE REQUIREMENTS - CONT.	
FT5	The design of the system (both hardware and software) shall permit the configuration of redundant components (e.g., dual rail Ethernet, redundant platforms running critical applications, backup power sources, etc.).
FT6	In the event of a communication link failure between nodes participating in the network, a rerouting capability shall be provided through other communication paths.
FT7	The hardware platforms and associated software for time-critical and real-time applications shall have an availability rate of 99 percent. Provisions for recovery from failures will be provided through redundancy. The time to recovery from a hardware or software failure should take no longer than 5 minutes. This assumes redundant workstations already booted with the necessary software loaded and configured.
PERFORMANCE REQUIREMENTS	
PERF 1	The system shall provide sufficient CPU, memory, disk, and network resources to simultaneously accomplish the following types of activities without severe degradation of system performance or response times: a. Receive, validate, and load the DBMS for the real-time data (both synchronous and asynchronous) entering the system. b. Retrieve from the DBMS and transmit real-time data (both synchronous and asynchronous) to external sources. This includes static network data, real-time traffic state data, incident data, routing information, traffic control, etc. c. Satisfy the requests of applications.
PERF 2	No system activity shall impair the performance of real-time or time-critical functions.
PERF 3	The system shall not use more than 75 percent of its primary resources (CPU, Disk, Memory, I/O Network) during normal operations; and not more than 90 percent during emergency situations. A subsequent analysis of primary functions versus demand on primary system resources will be necessary on a subsystem-by-subsystem basis.
PERF 4	User input via a keyboard or mouse should be accepted (not necessarily responded to) within .2 seconds.
PERF 5	The update of displays for real-time data shall occur at user-definable intervals with a minimum resolution of twice per second, accurate to I/I 0 of a second.