ITS Deployment Guidance for Transit Systems Technical Edition

Prepared for

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1. Introduction

1.1 Purpose and Intended Audience

This document provides guidance for the transit community on developing and implementing Intelligent Transportation Systems (ITS) and using the National ITS Architecture. It is written specifically for the transit community and focuses on transit applications of ITS and the National ITS Architecture. This guidance document provides practical assistance based on real-life experiences with developing and implementing transit ITS systems.

If you perform one of the following functions within your transit agency, this document is intended for you:

- Planning and Development
- Project Definition
- Project Approval
- Funds Identification and Allocation
- Design
- Project Management
- Procurement
- Project Implementation

1.2 Document Organization

This document is comprehensive and covers many subjects such as what ITS is, what the National ITS Architecture is, the application of ITS using a systems engineering approach, alignment with the National ITS Architecture, and best practices / lessons learned for developing and implementing ITS. The document covers many areas from Planning to Operations and Maintenance. The document also has four appendices. You are encouraged to read the entire document. However, if you are unable to do so, the following summary will point you in the right direction to find the information you are seeking.

This document is divided into six major sections and four appendices which are arranged as follows:

Section 1: Introduction

- ITS Benefits
- Some transit ITS applications
- Transit concerns about ITS and some possible solutions

Section 1 discusses the high level benefits of ITS, and three of the most commonly-implemented transit ITS applications and their benefits. This section also identifies some common concerns among transit agencies about developing and implementing ITS systems, and provides some potential solutions to address or mitigate these concerns.

Section 2: National ITS Architecture -- New Tool for the Trade

- Definition
- Benefits
- Major components
- Products (documents)

Section 2 provides a general definition of the National ITS Architecture and discusses its benefits. The section then explains what the National ITS Architecture is by discussing its major components. Finally, the National ITS Architecture documents are presented and a brief description of each of their contents is provided.

Section 3: How to Use the National ITS Architecture

- ITS Concepts Definition
- ITS Regional Framework Development
- Project Deployment
  - Design options and tradeoffs
  - Determine standards
  - ITS procurement
  - Procurement -- today and tomorrow
  - Aligning design and procurement with the National ITS Architecture -- data flows for transit
- Operations and Maintenance
- System Evaluation

Section 3 explains the ideal method of developing and implementing an ITS system -- based on a regional ITS framework that was developed using the National ITS Architecture tools and methodology. The section explains how to use the National ITS Architecture to develop and implement ITS through a systems engineering process. The section provides guidance for regions (e.g., metropolitan areas) and involved transit agencies on developing ITS concepts and a multimodal ITS framework, based on the National ITS Architecture, that supports those concepts. The section identifies transit agencies' contribution towards developing a multimodal, ITS regional framework, and provides guidance to transit agencies on deploying ITS applications once a regional framework has been developed. The section provides advice on planning for ITS operations and maintenance, and discusses evaluation planning and the means of evaluating ITS systems once they have been implemented.

Section 4: Alignment with the National ITS Architecture

- Existing Systems

- Pre-standardized New Systems
- Standardized New Systems
- Quick Reference National ITS Architecture Alignment Process

Section 4 explains how transit agencies can turn their transit ITS system into one that is aligned with the National ITS Architecture. This section is beneficial for transit agencies where no ITS regional framework exists, and who wish to start aligning with the National ITS Architecture. The section provides an explanation of what is meant by alignment (also referred to as conformance), and identifies how to align ITS applications for three cases -- existing systems, new systems developed before standards are available, and new systems developed with standards.

Section 4 also provides a quick reference process for aligning with the National ITS Architecture The process follows the systems engineering process outlined in Section 3. A transit agency should address each action in the process; however, circumstances may exist that prevent transit agencies from performing all of the processes (e.g., a regional ITS framework may not exist). In this case, a transit agency should address as many of the action items as possible or permissible.

Section 5: Best Practices / Lessons Learned

- Project Planning and Development
- Project Approval and Funding
- Project Design
- Project Management
- Procurement and Implementation
- Operations and Maintenance

Section 5 provides advice on how to best develop and implement transit ITS applications from transit agencies that have developed and implemented ITS systems, or are currently developing or implementing ITS projects. Information is provided for various phases or stages of a project (e.g., planning, approval, design, procurement, etc.).

Section 6: How Do I Find Out More About ITS and the National ITS Architecture?

Sections 6 identifies where to find additional information on ITS and the National ITS Architecture. Also included is a list of transit agency professionals who provided information found in the document.

Appendix A: Standards

- Overview
- Communications
- Application of Communication Standards
- Guide to Transit Related Standards

Appendix A relates existing and planned standards with different transit applications that have been described in the main body (Technical Edition). The need for these standards has been identified by transportation engineers and/or transit authorities.

Appendix B: Sample ITS Procurement Language

- Proposal Format/Procurement Method
- ITS Specifications
- Drawings/Documentation
- Software/Source Code
- Interface Criteria
- Installation
- Acceptance Tests
- Instruction and Training
- Warranties

Appendix B contains excerpts from procurement documents of proven, real-world transit ITS applications. This sample procurement language provides a model for transit agencies embarking on transit ITS projects.

Appendix C: Logical Architecture Data Flows Associated with Transit

- Logical Data Flows Into and Out of Manage Transit
- Logical Data Flows within Manage Transit

Appendix C lists the Logical Architecture data flows that flow into, out of, and within the Manage Transit process as identified in the National ITS Architecture. Definitions for each data flow are also provided.

Appendix D: Physical Architecture Data Flows Associated with Transit

Appendix D lists each of the Physical Architecture data flows for the Transit Management and Transit Vehicle subsystems as identified in the National ITS Architecture. A brief description of each (physical) data flow, and the logical data flows which compose the physical data flow are provided.

1.3 Intelligent Transportation Systems for Transit

ITS offers non-traditional solutions to problems faced by the entire spectrum of transportation service providers. Using ITS can reduce costs, improve efficiency, increase mobility, improve safety, reduce negative environmental impacts, and conserve resources. Many ITS applications, which have been implemented throughout the country, have proved beneficial and are available for implementation now.

Implementing new technologies is nothing new to the transit industry. Over the past few years more and more transit agencies have been implementing systems to improve operations and increase the marketability of transit. Transit has been broadly defined in ITS to include paratransit, personalized transit, park and ride, ridesharing, demand management, and other innovative approaches toward shifting the mode of travel away from single occupancy vehicles. A few of the most commonly-implemented ITS applications include automatic vehicle location, electronic payment services, pre-trip traveler information, and traffic signal priority.

ITS has the ability to produce the following broad benefits for transit users and operators:

- Improve the convenience and comfort of travel
- Improve safety
- Increase mobility
- Improve operational efficiency and capacity
- Reduce energy consumption and environmental costs
- Increase the economic productivity of individuals, organizations, and the economy as a whole

Specific ITS applications may provide benefits in a variety of forms to a variety of users. Sections 1.3.1, 1.3.2, 1.3.3, and 1.3.4 provide an overview of four of the most commonly-implemented transit ITS applications and their benefits. Other transit-related ITS services are discussed throughout the document.

1.3.1 Automatic Vehicle Location

Automatic Vehicle Location (AVL) determines the location of a vehicle. In this application, the location of a vehicle is determined using satellites or radio beacons and transmitted to the dispatcher. AVL systems are used by the military, trucking fleets, police, and emergency service providers. These computer-based systems have been implemented in many areas for use in transit. Figure 1.1 provides an illustration of AVL.

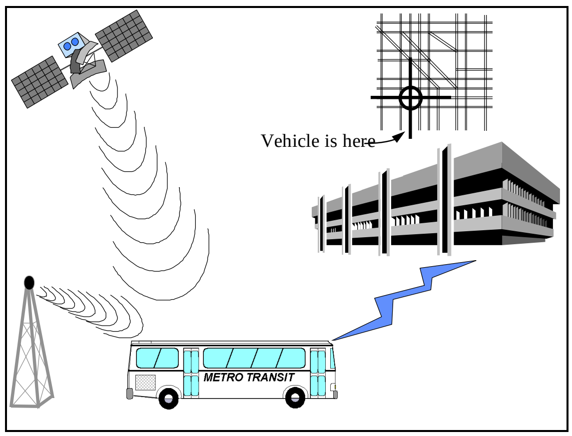


Figure 1.1 - Automated Vehicle Location

AVL may be used in the following ways:

- Transmitting emergency location of vehicle -- activated by the driver in times of crisis
- Monitoring schedule adherence
- Routing around incidents
- Planning and managing operations
- Providing input to passenger information services

The benefits of using AVL includes the following:

- Better management information on drivers and vehicles
- Increased dispatching efficiency and on-time operations
- More reliable services to passengers
- Increased ability to respond to disruptions in the roadway system
- Increased safety and security
- Quicker warning of mechanical problems
- More extensive and timely planning information

1.3.2 Electronic Fare Payment

Electronic fare payment systems allow passengers to pay for their transit trips electronically, using a card instead of directly using cash. They employ electronic communication, data processing, and data storage technologies. Electronic fare payment systems allow a common fare card to be used for multiple transit modes and provide the means for multiple operators to honor the same card. They enable automated accounting of transfers and simplify ridership data collection. Figure 1.2 provides an illustration of electronic fare payment.

Figure 1.2 - Electronic Fare Payment

The following benefits may be achieved through the use of an electronic fare payment system:

- ♦ An ability to have more sophisticated fare pricing systems based on distance traveled, time of day, and user classification (e.g., senior citizen, student, etc.)
- ♦ Improved cash flow
- ♦ Improved speed of fare payment
- ♦ Improved security
- ♦ Lower operating costs
- ♦ Less cash exchanging hands
- ♦ Reduced fare evasion
- ♦ Reduced costs for trip origin/destination studies
- ♦ More accurate and detailed data

1.3.3 Pre-Trip Traveler Information

Pre-trip information is information provided to the traveler prior to his or her departure. Information may be provided on transit routes, available modes, best routes, incidents, delays, construction, schedules, fares, location of stops, and park-and-ride lots. The most common media employed are touch-tone telephones and human operators. Other systems use the Internet, pagers, personal communications devices, cable television, and kiosks. Figure 1.3 provides an illustration of pre-trip traveler information services.

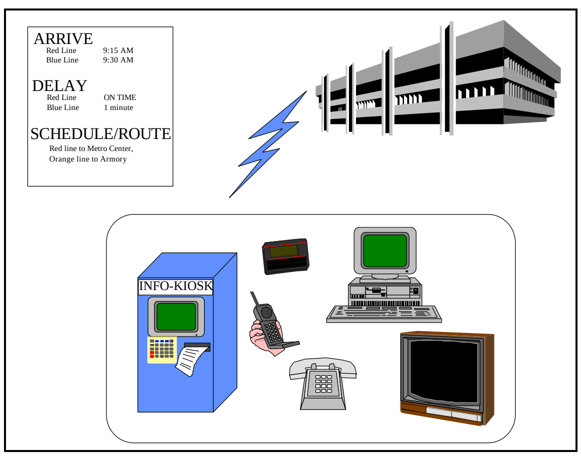


Figure 1.3 - Pre-Trip Traveler Information

Benefits of pre-trip traveler information include:

- Increased ridership
- Reduced traveler frustration
- More accurate travel times
- Increased travel efficiency and options

1.3.4 Traffic Signal Priority

Traffic signal priority allows buses and light rail vehicles to have limited control over traffic signals. These systems extend the green phase or shorten the red phase upon the arrival of a vehicle. This can reduce transit trip times and help induce travelers to switch from driving single occupancy vehicles (SOV) to riding transit vehicles. Traffic signal priority also can improve transit trip time reliability and schedule adherence so that better service can be provided to customers.

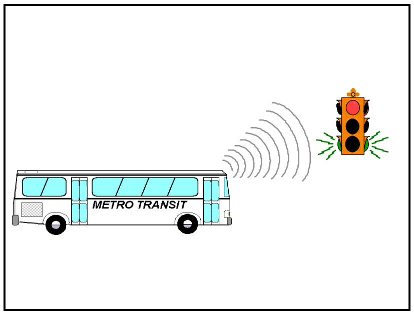


Figure 1.4 - Traffic Signal Priority

Two methods are used for signal priority. The first employs a special transmitter on the transit vehicle and a companion receiver located at or near the signalized intersection. As the vehicle approaches the signal, the receiver identifies the vehicle from its transmission and either holds the light green or changes it to green (once proper clearance times have been provided) until the vehicle passes through the intersection. The second method ties the transit agency's AVL system with the traffic signal system. As the transit vehicle approaches the traffic signal, the AVL system provides the traffic signal the proper cue to slightly alter the signal phasing. Figure 1.4 provides an illustration of traffic signal priority.

The benefits of using a traffic signal priority system includes the following:

- Reduced trip times for passengers
- More reliable (on-time) service to passengers
- Increased operations efficiency by reducing run time
- Induce SOV drivers to ride transit

1.4 Transit Concerns in ITS Implementation

Transit operators face a number of significant concerns regarding the implementation of ITS technology. However, these concerns can be addressed or at least mitigated by applying the National ITS Architecture principles and through the use of other ITS guidance material developed by the Federal Transit Administration and the Federal Highway Administration. These concerns and potential solutions are addressed below.

1.4.1 Funding

Transit funding at all levels has been significantly reduced over the course of the last several years. As budgets have shrunk, transit operators have faced an increasing backlog of basic system maintenance projects and a reduction in staff. As a result, many transit agencies have been forced to prioritize critical projects and sacrifice any projects that may be construed as anything less than critically needed. Even if ITS projects can be demonstrated to save the agency significant operations and maintenance costs over time, the agency often lacks the staff available to conduct the analyses required to gain support for the ITS projects.

The National ITS Architecture framework suggests a number of possibilities for addressing this funding issue. A wide range of funding resources (particularly at the federal level) are now available. Interagency and inter-jurisdictional approaches to procurements of ITS systems can spread costs over a larger number of agencies. Also, public/private partnerships can leverage private sector resources to complement the agencies' contributions.

1.4.2 Maintaining Basic Service Quality

As mentioned above, with reduced funding, many transit systems spend most of their resources on maintaining basic transit service. In order to preserve ridership, these basic services receive priority when project funding decisions are made.

Basic service quality can be greatly enhanced through ITS implementation. Improved traveler information and other services such as signal priority can increase ridership by making transit more appealing to travelers. Increased revenues can provide agencies with funding for other critical projects. By consolidating fare payment across transportation modes, transit agencies can simplify their financial management operations and, someday, turn them over to either public or private agencies to administer, reducing the transit agencies' costs and enabling them to concentrate on service quality. Enhanced fleet management can reduce the number of buses or trains needed by a transit agency. The collection of ridership data via ITS applications (e.g., AVL and automatic passenger counters) allows transit agencies to maximize use of their fleets by providing transit agencies more accurate and detailed ridership information, thus allowing agencies to develop more efficient routes and schedules.

1.4.3 Misconceptions of ITS Capabilities

Many transit agencies perceive the focus of ITS as being more on highways than transit. ITS applications for transit and intermodal integration of ITS components have only recently received widespread attention. Many transit officials express concern in implementing ITS without a clear sense of how a truly multimodal, integrated national transportation system is likely to be developed. In addition, ITS applications have often been characterized as "Star Wars" type technologies, despite the fact that ITS systems have been operating successfully for years and have provided substantial benefits to day-to-day transportation operations. This misunderstanding has discouraged transit operators from fully embracing ITS technologies.

The National ITS Architecture clearly identifies areas within the ITS program where transit plays a critical role, as indicated above. These ITS applications will provide transit users with improved service quality and increased operating efficiency.

1.4.4 Ability to Maintain Systems Over Time

As one transit agency official put it, “Even if [ITS projects] do work, they have to work forever.” The ability of transit systems to maintain ITS applications over time is a concern for transit operators, particularly in light of shrinking budgets. New technical systems that have become too complicated for many of the existing staff (operators, dispatchers, and bus mechanics) require transit agencies to provide training and retraining programs, or may result in changes to the hiring practices of many transit agencies.

The National ITS Architecture promotes a phased implementation approach that encourages maximum use of private sector resources to assist in operations and maintenance of the systems. Phased implementation will allow the transit agency time to develop a work force with the necessary skills to manage and operate the systems, while private sector companies, which install ITS systems, can be contracted to provide necessary maintenance and operational assistance, which may also reduce agency costs.

1.4.5 Fear of Installing Outdated or Proprietary Equipment

The public sector procurement process can be very time consuming. As the rate of technological change increases, transportation agencies fear procuring systems that will quickly become outdated. In addition, agencies are concerned that the ITS systems they install will not be upgradeable or compatible with future ITS transit applications or other modal ITS systems.

The National ITS Architecture is designed to encourage and support interoperability, compatibility, and multi-functionality. It also lays the foundation for the development of national and international standards, that may eventually allow transit operators to purchase “off-the-shelf” technology. The Transit Communications Interface Protocols (TCIP) standard is currently being developed. It is anticipated that this standard will be completed in two years. For additional information on TCIP, refer to Section 3.3.2 and Appendix A.

1.4.6 Quantifiable Benefits

In an era of declining resources, it is now even more important that projects competing for transit funding have clear and quantifiable benefits, such as statistics on improved safety, increased operating efficiency, and reduced operating costs. Transit agencies often lack such information when considering and planning for transit ITS projects, and even more frequently lack the staff required to conduct such analyses.

The Federal Transit Administration and the Federal Highway Administration have been compiling benefits data as more and more transit agencies deploy ITS systems. These data show that transit ITS applications are providing significant, measurable benefits (see "Transit ITS Success Stories" in the *ITS Deployment Guidance for Transit Systems Executive Edition*), and are providing bases upon which transit authorities can proceed with their own ITS systems. Additional data will be collected as more and more transit agencies implement ITS.

2. National ITS Architecture: New Tool for the Trade

2.1 What is the National ITS Architecture?

The need for a national ITS architecture was identified in the Intermodal Surface Transportation Efficiency Act of 1991 (ISTEA), the law that formalized the ITS program. ISTEA identified a need for compatibility among transportation technologies implemented throughout the United States. An architecture would address this need and would provide a model and framework for transportation agencies to develop and implement Intelligent Transportation Systems that fit together and operate in unison.

The National ITS Architecture:

- Provides a framework for transportation agencies to determine ITS solutions and implement ITS technologies and systems that are integrated and interoperable.
- Is a master plan that lays out the boundaries, players, and strategies for developing an integrated, multimodal Intelligent Transportation System with consistent character throughout the United States.
- Is a guide to developing standards and making deployment decisions that will result in efficiency, economies of scale, and national interoperability.
- Is a conglomerate of documents which describe physical connections and data flows enabling simpler and more cost effective information exchange between transportation management system components.
- Is a resource for specifications and for developing specifications.
- Is a resource for standards requirements and for developing standards.
- Identifies data flows to support and the needed interfaces for those data flows.
- Is a tool to be used in building a regional framework.
- Provides a methodology to develop a regional framework.

Through a consensus building process many agencies and stakeholders from throughout the U.S., including the Federal Transit Administration, had a role in the development of the National ITS Architecture. The U.S. DOT supports the use of the National ITS Architecture in guiding state and local ITS implementation efforts.

2.2 How Does It Benefit Me?

As discussed in the previous sections, ITS technologies produce a wide variety of benefits for systems that have been implemented as stand-alone operations. These isolated systems can be found in transit agencies, both large and small, throughout the United States. The National ITS Architecture will assist in implementing systems that can operate as stand-alone operations or be integrated with other systems. The net result will be greater benefits than those realized by individual implementation. These benefits fall into three main categories:

- Integration of systems
- Standards
- Synergy

2.2.1 Integration Of Systems

System integration is the process through which a number of products and services, both hardware and software, are specified and assembled into a complete system that will perform the intended functions and achieve the intended objectives. This may occur within the agency itself or among multiple agencies or service providers (transit as well as traffic).

System integration through the use of the National ITS Architecture may produce the following benefits:

- **Functional inter-operability:** Functions, such as AVL or electronic fare payment, are allocated to subsystems (defined in the National ITS Architecture) and interconnected through data sharing interfaces. Subsystems are grouped into four categories: center, roadside, vehicle, and remote access. As an example, center subsystems include the transit management subsystem, traffic management subsystem, emergency management subsystem, etc. As outlined in the National ITS Architecture, subsystems work together to cover all the desired objectives of ITS.
- **Data compatibility:** The same concepts mean the same thing in different portions of the system. For example, the definition of how a transit vehicle's position is defined is standardized (e.g., latitude and longitude) such that other systems and devices can use the data. Open system standards allow for other systems to communicate with minimum customization of hardware or software. TCIP will greatly enhance data compatibility.
- **Interoperability of components:** System definition that stops at the interface level allows for use of multiple vendors but maintains a firm control of what the components are, their requirements, and how they will interact. Components include subsystem and Market Package general equipment.
- **Inter-agency compatibility of data sharing:** The National ITS Architecture can help resolve coordination problems by providing tools to improve data sharing. A common architecture will facilitate the sharing of data among agencies and service providers (e.g., between transit agencies and between transit agencies and other agencies).

2.2.2 Standards

The National ITS Architecture has set in motion several movements in standards development. While many of these are still in their infancy, they have established the premise that standards are needed. The standards development process and project implementation go hand in hand. As projects are developed and implemented, their results directly influence the development process. Therefore, agencies need not wait for standards to be completed (as this may take several years), but can implement ITS as their needs and resources warrant.

Standardization may occur at many levels. High level standardization, such as User Services or Market Packages, ensures that general concepts have the same meanings. On the other hand, standards may be used at the interface level. This ensures common data sharing protocols and may even allow “plug and play” capabilities for hardware and software to be transplanted to other systems. In the long run, standards may help reduce the price of ITS products due to economies of scale on the producers’ side and the facilitation of getting competitive bids from multiple vendors on the transit buyers’ side.

User Services are short, general descriptions of the services the transportation system needs to provide.

Market Packages describe how to provide one or more User Service through the application of a group of general technologies. Market Packages provide a physical or tangible means of satisfying user requirements. They are the fundamental building blocks of ITS.

Standardization also has the potential to open the following new options in the form of equipment acquisition. Standards will allow for:

- Using products from multiple vendors (purchasing the best components from a variety of sources)
- Upgrading of systems without scrapping old systems (replacing pieces of a system with more modern components)
- Building upon existing systems (adding functions to systems at a later date)
- Expanding the market both nationally and internationally (lack of a standard may ultimately limit the size of the market)

For additional information on standards relevant to transit ITS, refer to Section 3.3.2 and Appendix A.

2.2.3 Synergy

Synergy is the interaction of discrete entities such that the total effect is greater than the sum of the individual effects. For ITS, synergy can be gained when combining individual technologies or functions, and sharing information. Several examples of synergies based on transit systems are as follows:

- An AVL system determines vehicle location, but when used with pre-trip traveler information services it may provide travelers with real-time transit schedule information, serve as probes for traffic management, or enhance emergency notification.
- Electronic fare payment media can be used to provide financial transactions for several surface transportation modes (tolls, transit fares, parking charges) as well as non-transportation purposes.

- Transit vehicle tracking facilitates more efficient public transportation management through route guidance and personalized public transit and also provides data for schedule adherence systems.
- Transit management systems allows for many functions to be performed at a single location enabling the beneficial sharing of equipment, facilities, and information across multiple user services.

2.2.4 Hypothetical Example

Let us revisit the previously discussed ITS applications (Automatic Vehicle Location, electronic fare payment, pre-trip traveler information, and traffic signal priority) and present how a system using these four applications may operate if implemented with the National ITS Architecture. First of all, one would need to look at the overall picture. To do so, the following questions may be asked:

- What systems are already in place (both within and outside the transit agency)?
- Which applications are needed now?
- What do we plan to do in the future?

Let's say an area already has a dispatching system (transit management center), a traveler information system, and a traffic management center. The first new application to be implemented will be a bus location system (AVL). Instead of a stand-alone system, this AVL system will be integrated with the existing systems. Figure 2.1 illustrates how the system may

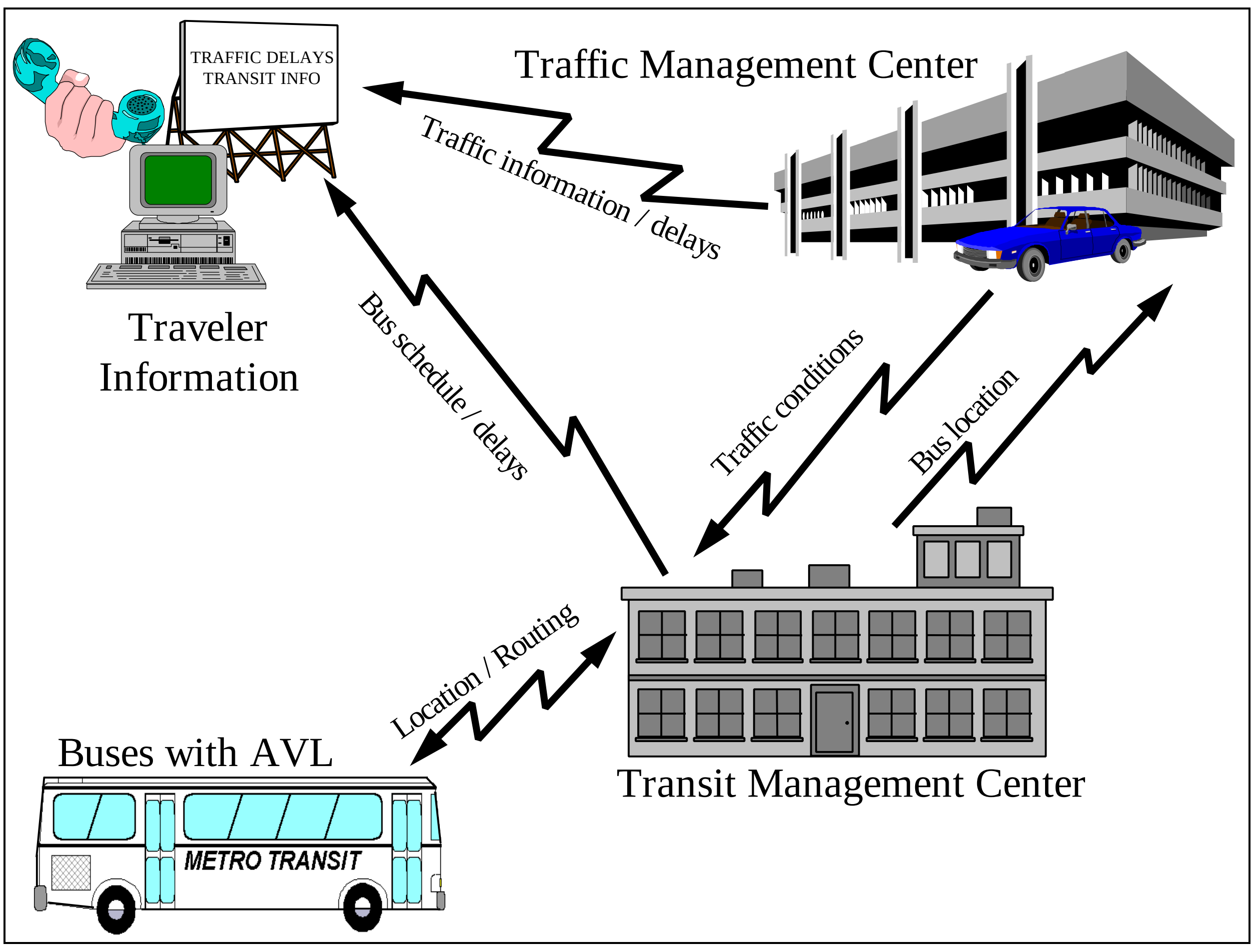


Figure 2.1 - Hypothetical Integrated System

operate.

By applying the National ITS Architecture and ongoing standards activities to guide the system design, the system, in addition to determining bus location, would be able to do the following:

- Provide travelers with current schedule information through the use of personal computers, telephone systems, variable message signs, and kiosks.
- Relay traffic information collected by the buses to the traffic management center (buses as probes).
- Receive information on roadway conditions and congestion and be routed around it. This information may be obtained from the traffic management center.
- Determine needs for additional buses or routes based on demand.
- Support the ability to determine vehicle diagnostics.
- Support the ability to collect stop-level ridership data.
- Support the ability to provide stop announcements.
- Relay real-time vehicle performance data and alarms.

If traffic signal priority is added to the system, a transit agency would be able to maintain its schedules more easily. For example, traffic signal priority combined with AVL would enable a bus operator to stay on schedule by automatically extending the green phase or shortening the opposing red phase of traffic signals when the bus is behind schedule. In addition, traffic signal priority combined with AVL would enable a transit agency to optimize its routes more easily. A transit agency may be able to serve routes with fewer buses while retaining frequency, or serve routes with the same number of buses while increasing frequency. In the long run, the improvement in travel time reliability and schedule adherence may induce single occupancy vehicle drivers to switch to riding transit, thus serving the goals of transportation demand management.

If electronic fare payment is combined with AVL, a transit agency would be able to have a more sophisticated fare pricing system -- one that is based on distance traveled. The combined system would also simplify ridership data collection.

As seen with this example**, performance of individual systems improves through the combined use with other systems.** Since ITS spans more than the transit industry, cooperation and coordination with other agencies will be necessary to achieve optimal results, depending on the technologies being implemented.

There may even be cases where **an agency can use parts of another agency's system, and thus not have to pay for the main components of a system.** For example, a transit agency could take advantage of another agencies' communications infrastructure or traffic management centers or private companies providing information services to the public. A transit agency may also be able to use a traffic signal priority system that is currently used for other purposes, such as an emergency vehicle priority system.

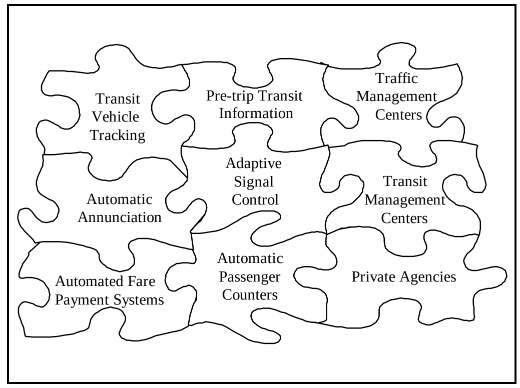


Figure 2.2 - Integrated Transit ITS System

The possibilities for integration are almost endless. Each technology or application may act as a component for providing mobility in a region. It is the responsibility of the involved agencies to build the transportation system with these components. ITS is not intended to be disjointed from traditional measures; it is intended as another method of addressing needs and problems. Figure 2.2 uses an analogy of a puzzle to illustrate that ITS components should fit together, or be integrated, to form an overall system. It should be noted that traffic and information service providers are included, as well as opportunities to add more pieces (ITS components/applications) as they are developed.

2.3 Key concepts of the National ITS Architecture

This section explores key concepts and components of the National ITS Architecture. These concepts/components include: User Services, Market Packages, Logical Architecture, and Physical Architecture. The application of the key concepts and components that relate to transit are illustrated throughout Section 3.

2.3.1 User Services

User Services are short, structured descriptions of all the functions and services that must be provided by the proposed system, if it is to be considered successful, from the users' (public, operator, etc.) perspective.

User Services are the *what* of the solution. They describe the services that will address the identified needs and goals. The User Services must be detailed enough to address all requirements and be concise enough to be useful in guiding architecture and system development. These may be grouped into bundles based on common functionality.

Table 2.1 presents the seven User Service bundles and their corresponding User Services as identified in the National ITS Architecture (this table is presented again in Section 3.1.4). This list may be expanded as new needs are identified.

Table 2.1 - User Services

User Service Bundle	**User Service**
Travel and Transportation Management	En-Route Driver Information Route Guidance Traveler Services Information Traffic Control Incident Management Emissions Testing and Mitigation Highway-Rail Intersection
Travel Demand Management	Pre-Trip Travel Information Ride Matching and Reservation Demand Management and Operations
Public Transportation Operations	Public Transportation Management En-Route Transit Information Personalized Public Transit Public Travel Security
Electronic Payment Services	Electronic Payment Services
Commercial Vehicle Operations	Commercial Vehicle Electronic Clearance Automated Roadside Safety Inspection On-Board Safety Monitoring Commercial Vehicle Administrative Processes Hazardous Material Incident Response Commercial Fleet Management
Emergency Management	Emergency Notification and Personal Security Emergency Vehicle Management
Advanced Vehicle Control and Safety Systems	Longitudinal Collision Avoidance Lateral Collision Avoidance Intersection Collision Avoidance Vision Enhancement for Crash Avoidance Safety Readiness Pre-Crash Restraint Deployment Automated Highway Systems

Each User Service Bundle and the corresponding User Services are listed below and are briefly defined in the following paragraphs.

2.3.1.1 Travel and Transportation Management

This bundle of User Services addresses and contributes to the resolution of traffic management problems. It supports two key functions: travel information management and transportation systems management, in which infrastructure owner/operators play a principal role. The common technical aspects are derived from the significant sharing of functional subsystems such as detection, surveillance and communications.

- **En-route driver information** contains driver advisories and in-vehicle instructions for convenience and safety.
- **Route guidance** assists travelers in reaching their final destination by providing travelers with directions.
- **Traveler services information** provides pertinent information to travelers including a business directory, or yellow pages, of service information.
- **Traffic control** manages the movement of traffic on streets and highways.
- **Incident management** helps public and private organizations quickly identify incidents and implement an effective response to minimize the incident's effects on transportation.
- **Emissions testing and mitigation** provides area-wide pollution information for monitoring air quality and framing air-quality improvement strategies.
- **Highway-Rail Intersection** controls highway and rail traffic in at-grade highway-rail intersections.

2.3.1.2 Travel Demand Management

These User Services provide information and incentives to manage transportation demand, primarily on a pre-trip basis, and encourage the use of more efficient travel times and modes (such as high occupancy vehicles).

- **Pre-trip travel information** provides information for selecting the best departure time, transportation modes, and routes.
- **Ride matching and reservation** assists commuters in finding ride sharing arrangements.
- **Demand and management operations** supports policies and regulations designed to mitigate the environmental and social impacts of traffic congestion.

2.3.1.3 Public Transportation Operations

Although the functions in this bundle are technical, this bundle reflects the commonality of the transit authority as the most probable provider of these services. All of the User Services can use a common public transit database.

- **Public transportation management** supports operations, planning, and management functions of public transit systems.
- **En-route transit information** provides information to travelers and transit vehicle operators using public transportation after they begin their trips.
- **Personalized public transit** routes transit and paratransit (e.g., dial-a-ride) vehicles on a more flexible path, which provides more convenient service to customers than traditional fixed-route public transit schedules.
- **Public travel security** creates a safe environment for public transportation patrons and operators.

2.3.1.4 Electronic Payment Services

This bundle contains a single User Service; however, it provides financial support for deployment of many other services, both within and outside the transportation arena. This User Service Bundle involves both public and private organizations.

- **Electronic payment services** allows travelers to pay for transportation services electronically.

2.3.1.5 Commercial Vehicle Operations

This bundle of User Services focuses on improving the efficiency and safety of commercial fleet operation, benefiting both states and the motor carrier industry. The CVO bundle reflects the commonality of using advanced computer and communications technologies to improve safety and productivity.

- **Commercial vehicle electronic clearance** facilitates domestic and international border clearance, minimizing stops.
- **Automated roadside safety inspection** facilitates roadside inspections.
- **On-board safety monitoring** senses the safety of a commercial vehicle, cargo, and driver.
- **Commercial vehicle administrative processes** provides electronic means of obtaining credentials, automates mileage and fuel reporting, and assists in the audit processes.
- **Hazardous material incident response** provides immediate location and description of hazardous materials contained on incident vehicles to emergency responders.
- **Commercial fleet management** provides enhanced, real-time communications between drivers, dispatchers, and intermodal transportation providers.

2.3.1.6 Emergency Management

The bundling of these User Services is based on the commonality of the deploying organizations (police, fire, and rescue services). These User Services share common technical functionality in the areas of vehicle surveillance, navigation, communications, and response.

- **Emergency notification and personal security** provides immediate notification of an incident and an immediate request for assistance.
- **Emergency vehicle management** reduces the time it takes emergency vehicles to respond to an incident.

2.3.1.7 Advanced Vehicle Control and Safety Systems

The institutional commonality among the User Services in this bundle lies in the necessary involvement of the automobile industry (together with the public-sector highway owner/operators) towards improved vehicle safety. With the exception of Automated Vehicle Operations, most of these User Services are characterized by near-term reliance on self-contained systems within the vehicle.

- **Longitudinal collision avoidance** helps prevent head-on and rear-end collisions between vehicles, or between vehicles and other objects or pedestrians.
- **Lateral collision avoidance** helps prevent collisions when vehicles leave their lane of travel.
- **Intersection collision avoidance** helps prevent collisions at intersections.
- **Vision enhancement for crash avoidance** improves the driver's ability to see the roadway and objects that are on or along the roadway.
- **Safety readiness** provides warnings regarding the condition of the driver, vehicle, and roadway infrastructure.
- **Pre-crash restraint deployment** anticipates an imminent collision and activates passenger safety mechanisms prior to collision.
- **Automated highway systems** fully automates vehicles on existing and/or instrumented highways, significantly improving today's safety, efficiency, and comfort standards.

It should be noted that these User Services range in development from experimental to established and proven. For each of the User Services, the National ITS Architecture provides a detailed definition description of the operational requirements, stage of maturity, and process specifications.

2.3.2 Market Packages

Market Packages are the basic building blocks of the ITS. They allow incremental deployment options that apply to different scenarios and time frames. User Services and Market Packages are closely related. User Services are the *what*, Market Packages are the *how* in addressing problems and needs. Market Packages describe how to provide one or more ITS User Service, and provide a physical or tangible means of satisfying user requirements. For example, the Market Packages, Transit Vehicle Tracking, Transit Fixed-Route Operations, Demand Response Transit Operations, Transit Passenger and Fare Management, Broadcast Traveler Information, Interactive Traveler information, and Dynamic Ridesharing, provide the User Service, En-Route Transit Information.

Market Packages are not a set of abstract functions, but concrete things that can be purchased on the market. Market Packages are groups of enabling technologies combined to create a deployable product that may be implemented separately or in combination with other Market Packages. They are technology dependent, but not technology specific. As technology advances and new devices are developed, Market Packages will change and new Market Packages will be developed. The National ITS Architecture identifies a total of 56 Market Packages that address the current trend in the technology market. A complete listing of ITS Market Packages, grouped according to their respective major application area, is found in Table 2.2 (this table is presented again in Section 3.2.3.1).

Table 2.2 - ITS Market Packages

Traffic Management
- Network Surveillance
- Probe Surveillance
- Surface Street Control
- Freeway Control
- HOV and Reversible Lane Management
- Traffic Information Dissemination
- Regional Traffic Control
- Incident Management System
- Traffic Network Performance Evaluation
- Dynamic Toll/Parking Fee Management
- Emissions and Environmental Hazards Sensing
- Virtual TMC and Smart Probe Data
- Standard Railroad Grade Crossing
- Advanced Railroad Grade Crossing
- Railroad Operations Coordination

Transit Management

- Transit Vehicle Tracking
- Transit Fixed-Route Operations
- Demand Response Transit Operations
- Transit Passenger and Fare Management
- Transit Security
- Transit Maintenance
- Multi-modal Coordination

Traveler Information
- Broadcast Traveler Information
- Interactive Traveler Information
- Autonomous Route Guidance
- Dynamic Route Guidance
- Information Service Provider (ISP) Based Route Guidance
- Integrated Transportation Management/Route Guidance
- Yellow Pages and Reservation
- Dynamic Ridesharing
- In Vehicle Signing

Advanced Vehicles
- Vehicle Safety Monitoring
- Driver Safety Monitoring
- Longitudinal Safety Warning
- Lateral Safety Warning
- Intersection Safety Warning
- Pre-Crash Restraint Deployment
- Driver Visibility Improvement
- Advanced Vehicle Longitudinal Control
- Advanced Vehicle Lateral Control
- Intersection Collision Avoidance
- Automated Highway System

Commercial Vehicles
- Fleet Administration
- Freight Administration
- Electronic Clearance
- Commercial Vehicle Administrative Processes
- International Border Electronic Clearance
- Weigh-In-Motion
- Roadside CVO Safety
- On-board CVO Safety
- CVO Fleet Maintenance
- HAZMAT Management

Emergency Management
- Emergency Response
- Emergency Routing
- MayDay Support

ITS Planning
- ITS Planning

Figure 2.3 illustrates the Market Package definition for Transit Vehicle Tracking as it appears in the National ITS Architecture documentation (Appendix A of the Implementation Strategy document).

Transit Vehicle Tracking
This Market Package provides for an Automated Vehicle Location system to track the transit vehicle's real-time schedule adherence and updates the transit system's schedule in real-time. Vehicle position may be determined either by the vehicle (e.g., through GPS) and relayed to the infrastructure or may be determined directly by the communications infrastructure. A two-way wireless communication link with the transit management center is used for relaying vehicle position and control measures. Fixed route transit systems may also employ beacons along the route to enable position determination and facilitate communications with each vehicle at fixed intervals. In this implementation, communications between the transit vehicle and transit management center includes both dedicated short range and wireline communications components. The transit management center processes this information, updates the transit schedule and makes real-time schedule information available to the information service provider via a wireline link.

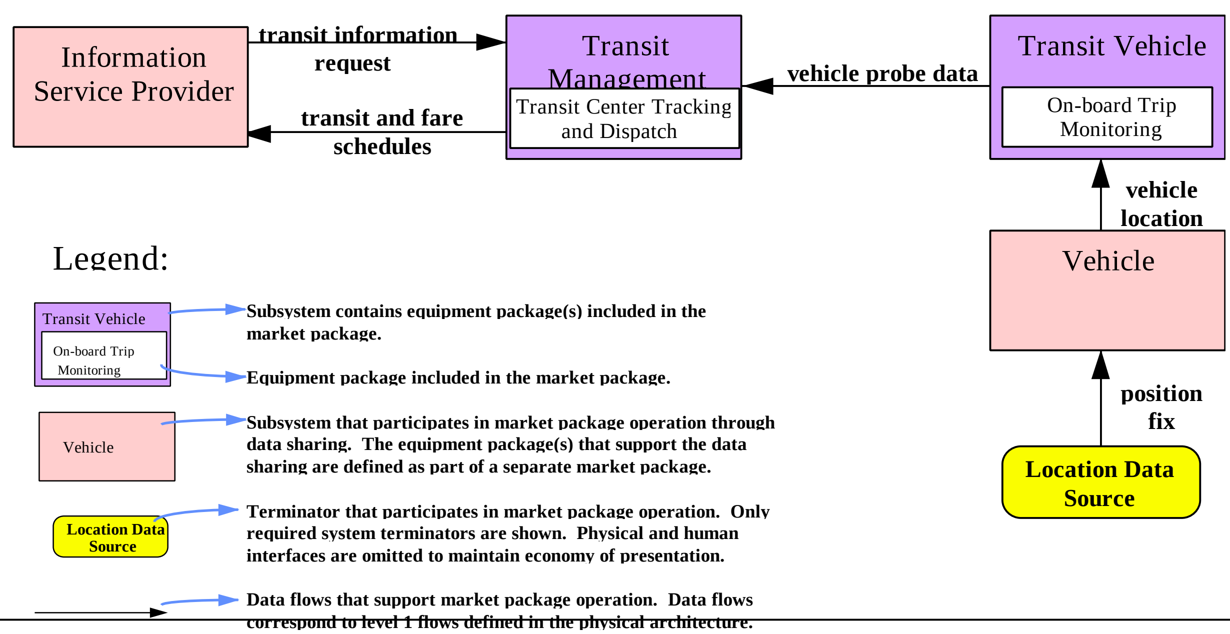


Figure 2.3 - Transit Vehicle Tracking Market Package

2.3.3 Logical Architecture

The Logical Architecture is a series of high level information processing and data flow diagrams depicting the functional requirement for the processing of information and the flow of data and control through the ITS. The Logical Architecture describes what has to be done (functions) using data flow and process diagrams, identifies the major processes required to achieve the system objectives and deliver the identified User Services, and defines the data flows required between major processes.

The Logical Architecture is essential for effective software development and efficient system design.

The data flow diagrams (DFDs) are also referred to as “bubble” diagrams, which detail the functions and data flows. Processes are represented as bubbles and data flows are represented as arrows. Each bubble is an information process which describes some logical function to be performed. Figure 2.4 illustrates a generic example of this format. For example, process 2 might be on a bus and be: acquire position. Data flow B might be: send position data to the dispatcher. Process 1 might be: compare position with schedule.

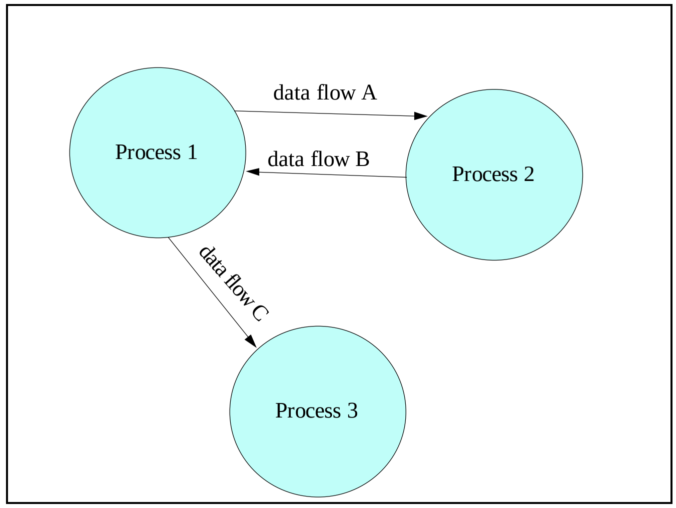


Figure 2.4 - Generic Data Flow Diagram

The data flow diagrams in the Logical Architecture contain levels. The top level data flow diagram is Manage ITS, which encompasses all ITS functions. Manage Transit is a process (bubble) within Manage ITS. The Manage Transit data flow diagram contains several processes (bubbles), each of which have their own data flow diagrams containing processes and data flows, and so on. Figure 2.5 illustrates a simplified data flow diagram for transit vehicle tracking.

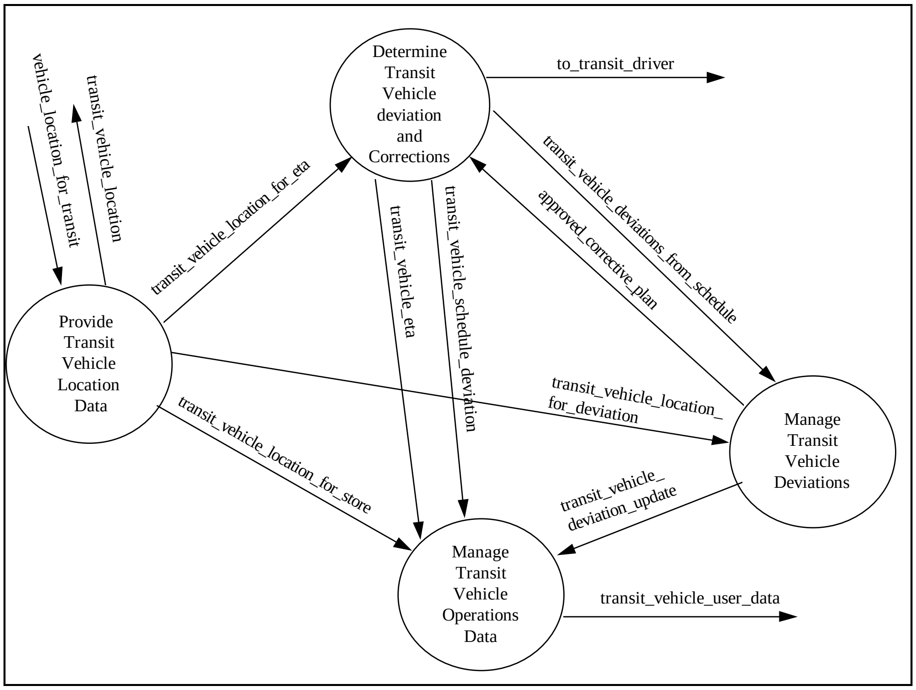


Figure 2.5 - Simplified Data Flow Diagram for Transit Vehicle Tracking

2.3.4 Physical Architecture

The Physical Architecture identifies the physical subsystems and data flows between subsystems that will support those processes identified in the Logical Architecture. As illustrated in Figure 2.6, the National ITS Architecture is structured in three layers: communications, transportation, and institutional.

The layers provide a physical representation of *how* the system should provide the required functionality, while satisfying the needs and constraints of key stakeholders. The transportation and communications layers are considered as parts of a technical layer. The transportation layer groups processes (defined by the Logical Architecture) of functional similarity, and assigns them to subsystems. The transportation layer is composed of 19 subsystems. Subsystems are composed of equipment packages.

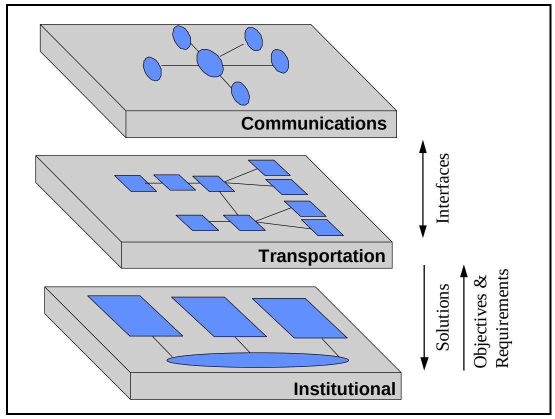


Figure 2.6 - Three Layers of the National ITS Architecture

> An **equipment package** is a set of equipment that is likely to be purchased by end users. Equipment packages are the smallest units defined by the Physical Architecture. The portion of the Market Package capabilities that are allocated to each subsystem are segregated and defined as equipment packages. Typically, systems engineers, designers, and procurers use equipment packages; and planners use Market Packages.

The communications layer identifies potential communications media that may be used to provide communications between subsystems. The institutional layer identifies the institutional, organizational, and commercial arrangements required to support the selected technical configuration.

Figure 2.7 illustrates the transportation and communications layers of the National ITS Architecture and is from the National ITS Architecture documentation (this figure is presented again in Section 3.2.2 and Section 3.3.4.2). The 19 subsystems are connected by four means of communication. This figure also:

- Shows the transportation system as a whole and that transit is a part of it.
- Identifies the major ITS interfaces and where standards are needed.
- Indicates integration.
- Illustrates the importance of communication and cooperation to fully achieve the benefits of implementing ITS technologies.

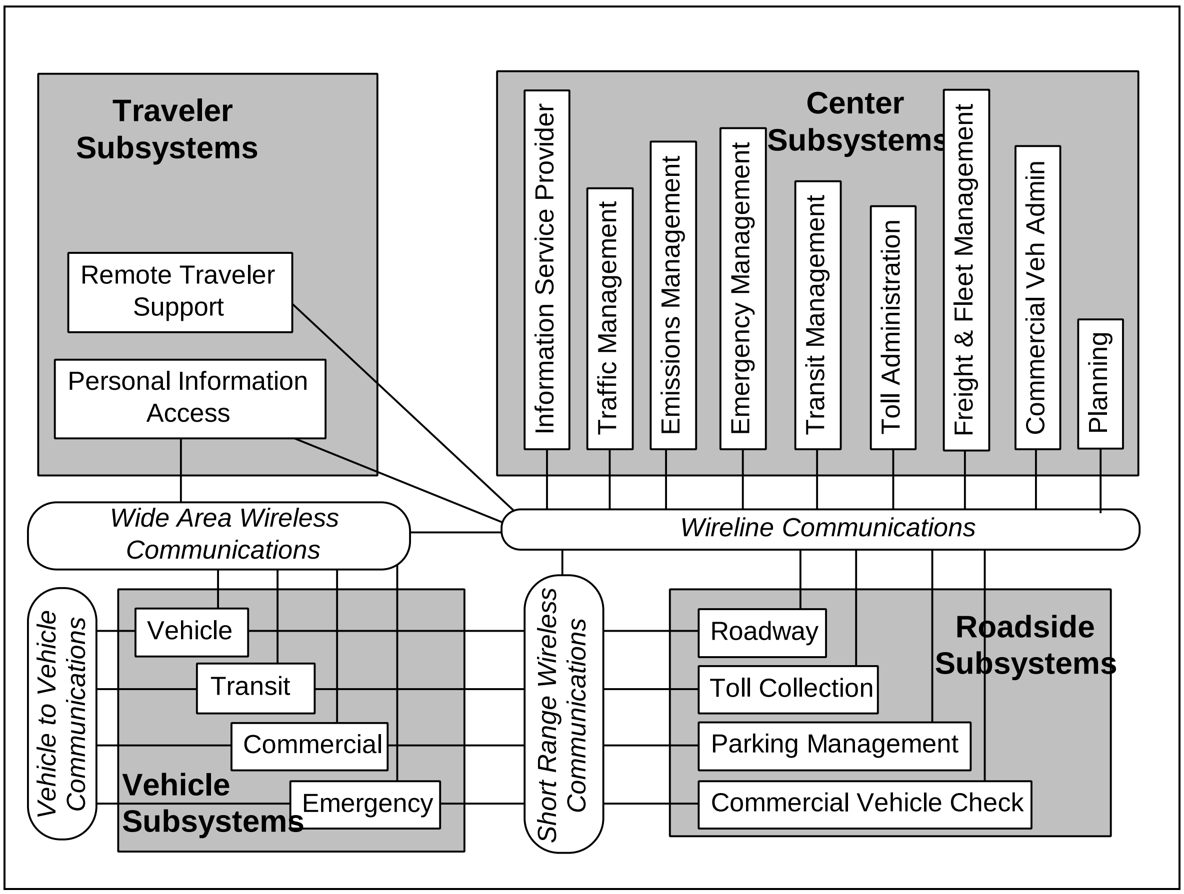


Figure 2.7 - National ITS Architecture Transportation and Communications Layers (Subsystems and Communication Media)

Figure 2.8 illustrates the institutional layer of the National ITS Architecture and is from the National ITS Architecture documentation. The figure presents the stakeholders of ITS, their roles, and their relationships as outlined by the National ITS Architecture.

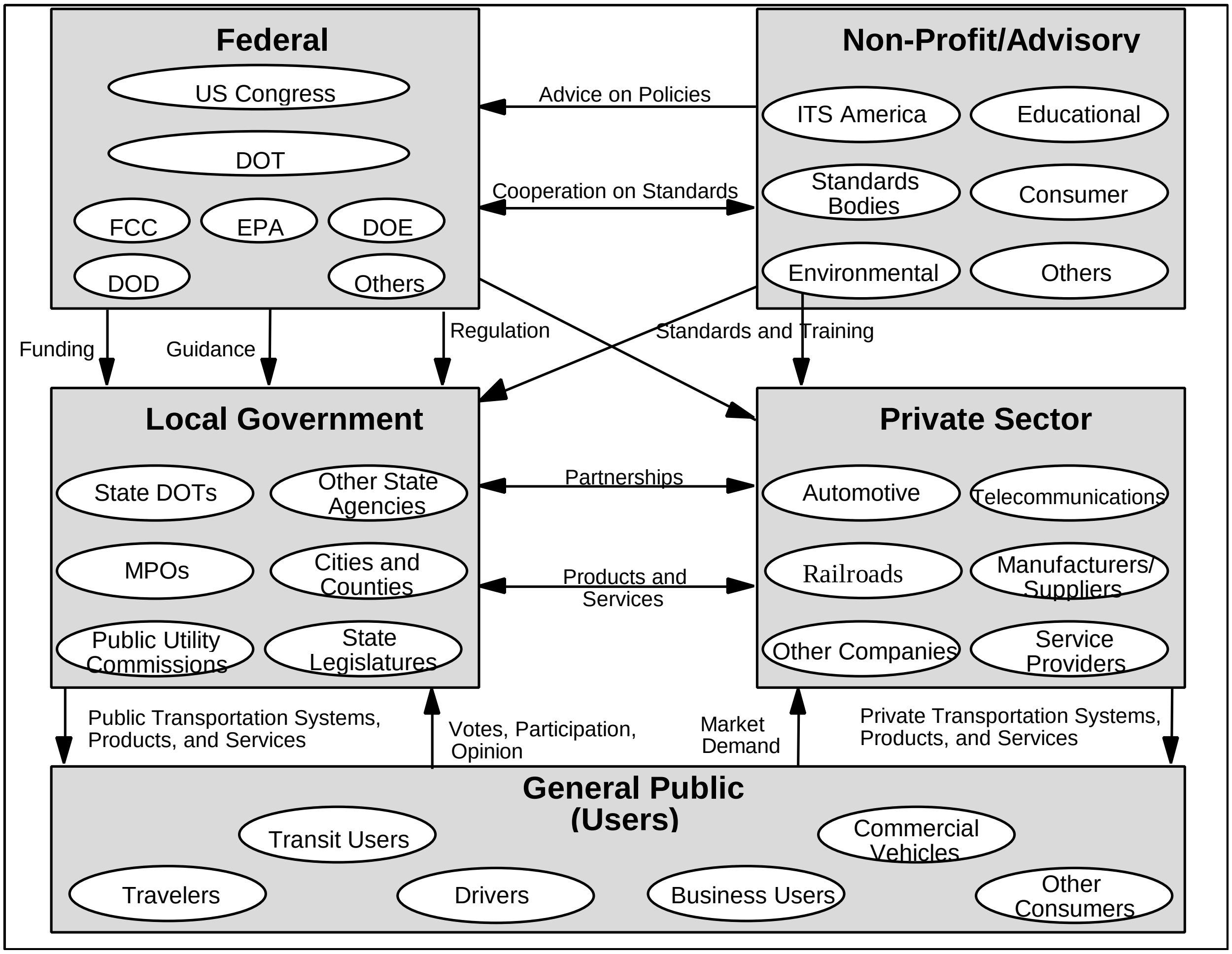


Figure 2.8-National ITS Architecture Institutional Layer

2.4 National ITS Architecture Products

The National ITS Architecture products provide specific knowledge and guidance for implementing ITS, and for developing regional frameworks that conform with the National ITS Architecture. **The 16 National ITS Architecture documents can be reviewed via three mediums -- hard copy (paper documents), CD-ROM, and the Internet.**

2.4.1 Hard Copy

The National ITS Architecture documents can be obtained and reviewed in paper format. Section 6 provides information on where to obtain a hard copy of the documents.

2.4.2 CD-ROM

The CD-ROM provides two ways to navigate through the National ITS Architecture documents:

1) All 16 documents are provided in their entirety and can be viewed using the browser provided with the CD-ROM.
2) Users can browse through an interconnected view of the Logical Architecture, Physical Architecture, and implementation oriented components of the architecture definition. This interconnected view provides access to all process specifications, data flows, subsystems, equipment packages, and terminators that make up the architecture definition. Entry may be through a number of different paths in this interconnected presentation.

The value of the CD-ROM version and the browser is that agencies will be able to quickly identify the elements of the National ITS Architecture that pertain to their situation using an electronic tool. Consequently, agencies will be able to extract and use electronic samples of the pertinent National ITS Architecture elements. Refer to Section 6 for information on where to obtain a copy of the CD-ROM.

2.4.3 Internet Web Sites

An alternative method for obtaining more information from the National ITS Architecture is to use the World-Wide-Web. The Internet version of the National ITS Architecture products has many of the same features as the DC-ROM version. Section 6 lists the current web sites that provide information on the National ITS Architecture.

2.4.4 National ITS Architecture Documents

Should the reader want to look further into the National ITS Architecture, a brief discussion on the contents of each document is provided below. Throughout the remainder of this document (ITS Deployment Guidance for Transit Systems Technical Edition), the National ITS Architecture documents are used to provide guidance on regional ITS framework development and transit ITS development and deployment.

2.4.4.1 Executive Summary

The Executive Summary provides background on the problems and needs of the current U.S. transportation system, discusses the opportunities of ITS, and provides an overview of the National ITS Architecture.

2.4.4.2 Vision Statement

The vision is the logical starting point for developing an architecture (framework), and is the component that drives everything else. The Vision Statement document provides a description of the likely transportation system in the next 5, 10, and 20 years based on the National ITS Architecture. In the vision, the ITS User Services that the transportation system is to provide are identified.

2.4.4.3 Mission Definition

The mission addresses the goals and objectives of the desired transportation system. In the mission, User Services are defined, and benefits that the transportation system is expected to provide are identified.

2.4.4.4 Logical Architecture

The Logical Architecture defines *what* has to be done; it identifies and defines the functions, that various parts of the total system are to perform in concert with one another. The Logical Architecture document contains three volumes: *Description* (Volume 1), *Process Specifications* (Volume 2), and *Data Dictionary* (Volume 3). These documents present a functional view of the ITS User Services, contain diagrams that show processes and data flows between them, and contain a data dictionary.

2.4.4.5 Physical Architecture

The Physical Architecture groups functions together and assigns them to particular subsystems. The Physical Architecture defines *how* it should be done, that is, how the ITS system is to perform by identifying the subsystems required to perform the processes that are defined in the Logical Architecture. The Physical Architecture document contains architecture flow diagrams that show data passing between subsystems, and presents characteristics and constraints on data flows between subsystems.

2.4.4.6 Theory Of Operations

The Theory of Operations Document explains how the National ITS Architecture supports ITS implementations, and illustrates the operational concepts used to implement the User Services. It also presents advantages and disadvantages of alternative operational concepts.

2.4.4.7 Traceability

The Traceability document shows how the National ITS Architecture satisfies the User Services. It contains tables that provide traceability of ITS User Services' requirements to National ITS Architecture elements, and traceability between Logical Architecture elements and Physical Architecture elements.

2.4.4.8 Evaluatory Design

The Evaluatory Design document provides a common set of assumptions for the analyses and evaluations of the architecture. It also defines a concrete implementation so that analyses and evaluations of the abstract architecture can be performed. The Evaluatory Design provides three scenarios (urban, interurban, and rural) across three time frames (5, 10, and 20 years), and provides overviews of the key design choices made in each of these environments. By providing one consistent set of design assumptions and decisions, this document allows true comparisons to be made and makes the different evaluation results more meaningful.

2.4.4.9 Communications Document and Highway-Rail Intersection (HRI) Addendum

The Communications Document and HRI Addendum presents an analysis of the communications aspects of the National ITS Architecture. It also presents a technology assessment that covers several potential communications technology alternatives. The alternatives are compared with estimated ITS requirements. This document proposes quantitative data loading requirements for a hypothetical system design, and contains an extensive set of appendices which deal with a specific communications study.

2.4.4.10 Risk Analysis

The Risk Analysis document assesses the risks that may pose challenges to National ITS Architecture deployment and suggests mitigation strategies for these risks. Risks have been classified in the following categories:

- Technical feasibility
- Market acceptance
- Operational performance
- Institutional and legal
- Organizational
- Budget and financial

In response to these challenges, mitigation strategies are discussed.

2.4.4.11 Cost Analysis and HRI Addendum

The Cost Analysis and Highway Rail Intersections (HRI) addendum provides typical unit costs for Market Packages and equipment packages. Methodologies for cost analysis are delineated. Market Packages are discussed in Section 2.3.2.

2.4.4.12 Performance and Benefits Study

The Performance and Benefits Study documents the results of a set of evaluation criteria applied to the National ITS Architecture. It also presents a discussion of the overall benefits of the National ITS Architecture.

2.4.4.13 Evaluation Results

The Evaluation Results document presents a summary of the results of the National ITS Architecture analyses and evaluations. The evaluations analyzed the architecture design for three time frames (5, 10, and 20 years) and three scenarios (urban, interurban, and rural). Summaries of the results for the evaluatory design, communications analysis, cost analysis/projections, performance and benefits, and risk analysis are presented. The complete results for each of these evaluations are presented in their respective documents.

2.4.4.14 Standards Development Plan

The Standards Development Plan presents the steps needed to produce a collection of interface standards and defines the standards required for national interoperability for nation-wide ITS deployment. The document also identifies existing standards activities and recommends new standards work for each deployment feature (e.g., transit vehicle communication). The Standards Development Plan is particularly useful for standards development organizations (ANSI, SAE, ITE, IEEE, ASTM, AASHTO, ISO, etc.), but is intended for all who are involved with ITS.

2.4.4.15 Standards Requirements

This document contains detailed information on requirements for 12 high-priority standards packages. The standards packages that apply directly to transit are as follows:

- Personal, transit, and HAZMAT maydays
- Signal priority for transit and emergency vehicles
- Transit management center to transit vehicles and transit stops
- Highway to rail intersection

Other standards packages associated with transit include the following:

- Dedicated short range communications
- Digital map data exchange and location referencing formats
- Traffic management subsystems to other centers (except EMS)
- Emergency management subsystems to other centers
- Information service provider subsystem to other centers (except EMS and TMS)

2.4.4.16 Implementation Strategy

The Implementation Strategy document presents a process for implementing ITS services in a phased approach. The process is part of an overall strategy that includes recommendations for future research and development, operational tests, standards activities, and training. The document includes sample ways in which current deployment activities can use the National ITS Architecture to identify interfaces that need to be standardized.

The Implementation Strategy translates the National ITS Architecture to implementation through Market Packages. It identifies the Market Packages that provide certain ITS User Services and recommends a phased deployment of those Market Packages to provide the most needed and most feasible User Services initially, and less needed/feasible User Services at a later date. The Implementation Strategy considers several items and issues regarding deployment, such as legacy systems, politics, funding, Market Package synergy, technology requirements, and standards requirements.

3. How to Use the National ITS Architecture

This section describes a top-down approach using the National ITS Architecture to develop and implement an Intelligent Transportation System. It describes the ideal method of developing and implementing an ITS system -- based on a multimodal, regional ITS framework developed by multi agency/stakeholder consensus using the National ITS Architecture tools and methodology. To develop an ITS system using the National ITS Architecture, one must identify and determine several key items. Some of these may pertain to the overall picture, while others may be project-specific. This section highlights several aspects of the National ITS Architecture that may prove most useful to the transit industry, and identifies transit agencies' role towards developing a multimodal, ITS regional framework. Where appropriate, examples are used to assist in communicating key points.

The National ITS Architecture provides both methodology and tools for implementing ITS. In developing an integrated system, such as the one in the hypothetical example, a systematic and comprehensive process should be followed. The best type of process for this is a systems engineering approach.

A systems engineering approach is advantageous for the following reasons:

- It considers the entire life cycle (design, development, deployment, operations, and maintenance) when determining the system's major components.
- It is a top-down approach that starts at needs and concepts and works down towards actual configurations and devices.
- It takes into account the processes and operations of individual systems to develop a more integrated system.
- It is a cost effective way of addressing the needs of users and stakeholders to produce a quality solution.
- It reduces project development risk by using proven industry standard processes and methods.
- It improves project understanding and communications among stakeholders by using a common language among those involved and identifying milestones and deliverables.

The process to determine the pieces and assemble the system is as important as implementing the correct applications. Figure 3.1 is a high-level illustration of a potential systems engineering methodology for using the National ITS Architecture. A brief description of each step is provided below.

ITS Concepts Definition
This process starts with the identification of ITS concepts. The ITS Concepts Definition takes the problems as well as the goals and objectives of the region and involved agencies and compiles them into Needs. These needs are a list of raw, unstructured problems or problem-addressing measures: we will increase ridership, more buses are needed, we need an AVL system, bus schedule adherence is a problem.

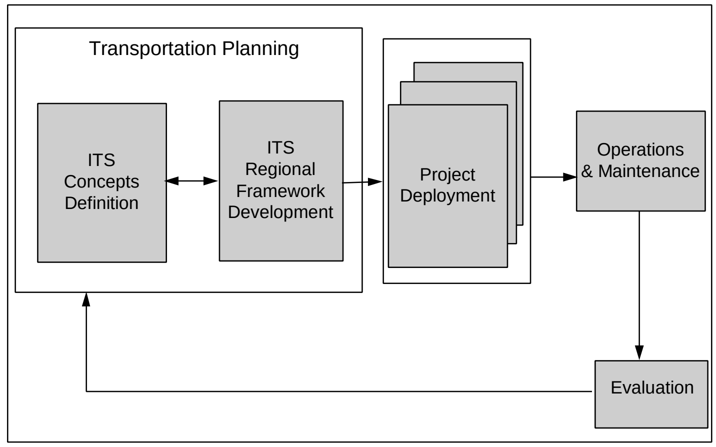


Figure 3.1 - High-Level National ITS Architecture Application Process (Example)

In ITS Concepts Definition *what* is needed is determined. Identifying *what* is needed before determining *how* to do it is an important aspect of systems engineering. By looking at the needs from different aspects, the requirements of a conceptual system may be determined for a variety of stakeholders. Also, this minimizes, the risk of implementing a certain technology just because it is new or popular.

ITS Regional Framework Development
Development of a multimodal, regional ITS framework is an important step in project development. The framework allows transportation agencies to develop and implement integrated and interoperable Intelligent Transportation Systems. It is a blueprint that provides a top-down approach for developing a seamless transportation system with consistent character. A regional ITS framework fosters a logical and organized approach to ITS deployment within a region, that will ease implementation of ITS applications. Therefore, a multimodal framework should be developed for a region prior to developing and deploying ITS projects, and ITS projects should be consistent with the framework. The framework should be developed cooperatively by all transportation providers and ITS stakeholders in the region, as much as possible.

A regional ITS framework takes into account the previous needs and requirements, and provides structure to assist in implementation and integration of potential solutions. It takes the *what* from ITS Concepts Definition and determines *how* it will be achieved. This is an iterative process that goes between the *what* and the *how* until a consensus is reached on the desired ITS framework.

Once a framework is developed and individual projects are identified, the individual projects are fed into Transportation Plan and Transportation Improvement Plan development.

Project Deployment

Project Deployment includes detailed design development, procurement, and implementation. It takes everything previously produced and develops an actual design for the system. Project deployment :

- Includes development of a detailed system design for a specific phase of the deployment.
- Includes procurement, construction, and acceptance testing of the system.
- Represents an implementable design incorporating technology-specific features, design choices, and procurement specifications.
- Represents one of a number of possible designs and phased modules that conform to the framework.

Operations And Maintenance

A step often overlooked in development and deployment of a system is the impact of operations and maintenance. Although the National ITS Architecture only assists in the development of a cost estimate, this step is crucial to the success of a project. Information from this process should be applied to other planning cycles of future planning projects.

Evaluation

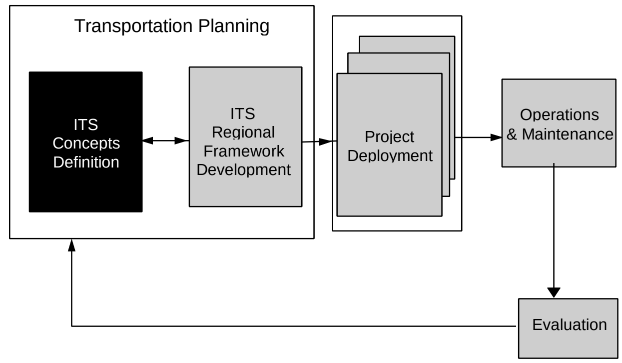
Post-implementation evaluation of the system design and the overall framework:

- Provides quantifiable information on performance, costs, and benefits of ITS applications.
- Assesses the degree to which stated objectives were satisfied.
- Assesses risks and/or mitigation strategies (towards architectural alignment).

The remainder of Section 3 discusses each of the steps outlined in the systems engineering process, in greater detail. The remainder of the section is therefore organized as follows:

- ITS Concepts Definition Section 3.1
- ITS Regional Framework Development Section 3.2
- Project Deployment Section 3.3
- Operations and Maintenance Section 3.4
- Evaluation Section 3.5

3.1 ITS Concepts Definition



ITS Concepts Definition is an important step in developing ITS projects. The ITS Concepts Definition takes the problems as well as the goals and objectives of the region and involved agencies and compiles them into Needs. These needs are a list of raw, unstructured problems or problem-addressing measures: e.g., we will increase ridership, more buses are needed, we need an AVL system, bus schedule adherence is a problem.

In ITS Concepts Definition, what is needed is determined. Identifying what is needed before determining how to do it is an important aspect of systems engineering. By looking at the needs from different aspects, the requirements of a conceptual system may be determined for a variety of stakeholders. Also, this reduces to a minimum, the risk of implementing a certain technology just because it is new or popular.

There is no real order to the steps under ITS Concepts Definition and often they are performed in parallel. They all relate to looking at needs in different ways and developing a structured needs assessment. The outcome of performing the steps is summarized in an ITS Concepts Report. The steps involved with ITS Concepts Definition are illustrated in Figure 3.2. As preliminary steps in developing a regional ITS framework, the Mission Statement, Measures of Effectiveness (MOEs), Vision, User Services, and Strawman Architecture assist in development of the big picture of the future. This regional ITS framework encompasses all future ITS plans and directs the implementation of projects. This section discusses the development of a Mission Statement, MOEs, Vision, User Services, and a Strawman Architecture. Framework development is discussed in Section 3.2. It is important that stakeholders in the region be involved in the whole process, especially the parts related to ITS Concepts Definition.

3.1.1 Mission Statement

A Mission Statement is a concise unambiguous statement of the primary goal or goals of the proposed system. This should be one or two paragraphs in length and no longer than a single page. It is composed of high-level objectives that have been agreed upon by the stakeholders. Goals may be determined for a region, agency, or for a specific project. The National ITS Architecture has identified six generic goals of ITS:

- Increase the operational efficiency and capacity of the transportation system
- Enhance personal mobility, convenience, and comfort for users of the transportation system

- Improve the safety of the nation's transportation system
- Reduce energy consumption and environmental costs
- Enhance the present and future economic productivity of individuals, organizations and

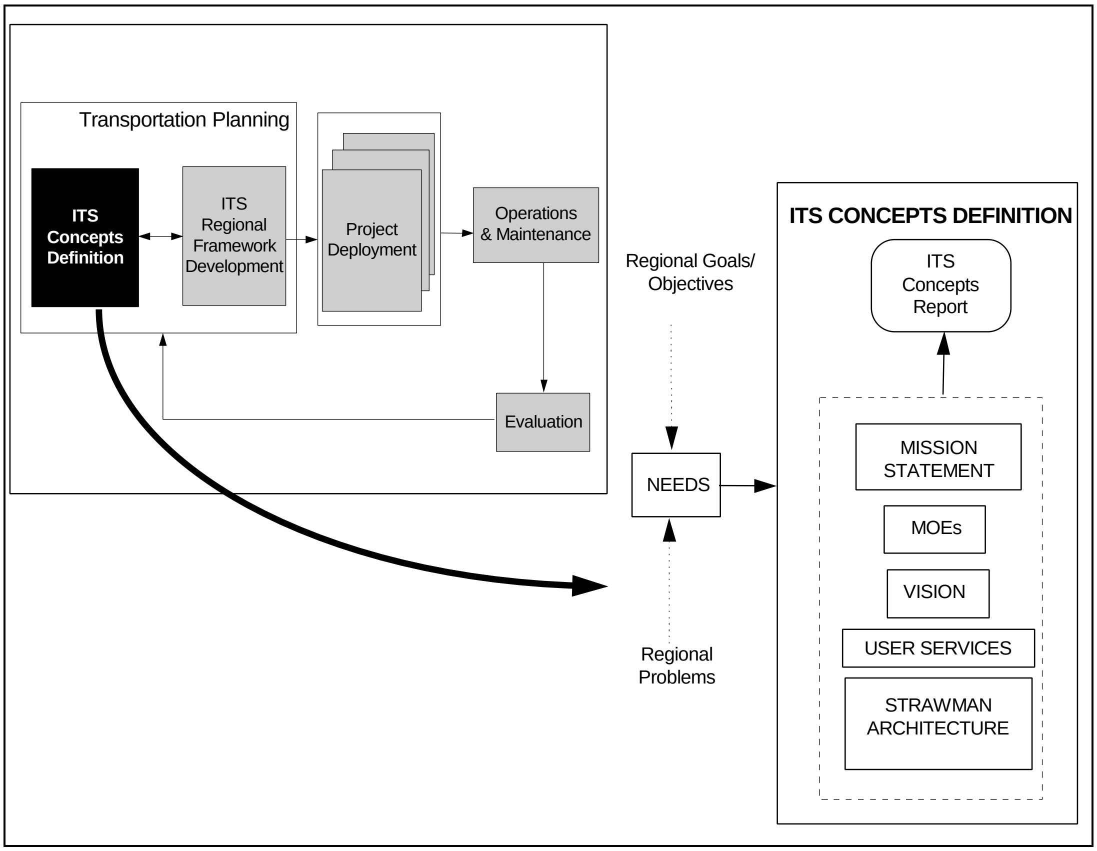


Figure 3.2 - ITS Concepts Definition

the community as a whole

- Create an environment in which the development and deployment of ITS can flourish

The National ITS Architecture also has identified specific goals for urban, inter-urban, and rural areas specific to the transit industry. The urban goals that pertain to transit include:

- Increase ridership
- Reduce delay associated with congestion
- Reduce emissions/energy use associated with congestion
- Increase average vehicle occupancy
- Increase capacity of existing facilities
- Reduce time lost in intermodal interchange
- Reduce travel time

- Enhance traveler security

The inter-urban goals that pertain to transit include:

- ♦ Increase trip end opportunities
- ♦ Reduce delay associated with congestion
- ♦ Reduce emissions/energy use associated with congestion
- ♦ Reduce travel time
- ♦ Increase multimodal and intermodal transportation choices
- ♦ Increase safety at highway-rail intersections
- ♦ Enhance personalized transit

The rural goals that pertain to transit include:

- ♦ Reduce travel time
- ♦ Increase trip end opportunities
- ♦ Improve rural routing
- ♦ Reduce safety impacts stemming from adverse road/weather conditions
- ♦ Increase rural population's access to transit
- ♦ Increase safety at highway-rail intersections
- ♦ Enhance personalized transit

The goals and objectives from the National ITS Architecture provide project developers with a base for developing their own goals and objectives.

★ **Useful National ITS Architecture document: Mission Definition**

3.1.2 Measures of Effectiveness

Measures of effectiveness are identified at this stage to represent the stakeholders' interests and concerns, and will be used in future evaluation. MOEs may be either qualitative or quantitative. Examples of MOEs are number of riders, travel time, rider satisfaction, delay, and emissions. Each of the goals or objectives should have at least one MOE associated with it. This is done to determine if the goal or objective has been met from the perspective of the stakeholders. If an MOE does not fulfill this requirement, it should not be used and a new MOE should be identified. The relative weights to be put on the MOEs by the various stakeholders may be quite different from each other. The explicit assessment of these weights can form the basis for consensus building among the stakeholders to develop common goals and cooperative programs. MOEs are also discussed in Section 3.5.1.

3.1.3 Vision

Vision is a narrative text providing a non-technical description of the post-implementation scenario from the viewpoint of various key user groups -- it describes what the world within and surrounding the implementing organization will be like in the future. This may be anywhere from a 5 to 20 year period and may highlight specific areas such as information and communications; public transit; commercial vehicles; cooperation and coordination of systems; demand management; incident and emergency management; and automated highway systems. Within the transit industry, this may entail the following:

- Number of vehicles operating
- Number of miles of service
- Number of riders
- Services offered (pre-trip scheduling, en-route information, reservations, personalized routes, automatic passenger counting, fare collection, park-and-ride, etc.)
- Operational enhancements (automatic vehicle location, vehicle safety monitoring, route optimization, etc.)
- Intermodal or other service provider interfaces

The vision statement should use layman's language understandable to all stakeholders and might include magazine style vignettes to convey vivid descriptions of future scenarios for the general public. The vision statement may be part of a regional transportation plan for a

★ **Useful National ITS Architecture document: Vision Statement**

specific area.

3.1.4 User Services

Problems or needs may be determined at any level within the transit agency hierarchy. Once a need is identified, and it has been determined that a solution is to be investigated, User Services need to be identified. User Services may be derived from the National ITS Architecture, must be detailed enough to address all requirements, and concise enough to be useful in guiding framework and system development. They may be grouped into bundles based on common functionality.

Table 3.1 presents the seven User Service bundles and their corresponding User Services as outlined in the National ITS Architecture (this table also appears in Section 2.3.1). The User Services in bold are those that directly relate to the transit industry. This list may be expanded as new needs are identified. Refer to Section 2.3.1 for a description of each User Service.

★ **Useful National ITS Architecture documents: Mission Definition, Implementation Strategy, Traceability**

Table 3.1 - User Services

User Service Bundle	User Service
Travel and Transportation Management	**En-Route Driver Information** **Route Guidance** **Traveler Services Information** **Traffic Control** **Incident Management** **Emissions Testing and Mitigation** **Highway-Rail Intersection**
Travel Demand Management	**Pre-Trip Travel Information** **Ride Matching and Reservation** **Demand Management and Operations**
Public Transportation Operations	**Public Transportation Management** **En-Route Transit Information** **Personalized Public Transit** **Public Travel Security**
Electronic Payment Services	**Electronic Payment Services**
Commercial Vehicle Operations	Commercial Vehicle Electronic Clearance Automated Roadside Safety Inspection On-Board Safety Monitoring Commercial Vehicle Administrative Processes Hazardous Material Incident Response Commercial Fleet Management
Emergency Management	Emergency Notification and Personal Security Emergency Vehicle Management
Advanced Vehicle Control and Safety Systems	**Longitudinal Collision Avoidance** **Lateral Collision Avoidance** **Intersection Collision Avoidance** **Vision Enhancement for Crash Avoidance** **Safety Readiness** **Pre-Crash Restraint Deployment** **Automated Highway Systems**

3.1.5 Strawman Architecture

A strawman architecture is a concept that helps to spur communication between those involved in the development of the architecture and provides a starting point for discussions, development, and definition. This can take many forms, but typically represents an informal, immature view of the final implementation. It is based on experience and expertise gained from earlier implementations. Figure 3.3 illustrates an example of a strawman architecture.

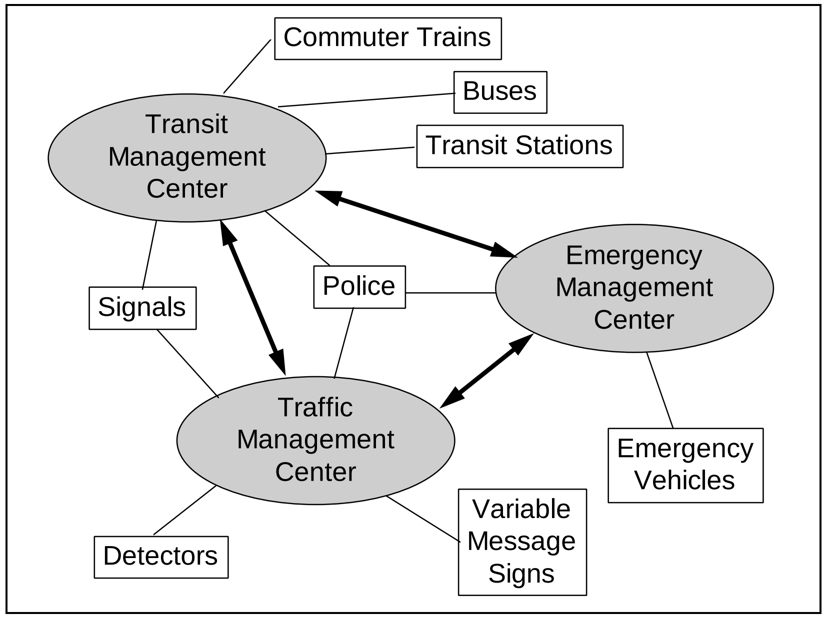
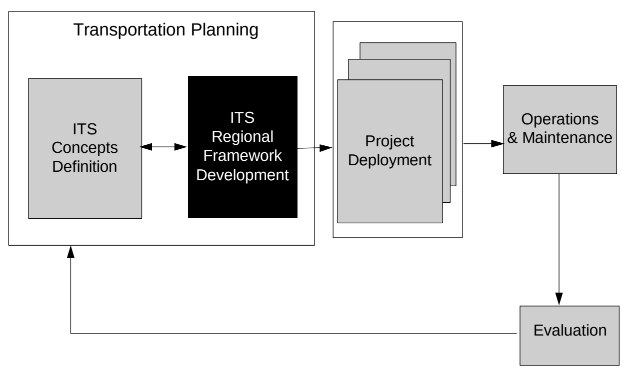


Figure 3.3 Sample Strawman Architecture

3.2 ITS Regional Framework Development



ITS Regional Framework Development is an advantageous approach in developing ITS projects. It is the next phase, after ITS Concepts Definition, in the National ITS Architecture Application Process. Note that since regional framework and National ITS Architecture development should follow similar methodologies, the materials in this section may appear somewhat repetitious to what has been presented in Section 2.4. Note, however, that the development of a regional framework does not entail the same rigor or amount of documentation as can be characterized by the National ITS Architecture.

A framework allows transportation agencies to develop and implement ITS systems that can integrate and operate with other ITS systems. It is a blueprint that provides a top-down approach for developing a seamless ITS with consistent character. A framework fosters a logical and organized approach to ITS deployment that will ease implementation of ITS applications.

The development of a regional ITS framework will help transportation agencies (including transit agencies) save time and money, and provide a big picture of an integrated, multimodal transportation system for a region. By taking the time initially to develop a consistent framework, a region will likely implement a well integrated, interoperable system, resulting in lower total costs while providing users more efficient and cost effective ITS services. Thus, a framework saves transit agencies time and money in the long run by identifying interfaces with other systems and identifying other agencies with whom to coordinate at the high-level planning stage. When interfaces are identified up front, transit agencies can incorporate them into their designs to accommodate integration with other ITS applications and systems in the future. This prevents time consuming and costly retrofits down the road. Coordination between agencies prevents duplication of services and provides system efficiency. A framework may also reduce procurement cost by supporting standards and creating economies of scale for manufacturers.

A regional ITS framework takes into account the needs and requirements that were identified in the ITS Concepts Definition phase, and provides structure to assist in implementation and integration of potential solutions. It takes the *what* from ITS Concepts Definition and determines *how* it will be achieved. This is an iterative process that goes between the *what* and the *how* until a consensus is reached on the desired ITS framework. The resulting framework:

- Identifies the major components of a system and how they interact (big picture)
- Enables system compatibility and interoperability
- Connects multiple agencies and users
- Shows the different participants of the entire system and what they are responsible for
- Identifies communications and data flows between participants
- Supports development of open systems
- Incorporates and optimizes the use of existing or planned systems
- Enables synergy between multiple systems
- Addresses new technologies
- Provides a framework for multiple design choices
- Minimizes ambiguity of system design
- Provides structure for future planning and growth

Once a framework is developed and individual projects are identified, the individual projects are fed into Transportation Plan and Transportation Improvement Plan development.

The remainder of Section 3.2 discusses the various steps involved in the development of a multimodal, ITS regional framework. The framework should be developed cooperatively by as many transportation providers and ITS stakeholders in the region as possible. Information is provided from the perspective of the transit agency's role and contribution in the development of the framework.

The steps involved in ITS Regional Framework Development are illustrated in Figure 3.4. Many of these steps may be performed simultaneously. However, the Logical Architecture needs to be developed before the Physical Architecture. The key step is the Physical Architecture, which draws information from most of the other steps.

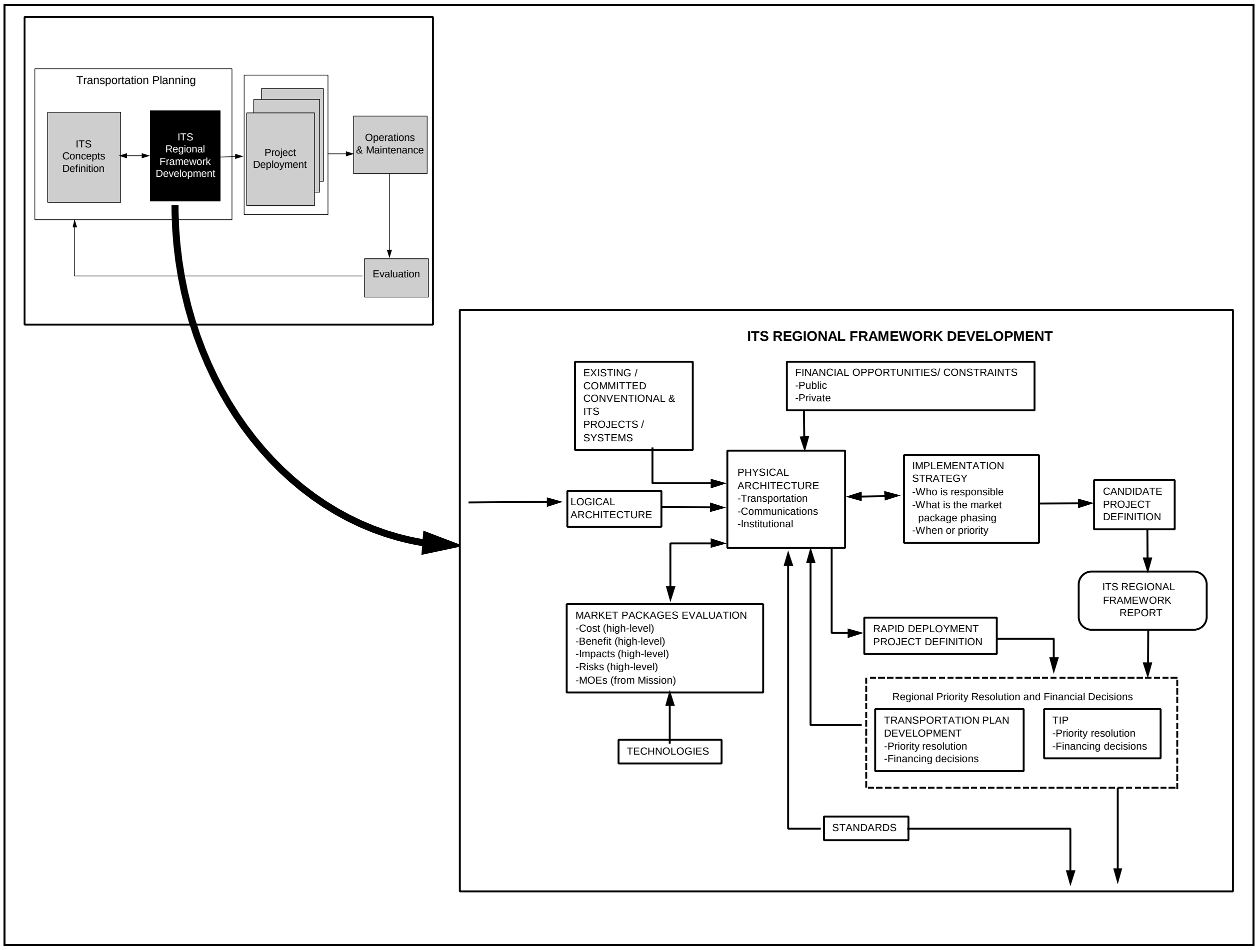


Figure 3.4 - ITS Regional Framework Development

3.2.1 Logical Architecture

The Logical Architecture identifies the information processes required to achieve the system objectives identified in the Mission Statement and to deliver the User Services. The Mission Statement and User Services are steps in ITS Concepts Definition. The Logical Architecture also defines the data that flow between these processes. The processes and data flows are grouped to form particular functions, and are represented graphically by data flow diagrams, or bubble charts, which contain several levels. In these diagrams, processes are represented as bubbles and data flows as arrows. Figures 3.5 through 3.7 depict simplified data flow diagrams from the National ITS Architecture documents. Note that each bubble in the Logical Architecture is an information process which describes some logical function to be performed.

The Logical Architecture is first illustrated as a single function to show external inputs and outputs as illustrated in Figure 3.5. Within this initial process (bubble), Manage ITS, eight sub-processes (bubbles) exist (see Figure 3.5).

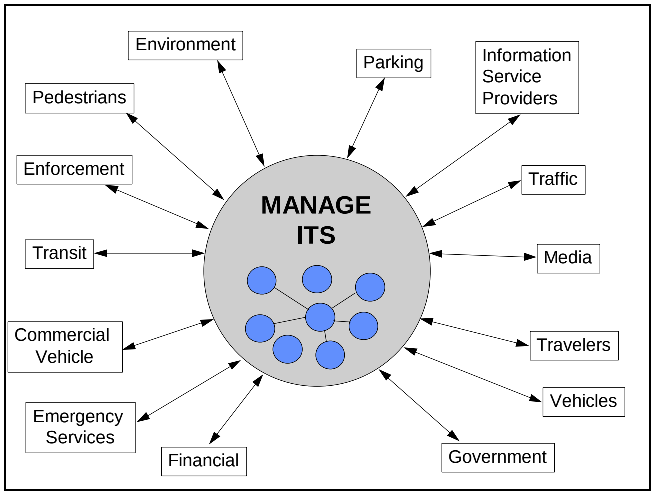


Figure 3.5 - Initial Level Manage ITS

As illustrated in Figure 3.6, the Manage ITS process is broken down into the eight sub-processes (bubbles), one of which is Manage Transit (ITS). This does not imply that all transit operations are contained within ITS. It merely indicates that transit ITS operations are contained within ITS. In Figure 3.6, the information processes (bubbles) pertinent to transit are

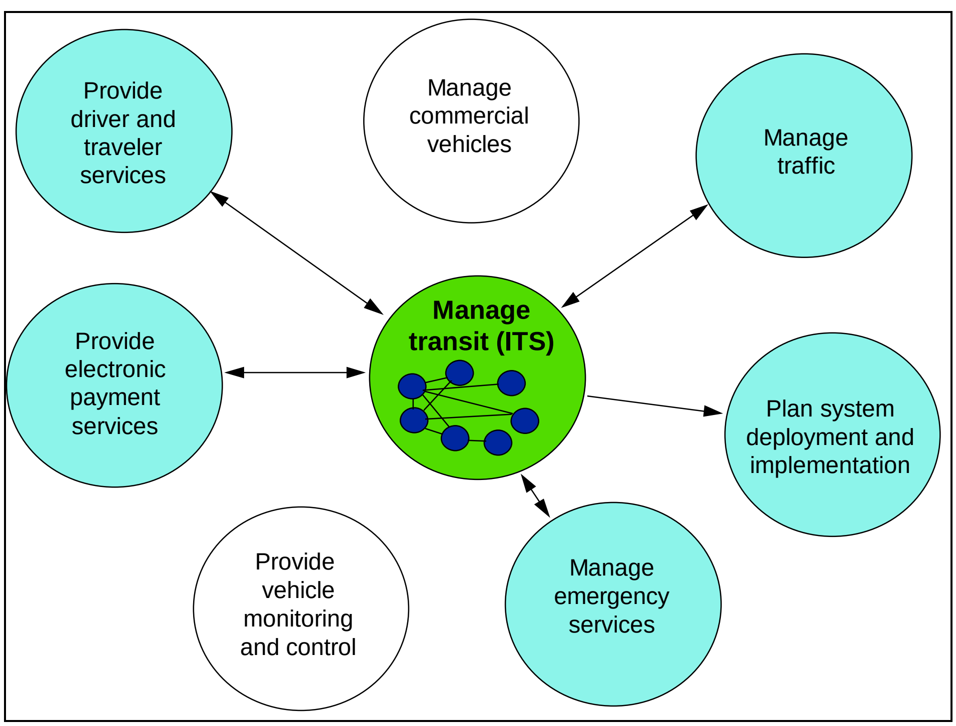


Figure 3.6 - The Eight Processes Within Manage ITS

shaded.

As illustrated in Figure 3.7, the Manage Transit (ITS) process may then be broken down into seven sub-processes (bubbles): operate vehicles and facilities, plan and schedule transit services, schedule transit vehicle maintenance, support security and coordination, generate transit drivers schedules, collect transit fares in the vehicle, and provide transit user roadside facilities. These processes may be broken down further and are contained in the Logical Architecture document (Volumes 1 through 3).

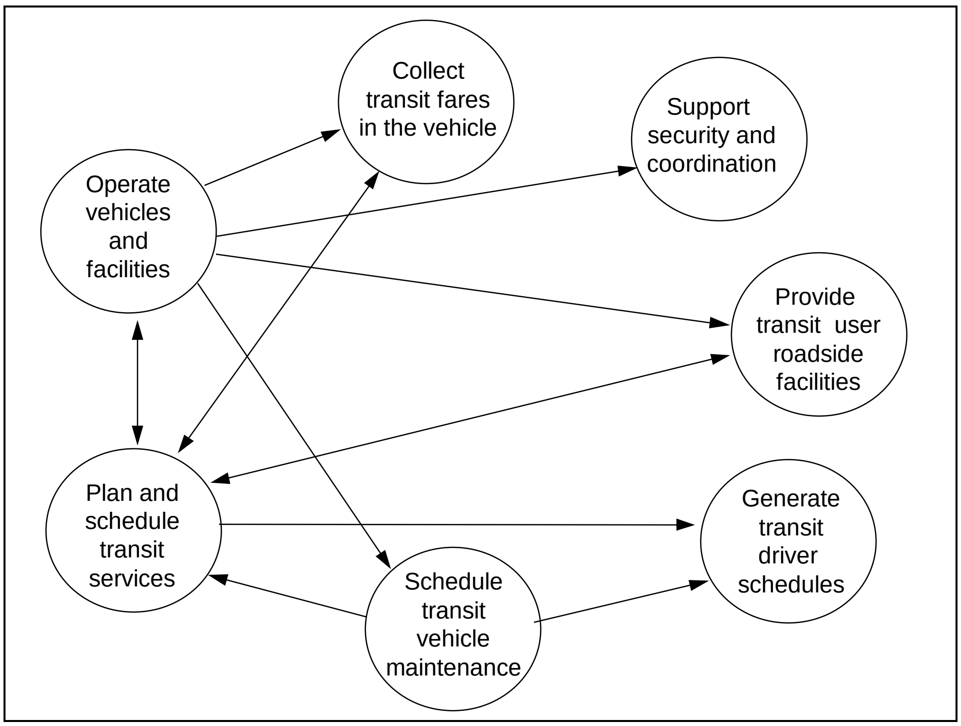


Figure 3.7 - The Seven Processes Within Manage Transit (ITS)

★ **Useful National ITS Architecture document: Logical Architecture - Volume 1**

3.2.2 Physical Architecture

The Physical Architecture is the principal component of an architecture (framework). It describes a physical representation of *how* the system should provide the required functionality, while satisfying the needs and constraints of key stakeholders.

The Physical Architecture has three layers: transportation, communications, and institutional. The transportation layer groups processes (defined by the Logical Architecture) of functional similarity, and assigns them to subsystems, which are composed of equipment packages. The communications layer identifies potential communications media that may be used to provide communications between subsystems. The institutional layer identifies the institutional, organizational, and commercial arrangements required to support the selected technical configuration.

Figure 3.8 represents the 19 subsystems (transportation layer) that are connected by four types of communications media (communications layer) (this figure also appears in Sections 2.3.4 and 3.3.4.2). Subsystems in Figure 3.8 that are in bold, exchange data with the Transit Management subsystem and the Transit Vehicle subsystem.

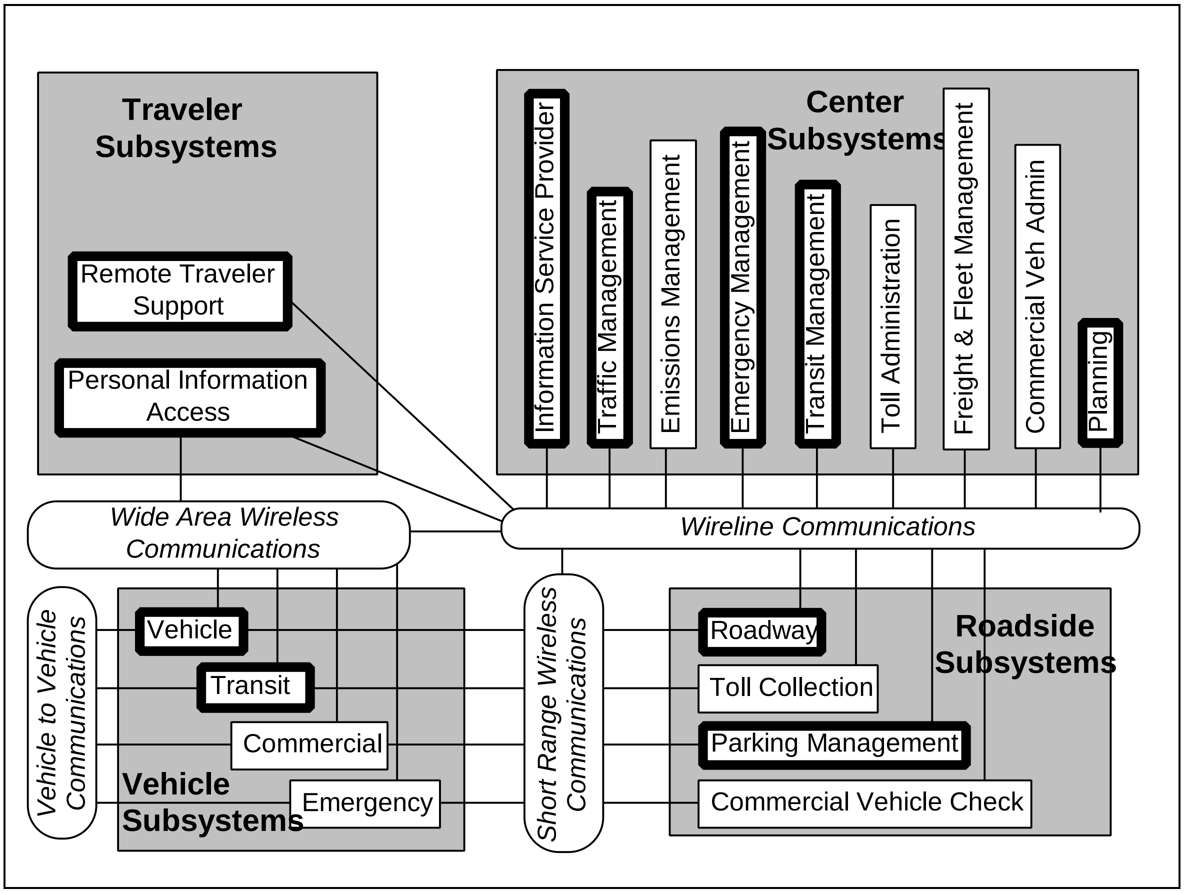


Figure 3.8 - National ITS Architecture Subsystems and Communications Media

The Transit Management subsystem provides the capability for determining ridership levels and implementing fare structures. The fare system will support travelers using a fare medium applicable for all surface transportation services. The subsystem also provides optimized flexibility for routed transit services. Traffic control will be integrated with traffic signal prioritization for transit schedule adjustments, and the transit vehicle maintenance management will be automated with schedule tracking. The Transit Vehicle subsystem also provides the capability for automated planning and scheduling of public transit operations. The subsystem will also provide the capability to furnish travelers with real-time travel information, continuously updated schedules, schedule adherence information, transfer options, and transit routes and fares. In addition, the capability for the monitoring of key transit locations with both video and audio systems will be provided with automatic alerting of operators and police of potential incidents including support of traveler activated alarms.

Transit management can support any management organization responsible for moving people. The following subsystem equipment packages operate within the Transit Management subsystem:

- ♦ Fleet maintenance management
- ♦ Transit center fare and load management
- ♦ Transit center fixed-route operations
- ♦ Transit center multi-modal coordination
- ♦ Transit center paratransit operations
- ♦ Transit center tracking and dispatch
- ♦ Transit center security

The following subsystem equipment packages operate within the Transit Vehicle subsystem:

- ♦ On-board maintenance
- ♦ On-board transit driver interface
- ♦ On-board transit fare and load management
- ♦ On-board transit security
- ♦ On-board trip monitoring
- ♦ On-board vehicle signal coordination
- ♦ Vehicle dispatch support

As found in the National ITS Architecture documentation, Figure 3.9 illustrates the physical data flows to/from the Transit Management subsystem and Figure 3.10 illustrates the physical data flows to/from the Transit Vehicle subsystem.

★ **Useful National ITS Architecture documents: Physical Architecture, Cost Analysis**

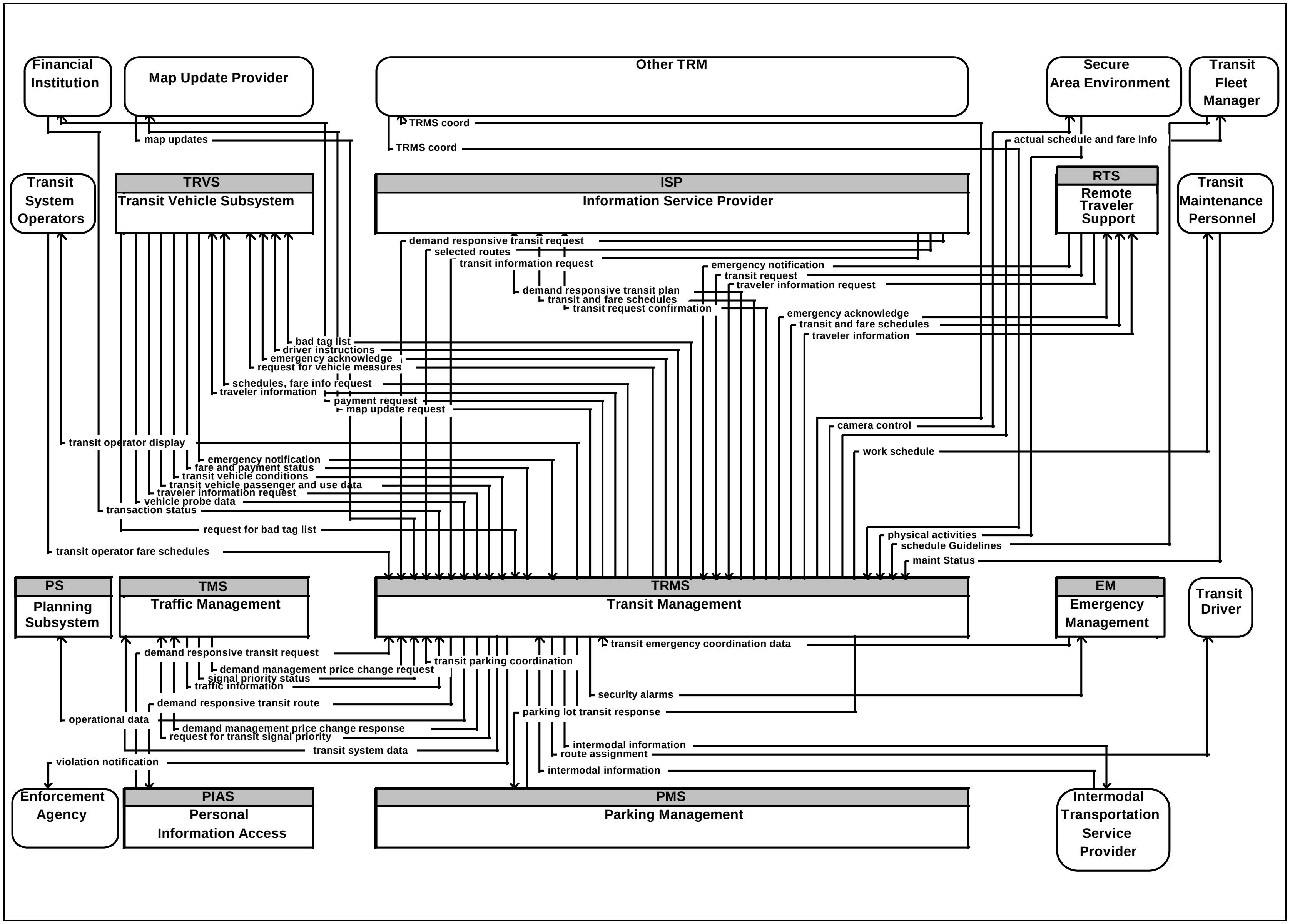


Figure 3.9 - Architecture Flow Diagram for Transit Management

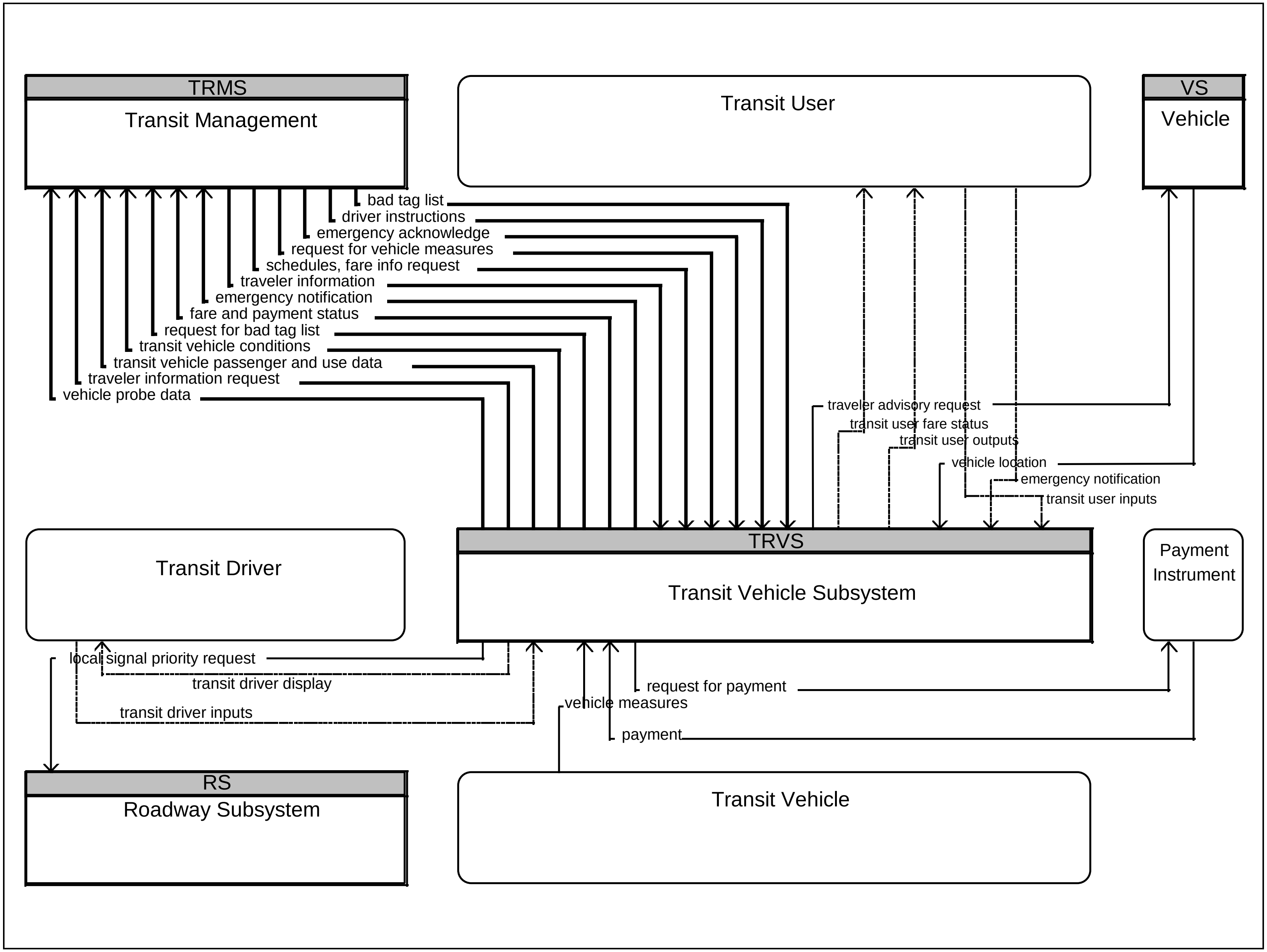


Figure 3.10 - Architecture Flow Diagram for Transit Vehicle

3.2.3 Market Packages Evaluation

Market Package Evaluation provides an assessment of each Market Package based on high-level costs, benefits, impacts, and risks. Market Packages are also evaluated in terms of the MOEs defined in the Mission Statement.

Market Package Evaluation provides the following benefits:

- Measures value, capability, and feasibility of Market Packages
- May be used to prioritize deployment of Market Packages

3.2.3.1 National ITS Architecture Market Packages

The National ITS Architecture identifies a total of 56 Market Packages that address the current trend in the technology market. A complete listing of ITS Market Packages is found in Table 3.2 below (this table also appears in Section 2.3.2). Market Packages that are in bold type apply directly to transit. Those in italics are indirectly associated with transit. It is important to note that Market Packages will change over time as technologies change and as new technologies are introduced into the market. An agency may use the Market Packages identified in the National ITS Architecture, may create its own, or do both. The Market Packages identified in the National ITS Architecture are a good model for agencies developing their own Market Packages.

Table 3.2 - ITS Market Packages

Traffic Management
- Network Surveillance
- Probe Surveillance
- Surface Street Control
- Freeway Control
- HOV and Reversible Lane Management
- Traffic Information Dissemination
- Regional Traffic Control
- Incident Management System
- Traffic Network Performance Evaluation
- Dynamic Toll/Parking Fee Management
- Emissions and Environmental Hazards Sensing
- Virtual TMC and Smart Probe Data
- *Standard Railroad Grade Crossing*
- *Advanced Railroad Grade Crossing*
- *Railroad Operations Coordination*

Transit Management
- **Transit Vehicle Tracking**
- **Transit Fixed-Route Operations**
- **Demand Response Transit Operations**
- **Transit Passenger and Fare Management**
- **Transit Security**
- **Transit Maintenance**
- **Multi-modal Coordination**

Traveler Information
- *Broadcast Traveler Information*
- *Interactive Traveler Information*
- Autonomous Route Guidance
- *Dynamic Route Guidance*
- *Information Service Provider (ISP) Based Route Guidance*
- *Integrated Transportation Management/Route Guidance*
- Yellow Pages and Reservation
- *Dynamic Ridesharing*
- *In Vehicle Signing*

Advanced Vehicles
- *Vehicle Safety Monitoring*
- *Driver Safety Monitoring*
- *Longitudinal Safety Warning*
- *Lateral Safety Warning*
- *Intersection Safety Warning*
- *Pre-Crash Restraint Deployment*
- *Driver Visibility Improvement*
- *Advanced Vehicle Longitudinal Control*
- *Advanced Vehicle Lateral Control*
- *Intersection Collision Avoidance*
- *Automated Highway System*

Commercial Vehicles
- Fleet Administration
- Freight Administration
- Electronic Clearance
- Commercial Vehicle Admin. Processes
- International Border Electronic Clearance
- Weigh-In-Motion
- Roadside CVO Safety
- On-board CVO Safety
- CVO Fleet Maintenance
- HAZMAT Management

Emergency Management
- Emergency Response
- Emergency Routing
- Mayday Support

ITS Planning
- *ITS Planning*

The National ITS Architecture has determined a deployment profile for implementing Market Packages. Deployment timing may be in the following periods: 0 to 5 years, 5 to 10 years, and 10 to 20 years. The National ITS Architecture also has determined the technologies that may comprise a Market Package. Technologies/processes have been grouped into the following areas:

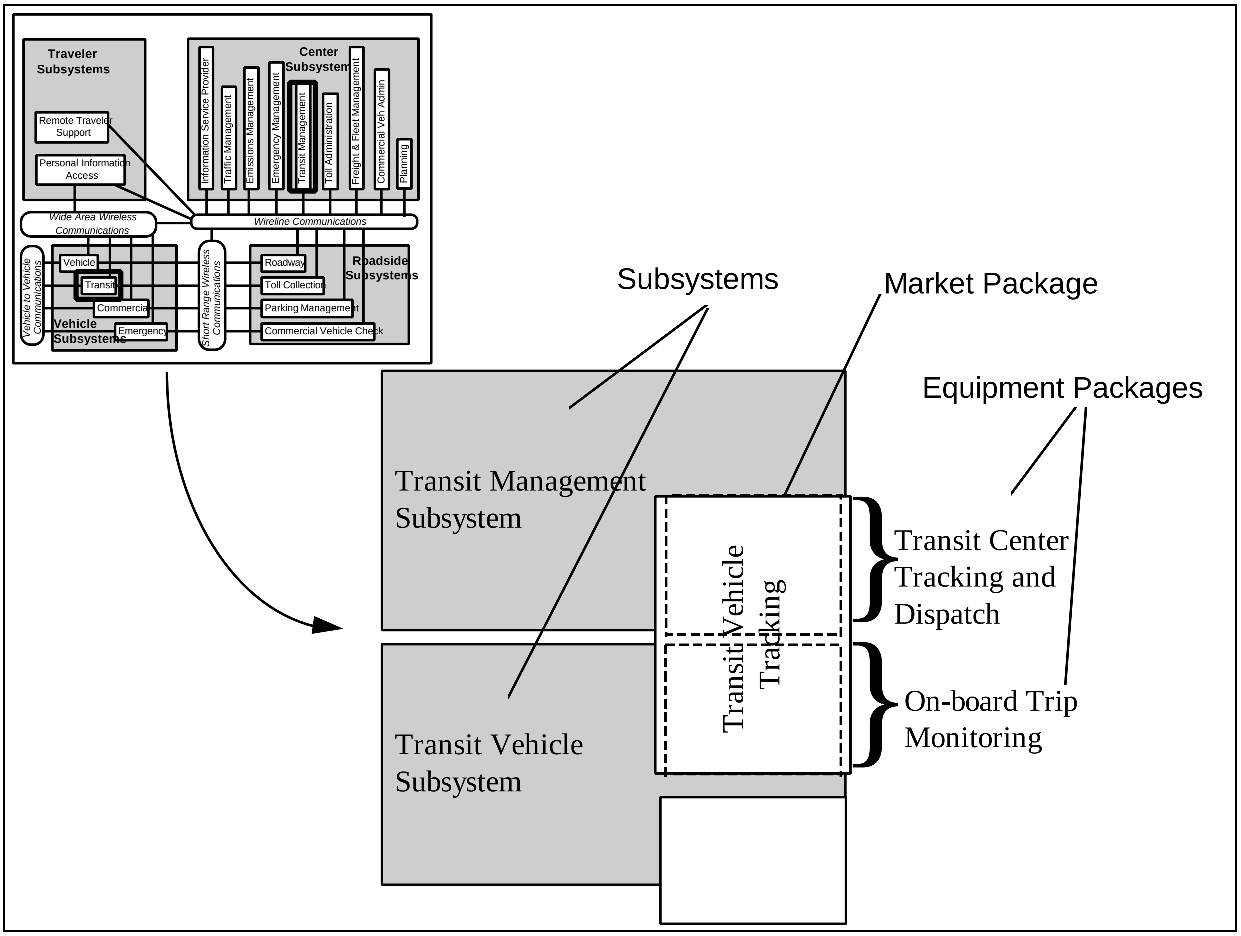
- Sensors
- Location determination
- Communications
- Algorithms
- Information management
- Payment
- User interface
- Control

In the National ITS Architecture, technologies within these areas are evaluated to determine the stage of maturity -- mature, mixed, or immature.

★ **Useful National ITS Architecture document: Implementation Strategy**

3.2.3.2 Market Package Costs

Market Packages are composed of equipment packages. Equipment packages are the smallest building blocks identified in the National ITS Architecture. They are finite in their use (i.e., they are associated with only one Market Package and one subsystem). The National ITS Architecture provides a description of each of the equipment packages. Figure 3.11 illustrates the relationship for the equipment packages that provide the Transit Vehicle



Tracking Market Package.

Figure 3.11 - The Relationship Among Equipment Packages, Market Packages, and Subsystems Regarding Transit Vehicle Tracking

As a tool to assist in the estimation of costs, the National ITS Architecture has developed a series of spreadsheets that contain approximate costs of equipment packages. These costs are in 1995 U.S. dollars and have been divided into non-recurring costs (initial capital investments) and recurring costs (operation and maintenance). Agencies should not use these spreadsheets as a recipe for determining the costs of their ITS system; actual costs of equipment packages will vary from region to region. The spreadsheets are intended to be used as a model to help agencies estimate costs. Table 3.3 lists the costs for Transit Center Tracking and Dispatch as found in the National ITS Architecture.

Table 3.3 - Costs for the Transit Center Tracking and Dispatch Equipment Package

Transit Center Tracking and Dispatch (TRM7)								
	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***				**Steady State ***	
	Vehicle Location Interface	20	10	15			10	
	TMS Communication line; DS1 Type	20	0.5	0.1			0.5	
	PIAS & Others Communication Line; DS0 Type	20	0.5	1			0.5	
	Communication Line DS3 (2) 1 Line to ISP & 1 Li	20	6	10			6	
	Vehicle Tracking & Scheduling	20	40	100			40	
	Database and Information Storage	20	20	40			20	
	Schedule Adjustment Software	20	40	80			40	
	Real Time Travel Information Software	20	215	500			215	
	Integration	20	500	1000			500	
	Workstations (3)	10	15	30			15	
	Note : Software is off-the-shelf technology and unit price does not reflect product development.							
Recurring (Operations & Maintenance)			**Introductory State ***				**Steady State ***	
	Building Space (Add'l. req'd. for ITS tech. - $12-18 /		6	9			6	
	Database Management Contract @ 10% of DB Sch		6	1.2			6	
	Additional Staff (3) @ $75,000 each		202	247			202	
	Note : Salary Costs are fully loaded prices (Base Salary, Overtime, Overhead, Benefits, etc.)							
	TMS Wireline Communication DS1 from Data Loading (see Common Equipment in Section 5.6)		4.8	8.4			4.8	
	PIAS & Others Wireline Communication DS0 from D Loading (see Common Equipment in Section 5.6)		0.6	1.2			0.6	
	ISP Wireline Communication DS3 from Data Loading (see Common Equipment in Section 5.6)		24	72			24	
	RTS Wireline Communication DS3 from Data Loading (see Common Equipment in Section 5.6)		24	72			24	
* *All prices are in thousands of 1995 dollars.*								

★ **Useful National ITS Architecture document: Cost Analysis**

3.2.3.3 Market Package Benefits

The National ITS Architecture has identified likely benefits of individual Market Packages and the context where these benefits may occur. Table 3.4 lists the seven Market Packages directly associated with transit (except those associated with traveler information), likely benefits of each, and the context where benefits may occur as found in the National ITS Architecture.

Table 3.4 - Likely Benefits of the Transit Market Packages

Market Package	Likely Benefits	Context Where Benefits May Accrue
Transit Vehicle Tracking	Improvement in vehicle on-time performance Reductions in field supervision	Higher benefits to areas with significant transit service reliability problems
Fixed-Route Operations	Improved productivity of vehicles, labor	All transit scenarios
Demand-Responsive Operations	Improved productivity of vehicles, labor Efficiencies in routing and trip scheduling	All transit scenarios
Passenger and Fare Management	Passenger convenience of common fare instrument Reduction in cash handling losses Reduction in costs of data collection and fare processing	Benefits clearest where multiple agencies share services, transfers, etc.
Transit Security	Faster response to incidents Record of security incidents	High benefits in less secure areas (e.g., large urban areas)
Transit Maintenance	Effective scheduling of maintenance activities Reduction in maintenance and system repair costs	All transit scenarios
Multi-modal Coordination	Reduction in transit travel times from signal priority	Good institutional cooperation between traffic and transit managers is necessary Level of benefits depends on ambient traffic volumes and cross traffic in selected corridors or in area-wide systems

Additional benefits can be obtained through synergy among Market Packages. The principal synergies identified for the Market Packages associated with Transit Management are illustrated in Figure 3.12. In the diagram, which is from the National ITS Architecture documents, the connections represent the synergies among the Market Packages and are coded to represent the four types of synergies between Market Packages, as listed in the legend in the upper left corner of the figure. Synergies between a Transit Management Market Package and a Market Package of another Market Package bundle (e.g., Traveler Information Market Packages that are reliant on information from Transit Management Market Packages) are represented by an oval. Note how transit vehicle tracking provides a foundation for many other Market Packages. For a description of the major synergies among Market Packages, refer to the Implementation Strategy document of the National ITS Architecture.

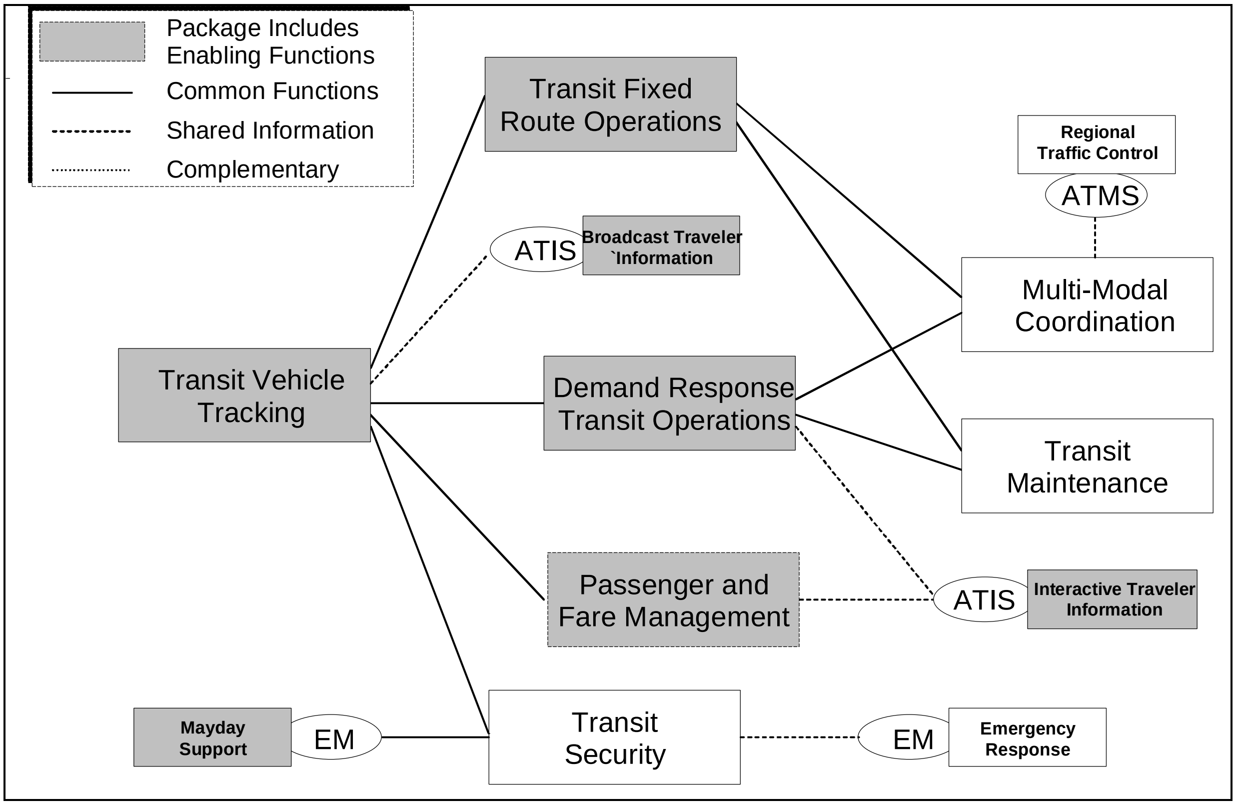


Figure 3.12 - Transit Management Market Package Synergies

Keeping in mind that ITS projects must address needs and achieve goals, the National ITS Architecture Market Packages have been mapped to the National ITS Architecture goals. Additionally, each of the Market Package bundles was evaluated to determine its benefit towards driver behavior, costs, accidents, and others which have a direct impact upon the transportation system. An example for transit vehicle tracking is seen below in Figure 3.13. This figure was taken from the National ITS Architecture documents.

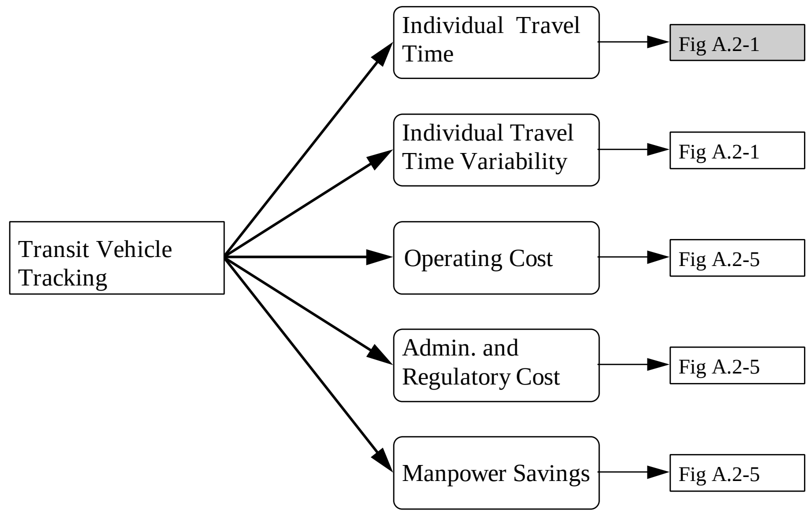


Figure A.1-22: Metrics from Transit Vehicle Tracking

Figure 3.13 - Transit Vehicle Tracking Benefits

As seen in Figure 3.13, individual travel time is a benefit of transit vehicle tracking. This benefit and the others may be tracked further to identify which National ITS Architecture goal it addresses. As seen in Figure 3.14, individual travel time may be tracked until it reaches the goal entitled Increase Economic Productivity. Figure 3.14 was also taken from the National ITS Architecture documents.

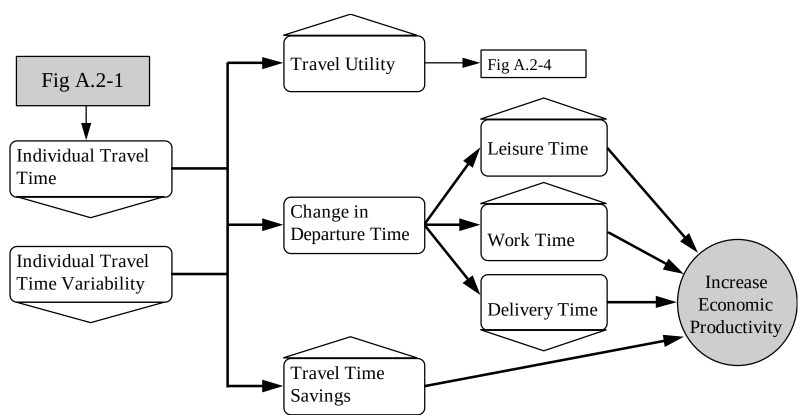


Figure A.2-1: Metrics of Travel Time and Travel Time Variability

Figure 3.14- Benefits Tracking for "Individual Travel Time"

★ **Useful National ITS Architecture document: Performance and Benefits Study, Implementation Strategy**

3.2.4 Technologies

A review and assessment of existing and emerging technologies is conducted in the Technologies step. This allows agencies to choose between different technologies for Market Packages it wishes to deploy. It provides an agency more than one design option. For example, an AVL system, which is a part of transit vehicle tracking, may employ GPS, signposts, or dead reckoning (or a combination of these).

3.2.5 Existing/Committed Conventional & ITS Projects/Systems

This step consists of a comprehensive inventory of existing and committed conventional and ITS projects/systems that are to be accommodated by the framework. These systems have already been designed or implemented, placing them outside the design scope of the current project. For example, a transit agency may already have in place a paratransit system and may be planning to build a new metro station.

This step involves a detailed assessment of the external items that the proposed system will be required to interface to and integrate with. Integration with other systems, whether existing or planned, needs to be addressed **early** in the ITS development process. Existing and committed systems -- legacy systems -- should be evaluated to determine the following:

- **Functions:** determine what Market Packages are contained in the system and the services provided.
- **Structure and components:** determine the control and communications structure within the system. Also determine specific technologies which are in place.
- **Information and data flows and formats:** determine inputs and outputs from the system as well as the format, structure, and protocols.
- **Responsibilities:** determine who is responsible for operations, maintenance, etc.

Once the evaluation of the legacy system is completed and the functions of the planned system have been determined, commonalities may be determined. Using common elements (e.g., communications infrastructure) that bridge across systems helps reduce costs and maximizes utilization of resources. The National ITS Architecture assists in finding common ties and similarities between systems on several levels:

- **User Services:** general description of what services the system offers to users.
- **Market Packages:** describe how to provide one or more User Service, and provide a physical or tangible means of satisfying user requirements; are the fundamental building blocks of ITS.
- **Market Package operational requirements:** define system processes, information flows, performance parameters, and technical and non-technical constraints.
- **Technologies:** technology groups that compose the Market Packages.
- **Data flows:** data flows between processes.

- **Process Specifications:** specifications related to the processes identified in the logical architecture.
- **Interface standards:** the structure, format, and protocols necessary for interaction.

Once these have been determined, specific requirements for the planned system or modifications to the existing system may be identified. Requirements may then be used for development of RFIs, RFPs, or product selection.

It is important to note that legacy systems do not need to be retrofitted immediately to align with the National ITS Architecture. It is appropriate to allow legacy systems to complete their life cycle. However, an ITS system that replaces a legacy system should align with the National ITS Architecture when it is determined that the legacy system needs retrofitting.

3.2.6 Financial Opportunities/Constraints

This step involves development of business plans and an analysis of cash and revenue flows associated with a proposed implementation. A financial analysis estimates costs associated with a framework, indicates potential revenue sources, and identifies payees and beneficiaries. This step is very important in the light of high emphasis by the U.S. DOT on public/private partnerships.

3.2.6.1 Using the National ITS Architecture to Identify Ties and Common Components

The National ITS Architecture allows the transportation system to be viewed as a whole. It then becomes apparent that there are many connections and commonalities with other systems outside the transit spectrum. These areas open other sources for funding.

Within the National ITS Architecture, the Physical Architecture identifies the interconnections between the transportation subsystems using four general communications media. This should assist agencies in determining common components of systems, thus allowing resources to be shared. These systems may be outside the transit agency, but may be able to be used as part of their own system. Common examples include a communications infrastructure, surveillance devices, and traveler information systems. The transit agency may be able to benefit by using these systems while minimizing capital and operating costs.

★ **Useful National ITS Architecture documents: Vision Statement, Implementation Strategy**

3.2.7 Standards

This step identifies interface areas that require standards for interoperability. It also describes the current status of ITS standardization initiatives and explains how these initiatives will be incorporated into the framework and eventual system design (refer to Section 3.3.2 and Appendix A for a discussion on standards). The benefits and characteristics of this step include the following:

- Allows compatible and interoperable ITS deployments

- Lowers deployment risks, thus stimulating public and private interest in ITS
- Reduces product costs by providing an incentive for multiple suppliers
- Widens market for suppliers

3.2.8 Implementation Strategy

In the Implementation Strategy step, strategies are developed to implement designs that satisfy the framework defined by the Physical Architecture. This step accounts for multiple influences on deployment, including existing systems, funding and revenue requirements, local political objectives, and sensible projects. This step identifies stakeholder roles, responsibilities, and contributions, and discusses funding issues. This step may also consider impediments to deployment and suggest possible solutions to these impediments.

In an implementation strategy, a phased deployment of Market Packages and individual projects is recommended. Prioritization may be based on a number of criteria such as political issues, revenue, amount of impact, and user visibility. The first components that should be implemented are those which:

- Fulfill common functions such as communications
- Have the potential to provide early visible benefits to the user such as reliable traveler information

3.2.9 Candidate Project Definition

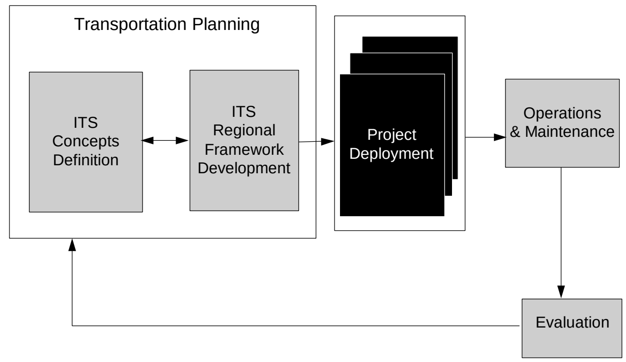
This step takes the phased deployments (project or projects) identified in the Implementation Strategy and further defines them. In this step, a spectrum of technology-specific configurations for each project is determined. The benefits and costs of each project configuration are estimated. The configurations for each project are then compared and ranked. Other functions performed in this step include locating funding and refining project requirements. Information from the developed regional ITS framework, implementation strategy, and candidate projects are documented in an ITS Framework Report. This report is used as input to the Regional Priority Resolution and Financial Decisions step (development of a Transportation Plan and Transportation Improvements Plan (TIP).

3.2.10 Rapid Deployment Project Definition

Rapid Deployment Project Definition is an alternative to developing an implementation strategy and defining a candidate project. In this case, a fast track approach is taken. Projects are defined specifically for deployment and are put directly into the Transportation Plan and TIP. The project would be considered as phase zero (0) in the implementation strategy.

An example includes the deployment of a system that was developed prior to an ITS regional framework, and which is to be accommodated by the framework (an agency desires to interface the system with the Layered Framework). Another example of this approach is the Strategic Assessment (formerly called Early Deployment Plan) process.

3.3 Project Deployment



Project Deployment is the next phase, after ITS Regional Framework Development, in the National ITS Architecture Application Process. Although the National ITS Architecture does not focus on ITS project deployment, it does provide some insight on deployment issues.

Project Deployment includes detailed design development, procurement, and implementation. It takes everything previously produced and develops an actual design for the system. Project deployment :

- Includes development of a detailed system design for a specific phase of the deployment.
- Includes procurement, construction, and acceptance testing of the system.
- Represents an implementable design incorporating technology-specific features, design choices, and procurement specifications.
- Represents one of a number of possible designs and phased modules that conform to the framework.

This section covers the following topics:

- Design options and tradeoffs
- Determining standards in design and procurement
- Procurement practices for ITS
- Aligning design and procurement with the National ITS Architecture (data flows for transit)

3.3.1 Design Options and Trade-offs

By providing interoperability through the use of standards and defining open interfaces between critical systems, the National ITS Architecture allows the implementor to select the best design to meet local needs. As listed in Table 3.5, the National ITS Architecture has identified major design options for Transit Management Market Packages.

The National ITS Architecture also provides a reference for selecting communications systems and technologies. Communications are divided into the following categories:

- Land mobile cellular type networks
- Satellite networks

- ♦ Broadcast systems
- ♦ Dedicated short range communications
- ♦ Wireline communications

★ **Useful National ITS Architecture documents: Communications Document, Implementation Strategy**

Table 3.5 - Major Transit Management Design Options

Market Package	Major Options
Transit Vehicle Tracking	• Technologies for vehicle location: signpost or wayside beacons, global positioning system (GPS), differential GPS, radio signal trilateration (e.g. Loran-C), dead reckoning. • Wide-area communications: cell-based, specialized mobile radio (SMR), trunked radio, other conventional two-way radio. • Real-time traveler information: may be provided directly by the transit agency and/or through a third-party information provider. Wide variety of possible communications technologies.
Fixed-Route Operations	• Data processing approaches: Centralized control at yard or operations center, distributed data sharing (via a local or wide-area network) between different units within the agency. • Wide-area communications of short standard data messages. • Short-range communications (e.g. beacon-tag) with vehicles at garage or yard for data dump to / from the vehicle as it enters or exits. • Traveler information: may be provided directly by the transit agency and/or through a third-party information provider. Wide variety of possible communications technologies.
Demand-Responsive Operations	• Data processing approaches: Centralized control at yard or operations center, distributed data sharing (via a local or wide-area network) between different units within the agency. • Wide-area communications of short standard data messages. • Short-range communications with vehicles at garage/yard to allow data dump to and from the vehicle at the beginning or end of shift. • Traveler information and rider requests: may be managed directly by the transit agency and/or through a third-party information provider. Wide variety of possible communications technologies.
Passenger and Fare Management	• Fare media: electronic credit or debit card, magnetic stripe, proximity card, other smart card technologies. • Data processing: data held on the vehicle and down-loaded off line, or may be communicated real-time to operations center.
Transit Security	• Video or other surveillance data may be retained locally (e.g. on the vehicle or in the stop/station) or may be communicated back to management center.
Transit Maintenance	• Vehicle condition data may be held on the vehicle and down-loaded off line, or may be communicated real-time to operations center.
Multi-modal Coordination	• Approaches to signal priority: one- or two-way short-range vehicle communication with roadside beacon; similar to signal obtaining central authorization from traffic management center; short automated message from vehicle to transit management to traffic management center. • Transit probe data shared over similar interfaces as other probes: roadside elements or wide-area wireless communication.

3.3.2 Determine Standards

A transit agency should use standards in the design and procurement of its ITS applications. Standards may define requirements at the system, subsystem, or equipment level and for the interfaces at these levels. A survey conducted in 1996 by ITS America identified 44 different areas for which standards are needed. As a result, ITS America has made recommendations for the development of protocols and standards for many ITS applications. The primary standards relevant to transit ITS, that have been created or are currently being developed are outlined below. Appendix A discusses these primary standards in greater detail, and presents a table containing additional ITS standards. The current status of the development of these standards, as well as contact names and addresses, are also provided in the appendix. Due to the pace of the standards development effort, a special home page is being implemented on the world wide web for the dissemination of standards information and status. Standards information can be obtained on the Internet at *http://www.itsa.org*.

- **National Transportation Communications for ITS Protocols (NTCIP):** NTCIP deals with communications from/to and between management centers such as transit, traffic, and service providers. The profiles are set up to conform to the Open Systems Interconnection (OSI) approach (see Appendix A) and have been termed class profiles. One of the class profiles (Class B) defines the secondary protocols needed to transmit data from a center to roadside devices without providing data routing capabilities while at the same time reducing transmission overhead needs. Others (Class A and Class C) provide these routing capabilities but address the different types of connection (connection-oriented and connection-less) while transmitting data. Center-to-center communications is another area, where different types of secondary standards are being developed.

  NTCIP also addresses and defines message sets (data elements or the smallest units of data that need to be transmitted) for various ITS applications such as signal controllers, variable message signs, highway advisory radios, automatic vehicle location and identification systems.
- **Transit Communications Interface Protocols (TCIP):** TCIP is a suite of protocols combining NTCIP and SAE standard development efforts. The primary focus is to identify applicable existing and/or planned communication standards (primary and secondary standards) that are needed for communicating data within the transit industry and associated other entities as well as transit-related message sets that have not been addressed elsewhere. Message sets to send data in a defined format from a vehicle to either a roadside device or directly to a management center, or from one subsystem within a transit vehicle to another subsystem within the same vehicle, are being defined and coordinated under this effort.
- **Dedicated Short Range Communications (DSRC) protocol:** This effort, which will be a mid-term effort (up to 10 years), will define the communications between roadside devices (beacons) and passing vehicles and/or passengers. The DSRC will, for example, define how to transmit data from a vehicle to a device, or deduct fare payments from passengers equipped with suitable hardware.
- **Vehicle Area Networks (VAN):** several standards for defining communications on vehicles currently exist or are being developed. Three of the main standards are described below:

- **Society of Automobile Engineers (SAE) J1708:** SAE J1708 is a standard developed by SAE defining communications within heavy-duty vehicles (which includes transit vehicles). The supporting standard SAE 1587 defines the message set for data that needs to be transmitted between the various subsystems within heavy-duty vehicles.
- **LonWorks:** LonWorks technology is a general purpose control networking technology developed by Echelon Corporation. LonWorks technology is designed to enable various devices to communicate across a range of media in a control network. A LonWorks technology control network utilizes the LonTalk communication protocol fully implemented in silicon and available as Neuron Chips, manufactured by Motorola and Toshiba.

  Besides the LonTalk protocol, the Neuron Chip performs most of the control functions which add distributed intelligence and inter-operability to network devices. Besides the Neuron Chips, LonWorks technology provides transceivers to couple Neuron Chips to the network devices and communications media, bridges to connect separate communications media on the LonWorks network, and network management and diagnostic equipment.
- **VDV-300 IBIS:** The Verband Deutscher Verkehrsunternehmen (German Association of Public Transport Operators - VDV) has developed VDV Standard 300 - Integrated on-Board Information System (IBIS). This is the VDV’s own specification for a vehicle area network. The VDV-300 specification, released in January 1992, was designed as a recommendation for data processing and transmission of data in public transportation vehicles.

  The VDV standard specifies a modular design with interchangeable devices. It specifies a protocol software design along with hardware operations and connections, including a central vehicle area network control unit.

★ **Useful National ITS Architecture documents: Logical Architecture, Standards Requirements, Standards Development Plan, Implementation Strategy**

3.3.2.1 Criteria for Choosing a Standard

The development of standards is an ongoing process. As agencies and vendors become educated in the implementation of standards, then transit ITS system performance should improve. Currently several standards exist within the transit industry and it is sometimes difficult to identify what standards should be followed. The following six-step process is recommended for choosing the appropriate standards:

1) Decide what the system should do
2) Identify the major interfaces
3) Identify future upgrades and their interface requirements

4) Go to the Tables in Appendix A (also found on the Internet at http://www.itsa.org) which list the different transit ITS functions and existing standards for those functions and identify your list of possible standards
5) Talk to transit agencies working with your identified standards, ITS America, the Institute of Transportation Engineers, and other standards organizations about their lessons learned
6) Choose the standard(s) that best fits the agencies' needs (current and future)

3.3.2.2 Development of New Standards and the National ITS Architecture

The following subsections provide guidance where no standard exists for a particular type of application or communication. The National ITS Architecture documents provide information on how to ensure interoperability of different types of entities working within the same or neighboring systems. Therefore, by following the processes identified, the integration of newly developed standards into existing systems will be possible.

Standards may define performance or system specifications at the following levels: subsystem interfaces, process specifications, and data dictionary. The previous section addressed subsystem interfaces such as center-to-center, center-to-roadside, roadside-to-vehicle, and center-to-vehicle communications. These subsystem interfaces are currently being addressed, but the development of process specifications, data dictionaries and message sets (to transmit data in a certain standard format) can and will be an ongoing process. In order to comply with the National ITS Architecture, the following approach is recommended.

3.3.2.2.1 Process Specifications

Process Specifications (P-Specs), which are based on the information processes that occur within the Logical Architecture, should be developed. The National ITS Architecture documents contain an extensive set of P-Specs. Therefore, prior to developing new P-Specs, an agency should first consult the National ITS Architecture documents. The main purpose of P-Specs is to provide a description of the data that needs to be transmitted from one function to another, as well as what input data requirements a particular function has in order to produce the anticipated result. Each P-Spec follows the following format:

- **P-Spec name and number:** The name and number appear in bold type at the top of the page.
- **Input Flows:** These are flows being input to the process from other processes or sources.
- **Output Flows:** These are outputs to other processes or databases.
- **P-Spec Description:** The descriptions have been divided into two portions. The first paragraph is an overview of the purpose and basic plan of the P-Spec. The text following the first paragraph provides more detailed specifics on exactly what the process needs and what information flows this process will generate.

- **User Service Requirements (USR):** Each P-Spec is provided to meet a specific need, and the User Service Requirements that drive that need are listed in Volume Two of the Logical Architecture. It should be noted that a low level USR automatically implies that its higher level parents are also being served by this P-Spec.
- **Output Flow Dynamics Assumption(s):** The Logical Architecture also uses P-Spec extended attributes to document output flow rate assumptions (in messages per second), primarily for data loading analysis.

Figure 3.15 illustrates the P-Spec for Provide Transit Vehicle Location Data. To obtain definitions of data contained in a data flow, reference the National ITS Architecture , Logical Architecture Volume 3 - Data Dictionary.

4.1.3 Provide Transit Vehicle Location Data

Input Flows

transit_vehicle_on_board_data
vehicle_location_for_transit

Output Flows

transit_vehicle_location
transit_vehicle_location_for_deviation
transit_vehicle_location_for_eta (eta = estimated time of arrival)
transit_vehicle_location_for_store

Description:

Overview: This process shall be responsible for providing the transit vehicle's current location to a high degree of accuracy. The location shall be computed by this process from data sent by other processes that provide basic vehicle location and on-board vehicle conditions, such as proximity to transit stop, vehicle doors opened or closed, etc. The data shall be output continuously by the process and sent to other processes for their use and for storage.

Data Flows: All input data flows are unsolicited and all output flows are solicited.

Functional Requirements: This process shall meet the following functional requirements:
(a) continuously monitor for receipt of the input flows listed above;
(b) when any of the inputs are received, generate the outputs identified above by combining the new data with the last output values;
(c) the calculation of the new location shall use the basic location data and refine it by use of data from on-board the vehicle, e.g. proximity of transit stop, vehicle doors open, etc.

User Service Requirements:

USR = 2.0;
USR = 2.1;
USR = 2.1.1;
USR = 2.1.1.1;

Output Flow Dynamics Assumptions:

transit_vehicle_location = 1*ITS_TRANSIT_VEHS;
transit_vehicle_location_for_deviation = 1*ITS_TRANSIT_VEHS;
transit_vehicle_location_for_eta = 1*ITS_TRANSIT_VEHS;
transit_vehicle_location_for_store = 1*ITS_TRANSIT_VEHS;

Figure 3.15 - Provide Transit Vehicle Location Data P-Spec

★ **Useful National ITS Architecture documents: Logical Architecture - Volumes 1 and 2, Traceability**

3.3.2.2.2 Data Dictionary

The National ITS Architecture has also developed an extensive data dictionary as part of the Logical Architecture. This data dictionary is liable to modification and extensions over time; however, it does provide a firm basis on which a transit ITS system can be developed. The need to develop several data dictionaries, each tackling a different area, is based on this understanding. However, if a data dictionary is being developed for a particular area, it should follow the format that has been developed for the data dictionary presented in the National ITS Architecture. Many of the items that agencies wish to define are probably defined in the National ITS Architecture data dictionaries.

A data dictionary is a formal repository of all model definitions of data flows and data stores. The format for each data dictionary entry is as follows:

- **Name:** flow or store in bold and italics type where:
  - Data Flow - data that is sent between two processes
  - Data Store - data held by a process that updates periodically, but is not forwarded to other processes
- **Description:** informal text description identifying whether the data is a flow or a store. The description may also contain comments and assumptions.
- **Definition:** formal definition of the data dictionary entry in terms of other data dictionary entries.
- **Additional Sizing Assumptions:** extended attribute of the data dictionary entry used to define sizing assumptions that are used primarily for data loading analysis.

Figure 3.16 illustrates the data dictionary entry for the flow “vehicle_location_for_transit”.

> ***vehicle_location_for_transit***
>
> This data flow is sent from the Provide Driver and Traveler Services to the Manage Transit function. It contains the vehicles location as computed from data input to sensors controlled by the processes that determine vehicle location. This is a low precision data flow that will be refined using data obtained from on-board the transit vehicle. It consists of the following data item which is defined in its own data dictionary entry.
>
> location_identity.
>
> **Additional sizing assumptions:**
> None

Figure 3.16 - Data Dictionary Entry for “vehicle_location_for_transit”

The data dictionary within the National ITS Architecture documents provides a generic overview of essential data entries. It will need to be accompanied by specific, application-oriented data dictionaries. These data dictionaries are being, or will be, developed by

★ **Useful National ITS Architecture documents: Logical Architecture - Volume 3** interested parties in close coordination with appropriate steering groups who will ensure interoperability of the different systems.

3.3.3 Procurement - Today and Tomorrow

This section provides guidance on procurement of contractors and equipment for transit ITS projects. It discusses how transit procurement is currently being conducted, and provides suggestions on how to procure “smarter” for ITS projects, because procurement needs of ITS projects are different than those of conventional transit projects. The National ITS Architecture does not provide specific guidance on ITS procurement, and thus information in this section was obtained from other literature, and advice from the transit industry. Language from procurement documents of proven transit ITS projects is located in Appendix B. These procurement samples provide a good reference and model for transit agencies embarking on transit ITS projects.

Traditional procurement processes used by state and local transportation agencies were developed for the design and construction of roads, bridges and rail projects. The traditional approach to procurement is a two-step process: 1) the letting and completion of a contract to retain architect/engineering services to prepare detailed design specifications for the facility, and 2) the letting and completion of another separate contract for the construction of the facility. This contract is publicly advertised and awarded to the lowest responsive and responsible bidder. This two-step approach to procurement, while effective for traditional construction projects, often lacks the flexibility to adapt to the particular circumstances of various procurements, which is required when contracting for rapidly evolving technologies and systems such as ITS. However, there are a number of alternative procurement methods that have been successfully used by transit agencies to procure ITS systems. These methods include two-step sealed bids, competitive proposals, competitive negotiations, sole source contracting, and unsolicited proposals. Traditional and alternative procurement practices for transit are discussed in greater detail below.

3.3.3.1 Traditional Practices

The following section outlines how transit agencies currently procure equipment, capital, and services.

3.3.3.1.1 Procurement Planning

Autonomy of the procurement function, or independence from its internal customers, is generally considered important to carrying out procurement responsibilities without undue influence from those who will ultimately use the goods or services procured. This autonomy will vary with the size of the agency as well as the types of procurements involved.

Transit agencies are generally encouraged to plan procurements more than one year in advance, particularly for major transit investments and complex capital projects, or when a substantial number of operating contracts are involved that span several years. Major design/construction and rail vehicle procurements are generally planned seven to 10 years in advance of needed completion because of the time intervals typically required. These include:

- One year advance planning before the Request for Proposals for the engineering services
- Four months from the RFP award to the award of the engineering services
- Two years to prepare the technical specifications
- Three months from completion of the specifications to system RFP
- Six months from the system RFP to the award
- Three years for system construction

In addition, it is recommended that bus procurements and major electronic/data systems be planned at least three years in advance. Cost estimates are also required as part of the transit system's annual procurement plan.

3.3.3.1.2 Federal Policies Governing Procurement

Federal policy requires transit agencies to adhere to the minimum needs doctrine. The Comptroller General has stated:

> "It has long been the rule, enforced by the accounting officers and the courts, that an appropriation of public moneys by the Congress, made in general terms, is available only to accomplish the particular thing authorized by the appropriation to be done. It is equally well established that public moneys so appropriated are available for uses reasonably and clearly necessary to the accomplishment of the thing authorized by the appropriation to be done."

In essence, the policy requires that, in preparing specifications of statements of work defining the commodity or service to be acquired in the procurement, the public entity should buy only what its minimum needs are, not what it wants (or would be nice) to have. While the policy only applies to "brand name or equal" specifications, transit agencies have been encouraged to apply this doctrine to all procurements.

FTA policy explicitly requires full and open competition from all entities. It encourages agencies to adopt practices which are selective or rule out offers only for business reasons (cost, quality and delivery). FTA policy also discourages the use of specifications that require the use of a brand name product.

Organizational conflicts of interest (OCI) are another area of concern for transit procurements. An OCI occurs when the type of work to be performed under a third party contract may, without some restriction, on future follow-on work:

- Result in an unfair competitive advantage to the contractor, or
- Impair the contractor's objectivity in performing the contract work.

Some OCI scenarios include:

- A firm may have a competitive advantage because of prior work done (e.g., it designed the information system to be installed), or
- A firm may have a competitive advantage in future or follow-on work as a result of the contract to be awarded (e.g., many firms may wish to submit a proposal in a preliminary engineering procurement and may also wish to submit a proposal for the final design of the same facility).

3.3.3.1.3 Contract Award Types

There are several methods of award in transportation contracting. They are briefly described below.

Sealed bids is the preferred method for the federal government, as well as most states for civil construction and off-the-shelf supply contracts. Sealed bidding requires that contracts are to be awarded only to the lowest cost responsive and responsible bidder (i.e. the bidder who offers the lowest cost, meets the minimum standards and is deemed to be a responsible contractor).

The **two-step sealed bid** method allows agencies to obtain the benefits of sealed bidding when adequate specifications are not available. In step one, an agency issues a request for a submission, evaluations, and discussion of a technical proposal. There is no discussion of price. In step two, those who have submitted acceptable technical proposals submit fixed price bids.

Competitive proposals, requests for proposals (RFP) or requests for quotations (RFQ), are used when contract awards are based on price and other factors. These are especially useful when procurements require a substantial amount of professional services and design work in addition to construction.

Agencies employing a **competitive negotiation** process will conduct an RFP/RFQ procurement and then choose one or more of the proposers to negotiate an agreement. This gives an agency some flexibility by not requiring it to accept a best and final offer, as is the case with sealed bids.

Sole source contracting is permitted only in limited circumstances. This method of contracting is generally only used when supplies or services required are available only from one responsible source, and no other source of supplies or services will satisfy the agency's needs.

Unsolicited proposals are a means for government agencies to obtain innovative or unique methods or approaches to accomplishing agency goals. These awards can be made only when there is no similar competitive proposal pending, and the facts and circumstances of the procurement preclude competition.

3.3.3.2 Overcoming Challenges to Transit ITS Procurement -- What I Can Do Today

Transit ITS presents new procurement challenges for transit agencies. But existing practices need not be challenges to procuring ITS. Solutions to some challenges are listed below.

Challenge: Need for Autonomy in Procurement Process. In order to ensure that public funds are properly expended and efficiently managed, it is generally recommended that agencies keep the procurement function independent from those who will use the goods or services procured. However, because of the complexity of some ITS systems and the need for these systems to be interoperable, technical advice is critical in making wise procurement decisions.

Solution: Transit agencies should balance the need for autonomy in procurement with the obvious need for those with the technical knowledge on ITS systems to participate in the procurement process. A sufficient degree of autonomy can be maintained while still involving technical staff, by adopting a team approach to procurement, which would include technical advisers and budget and procurement personnel. By bringing both sides together, each can gain a better understanding of the roles each brings to the table. This will allow the technical advisers to make recommendations on the types of technology and systems available to meet agency needs, and the procurement specialists to outline budget, financial, and procurement restrictions that may impact the type of technology or service to be procured.

Challenge: Authority of Agency to Participate in Multiagency Procurement. Some ITS applications, including many transit applications, may involve more than one transportation agency. Many agencies may face restrictions on their ability to participate in procurements with other agencies. In addition, they may be restricted in their ability to have their funds committed by another entity.

Solution: Unless expressly prohibited, an agency should broadly construe its power to enter into agreements necessary or incidental to the performance of its duties or incidental to executing its powers. If there is a prohibition on such an approach, the multiagency coalition participants can use an irrevocable offer made by a single vendor to each agency. In this way, the individual agency can make its own determination as to whether to be bound to the coordinated agreement.

Challenge: Difficulty in Estimating Costs. It is difficult for transit agencies to estimate costs of ITS applications accurately. Many agencies have not previously developed and implemented ITS applications -- they do not possess the cost estimate information. This creates problems for agencies trying develop a budget for an ITS project (prior to procurement).

Solution: While there may only be a few transit agencies with experience in contracting for transit ITS projects, they are an invaluable resource in obtaining realistic cost estimates as well as other guidance on ITS procurements. Transit agencies may also want to consider obtaining cost estimates from firms not interested in the procurement. In the case of facility design services, there are industry standards on estimating design costs as a percentage of construction available. Another source for estimating ITS costs is the equipment package cost estimates developed by the National ITS Architecture.

Challenge: Complying with Organizational Conflict of Interest Regulations. OCI rules were created to preserve fair and open competition and enable contracting agencies to obtain impartial advice from consultants. Some agencies have raised the concern that the application of OCI rules when separate design and construction contracts are planned may limit the extent that companies can be both designers and providers of ITS. This may deter the best qualified contractors from participating in a project's early stages if they will be unable to participate in later stages of the project.

Solution: How a project is characterized can determine how OCI rules apply. Different OCI rules may apply to systems engineering contracts, development contracts, evaluation contracts, or planning contracts. A contractor who participates in planning as opposed to design may still participate in construction. If applicable, OCI issues can be avoided by bundling activities into a single contract (such as design/build). Agencies should prepare specifications for projects in-house and allow ample opportunity for the private sector to comment on these specifications (for free). The design contractor should also be involved in oversight of the project once it has been implemented.

Challenge: Preference for the Sealed-Bid or Low-Bid Procurements. Although federal legislative requirements mandating the use of sealed bid procurements have been relaxed in recent years, many states still require its use for procuring many commodities and services. In addition, it is still the preferred method for acquiring construction services in the public sector, even by the FTA.

Solution: Traditional procurement approaches will usually not provide the flexibility necessary for acquiring ITS systems. Variations of sealed bid procurements and other innovative contracting procedures identified above should be considered when procuring ITS systems. These procedures will often result in agencies making wiser and more cost-effective decisions over the long term. Agencies should evaluate the nature of the ITS project, identify its unique characteristics, and employ a procurement process which will produce the most cost-effective result. Among the factors to be considered are source of funds, extent of project definition, phase of the project, and scope of services desired.

Challenge: Conflicts Among Federal, State, and Local Procurement Rules. In an effort to provide greater flexibility to state and local governments in their procurement procedures, the U.S. Office of Management and Budget established the Common Rule governing grants administration.
The rule provides that states will spend and account for grant funds according to their own laws and procedures. While some procurement methods have very specific federal rules to be followed (particularly procurements for architect/engineering services for construction projects), there is considerable flexibility in most other procurement models.

Solution: Involve procurement officials early in your project planning phase. They can help determine the most effective procurement mechanism to use for the project. To the extent possible, consider obtaining funding from sources with the least restrictive procurement rules. Projects using federal funds or local funds generally have fewer procurement restrictions than those using state funds.

3.3.3.3 Some Long-Term Procurement Strategies

Some transit agencies may find that longer-term solutions are necessary to create an environment conducive to aggressive ITS procurement. Strategies used by other transit agencies in ITS procurement are described below.

- **Seek legislative changes to restrictive procurement statutes.** A number of states have passed legislation to relax procurement procedures, particularly for non-traditional procurements such as ITS.
- **Engage in joint strategic planning with other agencies for combined/coordinated procurements.** As indicated previously, many ITS projects require multi-agency cooperation in order to be successful. Joint strategic planning for such projects and coordinated procurements to acquire the necessary equipment and services to carry them out have proven to be effective means to accomplish regional objectives. The Interagency Group in the Northeast corridor was created to conduct a joint procurement of compatible toll technology for the New York metropolitan area. Eight toll agencies have joined together to coordinate and implement interoperable equipment. The combined procurement was effective in using the group's collective leverage to negotiate a favorable irrevocable offer for each of the agencies involved. The San Francisco Bay region is home to more than two dozen transit properties. The Metropolitan Transportation Commission (MTC), the region's MPO, has been a focal point for combined and coordinated procurements for a number of transit and transit-related ITS projects. Its joint strategic planning process has allowed transit to be fully integrated into the TravInfo traveler information network. MTC will serve as the lead agency for the region's Translink project, which will allow for transit riders to use a single fare payment medium for most of the transit systems in the Bay area.
- **Review existing rules, regulations, and procedures to reduce administrative procedures which do not support the basic common rule without compromising internal controls (particularly those which add costs and exceed Federal requirements).**
- **Involve experienced contract personnel early in the planning process.** It is important to involve contract professionals early in the process who have extensive knowledge of the applicable rules, regulations, and procedures associated with public sector funding and procurement. They can help determine the most cost-effective procurement model for your ITS project.
- **Review intellectual property rights legislation to determine if changes are required to encourage transit ITS deployment.** The following questions should be considered: Are intellectual property rights adequately addressed and rights clearly assigned? Are there restrictions on the agency's ability to receive royalties from software developed in conjunction with ITS projects? If so, are those restrictions adequately addressed, or are changes necessary to encourage transit ITS projects?

Note: For more information on procurement and ITS issues, see *Federal Transit Administration Best Practices Procurement Manual for the Transit Industry* and FHWA's *Innovative Contracting Procedures for ITS* (see Section 7: References).

3.3.4 Aligning Design and Procurement with the National ITS Architecture - Data Flows for Transit

The National ITS Architecture has identified logical and physical data flows that should be accommodated in the design and procurement of transit ITS components and systems. Legacy systems should also accommodate these data flows when it comes time to retrofit the systems. Accommodation can be accomplished by including interfaces in subsystem and component designs and procurements that allow for these data flow now or in the future. The following sections identify the necessary data flows for a system to accommodate, fully communicate, and operate with all other ITS systems.

3.3.4.1 Logical Architecture Data Flows Associated With Transit

A key feature of alignment and compatibility with the National ITS Architecture is the ability to support all of the data flows defined in the Logical Architecture, either now, or in the near future. These data flows represent the data that must flow across the major system interfaces, if all the functionality of the National ITS Architecture is to be fully realized and all User Services provided. Therefore, current and future procurement of transit subsystems and application packages should accommodate all of the required data flows.

Appendix C contains the currently identified data flows with respect to the Manage Transit process as found in the base level data flow diagram (DFD), Manage ITS, DFD 0. Within the Manage Transit process exists several other levels of data flows. Appendix C also contains these data flows (data flows of Manage Transit, DFD 4).

★ **Useful National ITS Architecture documents: Logical Architecture - Volumes 1, 2, 3**

3.3.4.2 Physical Architecture Data Flows Associated With Transit

As previously discussed, there are a number of logical data flows identified in the Logical Architecture which need to be accommodated to achieve compatibility with the National ITS Architecture. This section takes the next step and identifies the physical data flows as found in the Physical Architecture. These data flows are important because they represent the actual communication ties among agencies and subsystems. Figure 3.17 highlights the subsystems (in bold) that are involved with transit operations (this figure also appears in Sections 2.3.4 and 3.2.2).

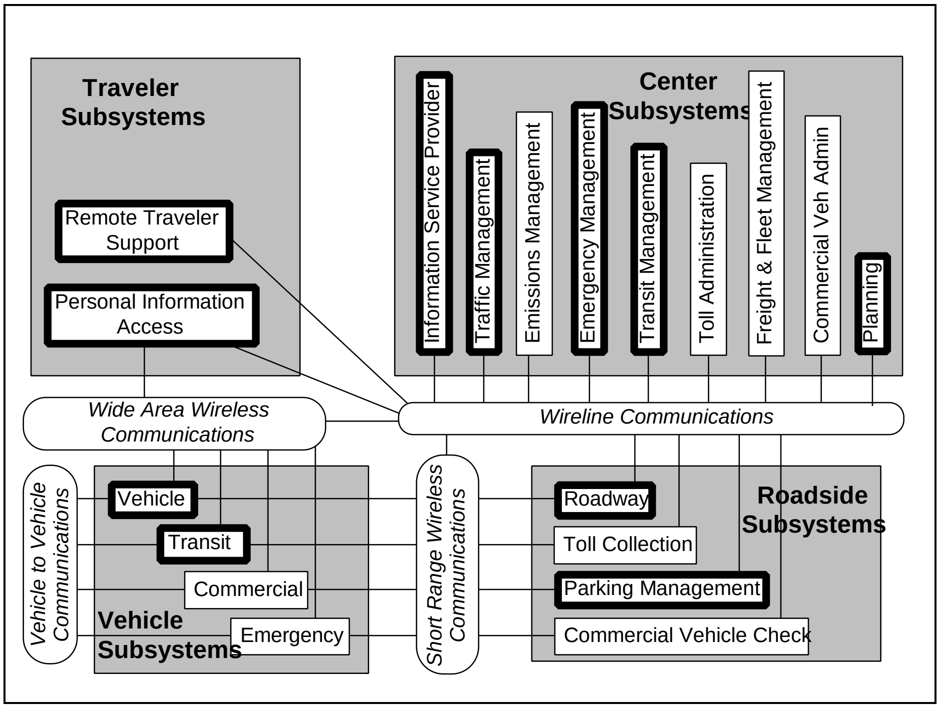


Figure 3.17 - Subsystems Involved With Transit Operations

In addition to these subsystems, there are numerous terminators which send and receive data for use in transit facility operation. Figure 3.18 illustrates the data flows associated with transit for subsystems, users, providers, and the environment.

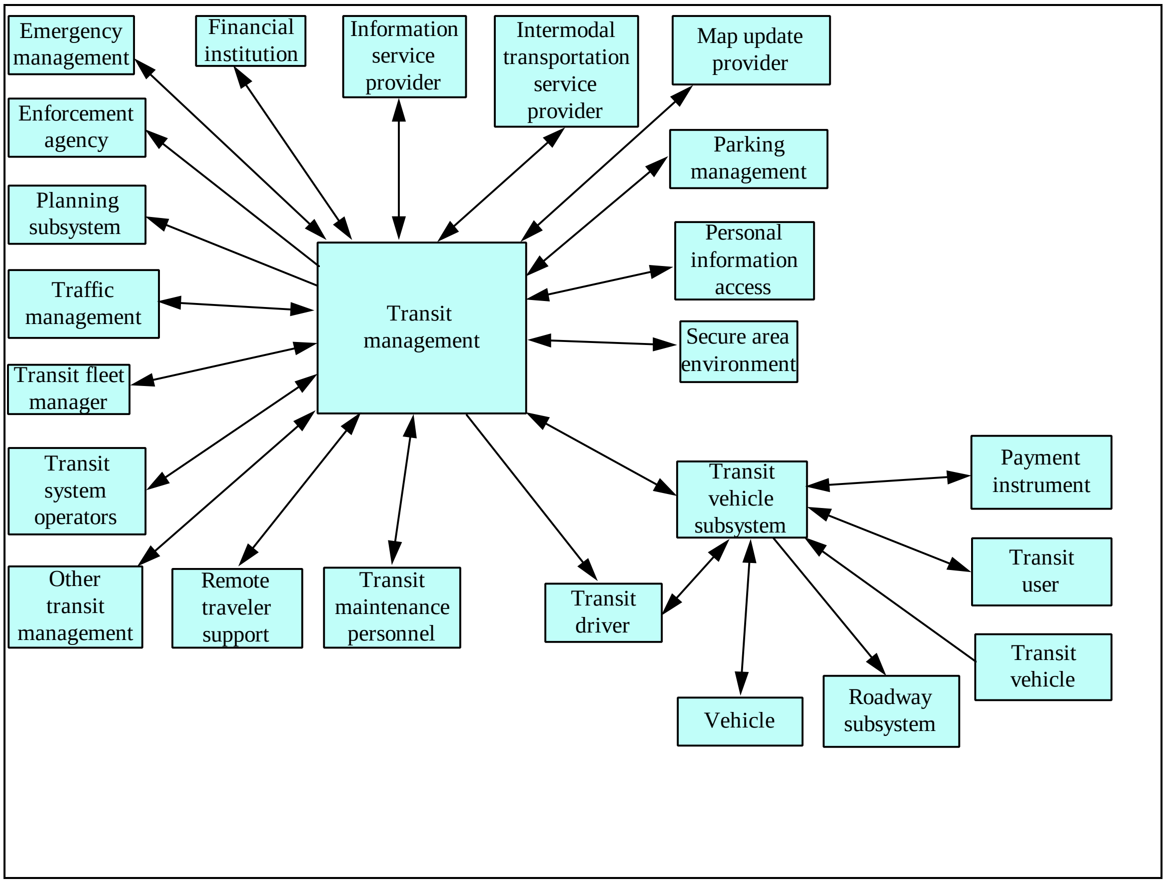


Figure 3.18 - Physical Architecture Data Flows for Transit

Tables 3.6 through 3.9 provide a list of the Physical Architecture data flows associated with the Transit Management and Transit Vehicle subsystems. Additional information (formats) on these physical data flows is presented in Appendix D.

★ **Useful National ITS Architecture documents: Physical Architecture**

Table 3.6 - Physical Architecture Data Flows to the Transit Management Subsystem

Source	Physical Architecture Flow Name
Emergency Management	transit emergency coordination data
Financial Institution	transaction status
Information Service Provider	demand responsive transit request
	selected routes
	transit information request
Intermodal Transportation Service Provider	intermodal information
Map Update Provider	map updates
Other TRM	TRMS coord
Parking Management	transit parking coordination
Personal Information Access	demand responsive transit request
Remote Traveler Support	emergency notification
	transit request
	traveler information request
Secure Area Environment	physical activities
Traffic Management	demand management price change request
	signal priority status
	traffic information
Transit Fleet Manager	schedule Guidelines
Transit Maintenance Personnel	maint Status
Transit System Operators	transit operator fare schedules

Table 3.7 - Physical Architecture Data Flows from the Transit Management Subsystem

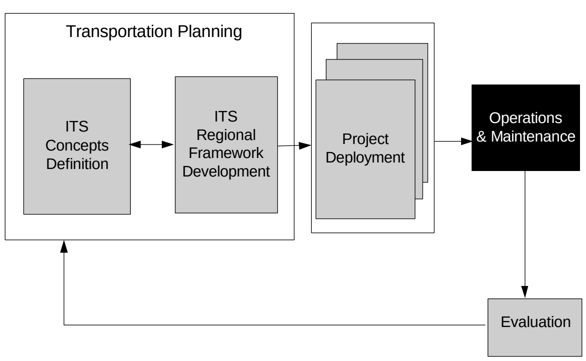
Destination	Physical Architecture Flow Name
Transit Vehicle Subsystem	bad tag list
	driver instructions
	emergency acknowledge
	request for vehicle measures
	schedules, fare info request
	traveler information
Emergency Management	security alarms
Enforcement Agency	violation notification
Financial Institution	payment request
Information Service Provider	demand responsive transit plan
	transit and fare schedules
	transit request confirmation
Intermodal Transportation Service Provider	intermodal information
Map Update Provider	map update request
Other TRM	TRMS coord
Parking Management	parking lot transit response
Personal Information Access	demand responsive transit route
Planning Subsystem	operational data
Remote Traveler Support	emergency acknowledge
	transit and fare schedules
	traveler information
Secure Area Environment	camera control
	emergency acknowledge
Traffic Management	demand management price change response
	request for transit signal priority
	transit system data
Transit Driver	route assignment
Transit Fleet Manager	actual schedule and fare info
Transit Maintenance Personnel	work schedule
Transit System Operators	transit operator display

Table 3.8 - Physical Architecture Data Flows to the Transit Vehicle Subsystem

Source	Physical Architecture Flow Name
Payment Instrument	payment
Transit Driver	transit driver inputs
Transit User	emergency notification
	transit user inputs
Transit Vehicle	vehicle measures
Vehicle	vehicle location

Table 3.9 - Physical Architecture Data Flows from the Transit Vehicle Subsystem

Destination	Physical Architecture Flow Name
Transit Management	emergency notification
	fare and payment status
	request for bad tag list
	transit vehicle conditions
	transit vehicle passenger and use data
	traveler information request
	vehicle probe data
Payment Instrument	request for payment
Roadway Subsystem	local signal priority request
Transit Driver	transit driver display
Transit User	transit user fare status
	transit user outputs
Vehicle	traveler advisory request



3.4 Operations and Maintenance

A step often overlooked in development and deployment of a system is the impact on operations and maintenance. Operations and Maintenance is the next phase, after Project Deployment, in the National ITS Architecture Application Process. Although the National ITS Architecture only assists in the development of a cost estimate, this step is crucial to the success of a project. Information from this phase should be applied to other planning cycles of future planning projects. For example, from operating and maintaining older ITS systems, it has become evident that field devices should be positioned so that they are easily accessible for maintenance. This information should be incorporated into future designs.

This section discusses planning for ITS operations and maintenance. The deployment of transit ITS will impact systems operations and maintenance (O & M) activities. In some cases, it may increase operations and maintenance costs with the introduction of additional equipment and new technology. These increased costs may arise from the need for additional staff (or staff training) to operate the systems and additional (and potentially more expensive) maintenance for these new systems. However, it is more likely that, while short-term operations and maintenance costs may increase, ITS systems will result in lower long-term costs due to improved system efficiency. There are two areas of primary concern in operating and maintaining transit ITS systems: 1) the actual operations and maintenance of the systems themselves, and 2) funding for operations and maintenance. These issues are discussed below.

3.4.1 Operating and Maintaining

Below are some considerations transit agencies should evaluate in operating and maintaining ITS systems:

A threshold question to be resolved is whether the system will be operated and maintained by in-house personnel, or whether it will be contracted out. If the operations and maintenance are to be handled in-house, the following steps should be taken:

- ♦ Involve the operations and maintenance personnel early in the development of the ITS project.
- ♦ Properly train the operators and technicians of the ITS system.
- ♦ Seek out the experience and expertise of other transit operators who have deployed similar ITS systems for guidance on operations and maintenance plans.
- ♦ Develop a thoughtful operations and maintenance plan which assigns roles and responsibilities for the various aspects of the system, provides comprehensive procedures, and determines staffing requirements and training needs.
- ♦ Determine O & M funding sources.

Contracting out operations and maintenance services can be cost-effective, especially for large, complex systems which may require significant staff training or new hires. While there may be concerns over maintaining service quality when contracting out these services, transit agencies can build protections for quality into their operations and maintenance service contracts (specify measurable quality requirements in contract). Again, transit agencies with experience deploying ITS systems can provide useful guidance in this area. Furthermore, ITS often can provide an opportunity for monitoring the performance of a contractor (e.g., schedule adherence can be monitored and made a contractual performance condition).

3.4.2 Operations and Maintenance for Multijurisdictional ITS Systems

Many transit ITS systems may span a number of jurisdictions, which create both concerns and opportunities regarding various agencies' policies and procedures on operations and maintenance. On-going maintenance of these systems is critical to system efficiency. Maintenance roles and responsibilities, and common standards need to be identified, along with ownership of the project components.

In these circumstances, it is useful to create a multijurisdictional maintenance plan that describes the roles and responsibilities for maintenance, address procedures, and outlines staffing, training and equipment needs. A maintenance committee with representatives from the O & M departments of each of the participating agencies should be the vehicle for developing such a plan. A lead agency should be identified to provide a coordinating role.

The program developed by the committee should include the following:

- O & M responsibilities for each agency
- Procedures and project logs
- Training needs
- Maintenance support contracts
- Equipment inventory
- Staffing requirements

These multijurisdictional arrangements also will likely need an interjurisdictional maintenance agreement to provide:

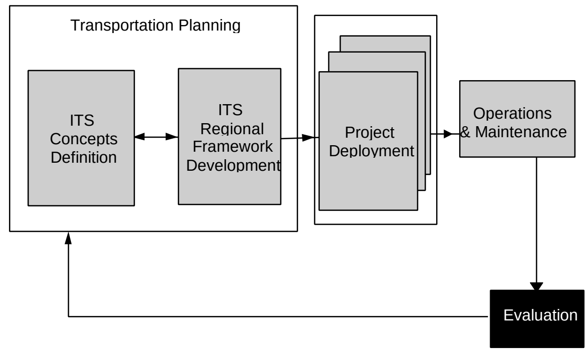
- Legal authority for one agency to perform maintenance activities on behalf of another
- Assignment of ownership
- Assignment of maintenance responsibilities
- Assignment of funding responsibilities

3.4.3 Operations and Maintenance Costs

Funding for operations and maintenance is critical and often not in enough supply. Proper planning for ITS systems can help. In planning for O & M funding, transit agencies should consider the following:

- Obtain operations and maintenance costs estimates from transit systems that have installed similar technologies and, if necessary, from technology providers.
- Consider all available funding sources. FTA provides Section 9 grants for operations and maintenance. Some agencies use local funding sources. Private sector funding (through cost sharing) may also be available if services are contracted out.
- Be sure to include potential cost offsets resulting from the implementation of ITS, such as reduced administrative costs, increased operating efficiencies, additional revenues, etc.

3.5 Evaluation



Evaluation is the next phase, after Operations and Maintenance, and the last phase in the National ITS Architecture Application Process. However, information obtained from the evaluation of the transportation system is fed back to the ITS Concepts Definition and ITS Regional Framework Developments phases (transportation planning process), thus providing a cyclical systems engineering process.

This section provides guidance on planning the evaluation of the transportation system and the means of evaluating ITS. Post-implementation evaluation of the system design and the overall framework:

- Mainstreams ITS in the transportation planning process by providing quantifiable information on performance, costs, and benefits of ITS applications.
- Assesses the degree to which stated objectives were satisfied.
- Assesses risks and/or mitigation strategies (towards architectural alignment).

To avoid conflicts of interest, evaluations should be performed by organizations or staff other than those involved with the design and implementation.

3.5.1 Evaluation

Evaluation is a crucial aspect of system implementation, involving the quantification of likely impacts and benefits that may be derived from the proposed implementation. Most ITS technologies are fairly new and still not deployed on a large scale. Consequently, it can be difficult to establish expected benefits and measures of effectiveness for the proposed system.

The National ITS Architecture, like any system architecture, should really be silent on design issues such as evaluation and quantification of benefits, since an architecture is capable of supporting multiple design approaches with varying features. However, during the course of the National ITS Architecture development program, it became clear that such issues would be central to decision-making for deployment of ITS and the National ITS Architecture. Consequently, some National ITS Architecture products go beyond architecture development and explore the application of a National ITS Architecture-compatible design to three hypothetical scenarios -- an urban, inter-urban, and rural design. Therefore the National ITS Architecture provides some useful guidance and methodology to help with this problem in the products associated with the evaluatory design, performance and benefits analysis, and

★ **Useful National ITS Architecture documents: Evaluatory Design, Performance and Benefits Study, Evaluation Results** evaluation of the design.

The above documents provide information on anticipated benefits of a range of Market Packages applicable to transit and provide comprehensive methodology for evaluating a proposed implementation. One of the key elements of the approach is the establishment of a range of measures of effectiveness (MOEs) for each group of technologies or Market Package. The MOEs are then used as yardsticks in the evaluation of system performance. A range of MOEs has been identified in the National ITS Architecture products. Here are some that may be particularly appropriate to transit. They may not include all the MOEs that represent stakeholders' interests and concerns (e.g., user's satisfaction) identified in the ITS Concepts Definition step.

- Number of Transit Rides per Year (# rides/year)
  Data Requirements: Boarding and alighting counts
  Data Collection Method: Transit gate records
- Transit Vehicle Occupancy (Average # of people/transit vehicle)
  Data Requirements: Transit vehicle trip data, passenger trip data
  Data Collection Method: Transit agency records
- Transit Revenue ($)
  Data Requirements: Fare-box data
  Data Collection Method: Transit agency records
- Number of Transit Routes Served (# of routes)
  Data Requirements: Transit routing data
  Data Collection Method: Transit agency records
- Transit Hours of Operation (# hours per day)
  Data Requirements: Transit hours of operation information
  Data Collection Method: Transit agency records
- Modal Split (% travelers per mode)
  Data Requirements: Vehicle counts and transit data
  Data Collection Method: Department of Transportation and transit agency records
- Number of Accidents (# of transit related accidents per year)
  Data Requirements: Accident records
  Data Collection Method: Police records, insurance records
- Travel Times (minutes)
  Data Requirements: Probe vehicle data, travel times by segment
  Data Collection Method: Travel time studies
- Person Throughput (persons/hour)
  Data Requirements: Vehicle counts, average vehicle occupancy, traffic flow data

Data Collection Method: Vehicle count studies

- Queue Lengths (# of persons in queue)

  Data Requirements: Number of patrons in line at ticketing facilities, turnstiles, bus stops, or train loading areas

  Data Collection Method: Queuing studies

- Headway (minutes between transit vehicles)

  Data Requirements: Transit vehicle location data

  Data Collection Method: Schedule evaluation, Headway study

- Total Annual Transit Miles (# miles/year)

  Data Requirements: Transit vehicle data

  Data Collection Method: Transit vehicle records

Other MOEs may be defined under the following categories:

- Ease of use
- Person throughput
- VMT per person trip
- Miles traveled
- Average vehicle ridership
- Number of communities served
- Environmental impacts (noise/emissions)
- Number of businesses and residents displaced
- Travel time reliability
- Profit / loss

An evaluation plan should be developed for the proposed implementation. This could be based on the model approach taken in the National ITS Architecture products, with some customization for local context. The plan should identify the major elements of the proposed system, in terms of Market Package descriptions, describe the anticipated benefits to be derived from each Market Package both individually and collectively, and explain the proposed data collection and evaluation approach to be taken, both during and after implementation. The National ITS Architecture products previously listed provide both an information source and a guide to possible methodology.

It is particularly important that the evaluation plan be developed **concurrently** with the framework definition and design process. Difficulties encountered in developing the evaluation plan, such as an inability to clearly quantify likely benefits or difficulty in measuring effectiveness of Market Packages, may lead to a desire to revise both the framework and the subsequent design. If the evaluation plan is developed at a later time, then this option may no longer be open, possibly leading to a sub-optimal implementation.

4. Alignment With The National ITS Architecture

It is advantageous for projects to align with the National ITS Architecture. Steps that are needed in order to determine alignment as well as the degree of alignment will depend on when a system is implemented. In simple terms, alignment (also referred to as conformance) with the National ITS Architecture means how closely an implementation agrees with the National ITS Architecture. In the short term, and fundamentally, it refers to general alignment with the National ITS Architecture's high-level description of interfaces and subsystems. Over time, the definitions of these interfaces and subsystems will become more detailed and precise as standards are developed.

This section explains what is meant by National ITS Architecture alignment, both in the near term and long term. It describes how a transportation agency can align with a regional ITS framework that is based on the National ITS Architecture. It also describes how a transportation agency can align with the National ITS Architecture today, prior to the development of a regional ITS framework (that is based on the National ITS Architecture) by presenting a quick reference National ITS Architecture alignment process.

In the near term, alignment with the National ITS Architecture is fairly loosely defined. It means using the National ITS Architecture framework as guidance in designing and deploying systems. It does not entail a strict, literal adoption of every word and concept in the National ITS Architecture. In general, it means that a subsystem or device:

- Supports some subset of the functions defined for that subsystem in the National ITS Architecture.
- Supports the data flows relevant to the included functions defined for that subsystem in the National ITS Architecture.
- Uses open system interface standards wherever they exist.

Additional means of alignment include the use of User Services, Market Packages, Equipment Packages, and communications technology media outlined in the National ITS Architecture.

The National ITS Architecture is very open and flexible, so most deployments will fit. However, some general categories of non-alignment include the following:

- Allocating the wrong functions to the wrong subsystems.
- Leaving out an interface without any appropriate rationale or justification.
- Leaving out a key data flow.
- Incorporating functions in the software design, but not including an open interface to communicate to other subsystems.

An example of non-alignment is the design of a transit management subsystem without providing a potential growth path for incorporating an interface to a traffic management subsystem. If, in the future, you decide to add a traffic management subsystem interface, major modifications would have to be made to the hardware and software in your transit management subsystem.

In the long term, the interfaces and subsystems identified in the National ITS Architecture will become more specific as standards are developed. As these standards are developed, the high-level definitions of the data flows and interfaces will gradually be replaced with references to the appropriate standards. At this stage, alignment is much more than just a simple existence of an interface; it entails the application of the recommended standard(s) for the interface, and that the technical details specified within the standard are being implemented. Conformance at this stage can be much more precisely defined and is technically verifiable.

The following three cases, concerning National ITS Architecture alignment, are discussed in detail next:

- Existing systems
- Pre-standardization new systems
- Standardized New systems

4.1 Alignment With The National ITS Architecture - Existing Systems

A very important consideration in alignment with the National ITS Architecture is the incorporation of existing, or legacy, systems. The benefits to be derived by deploying ITS as soon as possible, even if only in an interim or partial form, ensures that deployment proceeds concurrently with top-down architecture definition and development. Many ITS deployments predate the National ITS Architecture, taking no account of the new body of knowledge generated by the program, and consequently bear little or no relation to the National ITS Architecture. Immediate alignment or compatibility could only be achieved through a traumatic and abrupt change in deployment plans and abandonment of significant investment in deployed systems.

Consequently, a more productive approach is to view the National ITS Architecture as a future convergence point that has been very carefully researched and defined. Having identified this future milestone, it is then possible to plot a gradual course towards full compatibility and alignment over a period of time. This will enable future planning to take full account of the National ITS Architecture, while allowing existing systems to complete their life cycle and produce benefits.

Therefore, in instances where existing transportation systems, which predate the standard are installed and working, there will not be a real incentive to upgrade the system solely to achieve national inter-operability. Moreover, some of the standards still under development will take several years to complete. However, over time, such systems will be upgraded or replaced for other reasons, at which time standards-compliant systems will likely be implemented. In general, there may be no requirement to replace or retrofit existing systems that are not being upgraded or replaced for other reasons.

4.2 Alignment With The National ITS Architecture - Pre-Standardization New Systems

Setting standards during periods of rapid technological change can entail certain risks. Early adoption of existing standards, while it can ensure inter-operability, can also lock the system into dated products. For this reason, the National ITS Architecture identifies those areas that are candidates for standards and encourages the appropriate processes to ensure that the standards are developed in a fair and time-appropriate manner.

Even when facilitated, the standards development process time may well be measured in years rather than months. Characteristically, there are early adopters who deploy systems as soon as implementation becomes feasible, usually some time before mature standards for the system are available. These early adopters are spurred by a pressing problem that the implementation will address and are instrumental to furthering understanding. These pioneer deployments also often directly influence the standards that are ultimately developed. Consideration must be given to bridge from these early implementations to the more inter-operable, compatible, and interchangeable implementations that will be enabled by the standard.

There are several different ways to accommodate existing systems while incorporating new standards into the transportation system:

- Take the existing implementations into account in developing the new standard. By maintaining backwards compatibility within the new standard, graceful transition to new implementations is supported while preserving existing investments. This approach invariably incurs complexity, cost, and/or performance penalties in the backwards compatible products. This approach is normally only applicable when existing implementations are fairly uniform and can be enumerated and factored into the new standard.
- Operate parallel implementations during some reasonable transition period. This approach allows the new standard to have minimal overhead but does inherently limit the transition period. This approach requires the existing and new systems to be non-interfering or for the installation to preclude interference between old and new systems.

4.3 Alignment With The National ITS Architecture - Standardized New Systems

Given the availability of appropriate standards for ITS, the next step is to ensure that the standards are applied in transportation system implementations. For a standard to be adopted and used, the implementor must: 1) be aware of the standards, 2) have access to products that support the standard, and 3) must feel that the long-term benefits associated with adopting the standards outweigh any up-front costs associated with designing a new system.

It is important that information regarding emerging ITS standards be made available to practitioners in transportation. Outreach, education, and training are all important to promote early awareness of emerging ITS standards. This awareness may encourage participation in the standards development process, or at least enable practitioners to make informed procurement decisions when the standards are available.

It is largely the function of the private sector to ensure that products are available to support accepted standards. In most ways, the market will take care of itself in this regard. One unique approach that has been used to encourage adoption of the National Transportation Communications ITS Protocols (NTCIP) standard, the development of a public domain NTCIP software library to facilitate cost-effective adoption of the standard by financially strapped local governments, may be considered for other ITS standards that specifically address public infrastructure.

4.4 Quick Reference National ITS Architecture Alignment Process

There are some actions that a transit agency should take to be successful in developing and implementing Intelligent Transportation Systems that align with the National ITS Architecture. Below is a process for working towards aligning with the National ITS Architecture. Many of the items listed were provided by transit agencies that shared their experiences of developing and implementing ITS applications. A transit agency should address each action in the process; however, circumstances may exist that prevent transit agencies from performing all of the actions (i.e., a regional ITS framework may not exist). In this case, a transit agency should address as many of the action items as possible or permissible. The order in which the actions are presented is the general order in which the actions should be performed; however, some actions may be performed in parallel.

1. **Establish needs:** Establish regional transit needs and the needs of your transit system. This can be part of the ITS Concepts Definition process (discussed in Section 3.1). The identification of needs provides the means to establishing genuine solutions. From a pragmatic standpoint, ITS projects are much more likely to be approved if they address a legitimate and significant need.

2. **Develop the big picture:** Contribute to the development of an ITS framework for your region. Develop an overall view of what your transit ITS system will do and how it fits into the transportation plan (conventional and ITS) envisioned for the region. As a part of this process, determine how your transit ITS system will interact with other transportation management systems. This includes determining communications links between agencies and data to be shared, and determining who is responsible for operating the links and updating the data. Interaction with other transportation management systems will help you

develop a more powerful system that benefits from the sharing of information and coordination of transportation management policies.

2a. Identify champion(s): Identify individuals within the transit agency who will support ITS. These individuals can convince their peers of the capabilities of ITS and convince elected officials of the benefits of ITS. An ITS project is much more likely to be approved, developed, and implemented if senior managers, transit board members, and others who have decision-making powers support ITS.

2b. Communicate and coordinate with other agencies: Inter-agency communication and coordination is essential throughout the development and operation of an ITS system.

In the research/pre-planning stage of an APTS project, a transit agency should communicate with other transit agencies (throughout the nation) that have developed and deployed APTS applications similar to those being proposed. A great deal of knowledge can be gained by communicating with these agencies. Communication provides a catalyst for learning about the proposed APTS application, and can save an agency time and money in correcting needless mistakes.

Interagency cooperation is essential to maximize the benefits of ITS. A transit agency needs to communicate and coordinate with other agencies/organizations during planning, design, and operations of an APTS system. Communication is essential during the planning and design stages of a project, especially if the application is to interface or be integrated with other agencies' systems. During operations, communication and coordination is important to provide an efficient and effective regional ITS system. As discussed above, this includes sharing information with other agencies and coordinating transportation management policies. Agencies/organizations that a transit agency may need to communicate and coordinate with include the following:

- Other local transit agencies
- Traffic agencies (state DOT, counties, municipalities, etc.)
- Travel information service providers (e.g., paging companies)
- Financial institutions
- Park and ride facilities
- MPO
- FTA

For successful cooperation and interaction to occur, several issues need to be resolved:

- System ownership, operations, and maintenance
- Data ownership and upkeep (updating)

- Funding
- Cost and benefit allocations (agencies and users)
- Environmental impacts (of the transit project and the non-transit alternatives)
- Liability
- Patents
- Privacy
- Security
- Education and staffing
- Regulatory constraints

These issues need to be addressed **early** in the development process. High level support is typically the best method of developing support throughout the agencies. Once the institutional and technical issues have been determined and resolved, joint development of requirements or procurement of systems may occur.

2c. Communicate and coordinate with other departments within the transit agency: It is very important to frequently communicate with other departments within your transit agency during all phases of an ITS project. It is especially important to include the system end users (operators and maintainers). They should provide input during planning, project design, procurement, and implementation. In other words, a transit agency should practice total quality management (TQM). At a minimum, the departments that perform the following functions should coordinate with each other:

- Planning and Development
- Finance and Accounting
- Engineering
- Management Information Systems
- Operations
- Maintenance

3. Define requirements: Determine the services your transit agency will provide before developing a design and determining components to be implemented. In other words, at this stage determine *what* your system is to do rather than *how* it should do it. Identifying the requirements of the system early on in the development process will save your transit agency substantial time and money in the long run.

3a. Conduct research: Conduct research on ITS and technologies available for transit use. This includes communicating with organizations involved with ITS, such as academic, research, and consulting organizations, and other transit agencies that have experience with ITS. It also includes reviewing current literature on ITS and attending ITS workshops and conferences. Research allows agencies to be better informed on the capabilities and benefits of ITS. Research also allows agencies to be better prepared for developing and implementing their ITS projects.

3b. Identify potential for interoperability and synergy: Identify applications of your system that have potential to operate with other ITS applications. In particular, identify those ITS applications that, when combined, provide synergy -- for example, providing additional green time for buses running behind schedule (combining AVL and traffic signal priority).

3c. Consider legacy systems: Conduct an inventory of your transit agency's legacy systems (e.g., customer information system) and determine how those systems fit into the big picture. In addition, identify interfaces between legacy systems and future ITS applications. Whenever possible, use existing equipment. For example, use the existing radio system if it is capable of relaying AVL data adequately between buses and the control center. Legacy systems include conventional and ITS systems that exist or are proposed.

4. Determine system design: Design your system based on the requirements established. Use modular open systems. Physical interfaces must be considered and the data that will be sent to systems.

4a. Design modular, open systems: When designing your system, use open standards to ensure compatibility and interoperability at interfaces. It is important that the interfaces between major subsystems, as defined by the National ITS Architecture, are open and not proprietary. One way to find out if an interface is open is to ask the vendor for a copy of the interface standard. The standard is typically open if the documentation for the interface is provided free or at a low cost. Another indication of openness is whether the standard is maintained by a Standards Development Organization, such as IEEE, SAE, ITE, and AASHTO.

The use of open standards reduces system costs and provides flexibility by allowing system components to be purchased off the shelf. Consider existing standards, such as SAE J1708, and those being developed or planned, such as the Transit Communications Interface Protocol (TCIP). Make sure the open standard you intend to use is generally accepted by the user community. There may be good technical reasons for preferring one standard over another. Refer to Section 3.3.2 and Appendix A for more information on standards for transit ITS.

4b. Identify physical interfaces and data flows: Your transit agency's ITS system will need to exchange information between its subsystems and with subsystems of other agencies. Information exchange reduces or eliminates the need for each agency to collect identical transportation information. In addition, there are benefits for agencies to provide information from their systems to each other, particularly when major accidents occur. Therefore, identify subsystem interfaces and data flows between subsystems. Accommodate potential future data flows identified in the

National ITS Architecture to ensure that the system will be open and able to be expanded in the future. This is especially important for interoperability and synergy of systems.

5. **Determine costs:** As a tool to assist implementors, the National ITS Architecture has estimated unit costs for ITS components. This assists in determining the capital costs that may be encountered as well as the costs for maintenance. In addition, many transit agencies have recommended using the bidding process as a means to determining costs.

6. **Identify alternative funding:** Identify areas of your transit ITS systems that have the potential for public/public partnerships, public/private partnerships, and privatization. An additional mechanism for funding is the sale of transit data, such as real-time vehicle location data, to private information service providers who may add value to the data and sell it to travelers. Also, revenue may be gained through advertising at various locations such as on buses and at kiosks.

7. **Procure with respect to the National ITS Architecture:** When procuring equipment for an ITS system, align with the National ITS Architecture. Consider using National ITS Architecture materials in RFPs, such as Logical Architecture flows, Physical Architecture flows, Market Packages, equipment packages, and national ITS Architecture recommended communications technologies. As mentioned above, use existing standards, and consider using developing/planned standards at interfaces that require standardization as discussed in the National ITS Architecture. Procuring with respect to the National ITS Architecture will reduce costs, reduce risks, and ensure system compatibility and interoperability.

8. **Allocate funding to education and training:** It is very important that personnel be technically qualified to operate and maintain the transit ITS system properly. This may require hiring additional staff or educating and training the current staff to use and maintain the new equipment. For large and complex systems, it may be wise to have a systems manager oversee the system.

9. **Revise the big picture based on implementation experience:** Once a project is implemented, revisit the overall picture and modify it based on experience and lessons learned. This ensures that the overall plan does not become stagnant and out of date. Experiences that several transit agencies have gained, and lessons they have learned from developing and deploying ITS, are provided throughout the remainder of this document.

5. Best Practices / Lessons Learned

This section provides a summary of the lessons transit agencies learned while developing and deploying ITS projects, and some of the best practices that they recommend. These best practices and lessons learned are organized and presented according to the following functions:

- Project planning and development
- Project approval and funding
- Project design
- Project management
- Procurement and implementation
- Operations and maintenance

Information contained in this section was obtained through a series of phone interviews and site visits with agencies in the transit community that are involved with transit ITS projects.

5.1 Project Planning and Development

The agencies interviewed provided the following consensus of the general requirements that should be kept in mind when planning ITS for transit applications:

- Identify the agencies' needs
- Develop a long range plan
- Start educating all participating parties
- Communicate with other transit agencies

5.1.1 Determining Needs

Transit agencies are in the business of providing a transportation mode for their city and/or region. The transit system should be a safe, effective system that is affordable to the passenger. Every transit system is different based on their number of vehicles, area of coverage, and focus of operation. Also, of the myriad of transit ITS applications available, not all agencies will want and or need to implement a full scale system. Therefore, when deciding to deploy transit ITS applications, it is important that the agency first determine their needs. Here are some lessons learned by transit agencies on how to determine their needs:

- The Metropolitan Transit Authority for the New York City Region has developed a vision and goals document, which outlines their needs.
- King County DOT's Metro Transit Division in Washington State was spending $4 million a year collecting fares. Consequently, they decided an automated fare payment system may be a way to reduce the fare collection cost.

- While wanting to add an AVL system and needing to replace their computer-aided dispatch system and radio system, Portland's TRI-MET determined that at a minimal extra cost, an AVL system could be added.

5.1.2 Developing a Long Range Plan

Transit agencies need to develop long term plans for implementing ITS applications based on their needs assessment. The current emphasis in transportation is to provide a seamless transportation system that allows integration with the transit systems themselves and also with other modes. Most agencies only have local plans. The metropolitan planning agencies in many areas have also noted that there is a reluctance to develop a regional plan because many agencies have too many pressing local concerns. In spite of the general reluctance, the following agencies are moving towards regional coordination:

- The Gary-Chicago-Milwaukee ITS Priority Corridor has developed a forum for transit agencies to determine the regional transit needs.
- The Portland area developed a regional plan in an attempt to become one of the ITS Model Deployment Initiative Sites.
- TravInfo, in the San Francisco Bay Area is a regional transportation information system.

5.1.3 Start To Educate

It is never too early to start educating about ITS. Educating your agency, from the maintenance personnel and operators to the decision makers is a must. Planning an ITS project in-house can be challenging due to the technical nature, but with proper education, the agency will be able to avoid resistance. Transit agencies are particularly concerned about the resources (both staffing and funding) required to operate and maintain new and advanced equipment.

Many agencies identified that it was very difficult to conduct an analysis of the potential benefits of the system. Most of the technologies that support the system are relatively new, and thus unproven. This can become a major problem when attempting to justify the system to decision makers. ITS may be a logical and beneficial solution for the transit operator, but not necessarily for the decision makers. On the other hand, success stories would help convince these decision makers to consider ITS seriously.

5.1.4 Communication

Communication with other transit agencies is also critical to effectively develop, implement, and operate ITS applications. Agencies operating transit ITS can provide the most current information available, as well as identify challenges and problems to avoid. Site visits are encouraged, because this will provide the agency with the opportunity to observe the performance of a comparable system that has already been deployed. Examining other systems that have been deployed may also help to define and quantify the system needs, which will be beneficial when it is time to propose the project to the decision makers.

5.2 Project Approval and Funding

After the project planning and development stage, the next step towards beginning a transit project is to obtain approval and funding. The lessons learned and best practices determined from the site visits and phone interviews have been used to develop advice on the following:

- Obtaining funding
- Identifying benefits
- Proposing a project approval process

5.2.1 Obtaining Funding

One of the difficulties the transit community has with approving ITS projects, is that there is a shortage of funding. In general, funding sources are limited for both the provision of basic services, as well as for ITS projects. Factors that contribute to this challenge include the following:

- A significant backlog of traditional non-ITS projects exists which compete with ITS for funding.
- Starting new projects is generally a last priority as maintaining and purchasing new buses is always a higher priority.
- Benefits information for ITS projects is not readily available.
- Most agencies indicated that obtaining funding is a piecemeal process where funding is not secured through one dedicated source. Agencies also indicated that all of the funding required for a given project may not be available when the project is initiated.
- Determining what sources are available for funding is crucial to project implementation. Through the use of several sources, many projects can find the appropriate funds for implementation. Potential funding sources for transit ITS applications include the following:
  - Federal aid through the National Highway System (NHS) funds
  - Surface Transportation Program (STP) funds
  - Congestion Mitigation and Air Quality Improvement (CMAQ) sources
  - Federal Transit Administration grants (Section 3, Section 9)
  - State and local funds (grants)
  - Privatization projects (public/private partnerships)
  - Sale or lease of right-of-way for communications

Other factors that were identified as affecting the acquisition of funding include the following:

- The acquisition of federal funding is easier if the transit agency can secure private sector participation.
- The higher the federal match, the more likely the project will be included in the capital improvements program.

- ITS projects generally get more favorable matching ratios.
- Practical projects are more likely to receive funding than spectacular projects.
- Procurement laws may prohibit seeking private sector funds or participating in partnerships.

5.2.2 Identifying Benefits

Even if funding is available, transit agencies will have several different projects with which to spend the funds. Therefore, it is necessary to identify quantifiable benefits of transit-related ITS projects. Quantifiable benefits are recognized by transit agencies as a very useful tool for justifying significant expenditures to decision makers. In order for the funding to be approved for ITS projects, decision makers must “buy into” the project. Transit agencies need to publish their benefits, so that other agencies can prosper. Refer to the *ITS Deployment Guidelines for Transit Systems Executive Edition* for more information on ITS benefits.

5.2.3 Approval Process

Based on interviews with transit managers who have or plan to deploy ITS systems, we have identified a general process for ITS project approval. This process is merely illustrative of how a transit agency might go about obtaining approval for an ITS transit project. It should be modified to conform with the specific needs and processes of individual properties. Below are some recommended strategies for ITS project approval:

1) **Identify agency needs.** Transit properties should clearly identify its needs and the needs of its customers, then determine to what extent transit ITS projects can meet those needs (see also Section 3.1).
2) **Visit sites with operating transit ITS applications.** By seeing how transit ITS projects work during real world situations, agencies will be able to identify what applications will best suite their needs.
3) **Estimate costs and benefits.** Transit properties should conduct cost/benefit analyses of proposed transit ITS projects. Included in this estimate should be capital costs, operations and maintenance expenses, etc. In addition, the savings gained from the project, the potential for increased revenue, and the opportunities for cost sharing with other public partners or with the private sector should be evaluated as well (see also Sections 3.2.3, 3.2.6, and 3.4.3).
4) **Obtain internal agency support.** Transit managers should solicit internal agency support for the project and coordinate with other departments within the agency for project approval and implementation. Educate key personnel in the agency about ITS. Take decision makers on site visits to show them first hand benefits of the applications. This will demonstrate the value of the project to the transit agency as well as help to speed approval of the project (see also Section 3.1).

   The following is a checklist of key points that need to be addressed in the project development process to build support and gain approval for transit ITS projects. This checklist should also be used to insure that good transportation systems engineering practices are conducted.

- Does the project relate to overall goals of the agency?
- Are the objectives clearly defined (definitions of success)?
- How does the project contribute towards fulfilling goals, objectives, and needs?
- Are legacy systems taken into account?
- Is the system expandable?
- Is the system not locked into outdated technologies?
- Will the system integrate and share components/information with other systems?
- How much will the project cost (capital, operation, and maintenance)?
- What are future possibilities for adding to the system?
- What benefits will result from the project? What are the negative impacts?
- Who will be impacted? How soon and for how long?
- How long after implementation will it take to see a positive result?
- What risks are involved in implementing the system?
- Is there a firm understanding of the technologies used and the interaction between them?
- Does the project align with the National ITS Architecture?
- If the project does not totally or immediately align with the National ITS Architecture, is the path for future migration toward alignment specified satisfactorily?
- Do the costs and benefits of the project compare favorably with those of other competing projects?

5) **Identify funding source(s).** Transit properties should identify all available funding sources. These include FTA grants, other federal aid, state transportation funds, agency revenues from fares, cost sharing opportunities with other transportation agencies, and partnerships with the private sector. Potential revenue streams also should be identified.
6) **Coordinate with other agencies.** Transit agencies may be able to increase support for a transit ITS project, and potentially reduce their direct costs for such a project, by engaging in coordinated, multiagency projects. Even in projects implemented solely by the transit property, coordination with other agencies affected by the project will also help to ensure that the project is fully integrated into the overall transportation system and that the equipment is compatible with systems already in place (see also Section 3.1).
7) **Leverage private sector involvement.** Private sector involvement in ITS projects can achieve several objectives. **First,** it may help to reduce costs to the transit agencies through public/private partnerships and other cost sharing arrangements. **Second,** private sector involvement may assist the agency in operating and maintaining ITS

systems. **Third,** private firms may bring a range of creative options on how to implement the project, potentially saving the agency time and money (see also Sections 3.1, 3.2.6, and 3.2.8).

8) **Find a champion.** An articulate, high-level agency executive or member of the transit board who supports the project can go a long way in advancing the proposal. Champions can also build support across the agency and potentially with other transportation agencies to better the project's chances for approval (see also Section 4.4).
9) **Make the project necessary.** Characterize the project as a necessary improvement to the existing system which can improve operating efficiency and reduce costs, rather than as something "new". This characterization can minimize anxiety and increase support for the project.

5.3 Project Design

The agencies interviewed provided a consensus of the following general requirements that should be considered when designing an ITS system for transit applications:

- Design for agency needs, not desires
- Use standards
- Coordinate between systems and agencies
- Determine design options and trade-offs
- Beware of other design issues

5.3.1 Design For Needs

Several of the agencies recognized the importance of considering the long-term implications in systems design. An agency must first determine what the system should do, and then analyze the system to determine if it is what the agency really needs. In order to accurately determine the needs of the system, project stakeholders must be involved in the design process and understand and accommodate each other.

5.3.2 Use Standards

Agencies emphasized that system designs remain current by utilizing standards that prevent obsolescence. However, the lack of an overall standard for the transit industry was recognized as a major problem for most of the agencies interviewed. The transit industry has subsequently embraced the SAE J1708/J1587 standard for buses and recommends that the J1708/J1587 standard be used for the design and procurement of transit ITS. Some agencies are using standards from other countries (e.g., German VDV) to overcome this challenge. TCIP is expected to address the lack of standards within two years. For information on TCIP and other ITS standards, refer to Section 3.3.2 and Appendix A.

The J1708/J1587 standard for wiring buses and for communication protocols was not available to the Milwaukee County Transit System at the start of the AVL project. Now, Milwaukee County Transit wants to add automated passenger counters to their system. The J1708 standard is now available, so the County is currently negotiating with the vendor to retrofit the buses to meet the J1708/J1587 standard.

5.3.3 Coordinate Between Systems

The first step towards coordination is to involve as many departments within the agency as possible (planning and development, finance and accounting, engineering, management information systems, operations, maintenance, etc.), especially end users (operators, mechanics, etc.). When designing systems it is important to determine what systems are interdependent. For example, the King County DOT, Metro Transit Division in Washington State redesigned their geographic information system as part of a new corporate distribution database. The new database provides information for many of the current transit ITS applications.

It is also important to coordinate with other agencies in the region. TRI-MET has an ongoing understanding with the City of Portland DOT, that if they can provide quantifiable benefits for signal priority, then the City will work with TRI-MET to implement a signal priority system in the region. Chicago PACE has implemented their buses with the same sort of fare collection equipment as has the Chicago Transit Authority, so that in the future the systems will be compatible.

5.3.4 Design Options and Trade-offs

5.3.4.1 Design Option and Trade-off Evaluation Criteria

Information concerning ITS design options and trade-offs was obtained from several transit agencies involved with transit ITS projects. The following general guidelines are recommended by the agencies for consideration when evaluating design options and trade-offs:

- The agency should reach an in-house consensus on trade-offs.
- Design trade-offs should be considered early in the design process.
- Design trade-offs should be considered a continuous process.
- Trade-off process should be kept in tune with the approval and budget process.

5.3.4.2 Design Option and Trade-off Factors

The following factors were identified as general considerations when evaluating trade-offs between one design and another:

- System costs
- Availability of standards

- Anticipated level of maintenance required
- System features
- Identify bells and whistles versus necessary functions
- Ability to integrate additional features later
- Compatibility with existing equipment

5.3.4.3 Design Option and Trade-off Examples

- One agency had initially planned to equip an entire fleet with an AVL system. Subsequently the agency decided that it wanted additional transit ITS applications such as traveler information, automatic passenger counters, annunciators, in addition to an AVL system that the agency considered as a "superbus". However, the agency realized it would not be able to afford to deploy these applications on all of its buses. As a result, a trade-off with AVL was made to implement on only a third of the buses and to implement annunciators and passenger counters on a fraction of those buses.
- Another agency stated that it engaged in a process of risk analysis when determining whether to replace the current radio system with a similar system, or install a broad, advanced radio system. The agency recognized that the process of evaluating trade-offs was not completed early enough in the project. It should have been initiated in the early phases of project development.
- One agency considered compatibility with existing equipment when evaluating design trade-offs, as well as considering different technologies to support the system. For example, the agency considered GPS, LORAN, and the signpost method for their AVL system. The agency was aware that during that time using GPS for AVL was still relatively new, and that LORAN and signpost technologies were more reliable. However, the agency speculated that GPS would be the technology of choice in the future, and that LORAN and the signpost method would become obsolete.
- As a result of analyzing system costs, available standards, maintenance requirements, and the ability to add additional features to the system, one agency decided to drop in-vehicle signs, and a computer system that would scan and analyze data received from the system.

5.3.5 Other Design Issues

Several of the agencies interviewed identified issues relating to contractors responsible for system design:

- Vendors may make promises that they are not capable of delivering.
- System design will usually take longer than estimated. One agency recommended to take adequate time in designing a system so that it fully meets the needs of the user (i.e. make the schedule flexible). It is more important to have system that works correctly, but was a little behind schedule, than it is to have a system that was delivered on time, but does not provide the desired performance level.

- Vendors must furnish all of the detailed supporting/supplementary/interface documentation that is available on the products/hardware/software. This is necessary to ensure that the system will not become obsolete if the vendor goes out of business.
- Design/build contracts are an appropriate approach to designing and deploying ITS projects.

5.4 Project Management

The agencies interviewed shared their experiences on the management of ITS projects:

- Cooperation and communication among all stakeholders is critical to a project's success.
- Project schedule adherence is difficult, especially with ITS where many of the projects have never been developed or implemented.
- Everything should be documented.

5.4.1 Cooperation and Communication

The project manager needs to stress coordination and cooperation of all parties involved in a project. One agency stated that the project management effort required to manage such large and complex projects (like ITS) is often underestimated. The amount of project management required increases significantly when other parties outside the agency are involved. The agency stated that managing outside parties with a single project manager is very difficult. A project manager must be flexible in scheduling when involving parties outside the agency. Vendors are typically optimistic with their schedules for software development.

Transit agencies emphasized the importance of communicating with other agencies that have deployed similar projects to identify management techniques that have been successful for these agencies. Each project participant's expectations need to be fully understood.

Several agencies stated that it is critical to match the correct personnel with the assignment. For ITS, there is a shift from traditional civil engineering projects to electrical engineering projects. Therefore, an agency must determine if it is necessary to hire new personnel to match the needs of the ITS system, which may be a challenge in itself. Another transit agency expressed concerns about the ability of the agency to attract and retain computer personnel.

Through interviews, transit agencies provided the following critical lessons they learned from managing transit ITS projects:

- The ideal manager has skills in the following areas: planning, engineering, and operations.
- The project manager should use the matrix approach where he/she can put together a team of personnel from across the agency to work on a project. This allows for a vast amount of expertise to be used in managing the project.
- Request frequent status reports from those involved. This helps to identify any problems and also serves to document any changes.

- The scope, schedule, and budget should be flexible. As there are uncertain factors which impact the project, flexibility needs to be maintained as uncontrollable situations arise.
- The better the design, the easier the management of the project. If the design is detailed and well thought out, ambiguity is reduced, which in turn reduces the possibility of cost overruns, delays, or scope changes.
- Match the correct personnel with the assignment. If applicable, hire someone who has expertise or use a consulting firm to oversee the management of the project and the field implementation.

5.4.2 Scheduling

The project schedule incorporates and interrelates all project activities and resources, establishes activity priorities, and focuses attention on activities critical to on-time project completion. A good schedule should:

- Be realistic
- Be easily communicated and understood
- Be practical
- Be pertinent to the user
- Be flexible, easy to update, and change
- Have the commitment of the project team
- Show task interrelationships
- Be kept on a calendar basis
- Include review and correction time
- Allow for activities beyond the contractual due date
- Show the critical path
- Show when inputs are needed

5.4.3 Document Everything

By documenting all conversations, meetings, and expectations, the project management task will become easier. The Milwaukee County Transit System developed an action list and updated the action list after every meeting and phone conversation. The action list was made available to all participating parties.

5.5 Procurement and Implementation

The major lessons learned on procurement and implementation are as follows:

- Understand the system
- Evaluate procurement and implementation options

- Plan ahead

5.5.1 Understand the System

The agencies that were interviewed identified the following critical issues relating to understanding procurement and implementation issues:

- Technical issues must be considered when procuring and implementing ITS.
- Coordination needs to exist among all those affected, both decision makers and users.
- When procuring ITS projects, it helps to have a firm understanding of all the levels of the approval process.
- Use of existing or available standards is critical and should be stated in the RFP.
- Know exactly what you want and be as clear as possible when dealing with vendors. This will help to reduce ambiguity.
- Negotiate during the procurement process to get exactly what you want. This will provide an opportunity to further evaluate the credentials of the vendors and also another opportunity to educate the vendors about the transit environment.

One agency stated that before a transit agency engages in a project, it should do considerable research. It should obtain input internally from several departments, especially where end users are concerned. It is also important to get warranties on systems. In addition, when procuring and implementing transit related ITS projects, it is best to use proven technologies that will effectively keep projects simple and focus on the practical functions of the system.

5.5.2 Evaluate Procurement and Implementation Options

The agencies surveyed suggested that **one system integrator should be hired.** The advantages of one system integrator, is that there is only one company that is responsible for the entire system. If there are delays due to one companies' efforts, the transit agency will not have to negotiate change orders with other companies who may become affected.

Many agencies have stated that **using a phased implementation has been very helpful.** The phased approach allows the agency to test the system on a portion of their fleet before expanding to the whole system. This allows the agency to establish operations and maintenance procedures and gives time for the operators and maintainers to become familiar with the technology that is new to them. It also provides a means to gather benefits information that can be used to prove the usefulness of the system to decision makers when it is time to expand and or enhance the system.

Transit agencies also stated that when evaluating proposals that more weight should be awarded to vendors that are implementing proven technology. Transit agencies noted that many vendors do not understand the transit operating environment. Therefore, vendors need to be able to illustrate their ability to develop and implement the system they are proposing.

5.5.3 Plan Ahead

Many transit ITS projects include software systems. In order to easily modify and expand the system it will be beneficial for transit agencies to obtain the source code.

- TRI-MET had the source code placed in escrow, so that if the vendor went out of business or was deemed to be providing unfair maintenance costs, TRI-MET would be able to obtain the source code.
- The Chicago Transit Authority was able to place wording in their contract stating that the source code would be available to the CTA and other third party vendors (deemed not to be competitors).

All vendors should have a quality assurance program in place. The program should state how systems will be tested both in-house and in the field. The program should also identify maintenance procedures and when possible mean time between failure information for equipment.

The Milwaukee County Transit system is planning for future ITS applications to be added to their buses. Therefore, they are only purchasing buses with the wiring for these applications already installed. The agency stated that the up-front cost for wiring the buses is significantly cheaper than wiring the buses at a later date.

5.6 Operations and Maintenance

The agencies that were interviewed identified the following critical elements in operations and maintenance:

- Staffing and training
- Funding
- Software

5.6.1 Staffing and Training

Transit agencies stated that the **staffing requirements for ITS applications need to be considered.** The agencies stated that staffing is not always reduced, but is instead shifted. Computer programmers, network administrators, and electricians are now needed. Agencies need to consider how they will attract and keep these types of employees. Also, for complicated ITS applications, one contractor (a systems manager) is recommended to oversee the entire system.

Proper training of operators and technicians is also critical to the successful operation of the system. Vendors should be responsible for providing training programs for the operators. Operators manuals also need to be supplied.

5.6.2 Funding

Securing appropriate funding for operations and maintenance is critical. Prior to awarding the contract, an agency needs to make sure that funds will be available to both operate and maintain the system. Funds for maintaining in-house expertise are required. Agencies could however contract out maintenance if it is determined that the agency can not afford to keep the necessary staff in-house.

5.6.3 Software

Several agencies noted that the major costs associated with operating and maintaining ITS applications, will be in modifying software. Every time the vendor provides a software upgrade, the agency may have to go through a debugging period. Also, when agencies want to modify the system, they will need to consider software issues. Consequently, it is important that source code, which has been written to support the system, be made available to the systems manager. See section 5.5.3, Plan Ahead, for more information on lessons learned in obtaining source code.

6. How Do I Find Out More About ITS and the National ITS Architecture?

Additional information on ITS and the National ITS Architecture may be found in the following locations:

- *ITS Deployment Guidance for Transit Systems Executive Edition*. This is an accompanying volume to this document intended for transit board members and upper-level management.
- World-Wide Web at:
  - http://www.its.dot.gov
  - http://www.rockwell.com/itsarch
  - http://www.fta.dot.gov/library/technology/APTS/t_its.htm
  - http://www.fta.dot.gov/ntl/index.html and choose Intelligent Transportation System
  - http://www.itsa.org
- ITS Joint Program Office, (HVH-1), Federal Highway Administration, U.S. Department of Transportation, 400 Seventh Street SW, Washington, DC 20590; phone: 202-366-9536, fax: 202-366-3302
  - Copies of the National ITS Architecture documents are available in hard copy as a set or individually for a fee.
  - National ITS Architecture documents are also available on CD-ROM.
  - *The National ITS Architecture for ITS: A Framework for Integrated Transportation into the 21st Century.*
  - *Building the ITI: Putting the National ITS Architecture into Action*
- Office of Mobility Innovation, (TRI-10), Federal Transit Administration, U.S. Department of Transportation, 400 Seventh Street SW, Washington, DC 20590; phone: 202-366-4995
- ITS America, 400 Virginia Avenue SW, Suite 800, Washington, DC 20024; phone: 202-484-4847

6.1 Compilation of Transit Agency Contacts

The following individuals were interviewed to gain information on their experiences of developing and implementing transit ITS systems (e.g., best practices and lessons learned). The information they provided is contained in and applied throughout the *ITS Deployment Guidance for Transit Systems* documents.

AGENCY	CONTACT	PHONE NUMBER
Beaver County Transit Authority	Bruce Ahern	412-728-4255
New York City Transit	Andrew Bata	718-694-3672
King County DOT, Metro Transit Division	Catherine Bradshaw	206-684-1770
Metropolitan Atlanta Rapid Transit Authority	Catherine Conner Cannon	404-848-5493
Montgomery County, Department of Public Works and Transportation	Gene Donaldson	301-217-2190
Denver Regional Transportation District	Tom Gardner	303-299-4146
Denver Regional Transportation District	Lou Ha	303-299-6265
Ann Arbor Transportation Authority	Bill Hiller	313-677-3944
San Francisco Bay Area Metropolitan Transportation Commission	Joel Markowitz	510-464-7760
City of Phoenix, Public Transit Department	Mike Nevarez	602-262-7242
Pace Suburban Bus	John Paquet	847-228-2401
Chicago Transit Authority	Dave Phillips	312-432-8005
Milwaukee County, Department of Public Works	Ron Rutkowski	414-278-4888
ITS America	Harriet Smith	404-467-9297
Houston Metropolitan Transit Authority	Loyd Smith	713-739-3870
Houston Metropolitan Transit Authority	Gloria R. Stoppenhagen	713-881-3310
City of Winston-Salem DOT	Suzanne Tellechea	910-727-2648
Bay Area Rapid Transit District	Marcus Thint	510-287-4717
Tri-County Metropolitan Transportation District of Oregon	Ken Turner	503-238-4918

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DeBlasio, Allan J., David W. Jackson, Anne C. Tallon, Anne C. McEwan, John P. O'Donnell. 1996. Intelligent Transportation Systems Assessment of ITS Deployment, Review of Metropolitan Areas: Discussion of Crosscutting Issues. Cambridge, Massachusetts: U.S. Department of Transportation, Volpe National Transportation Systems Center. FHWA-JPO-96-0035.

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- Stephan Bruenig, Chicago Transit Authority, Chicago, IL
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- Paul Comeaux, VIA Metropolitan Transit, San Antonio, TX
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- Mike Nevarez, City of Phoenix Public Transit Department, Phoenix, AZ
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- John Paquet, Pace, Arlington Heights, IL
- Dave Phillips, Chicago Transit Authority, Chicago, IL
- Bill Reynolds, Pace, Arlington Heights, IL
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- Harriet Smith, ITS America, Atlanta, GA
- Loyd Smith, Metropolitan Transit Authority, Houston, TX
- Gloria R. Stoppenhagen, Houston Metropolitan Transit Authority, Houston, TX
- Suzanne Tellechea, City of Winston-Salem, DOT, Winston-Salem, NC
- Marcus Thint, Bay Area Rapid Transit District, Oakland, CA
- Ken Turner, Tri-County Metropolitan Transportation District of Oregon, Portland, OR

Appendix A: Standards

A.1 Overview

The intent of this appendix is to relate existing and planned standards with different applications that have been described in the main document. The need for these standards has been identified by transportation engineers and/or transit authorities.

The development, promulgation, and adoption of standards is an issue of utmost importance in the use of a new technology. Adoption of standards can have a number of different effects. On one hand, the adoption of a technology in the marketplace can be stimulated. On the other hand, the further development of a technology could be frozen. Commercial broadcast television in the United States serves as an example of both of these effects.

Early adoption of standards for commercial TV in the United States allowed for explosive growth of industry here in the immediate post-World War II years. However, U.S. technology was frozen at a level that subsequently proved to be inferior to that achieved soon after in Europe. The technology of communicating data over telephone lines provides a counter example. New standards for increasingly fast data transmission over the phone lines periodically emerge, but the new modems that capitalize on these standards also generally operate according to the old ones if such operation is needed. This capability for backward compatibility increases the flexibility for all users of a technology, thus spurring both greater adoption on the marketplace and further technological advancement.

Standards development is critical to the success of implementing ITS. Well defined standards help agencies better prepare procurement specifications, RFIs, and RFPs. These standards need to be open instead of proprietary in order to allow for new technologies to be added. Open standards are generally owned by a public organization and made available to anyone wanting the documentation for an interface. Proprietary standards have restricted access, usually to the company that developed the standard.

Utilizing standards to ensure the interchangeability of equipment will benefit the transit industry by decreasing procurement costs (larger numbers of competing manufacturers will spur competition), increase system flexibility, and provide easy upgrade paths.

Even though equipment standards are important, this section does not provide equipment-specific standards because of the vast number of different equipment technologies. In addition, the establishment of strict standards for device-specifications is not only location-dependent but it would also restrict progress and innovation, and is therefore not desirable.

A.2 Previous Work

Several organizations have been tasked, voluntarily and through contracts, to develop standards. Existing standards are generally based on the need of a particular industry or agency. Very little emphasis was given to interoperability or interchangeability of equipment using these standards. The U.S. DOT subsequently awarded a contract to the Jet Propulsion Laboratories (JPL) to serve as the lead organization to:

- Collect ITS-related standards
- Create a database
- Organize the standards in the database
- Maintain and update the database content
- Provide interested parties with the entire content or excerpts of it

The content of this database is updated continuously and it can be visited on the ITS America Internet homepage at **http://www.itsa.org/standards** under the heading "Standards Catalog".

To receive more information or the entire listing of the standards, contact:

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Member, Technical Staff
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Fax: 818-393-1993
E-mail: robert.m.barret@jpl.nasa.gov or r.barrett@ieee.org

A.3 Communication Standards

This overview of communication standards is designed to provide the reader with information on transit-related communications protocols. The communication standards presented allow agencies to transmit data from one device or system to another. Some of these standards currently exist or are very close to being completed, while others are either in an early development or planning stage.

A.3.1 Overview

A variety of standards specify communication between devices. These standards are very valid tools to determine if a particular standard of a specific interface exists. All standards are not compatible with each other.

Since many interfaces have not been standardized, the U.S. DOT funded the development effort of creating standards for ITS technologies. This development effort will also increase public safety, increase utilization of existing facilities, and ease the use of existing and planned facilities.

Some of these new standards for ITS are described below. The listing is neither complete nor does it indicate levels of importance.

A.3.1.1 NTCIP

The National Transportation Communications for ITS Protocol (NTCIP) was originally conceived to be an extension of the NEMA TS2 Controller Standard [7] covering traffic controller communications. The NEMA traffic control equipment manufacturers recognized that for true hardware interchangeability, the standard had to cover the more complex issues of systems interoperability and communications standards. As the NEMA development work grew, a general industry forum evolved and ultimately the Federal Highway Administration (FHWA) identified the concerns of ITS designers.

Today, the Joint NTCIP Committee, a steering committee consisting of members of the SDOs (NEMA, ITE, and AASHTO), is overseeing and directing all efforts with respect to NTCIP that are being executed within each of the above SDOs.

For ITS to be a reality, all the components that make up the traffic and transportation monitoring and control community must be able to communicate with a common, or at least understandable, language. The words that are spoken must have a clear and unambiguous meaning to everyone. The NTCIP development participants started out by defining a language needed for a traffic controller, and extended it to include Traffic Management Centers (TMCs). It has been further refined into an open set of protocols that meet the diverse needs of ITS.

This openness is achieved by embracing features of several existing worldwide communications standards established by the International Standards Organization (ISO), the International Telecommunications Union, Telecommunications Sector (ITU-T; formerly CCITT), and the Internet Engineering Task Force (IETF). These standards map onto the ISO Open Systems Interconnect Reference Model (OSI Model) that deals with how information can be passed through the various processing layers in an open system. The OSI Model breaks down the aspects of communications into seven layers or discrete functions to reduce complexity. Each layer is built upon its predecessor [10]. These seven layers are shown in Figure A1.

The seven layers of the RM-OSI are defined as the Physical, Data Link, Network, Transport, Session, Presentation, and Application Layers. These seven layers can be viewed as forming two groups of functionality to support open communications. The first group (Layers 1-4) is responsible for data transport while the second group (Layers 5-7) is responsible for data processing.

Layer 7	Application Layer
Layer 6	Presentation Layer
Layer 5	Session Layer
Layer 4	Transport Layer
Layer 3	Network Layer
Layer 2	Data Link Layer
Layer 1	Physical Layer

Figure A1: OSI Layers

Protocols utilized on the different layers of the OSI models are mostly existing computer standards that have been used for years within the industry. However, due to the nature of transportation infrastructures, a few new protocols and modifications to existing protocols had to be defined such as the development of the Simple Transportation Management Protocol (STMP) [8] - a new application layer protocol - and Point-to-MultiPoint Protocol (PMPP), which follows the existing PPP. PMPP has not yet been approved.

A.3.1.1.1 Class Profiles

Within the NTCIP there are various profile classes defined:

- A - Connectionless
- B - Central direct to field
- C - Connection oriented
- D - Undefined
- E - Center to Center
- F - Alternate Center-to-Center

Where defined, these classes are described below. Note, the Class B Profile is the only Class Profile that has been standardized to date.

A.3.1.1.2 Class A Profile

Class A is a suite of protocols allowing the connectionless transmission of data packets over a medium that does not require a permanent connection between two devices. For example, when sending two letters via regular mail, it cannot be ensured that both letters will take the same route (one letter might get from location A to location B via location C, while the other letter is sent via location D). The Class A Profile is based on existing protocols already in use by the Internet community and other network systems, therefore utilizing proven protocols. The only exception is the utilization of STMF [8] as the application layer protocol and the modification of the HDLC protocol to include an initial protocol identifier (IPI) as the data link layer protocol.

The Class A Profile suite of protocols will use the Transmission Control Protocol (TCP) as its Network Layer protocol to guarantee delivery or signal when a message cannot be delivered correctly. TCP uses sequence and acknowledge information and timers to make sure the individual frames are received and that they are put in their proper order. If a frame is garbled or lost, re-transmissions are attempted. If a frame cannot be delivered, the upper layer is notified. This class of service ensures data integrity and correctness; its primary use is for large data transfers.

This standard has not yet been approved but is in the process of being developed by knowledgeable device manufacturers in conjunction with users of these devices. This development process ensures that the devices utilizing this protocol will meet the requirements of the user community.

The main difference between the Class A Profile and the Class B Profile is that messages can be routed through an intermediate device, e.g., from a central location to a field device.

A.3.1.1.3 Class B Profile

The NTCIP Class B Profile [9] defines a set of communication protocols to be used in field devices and their management systems that are part of an Intelligent Transportation System. The profile provides for exchange of information between a primary station and each secondary station on a particular communications channel or subnet. The profile sets forth standards to allow devices to share a common interconnect, establish a common language for them to communicate and define the structure under which the data in these devices is structured and managed. It does not address the need for the exchange of information between devices on different subnets.

Class B provides for bandwidth efficient exchange of information between the primary station and each secondary station on the same physical link. Class B does not ensure delivery. Frames received with errors are discarded. If re-transmissions are needed, it is the responsibility of the Application Layer to provide them. This class of service is primarily intended for short command and reply messages where delivery time is a strong consideration.

The Class B Profile can be used within the transit industry to poll or transmit data to and from roadside devices such as beacon transponders, variable message signs, or traffic signal systems for transit priority. It can also be used for communicating with traveler information kiosks or similar devices. A prerequisite is the direct connection of management center and roadside device, because the Class B Profile does not allow for routing of messages. The size of the message must also be kept short; otherwise, the use of the not-yet standardized Class A or Class C Profiles should be considered.

A.3.1.1.4 Class C Profile

Class C is a profile providing connection-oriented services similar to the data transmission within the Internet. In fact, the Class C Profile includes the same protocols on the Network (using Internet Protocol or IP) and Transport (using TCP) Layers of the OSI model. This profile is not yet finalized but will probably not include the untested Simple Transportation Management Protocol (STMP), as required for the Class B and Class A Profiles. Instead, it will utilize the Simple Network Management Protocol (SNMP), TELNET, and the File Transfer Protocol (FTP), which are well-tested and implemented within the Internet and intranet networks.

Class C may seem to provide the ideal service; however, it imposes additional overhead. Before any information can be passed, a connection between the devices must be established. The connection procedure takes a certain amount of time. When the information transfer is completed, the connection must be formally closed.

The main difference between the Class C Profile and the Class B Profile is that Class C messages can be routed through an intermediate device, e.g., from a central location to a field device. Another aspect is the capability to “chop” large data files into smaller data packets (file transfer) and to sequence these packets so that they can be assembled correctly at the receiving end.

A variety of transit applications can benefit from the Class A and/or Class C Profiles. Different types of field devices, such as transponder beacons and VMS signs, from various different manufacturers could be connected to one common communications line and still be controlled and monitored from the management station. Currently, it is not possible to connect existing field devices that utilize different communications protocols to one common communications line.

A.3.1.1.5 Class E Profile

The Class E Profile specifies the suite of protocols that allows for center-to-center communications. The specification of this Profile is in a very preliminary stage and its development will probably take several years (anticipated completion date is 1999). One of the first steps in developing this standard is the definition of the Transportation Management Data Dictionary (TMDD) specifying the content of data that needs to be transmitted between management centers.

Several different existing and emerging protocols, mostly specifying the application layer protocol and ultimately influencing the underlying layers of the OSI model, are under consideration for this profile but a consensus has not been reached.

The transit industry can utilize this standard to ensure compatibility between transit management centers and between transit management and other transportation centers or service providers. Please note that the Class E Profile should not be used separately unless the data format of messages to be exchanged are known to both the transmitting and receiving management centers. As indicated before, the TMDD and the transit-related Message Sets as indicated in the bullet list under A.1.3, will provide a uniform setup of data formats and ensure future expandability of the overall regional transportation system.

A.3.1.1.6 Class F Profile

Another NTCIP compatible and NTCIP-compliant method for center-to-center communications has been introduced. The introduction of a Class F Profile took place in December 1996 but the information regarding this proposed standard development effort has not yet been specified in writing.

A.3.1.1.7 Message Sets

NTCIP utilizes message sets that define how a particular function or parameter is defined and described, and what the allowed ranges for each parameter (or objects as they are called) are. All objects have a unique name which is based on a location under a global tree. NEMA has a node (or branch) within the global tree and assigns unique names to each known and defined object. Because of the history, NEMA first tried to define signal controller objects, but detected very quickly that many objects (parameters and/or functions) are not unique to signal controller applications (e.g., time) and created another message set that contains common objects (referred to as Global Object Definitions). These message sets were finalized in Winter 1996/97 and are available from one of the NTCIP Committee members (see Table A1 below).

In addition to the message sets described in the table below, it is anticipated that additional message sets will be developed for use with the NTCIP communication Class Profiles.

Table A1: NTCIP Message Sets

Message Set Name	***Anticipated Completion Date***	***Contact***
Global object definitions	Summer 1997	Nu Rosenbohm (Viggen) 703-903-0306
Actuated Signal Controllers (ASC)	Summer 1997	Shawn Morrissey (IDC) 510-353-9415
Dynamic Message Signs (DMS, formerly known as VMS)	Spring 1997	Bob Blasi (FDS) 401-232-3370
Environmental Sensor Systems (ESS, formerly also known as RWIS)	Spring 1998	Ken Vaughn (Viggen) 703-903-0306
Highway Advisory Radio (HAR)	Summer 1997	John Wintermute (PBFI) 301-816-1837
Ramp Meters	Summer 1997	Jeff McRae (CalTrans) 916-654-3781
Video Camera Control (CCTV control)	Summer 1997	Mike Forbis (WashDOT) 206-440-4475
Advanced sensors	Fall 1998	Paul Bell (PEEK) 904-562-2253

Weigh-In-Motion (WIM)	Summer 1998	
Automated Vehicle Identification (AVI)	Spring 1999	
Bus Interface Unit (BIU)	Winter 1998/99	Earl Hoekman (3M)

A.3.1.1.8 Future Developments

NTCIP is envisioned to cover many different types of communications, and may be expanded to a Class D Profile that deals exclusively with dial-up connections. The flexibility of NTCIP achieved through following the OSI Reference Model allows the expansion to various, not yet considered communications protocols on the different layers of the OSI model. Interoperability is provided by defined interface setups (APIs) that the layer protocols are required to follow.

It is also envisioned that NTCIP will be limited to center-to-roadside and center-to-center communications, and will not be expanded into the wireless communication technology arena. To obtain information on the NTCIP Class Profiles, please contact:

Ed Seymour, Chair of the Joint NTCIP Committee
Research Engineer
Texas Transportation Institute
8180 North Central Expressway, Suite 815
Dallas, TX 75206-1827
Phone: 214-691-8124
Fax: 214-691-8172
E-mail: ejs@tamu.edu

A.3.1.2 TCIP

The Transit Communications Interface Protocols (TCIP) is a standards development effort that may consist of several suites of protocols and data message sets. TCIP's primary goal is the definition of data interfaces to both transit-related applications and the National ITS Architecture data flows. Transit-related application interfaces are anticipated to include the FTA National Transit GIS standard (under development, see below), under consideration of the Advanced Public Transit Systems (APTS) Map and Spatial Database User Requirement specifications (also under development) as well as the NTCIP, DSRC, and other standardization efforts. TCIP will be developed by addressing data flows as identified within the National ITS Architecture to the extent possible. Interfaces needed for other transit-related applications that have not been addressed will also be identified.

The TCIP development effort is expected to augment the information management area of NTCIP with transit-related information and message formats that facilitate the exchange of transit information among operations centers, transit vehicles and the infrastructure. The TCIP will provide additional NTCIP Class Profiles or subsets of existing and planned Class Profiles, and the necessary bridges for information transfer from legacy transit systems to advanced information systems developed conforming to the National ITS Architecture. The characteristics of transit information exchange may be best served, for example, by one of the five NTCIP Class Profiles, by one of the Profiles of SAE J1708, or by TCIP. However, the main focus of TCIP will be the development of message formats to exchange transit information in a standardized manner.

The TCIP effort is lead by the Institute of Transportation Engineers (ITE) and supported by a large group of technical advisors consisting of members of the transit community such as FTA, APTS, and APTA. ITE is a recognized Standard Development Organization (SDO) that was awarded a contract by a branch of the US DOT in November 1996 to develop the TCIP standard. The time frame for the TCIP development is 20 months, and ends in June 1998.

Within a short time frame (from November 1996 to mid December 1996), the following has been identified as preliminary targets for the TCIP work:

- Data flows internally and externally:
  - Internal data flows: interdepartmental within a transit property or within the different branches (remote offices), Transit Management Center (TrMC) to transit vehicles, transit kiosks, and other items such as roadside transmitters
  - External data flows: TrMC to TMC or other centers such as service providers and financial agents (e.g., credit card companies and banks)
- Static reference and dynamic data transfers:
  - Static reference data flows: for example, route and bus stop inventory, schedule, fare, and spatial data transfers
  - Dynamic data flows: for example, pre-trip itinerary planning, safety and security information, and detour and service delay data transfers

TCIP will ensure interoperability and compatibility to NTCIP and SAE J1708/J1587 by creating gateway protocols, also termed application programming interfaces (APIs).

Further information can be obtained from the following source:

Eva Lerner-Lam
President
The Palisades Consulting Group, Inc.
24 West Railroad Ave., Suite 161
Tenafly, NJ 07670
Phone: 201-567-0088
Fax: 201-567-8066
Voice Mail: 800-765-9542
E-Mail: pgi@dx.com

A.3.1.3 Vehicle Area Networks

Standards are being developed for interfacing ITS devices on transit vehicles. Currently three different standards are being applied across the United States.

A.3.1.3.1 SAE J1708 / J1587

The Society of Automotive Engineers, SAE develops recommended practices to be used for the automobile industry, including transit vehicles. SAE maintains an ITS program office to develop and promote ITS standards, not just on the national level but also internationally.

The Recommended Practice J1708/J1587 developed in October 1993 *"defines a general-purpose serial data communications link that may be utilized in heavy-duty vehicle applications [including transit vehicles]. It is intended to serve as a guide towards standard practice to promote serial communications compatibility among microcomputer-based modules [within a vehicle]. The primary use of the general-purpose communications link is expected to be the sharing of data among stand-alone modules to cost effectively enhance their operation. Communication links used to implement functions that require a dedicated communication link between specific modules may deviate from this document.*

It is recommended that a separate applications document be published by the manufacturer of each device using the serial link. These documents should define the data format, message ID's, message priorities, error detection (and correction), maximum message length, percent bus utilization, and methods of physically adding/removing units to/from the line for the particular application." (quote from SAE J1708 description)

The Recommended Practice J1587 developed in January 1994 is the extension to J1708 and *"define[s] the format of the messages and data being communicated between microprocessors used in heavy-duty vehicle applications [including transit vehicles]. It is meant to serve as a guide toward a standard practice to promote software compatibility among microprocessor-based modules. This document is to be used with SAE J1708 [, which] ... defines the requirements for the hardware and basic protocol that is needed to implement this document.*

The primary use of the communications link and message format is expected to be the sharing of data among stand-alone modules [within a vehicle]. It is anticipated that this document (when used in conjunction with SAE J1708) will reduce the cost and complexity associated with developing and maintaining software for heavy-duty vehicle microprocessor applications." (quote from SAE J1587 description)

Recommended Practice J1708, and most likely J1587, is already being used as a "quasi" standard within the transit industry (as long as the implementing or specifying transit property was aware of it) for the setup within the transit vehicles. It is anticipated that J1708 or a modified deviation will be the basis for the Vehicle Area Network (VAN) standard. The transit community strongly recommends that the J1708/J1587 standard be used for the design and procurement of transit ITS.

To obtain information on the status of these protocols please contact:

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096-0001

Phone:412-776-4970
Fax: 412-776-0790

A.3.1.3.2 LonWorks

LonWorks technology is a general purpose control networking technology developed by Echelon Corporation. LonWorks technology is designed to enable various devices to communicate across a range of media in a control network. A LonWorks technology control network utilizes the LonTalk communication protocol fully implemented in silicon and available as Neuron Chips, manufactured by Motorola and Toshiba.

Besides the LonTalk protocol, the Neuron Chip performs most of the control functions which add distributed intelligence and inter-operability to network devices. Besides the Neuron Chips, LonWorks technology provides transceivers to couple Neuron Chips to the network devices and communications media, bridges to connect separate communications media on the LonWorks network, and network management and diagnostic equipment.

A.3.1.3.3 VDV-300 IBIS

The Verband Deutscher Verkehrsunternehmen (German Association of Public Transport Operators - VDV) has developed VDV Standard 300 - Integrated on-Board Information System (IBIS). This is the VDV's own specification for a vehicle area network. The VDV-300 specification, released in January 1992, was designed as a recommendation for data processing and transmission of data in public transportation vehicles.

The VDV standard specifies a modular design with interchangeable devices. It specifies a protocol software design along with hardware operations and connections, including a central vehicle area network control unit.

A.3.1.4 Dedicated Short Range Communications (DSRC)

Dedicated Short Range Communications (DSRC) consists of short-range communications devices that are capable of transferring high rates of data over an air interface between mobile or stationary vehicles and normally stationary devices that are either mounted to structures along the roadway or are hand-held. One way of accomplishing these communications is through use of radio frequency (RF) beacons. RF beacon technology generally consists of a transponder (tag), transceiver (reader), and transceiver antenna (beacon). DSRC is also known as vehicle-roadside communications (VRC).

The National ITS Architecture program recognizes the need for DSRC systems for those specific applications that require a close physical interaction between the vehicle and the roadside infrastructure, such as in toll collection, commercial vehicle electronic clearance and roadside safety inspection, etc. However, DSRC is considered inappropriate for applications such as route guidance that can be more efficiently served by wide-area ITS communications. Because of the dedicated nature and limited range of DSRC systems, the National ITS

Architecture realizes that the costs of deploying DSRC will have to be absorbed by the ITS applications they support, including both public and private investment. The technical and applications aspects of DSRC are covered in the Communications, Physical Architecture and Theory of Operations documents produced by the National ITS Architecture program [1].

The following applications have been identified as candidates to utilize DSRC as a primary communications technique or mechanism:

- Electronic Toll and Parking Payments
- Commercial Vehicle Operations
  - International Border Clearance
  - Electronic Clearance
  - Safety Inspection
  - Automated Equipment Identification and Freight Management
  - Off-Line Verification
- Transit and Emergency Vehicle Operations
- Fleet Management
- In-Vehicle Signing
- Intersection Collision Avoidance and Automated Highway Systems
- Commercial Applications (e.g., drive-through purchases)
- Intersection Safety Warning

To support deployment of nationally, and perhaps internationally, compatible Intelligent Transportation Systems using DSRC, the ITS Joint Program Office (JPO) in the U.S. Department of Transportation issued a work order to build consensus and generate the necessary documentation to support the process for developing a dedicated short range communications standard for ITS applications, both for the near term and for the long term. PB Farradyne Inc. has been selected for this work order that will produce a concept of operations, a Migration Plan, and a Global Harmonization document to serve as the foundation for the standard setting efforts. Separate work orders were issued to begin establishing standards using the OSI Reference Model as a basis. Leading this effort are the American Society for Testing and Materials (ASTM) and Institute of Electrical and Electronic Engineers (IEEE).

A report has been prepared that functions as a Concept of Operations. It describes consensus among the user and vendor communities as to the operation of all ITS applications that require use of DSRC. This is largely based on the state of the practice, and activities underway to support integration of different applications and technologies, so that a single tag could be used for multiple applications, or tags from multiple vendors could be used for the same application. The Concept of Operations document also asserts an Integrated Concept of Operations for the state of DSRC evolution 10 years into the future.

Further information can be obtained from the following source:

Sompol Chatusripitak
PB Farradyne Inc.
3200 Tower Oaks Blvd.
Rockville, MD 20852
Phone: 301-998-6620
Fax: 301-816-1884
E-mail: chatusripitak@pbworld.com

A.3.1.5 Other Standards

The following is only an excerpt of currently initiated standards because of the number of contracts awarded by the U.S. DOT to enhance ITS Technology interoperability and compatibility. However, the listing below is viewed as a promising trend where traditional transportation entities (AASHTO, ITE), automobile manufacturing and vehicle electronic manufacturer association (SAE), and telecommunications entities (NRSC, TIA) are working together to develop standards.

SAE was awarded funding for six different standard development efforts (application for funding of one additional standard development effort was submitted but is pending approval). These are as follows:

- Location Referencing: A standard that will address route determination, address location, vehicle positioning, and route guidance applications. This standard will be developed under consideration of the current work of the Oak Ridge National Laboratories that will define a location reference message protocol.
- ITS Data Bus: An architecture reference model for in-vehicle ITS electronics, also including detailed user requirements for the ITS Data Bus, such as auto OEMs and consumer electronics. This standard will also specify protocol layers and associated protocols as well as gateway requirements. Basically, an electronic device within a vehicle will be defined that ensures plug and play functionality. Different manufacturers could build products that simply connect to this ITS Data Bus.
- FM ATIS Broadcasting: Defining specific messages to be sent over commercial FM subcarrier radio broadcasts similar to the European RDS/TMC system or the American Radio Broadcast Data (RBDS) system. This message set will be compatible with the message transmission structure, which regulates how messages are transmitted utilizing FM subcarriers. This message transmission structure standard is also under development by the National Radio Systems Committee (NRSC).
- Navigation Messages: SAE developed the Recommended Practice termed J2256 in 1995, but it is not yet field tested. The project is to field-test and debug this navigation message set and to promote it to an accepted industry standard.

- MayDay Reporting: A standard that tries to address the standardization of the message content for exchanging data between the vehicle and the response agency, the internal methods of interconnection between the MayDay system within a vehicle and other vehicle-internal systems, and the protocol to transmit data between the vehicle and the response management center.
- Navigation Human Interfaces: This effort will define a navigation and route guidance standard under consideration of human factor issues such as ease-to-learn and ease-to-use. This standard is also referred to as man-machine interface standard.
- ATIS Message Set (pending funding): Under the current proposal, the committee (SAE's International travelers information interchange standards working group [ITIIS] and AASHTO) will publish a full list of ATIS messages, an ATMS-specific ATIS message list, and requirements for a National ITS Architecture message list. The work will also include the development of three SAE standards, thereby fulfilling three of the 44 interfaces defined as high priority by the U.S. DOT. These are ATIS Message Template, ATIS Data Dictionary, and ATIS Message List.

To obtain future information on the status of these protocols please contact:

Society of Automotive Engineers
400 Commonwealth Drive
Warrendale, PA 15096-0001
Phone:412-776-4970
Fax: 412-776-0790

A.4 Application of Communication Standards

This section describes how various applications utilize communication standards. It also provides greater insight on how to use communication standards for transit. Applications of the greatest relevance to transit agencies are as follows:

- Geographic Information Systems (GIS)
- Automated Vehicle Location (AVL) systems
- Electronic Fare Payment Systems
- Traffic signal priority systems
- Advanced Traveler Information Systems (ATIS)

Various communications standards are relevant to these transit applications. The following paragraphs describe the communications standardization efforts relevant to these specific applications.

A.4.1 Geographic Information Systems (GIS)

Currently, there is a lack of standards for utilizing GIS within the transportation and transit industry. GIS systems within the transportation industry are generally used in association with

AVL systems, where AVL determines the location while GIS provides the reference points for the location.

There is a need for standards in addition to those for a GIS system setup and the message set. Since GIS databases or GIS access systems can reside at different locations (in relation to the National ITS Architecture this could be the Remote Access Subsystem, one of the different management centers or even one of the vehicle subsystems), not only the message format but the underlying database setup needs to be standardized. Standards are also required for the communications media utilized for transmitting the GIS data, which reasserts the need for the development of communications protocols.

The Federal Transit Administration (FTA) recognized the need for a standardized GIS system to overcome interoperability and interchangeability problems. Currently, it is developing the National Transit GIS standards, which will focus on utilized standards (existing and future), guidelines, and recommended practices. The major effort will be the development of a national database containing information pertinent to the transportation and transit industry, such as information on existing and planned roadways and transit routes. In order to assure the broad applicability of this standard, the FTA is working in conjunction with the following organizations:

- American Association of State Highway and Transportation Officials (AASHTO)
- American Bus Association (ABA)
- American Public Transportation Association (APTA)
- American Public Works Association (APWA)
- Conference of Minority Transportation Officials (COMTO)
- Community Transportation Association of America (CTAA)
- Institute of Transportation Engineers (ITE)
- National Association of Regional Councils (NARC)

The standard will also integrate efforts of the National Spatial Database Infrastructure (SDI) process into its development.

Further information can be obtained from the following source:

Federal Transit Administration
Office of Research, Demonstration and Innovation
400 7th Street, SW.
Washington, D.C. 20590
Phone: 202-366-4991
Fax: 202-366-3765

A.4.2 Automated Vehicle Location (AVL) Systems

The application of AVL within the transit industry is one of the most beneficial applications in terms of implementing ITS technologies. It will enable transit managers to manage transit vehicles in real-time with reference to the roadway network and the planned schedule.

There are many AVL systems in existence. However, all of these AVL systems are proprietary, locking implementing agencies into a vendor-specific system. Most of these AVL systems have not been designed to allow for integration with an overall management system. Therefore, expansion to include upgrades, include other subsystems, or the integration of an AVL system into an overall management system will be very expensive.

The transit industry, among other transportation entities, expressed the need for an AVL standard to allow for interoperability and integration of subsystems. The U.S. DOT placed AVL high on the priority list of standards that need to be developed for ITS technologies.

The Institute of Electrical and Electronic Engineers (IEEE) has been designated as the lead organization to develop the message set (applications standard) for AVL. However, other standards specifying the communications protocols are also needed.

Currently existing and planned standards usable for AVL are listed in the ITS Standards Catalog available on-line at the following website: http:\\www.itsa.org

A.4.3 Electronic Fare Payment Systems

The electronic fare payment systems application area is expected to make payment methods more user friendly and make the accounting system more efficient.

As with AVL systems, existing electronic fare payment systems utilize different technologies and no overall standard exists.

The DSRC protocol is one standard that could be used for contact-less data transmission between an electronic fare payment media and a reader device installed in a transit vehicle. IEEE has been designated the lead organization in the development of the message set (application standard) for transit fare collection and is involved in specifying the data format and data content. For existing and planned standards, please refer to the previously mentioned website address.

In addition, TCIP will address the need to exchange data with banking institutions to allow for automatic deduction of fare payments. The TCIP effort will also ensure that the needs of the transit industry are met in the electronic fare payment message set development led by IEEE, by conducting extensive with selected transit properties.

A.4.4 Traffic Signal Priority

Traffic signal priority is important for transit agencies for schedule adherence and travel time savings. Various technologies are used to enable traffic signal prioritization (e.g. roadside beacons are activated upon passage of a transit vehicle and the transmitter in the transit vehicle or the beacon itself sends out a message). This message can also be generated after determining the vehicle's location with the Global Positioning System (GPS or AVL).

Existing communications standards for transmitting data between roadside devices and vehicles are all proprietary. National and international efforts are underway to develop standards to overcome interoperability problems. The DSRC protocol is a significant development in this direction.

The message set (applications standard) that is needed to allow for signal priority at intersections will be developed largely under the TCIP effort. It is not yet clear what information needs to be transmitted and what technologies are involved, but it is anticipated that different message sets will be needed for different technologies. For example, if a transit vehicle provides a direct input to a roadside device such as a traffic signal controller, then, as a minimum, only an input indicating that a transit vehicle needs a priority signal needs to be placed. The NTCIP describes the most common and simple method of doing this.

A.4.5 Advanced Traveler Information System (ATIS)

The transportation community has identified a need for standards for traveler information systems. Traveler information systems can be either pre-trip or en-route. Pre-trip traveler information is provided to potential users at work, at home or while at other places such as malls or public buildings. Information can be provided through the Internet, telephone systems, personnel digital assistants, or kiosks.

En-route advanced traveler information can be accessed by a traveler (either a driver in a vehicle or a passenger in a transit vehicle) during their trip. There are different types of systems that enable the user to access information. Some of these systems are located next to the roadway or within passenger exchange stations (train or bus stations) while others are used within vehicles (in-vehicle devices for cars and kiosk-type devices in transit vehicles).

A.5 Guide to Transit Related Standards

In December 1996 for the National ITS Architecture Transit Guidelines, the JPL provided a list of transit related standards. The tables shown in section A.4.3 and A.4.4 on the following pages have been derived from this list and modified in order to relate them to the different applications and communications methods as introduced by the National ITS Architecture. The status (approved = A, proposal = P, or draft = D), a brief description, the main intended purpose, an envisioned purpose, and the name of the maintaining organization are included in these tables. Sections A.4.1 and A.4.2 briefly describe the types of standards found in the application standards and communication standards tables respectively.

Reminder: *the content of the JPL database used to create the tables in section A.4.3 and A.4.4 is updated continuously thus making some of the material included in the tables obsolete with each update. The tables are provided here to show the breadth of standards available for* *transit ITS applications. Users can find the latest status of the standards by either contacting the JPL or by accessing the ITS America Internet homepage at: http://www.itsa.org/standards under the heading "Standards Catalog."*

A.5.1 Application Standards Table Descriptions

Tables A.4.3.1 through A.4.3.7 relate to different applications within transit that require standards. The applications include:

- **General Use** - basic standards for transit, communications, human factors, message transfer, and navigation
- **GIS**: specific standards relating to digital maps and navigation
- **VMS**: NTCIP based standards for message signs used in traffic control
- **CCTV**: television and communications standards
- **ETTM**: interface, payment, and testing procedure standards for automated electronic toll collection and traffic management
- **ATIS**: architecture, message lists, navigation, and communication standards for traveler information systems
- **Other**: identifies other areas where standards can be applied: vehicle area networks, sensors, data exchange, and emergency services

A.5.2 Communications Standards

Tables A.4.4.1 through A.4.4.6 relate to different communication interfaces and possible standards to employ:

- **Center-to-Center**: standards for databases, operating systems, security, Internet service, networks, quality assurance, television, navigation, and human factors
- **Center-to-Roadside**: standards for traveler information requirements, safety plans, packet switching, ISO-OSI model requirements, navigation, and cellular phone requirements
- **Roadside-to-Vehicle**: DSRC, Internet, navigation, message sets, and vehicle location standards
- **Vehicle-to-Vehicle and In-Vehicle**: database, safety, vehicle area network, emergency services, DSRC, Internet, navigation, and ISO-OSI model requirement standards
- **Center-to-Remote Access**: traveler information, traffic control, safety, packet switching, data systems, database queries, transit, Internet, and workstation standards
- **Center-to-Vehicle**: traveler information, traffic control, information service providers, safety, packet switching, navigation, database, human factors, Internet, and ISO-OSI model requirement standards

A.5.3 Application Standards

A.5.3.1 Listing of possible Application Standards for General Use

Number	Abbr.	Title	Abstract	Status	Projected Application	User	Developing Organization
ANSI X3.4	ANSI	American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See FIPS-1)	A	Computers	Message transfer	American National Standards Institute
FIPS 1	NIST	Federal Information Processing Standard, American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See ANSI X3.4)	A	Computers	Message transfer	National Institute of Science and Technology
FIPS 148	NIST	Federal Information Processing Standard, Government Open System Interface Procedures.	U.S. Government standard for ISO Open System Interconnection.	A	Communications	Communications	National Institute of Science and Technology
IEEE 1228	IEEE	Software Safety Plans	Software safety.	A	Safety	Human factors, Safety	Institute of Electrical and Electronics Engineers
ITE-96-02	ITE	Transit Communications Interface Protocols (TCIP)	Transit protocols and messages for use with the vehicles, operations, maintenance and public information.	P	Transit	Transit	Institute of Transportation Engineers
ITE-96-04	ITE	ITS Recommended Practices for Public Agencies	Recommended practices for ITS including messages for Variable message signs, Highway advisory radio, and between TMCs.	P	Communications	Communications	Institute of Transportation Engineers
NAD 27	USGS	North American Datum - 1927.	Geodetic datum for the North American Continent per 1927. Most US maps are based on NAD 27 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NAD 83	USGS	North American Datum - 1983.	Geodetic datum for the North American Continent per 1983. Some US maps are based on NAD 83 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
VDV 04.05.2	VDV	Technical Requirements for Location Beacon Systems	Defines protocols and data formats for communications between infrared and microwave wayside beacons and transit vehicles. Defines formats for location, change in voice radio channel and traffic signal preemption. (German Association of Public Transport)	A	Automated Vehicle Location	Automated vehicle location	Verbund Deutscher Verkehrsunternehmen
VDV 04.05.5	VDV	Radio Data Interface	Defines Protocols and data formats to be used in interface between the central computer and radio system in transit Automatic Vehicle Location/Control (fleet management) system. (German Association of Public Transport Operators)	A	Automated Vehicle Location	AVL, control	Verbund Deutscher Verkehrsunternehmen
VDV 420	VDV	Technical Requirements for Automatic Vehicle Location/Control Systems - Radio Data Transmission.	Protocols and message structure for public transit fleet management. Communications between vehicle to/from transit control center. (German Association of	A	Communications	Communications, Transit	Verbund Deutscher Verkehrsunterne

			Public Transport Operators)				hmen
TMC-to-TMC	NEMA	NTCIP Object Set for Traffic Management Center to Traffic Management Center		P	Communications	Traffic control	NEMA

A.5.3.2 Listing of possible GIS Application Standards

Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
CEN GDF	CEN	Geographic Data File.	Geographic data file structure and transfer standard for European geographic digital maps.	A	Digital Maps	GIS data transfer	Committee for European Normalisation
FIPS 173	NIST	Federal Information Processing Standard, Spatial Data Transfer Standard	Standard for transferring data from one geographic information system (GIS) to a second GIS. Defines the requirements for a transfer module.	A	Digital Maps	GIS data transfer	National Institute of Science and Technology
J1663	SAE	Truth-In-Labeling Standard for Navigation Map Databases	Truth-in-labeling standard for navigation digital map databases. Provides criteria for labeling contents of map database.	A	Digital Maps	Digital maps, Navigation	Society of Automotive Engineers
MDB-01	SAE	Recommended Practice for Location Reference Message Specification.	Recommended practice for a Geodetic location reference system for spatial data transfer between different digital map databases.	P	Navigation	Navigation	Society of Automotive Engineers
WGS 84	U.S.DOD	World Geodetic System - 1984.	Geodetic constants and datum used with the Global Positioning System (GPS). Constants for transformation to other datums are included.	A	Navigation	Navigation	United States Department of Defense

A.5.3.3 Listing of possible VMS-Applications Standards

Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
CMS	CALTRANS	Specifications for Changeable Message Sign System.		A	Traffic Control	Traffic control, Information	California Department of Transportation
DMS	NEMA	Dynamic Message Sign Object Definitions	Specifies the message format of data for variable message sign, changeable message signs and blank-out signs for use with NTCIP	P			NEMA, ITE, AASHTO

A.5.3.4 Listing of possible CCTV-Applications Standards

Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
EIA-330	EIA	Electrical Performance Standards for Closed Circuit Television Camera 525/60 Interlaced 2:1.	Basic TV Camera, 525 lines per screen, 60 frames per second, two scans per frame.	A	Television	Security	Electronics Industries Association
EIA-439	EIA	Engineering Specifications Format for Color CCTV Camera Equipment	List the electrical, mechanical, and environmental specifications which should be provided for color CCTV equipment.	A	Communications	Communications	Electronics Industries Association

A.5.3.5 Listing of possible ETTM-Applications Standards

Number	*Abbr.*	*Title*	*Abstract*	*Status*	*Projected Application*	*User*	*Developing Organization*
ETTM	ITSA	Electronic Toll & Traffic Management (ETTM) User Requirements for Future National Interoperability	White paper defining electronic tag requirements, for toll collection and traffic management.	A	ETTM	Electronic toll, traffic mgmt.	Intelligent Transportation Society - America
ISO 4909:1987	ISO	Bank Cards - Magnetic Stripe data for track 3.	Magnetic card format for electronic banking data.	A	Banking	Electronic funds transfer	International Standards Organization
NP 5.1	ISO	Interface Specification for Clearing Between Operations	ISO Technical Committee TC204, Traffic Information and Control Systems, WG5, Fee & Toll Collection (FTC), effort.	P	ETTM	ETTM	International Standards Organization
NP 5.2	ISO	Integration of Payment Systems through an Enabled End-to-end Chain of information.	ISO Technical Committee TC204, Traffic Information and Control Systems, WG5, Toll & Fee Collection (FTC), effort.	P	ETTM	ETTM	International Standards Organization
NP 5.3	ISO	Automatic Fee Collection Application Interface Definition for Dedicated Short Range Vehicle Beacon Communications.	ISO Technical Committee TC204, Traffic Information and Control Systems, WG5, Fee & Toll Collection (FTC), effort.	P	Electronic Toll Collection	ETC	International Standards Organization
NP 5.4	ISO	Test Procedures for Automated Fee Collection User Equipment and Automatic Fee Collection Fixed Equipment	ISO Technical Committee TC204, Traffic Information and Control Systems, WG5, Fee & Toll Collection (FTC), effort.	P	Electronic Toll Collection	ETC	International Standards Organization
NP 5.5	ISO	Automatic Fee Collection Requirements for Dedicated Short Range Vehicle-Beacon Communications.	ISO Technical Committee TC204, Traffic Information and Control Systems, WG5, Fee & Toll Collection (FTC), effort.	P	Electronic Toll Collection	ETC	International Standards Organization
NP 5.6	ISO	Automatic Fee Collection Requirements for IC-cards.	ISO Technical Committee TC204, Traffic Information and Control Systems, WG5, Fee & Toll Collection (FTC), effort.	P	Electronic Toll Collection	ETC	International Standards Organization

A.5.3.6 Listing of possible ATIS-Applications Standards

Number	*Abbr.*	*Title*	*Abstract*	*Status*	*Projected Application*	*User*	*Developing Organization*
J1746	SAE	Recommended Practice for Traveler Information Service Message List.	Overall message list for all communications within an Intelligent Transportation System (ITS).	D	Communicatio ns	Communicatio ns	Society of Automotive Engineers
J1763	SAE	Information Report - A Conceptual IVHS Architecture: an ATIS Perspective.	An overview conceptual framework for ITS Architecture and Protocols. Emphasis on communications.	A	Architecture	ATIS architecture	Society of Automotive Engineers
J2256	SAE	In Vehicle Navigation and Related ATIS Communications Device Message Set Standard	Recommended practice defining a message set for navigation. The navigation message set is to be a proper subset of the ITIIS message set.	D	Navigation	Vehicles, Emergency	Society of Automotive Engineers
J2352	SAE	Existing ATIS Message List Information Report	A compilation of existing messages list from Asian, European and North American deployed ATIS systems.	P	ATIS	ATIS	Society of Automotive Engineers
NP 10.7	ISO	User Services Integration for Traffic and Traveler Message List	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Traveler Information	Traveler information	International Standards

							Organization
P1477	IEEE	Standard for Passenger Information System for Rail Transit Vehicles		P	Traveler Information	Traveler Information	Institute of Electrical and Electronics Engineers
J2354	SAE	ATIS Data Dictionary Standard	Data dictionary for the overall Intelligent transportation System (ITS) traveler information system message list. To be at the bit level detail. Companion to J1746.	P	Traveler Information	Traveler information	Society of Automotive Engineers

A.5.3.7 Listing of possible Other-Application Standards

Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
ISO 9735	ISO	Electronic data interchange for administration, commerce and transportation (EDIFACT).	Application of EDIFACT syntax.	A	Data Interchange	Data interchange	International Standards Organization
J1455	SAE	Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design of Heavy Duty Trucks and Busses	Design Goals for climatic, mechanical, chemical, electrical and dynamic conditions found on, and generated by, heavy duty trucks and buses.	A	Vehicle Area Network	Vehicle area network	Society of Automotive Engineers
J1708	SAE	Truck and Bus Practice. Serial Data Communications between Microcomputer Systems in Heavy Duty Vehicle Applications.	Serial Data Communications Between Microcomputer Systems in Heavy Duty Vehicle Applications. Details the hardware interface and outlines the communications protocol.	A	Vehicle Area Network	Vehicle area network	Society of Automotive Engineers
J1757	SAE	R. P. for In Vehicle Sensor Interface for IVHS Applications.	Recommended Practice for interface requirements for vehicle sensors, including gyroscopes, compasses, odometer, etc. to an in-vehicle navigation computer.	P	Sensors	Vehicles	Society of Automotive Engineers
Jxxx0	SAE	DRAFT Standard for On-board Land Vehicle Positioning Device Interface.	Interface requirements, messages, and protocols for position device (e.g., GPS receiver) to an in-vehicle navigation computer.	D	Sensors	Vehicles, Navigation	Society of Automotive Engineers
Title 21	Caltran s	AVI Compatibility Specification	Specification for Automated Vehicle Location transponder requirements.	Law	Automated Vehicle Location	Automated vehicle location	California State Code of Regulations
AVI	NEMA	NTCIP Object Set for Automated Vehicle Identification	Center to/from the roadside reader/beacon.	P	Automated Vehicle Location	Automated Vehicle Location	National Electrical Manufacturers Association
ESS	NEMA	NTCIP Object Set for Environmental Sensors		P	Weather Information	Weather information	National Electrical Manufacturers Association
HAR	NEMA	NTCIP Object Set for Highway Advisory Radio	Center to the radio transmitter	D	Communicatio ns	Communicatio ns	National Electrical Manufacturers Association
J2313	SAE	Standard for On-Board Land Vehicle MAYDAY Reporting Interface	This standard describes the message protocol between an on board mayday detection system and the external response center (E911 center).	D	Emergency Services	Emergency services	Society of Automotive Engineers

Number	Abbr.	Title	Abstract	Status	Projected Application	User	Developing Organization
jxxx1	SAE	Information Report, 9 1 1 Message List	Message list for cellular telephone 9 1 1 calls. Appropriate for two-way signaling using very short tone bursts. May be part of MayDay protocol. Companion to J2313.	P	Communications	Communications	Society of Automotive Engineers
bap	Ent	ITIS Bearer Application Protocol (BAP)	Network level protocol for International Travelers Information Interchange System (ITIIS) message transmission by a specified communications system. Each communications system would use a separate network application protocol.	D	Communications	Communications	Enterprise
bif	Ent	ITIS Bearer Independent Format (BIF) Protocol	Transport layer message protocols, formats and contents for transmission of traffic data from traffic management/information center to vehicle, traveler or driver.	D	Communications	Communications	Enterprise

A.5.4 Communications Standards

A.5.4.1 Listing of possible Center-to-Center Communication Standards

Center to Center Communications Standards							
Number	**Abbr.**	**Title**	**Abstract**	**Status**	**Projected Application**	**User**	**Developing Organization**
ANSI X3.135	ANSI	Structured Query Language.	Structured Query Language is a standardized set of commands for accessing and updating databases.	A	Database Queries	Database queries	American National Standards Institute
ANSI X3.4	ANSI	American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See FIPS-1)	A	Computers	Message transfer	American National Standards Institute
ANSI/IEEE 1003.1	IEEE	Portable Operating System Interface (POSIX) for Computer Environments	Standard for UNIX. Compatible with multiple, different computer hardware systems.	A	Operating System	Computer operating system	Institute of Electrical and Electronics Engineers
DoD 5200.28-STD	U.S.DOD	Department of Defense Trusted Computer System Evaluation Criteria (TCSEC)	Defines the basic security features of a trusted computer system and the assurance levels required for protecting information. Various levels and complexities of computer security and protection of information are discussed in detail.	A	Security	Security	United States Department of Defense
FHWA-STD-WP-16	Nat'l Arch.	Information Service Provider Subsystem To Other Centers Standard Requirements Package.	Describes the wireline communications messages / interfaces between the Information Provider and users / data providers. Provides message sequences, contents and data dictionary.	P	Traveler Information	Traveler information	National Architecture Team
FIPS 1	NIST	Federal Information Processing Standard, American National Standard Code for	Computer eight bit code for 256 character set of printing and control characters. (See ANSI X3.4)	A	Computers	Message transfer	National Institute of Science and

Center to Center Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
		Information Interchange (ASCII).					Technology
FIPS 127	NIST	Federal Information Processing Standard, Structured Query Language.	Structured Query Language is a standardized set of commands for accessing and updating databases.	A	Database Queries	Database queries	National Institute of Science and Technology
FIPS 148	NIST	Federal Information Processing Standard, Government Open System Interface Procedures.	U.S. Government standard for ISO Open System Interconnection.	A	Communications	Communications	National Institute of Science and Technology
FIPS 151-1	NIST	Federal Information Processing Standard, POSIX	U.S. Government standard for UNIX operating system.	A	Operating System	Computer operating system	National Institute of Science and Technology
FIPS 158	NIST	Federal Information Processing Standard, X-windows.	U.S. Government standard for MIT X-windows. X-windows is a terminal based graphics user interface.	A	Terminal User Interface	Terminal MMI	National Institute of Science and Technology
IEEE 1228	IEEE	Software Safety Plans	Software safety.	A	Safety	Human factors, Safety	Institute of Electrical and Electronics Engineers
IEEE 802.2	IEEE	Standard for Local Area Networks: Logical Link Control.	Basic standard for ethernet and other local area networks. Also see IEEE 802.(3, 4, 5). Also ISO 880(2, 3, 4, 5).	A	Communications	Communications	Institute of Electrical and Electronics Engineers
IEEE 802.3	IEEE	CSMA/CD Access Method and Physical Layer Specification.	Ethernet - Carrier Sensing Multiple Access/Collision Detecting protocol standard.	A	Communications	Communications	Institute of Electrical and Electronics Engineers
IEEE 802.4	IEEE	Token - Passing Bus Access Method and Physical Layer Specification.	Networking using token passing access protocol.	A	Communications	Communications	Institute of Electrical and Electronics Engineers
IEEE 802.5	IEEE	Token Ring Access Method and Physical Layer Specification.	Networking using token passing access protocol.	A	Communications	Communications	Institute of Electrical and Electronics Engineers
IEEE 802.6	IEEE	Dual Queue Data Bus - Metropolitan Area Network	Specification for a Metropolitan Area Network.	A	Communications	Communications	Institute of Electrical and Electronics Engineers
IEEE 802.9	IEEE	Standards for Local and Metropolitan Area Networks	Supplement to Integrated Services (IS) LAN Interface at the Medium Access Control (MAC) and Physical (PHY) Layers: Specification for ISLANG.	A	Communications	Communications	Institute of Electrical and Electronics Engineers
IEEE 9121	IEEE	Software Quality Assurance.	Software (computer programs) quality assurance provisions.	A	Quality Assurance	Software quality	Institute of Electrical and

Center to Center Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
							Electronics Engineers
IEEE C95.1-1992	J-A/I	Safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz.	Standard specifies maximum power densities tolerable in a 30 minute time period.	A	Communications	Communications, Safety	Joint ANSI / IEEE
ISO 3309:1991	ISO	Data Communications - HDLC Procedures - Frame Structure.	High level digital data link control - Link protocols.	A	Packet Switching	Packet switching	International Standards Organization
ISO 4335:1991	ISO	Data Communications - High Level Data Link Control (HDLC) Procedures.	HDLC procedures (Link protocols.)	A	Packet Switching	Packet switching	International Standards Organization
ISO 7498:1990	ISO	Information Processing Systems - Open System Interconnect - Basic Reference Model.	ISO OSI model of seven layer data communications model.	A	Data Communications	Data communications	International Standards Organization
ISO 8072:1984	ISO	Information Processing Systems - Open System Interconnection - Transport Service Definition	Defines the transport layer (layer 4) requirements for network service. Class 4, Type C is similar to, and based on MIL-STD 1778 Transport Control Protocol.	A	Communications	Communications	International Standards Organization
ISO 8073:1984	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Transport Protocol Specification.	Defines the transport layer (layer 4) protocol requirements for network service. Class 4, Type C is similar to, and based on MIL-STD 1778 Transport Control Protocol.	A	Communications	Communications	International Standards Organization
ISO 8208:1990	ISO	Information Technology - Data Communications X.25 Packet Layer Protocol for Data Terminal Equipment.	Network protocol for data communications.	A	Packet Switching	Packet switching	International Standards Organization
ISO 8822	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Definition	Defines service for connection (circuit) presentation.	A	Communications	Communications	International Standards Organization
ISO 8823	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Protocol Specification	Protocol requirements for connection-oriented presentation service.	A	Communications	Communications	International Standards Organization
ISO 9075:1988	ISO	Structured Query Language.	Structured Query Language is a standardized set of commands for accessing and updating databases.	A	Database Queries	Database queries	International Standards Organization
ISO 9595	ISO	Information Technology - Open System Interconnect- Common Management Information Service Definition	Defines the common management information protocol (CMIP, analogous to TCP) and service.	A	Communications	Communications	International Standards Organization
ISO 9596	ISO	Information Technology - Open System Interconnect - Common Management Information Protocol (CMIP) Specification	CMIP is similar to TCP. CMIP provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May replace TCP about 2001.	A	Communications	Communications	International Standards Organization
ISO 9735	ISO	Electronic data interchange for administration, commerce and transportation (EDIFACT).	Application of EDIFACT syntax.	A	Data Interchange	Data interchange	International Standards Organization

Center to Center Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
ISO 9945-1	ISO	Portable Operating System Interface (Posix).	UNIX operating system for multiple, different hardware.	A	Operating System	Computer operating system	International Standards Organization
ISO/IEC 11172	ISO	Information technology -- Coding of moving pictures and associated audio for digital storage media at up to about 1.5 Mbit/s	A video data coding and compression standard being formed to allow high definition video television and stereo audio to be transmitted over existing 5 MHz bandwidth channels. May reduce standard TV to approx. 64 kHz for transmission over ISDN circuits.	A	Television	Television, Monitoring, Security	International Standards Organization
ITE-96-02	ITE	Transit Communications Interface Protocols (TCIP)	Transit protocols and messages for use with the vehicles, operations, maintenance and public information.	P	Transit	Transit	Institute of Transportation Engineers
ITE-96-04	ITE	ITS Recommended Practices for Public Agencies	Recommended practices for ITS including messages for Variable message signs, Highway advisory radio, and between TMCs.	P	Communications	Communications	Institute of Transportation Engineers
MIL-STD 1472D	U.S.DOD	Human Engineering Design Criteria for Military Systems, Equipment and Facilities	Human engineering design criteria, principles and practices to integrate the human into the system; and achieve effectiveness and safety of operations and maintenance.	A	Human Factors	Human factors	United States Department of Defense
MIL-STD 1777	U.S.DOD	Internet Protocol (IP)	Internet protocol supports the interconnection of networks, using an internal datagram service to determine the shortest time distance to the end connection.	A	Communications	Communications	United States Department of Defense
MIL-STD 1778	U.S.DOD	Transport Control Protocol (TCP)	Transport control protocol provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May be replaced by ISO 8072 and 8073.	A	Communications	Communications	United States Department of Defense
MIL-STD 1780	U.S.DOD	File Transport Protocol	File transport protocol is the "upper-layer protocol" that commands the transport control protocol issuing 'service requests' and receiving 'service responses'.	A	Communications	Communications	United States Department of Defense
MIL-STD 1781	U.S.DOD	Simple Mail Transfer Protocol	an "upper layer protocol" for mail transfer through a network based on transfer control protocol (TCP) and Internet protocol (IP).	A	Communications	Communications	United States Department of Defense
MIL-STD 1782	U.S.DOD	TELNET Protocol	TELNET is a virtual circuit switching system (CCITT X.75) similar to Internet.	A	Communications	Communications	United States Department of Defense
NAD 27	USGS	North American Datum - 1927.	Geodetic datum for the North American Continent per 1927. Most US maps are based on NAD 27 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NAD 83	USGS	North American Datum - 1983.	Geodetic datum for the North American Continent per 1983. Some US maps are based on NAD 83 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NP 10.2	ISO	Traffic Message Coding for Traffic and	ISO TC 204 Working Group 10 Traveler Information	P	Communicatio	Communicatio	International

Center to Center Communications Standards

Number	*Abbr.*	*Title*	*Abstract*	*Status*	*Projected Application*	*User*	*Developing Organization*
		Traveler Information.	Systems effort.		ns	ns	Standards Organization
NP 10.5	ISO	Medium-Range Pre-Information	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Communications	Communications	International Standards Organization
NTSC	NAB-T	United States Color Television Standard	U.S. Standard for color television broadcast.	A	Television	Color TV	National Television System Committee
RBDS	NAB-R	United States Radio Broadcast Data System (RBDS) Standard - FM subcarrier data transmission.	Proposed FM subcarrier signaling for wide area data transfer to vehicles.	D	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
RDS	NAB-R	United States Radio Data System (RDS) Standard - FM subcarrier data transmission. Approximately 1000 bits per second (bps) NOTE: THIS SOUNDS THE SAME TO THE ABOVE RBDS		A	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
TIA/EIA/IS-124	TIA	Cellular Radio Telecommunications Intersystem Non-Signaling Data Communications	Interim standard describes procedures to provide non-signaling data communications.	D	Communications	Communications	Telecommunications Industry Association
TIA/EIA/IS-95	TIA	Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System.	Code Division Multiple Access (CDMA). A cellular telecommunications scheme in which multiple users may simultaneously share a frequency as each is using a different code for their information transfer.	D	Communications	Communications	Telecommunications Industry Association
V.28	ITU	Electrical characteristics for interface circuits.	Characteristics of electrical circuits used between terminal and communications devices.	A	Communications	Communications	International Telecommunications Union
V.35	ITU	Transmission of 48 kilobits/second data using 60 to 108 kiloHertz group bank circuits.	Transmission of 48 kilobits per second digital data over telephone group circuits with bandwidths of 60 to 108 kiloHertz (kHz).	A	Communications	Communications	International Telecommunications Union
X-11	MIT	X-Windows, Version 11.	Standard for MIT X-windows. X-windows is a terminal based graphical user interface.	A	Terminal User Interface	Terminal MMI	Massachusetts Institute of Technology
X.21	ITU	General-purpose interface between data terminal equipment and data circuit-terminating equipment for start-stop transmission services on public networks.	Defines the physical characteristics and control procedures for a synchronous digital transmission between the user machine and network. Provides end-to-end digital transmission.	A	Communications	Communications	International Telecommunications Union
X.25	ITU	Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode on Public Data Networks.	Interface protocol standard specifying physical control (layer 1), link control (layer 2) and network control (layer 3) for packet format data transfer connection to a network.	A	Communications	Communications	International Telecommunications Union
X.400	ITU	Message Handling Systems: System Model-	"Upper Level Protocols" for Message and Mail transfer	A	Communicatio	Communicatio	International

Center to Center Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
		Service Elements	on networks.		ns	ns	Telecommunications Union

NOTE: Some of the above communication standards are not limited to Center-to-Center communications and can be used for other types of communication such as Center-to-Roadside, Center-to-Vehicle, Roadside to Vehicle and especially Center-to-Remote Access. Not all of these multiple use communication standards are repeated in the tables below.

A.5.4.2 Listing of possible Center-to-Roadside Communication Standards

Center to Roadside Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
ANSI X3.4	ANSI	American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See FIPS-1)	A	Computers	Message transfer	American National Standards Institute
ETTM	ITSA	Electronic Toll & Traffic Management (ETTM) User Requirements for Future National Interoperability	White paper defining electronic tag requirements, for toll collection and traffic management.	A	ETTM	Electronic toll, traffic mgmt.	Intelligent Transportation Society - America
FHWA-STD-WP-10	Nat'l Arch.	Transit Management to Transit Vehicle and Remote Traveler Service Interfaces Standards Requirements Package	Describes the communications messages between transit management and the remote traveler (kiosk) and between transit management and the transit vehicle. Includes message sequencing, content and data dictionary.	P	Traveler Information	Traveler information	National Architecture Team
FIPS 1	NIST	Federal Information Processing Standard, American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See ANSI X3.4)	A	Computers	Message transfer	National Institute of Science and Technology
FIPS 148	NIST	Federal Information Processing Standard, Government Open System Interface Procedures.	U.S. Government standard for ISO Open System Interconnection.	A	Communications	Communications	National Institute of Science and Technology
IEEE 1228	IEEE	Software Safety Plans	Software safety.	A	Safety	Human factors, Safety	Institute of Electrical and Electronics Engineers
ISO 3309:1991	ISO	Data Communications - HDLC Procedures - Frame Structure.	High level digital data link control - Link protocols.	A	Packet Switching	Packet switching	International Standards Organization
ISO 4335:1991	ISO	Data Communications - High Level Data Link Control (HDLC) Procedures.	HDLC procedures (Link protocols.)	A	Packet Switching	Packet switching	International Standards Organization
ISO 7498:1990	ISO	Information Processing Systems - Open System Interconnect - Basic Reference Model.	ISO OSI model of seven layer data communications model.	A	Data Communications	Data communications	International Standards Organization
ISO 8072:1984	ISO	Information Processing Systems - Open System Interconnection - Transport Service	Defines the transport layer (layer 4) requirements for network service. Class 4, Type C is similar to, and	A	Communications	Communications	International Standards

Center to Roadside Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
		Definition	based on MIL-STD 1778 Transport Control Protocol.				Organization
ISO 8073:1984	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Transport Protocol Specification.	Defines the transport layer (layer 4) protocol requirements for network service. Class 4, Type C is similar to, and based on MIL-STD 1778 Transport Control Protocol.	A	Communications	Communications	International Standards Organization
ISO 8208:1990	ISO	Information Technology - Data Communications X.25 Packet Layer Protocol for Data Terminal Equipment.	Network protocol for data communications.	A	Packet Switching	Packet switching	International Standards Organization
ISO 8822	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Definition	Defines service for connection (circuit) presentation.	A	Communications	Communications	International Standards Organization
ISO 8823	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Protocol Specification	Protocol requirements for connection-oriented presentation service.	A	Communications	Communications	International Standards Organization
ITE-96-02	ITE	Transit Communications Interface Protocols (TCIP)	Transit protocols and messages for use with the vehicles, operations, maintenance and public information.	P	Transit	Transit	Institute of Transportation Engineers
ITE-96-04	ITE	ITS Recommended Practices for Public Agencies	Recommended practices for ITS including messages for Variable message signs, Highway advisory radio, and between TMCs.	P	Communications	Communications	Institute of Transportation Engineers
MIL-STD 1777	U.S.DOD	Internet Protocol (IP)	Internet protocol supports the interconnection of networks, using an internal datagram service to determine the shortest time distance to the end connection.	A	Communications	Communications	United States Department of Defense
MIL-STD 1778	U.S.DOD	Transport Control Protocol (TCP)	Transport control protocol provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May be replaced by ISO 8072 and 8073.	A	Communications	Communications	United States Department of Defense
MIL-STD 1780	U.S.DOD	File Transport Protocol	File transport protocol is the "upper-layer protocol" that commands the transport control protocol issuing 'service requests' and receiving 'service responses'.	A	Communications	Communications	United States Department of Defense
MIL-STD 1781	U.S.DOD	Simple Mail Transfer Protocol	an "upper layer protocol" for mail transfer through a network based on transfer control protocol (TCP) and Internet protocol (IP).	A	Communications	Communications	United States Department of Defense
MIL-STD 1782	U.S.DOD	TELNET Protocol	TELNET is a virtual circuit switching system (CCITT X.75) similar to Internet.	A	Communications	Communications	United States Department of Defense
NAD 27	USGS	North American Datum - 1927.	Geodetic datum for the North American Continent per 1927. Most US maps are based on NAD 27 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NAD 83	USGS	North American Datum - 1983.	Geodetic datum for the North American Continent per 1983. Some US maps are based on NAD 83 geodetic	A	Navigation	Navigation	United States Geodetic Service

Center to Roadside Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
			constants.				
NP 10.2	ISO	Traffic Message Coding for Traffic and Traveler Information.	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Communications	Communications	International Standards Organization
NP 10.5	ISO	Medium-Range Pre-Information	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Communications	Communications	International Standards Organization
RBDS	NAB-R	United States Radio Broadcast Data System (RBDS) Standard - FM subcarrier data transmission.	Proposed FM subcarrier signaling for wide area data transfer to vehicles.	D	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
RDS	NAB-R	United States Radio Data System (RDS) Standard - FM subcarrier data transmission. Approximately 1000 bits per second (bps) NOTE: THIS SOUNDS THE SAME TO THE ABOVE RBDS		A	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
TIA/EIA/IS-124	TIA	Cellular Radio Telecommunications Intersystem Non-Signaling Data Communications	Interim standard describes procedures to provide non-signaling data communications.	D	Communications	Communications	Telecommunications Industry Association
TIA/EIA/IS-95	TIA	Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System.	Code Division Multiple Access (CDMA). A cellular telecommunications scheme in which multiple users may simultaneously share a frequency as each is using a different code for their information transfer.	D	Communications	Communications	Telecommunications Industry Association
V.28	ITU	Electrical characteristics for interface circuits.	Characteristics of electrical circuits used between terminal and communications devices.	A	Communications	Communications	International Telecommunications Union
V.35	ITU	Transmission of 48 kilobits/second data using 60 to 108 kiloHertz group bank circuits.	Transmission of 48 kilobits per second digital data over telephone group circuits with bandwidths of 60 to 108 kiloHertz (kHz).	A	Communications	Communications	International Telecommunications Union
X.21	ITU	General-purpose interface between data terminal equipment and data circuit-terminating equipment for start-stop transmission services on public networks.	Defines the physical characteristics and control procedures for a synchronous digital transmission between the user machine and network. Provides end-to-end digital transmission.	A	Communications	Communications	International Telecommunications Union
X.25	ITU	Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode on Public Data Networks.	Interface protocol standard specifying physical control (layer 1), link control (layer 2) and network control (layer 3) for packet format data transfer connection to a network.	A	Communications	Communications	International Telecommunications Union
X.400	ITU	Message Handling Systems: System Model-Service Elements	"Upper Level Protocols" for Message and Mail transfer on networks.	A	Communications	Communications	International Telecommunications Union

A.5.4.3 Listing of possible Roadside-to-Vehicle Communication Standards

Roadside to Vehicle Communications Standards

Number	Abbr.	Title	Abstract	Status	Projected Application	User	Developing Organization
ANSI X3.4	ANSI	American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See FIPS-1)	A	Computers	Message transfer	American National Standards Institute
ETTM	ITSA	Electronic Toll & Traffic Management (ETTM) User Requirements for Future National Interoperability	White paper defining electronic tag requirements, for toll collection and traffic management.	A	ETTM	Electronic toll, traffic mgmt.	Intelligent Transportation Society - America
ASTM Exx.xx	ASTM	Standard for Dedicated Short Range Two-Way Vehicle to Roadside Communications Equipment	Draft Standard and protocol for beacon to vehicle and return communications	D	Communications	APTS, ATMS, ETC, vehicles	American Society for Test and Materials
FIPS 1	NIST	Federal Information Processing Standard, American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See ANSI X3.4)	A	Computers	Message transfer	National Institute of Science and Technology
FIPS 148	NIST	Federal Information Processing Standard, Government Open System Interface Procedures.	U.S. Government standard for ISO Open System Interconnection.	A	Communications	Communications	National Institute of Science and Technology
IEEE 1228	IEEE	Software Safety Plans	Software safety.	A	Safety	Human factors, Safety	Institute of Electrical and Electronics Engineers
MIL-STD 1777	U.S.DOD	Internet Protocol (IP)	Internet protocol supports the interconnection of networks, using an internal datagram service to determine the shortest time distance to the end connection.	A	Communications	Communications	United States Department of Defense
MIL-STD 1778	U.S.DOD	Transport Control Protocol (TCP)	Transport control protocol provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May be replaced by ISO 8072 and 8073.	A	Communications	Communications	United States Department of Defense
MIL-STD 1780	U.S.DOD	File Transport Protocol	File transport protocol is the "upper-layer protocol" that commands the transport control protocol issuing 'service requests' and receiving 'service responses'.	A	Communications	Communications	United States Department of Defense
MIL-STD 1781	U.S.DOD	Simple Mail Transfer Protocol	an "upper layer protocol" for mail transfer through a network based on transfer control protocol (TCP) and Internet protocol (IP).	A	Communications	Communications	United States Department of Defense
MIL-STD 1782	U.S.DOD	TELNET Protocol	TELNET is a virtual circuit switching system (CCITT X.75) similar to Internet.	A	Communications	Communications	United States Department of Defense
NAD 27	USGS	North American Datum - 1927.	Geodetic datum for the North American Continent per 1927. Most US maps are based on NAD 27 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service

Roadside to Vehicle Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
NAD 83	USGS	North American Datum - 1983.	Geodetic datum for the North American Continent per 1983. Some US maps are based on NAD 83 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NP 10.2	ISO	Traffic Message Coding for Traffic and Traveler Information.	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Communications	Communications	International Standards Organization
NP 10.5	ISO	Medium-Range Pre-Information	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Communications	Communications	International Standards Organization
RBDS	NAB-R	United States Radio Broadcast Data System (RBDS) Standard - FM subcarrier data transmission.	Proposed FM subcarrier signaling for wide area data transfer to vehicles.	D	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
RDS	NAB-R	United States Radio Data System (RDS) Standard - FM subcarrier data transmission. Approximately 1000 bits per second (bps)		A	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
TIA/EIA/IS-95	TIA	Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System.	Code Division Multiple Access (CDMA). A cellular telecommunications scheme in which multiple users may simultaneously share a frequency as each is using a different code for their information transfer.	D	Communications	Communications	Telecommunications Industry Association
TIA/EIA/IS-95	TIA	Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System.	Code Division Multiple Access (CDMA). A cellular telecommunications scheme in which multiple users may simultaneously share a frequency as each is using a different code for their information transfer.	D	Communications	Communications	Telecommunications Industry Association
V.35	ITU	Transmission of 48 kilobits/second data using 60 to 108 kiloHertz group bank circuits.	Transmission of 48 kilobits per second digital data over telephone group circuits with bandwidths of 60 to 108 kiloHertz (kHz).	A	Communications	Communications	International Telecommunications Union
VDV 04.05.2	VDV	Technical Requirements for Location Beacon Systems	Defines protocols and data formats for communications between infrared and microwave wayside beacons and transit vehicles. Defines formats for location, change in voice radio channel and traffic signal preemption. (German Association of Public Transport)	A	Automated Vehicle Location	Automated vehicle location	Verbund Deutscher Verkehrsunternehmen

A.5.4.4 Listing of possible Vehicle-to-Vehicle and In-Vehicle Communication Standards

Vehicle to Vehicle and In-Vehicle Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
ANSI X3.4	ANSI	American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See FIPS-1)	A	Computers	Message transfer	American National

Vehicle to Vehicle and In-Vehicle Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
							Standards Institute
FIPS 1	NIST	Federal Information Processing Standard, American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See ANSI X3.4)	A	Computers	Message transfer	National Institute of Science and Technology
FIPS 148	NIST	Federal Information Processing Standard, Government Open System Interface Procedures.	U.S. Government standard for ISO Open System Interconnection.	A	Communications	Communications	National Institute of Science and Technology
IEEE 1228	IEEE	Software Safety Plans	Software safety.	A	Safety	Human factors, Safety	Institute of Electrical and Electronics Engineers
IEEE C95.1-1992	J-A/I	Safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz.	Standard specifies maximum power densities tolerable in a 30 minute time period.	A	Communications	Communications, Safety	Joint ANSI / IEEE
ISO 3309:1991	ISO	Data Communications - HDLC Procedures - Frame Structure.	High level digital data link control - Link protocols.	A	Packet Switching	Packet switching	International Standards Organization
ISO 4335:1991	ISO	Data Communications - High Level Data Link Control (HDLC) Procedures.	HDLC procedures (Link protocols.)	A	Packet Switching	Packet switching	International Standards Organization
ISO 7498:1990	ISO	Information Processing Systems - Open System Interconnect - Basic Reference Model.	ISO OSI model of seven layer data communications model.	A	Data Communications	Data communications	International Standards Organization
ISO 8072:1984	ISO	Information Processing Systems - Open System Interconnection - Transport Service Definition	Defines the transport layer (layer 4) requirements for network service. Class 4, Type C is similar to, and based on MIL-STD 1778 Transport Control Protocol.	A	Communications	Communications	International Standards Organization
ISO 8073:1984	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Transport Protocol Specification.	Defines the transport layer (layer 4) protocol requirements for network service. Class 4, Type C is similar to, and based on MIL-STD 1778 Transport Control Protocol.	A	Communications	Communications	International Standards Organization
ISO 8208:1990	ISO	Information Technology - Data Communications X.25 Packet Layer Protocol for Data Terminal Equipment.	Network protocol for data communications.	A	Packet Switching	Packet switching	International Standards Organization
ISO 8822	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Definition	Defines service for connection (circuit) presentation.	A	Communications	Communications	International Standards Organization
ISO 8823	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Protocol Specification	Protocol requirements for connection-oriented presentation service.	A	Communications	Communications	International Standards Organization
ISO 9075:1988	ISO	Structured Query Language.	Structured Query Language is a standardized set of commands for accessing and updating databases.	A	Database Queries	Database queries	International Standards Organization

Vehicle to Vehicle and In-Vehicle Communications Standards

Number	*Abbr.*	*Title*	*Abstract*	*Status*	*Projected Application*	*User*	*Developing Organization*
ISO 9595	ISO	Information Technology - Open System Interconnect- Common Management Information Service Definition	Defines the common management information protocol (CMIP, analogous to TCP) and service.	A	Communications	Communications	International Standards Organization
ISO 9596	ISO	Information Technology - Open System Interconnect - Common Management Information Protocol (CMIP) Specification	CMIP is similar to TCP. CMIP provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May replace TCP about 2001.	A	Communications	Communications	International Standards Organization
ISO 11898	ISO	Controller Area Network (CAN)	ISO version of the Bosch developed Controller Area Network (CAN) in-vehicle area network for automobiles and lorries. Supported by a number of European manufacturers.	A	Vehicle Area Network	Vehicle area network	International Standards Organization
ITE-96-02	ITE	Transit Communications Interface Protocols (TCIP)	Transit protocols and messages for use with the vehicles, operations, maintenance and public information.	P	Transit	Transit	Institute of Transportation Engineers
J1455	SAE	Joint SAE/TMC Recommended Environmental Practices for Electronic Equipment Design of Heavy Duty Trucks and Busses	Design Goals for climatic, mechanical, chemical, electrical and dynamic conditions found on, and generated by, heavy duty trucks and buses.	A	Vehicle Area Network	Vehicle area network	Society of Automotive Engineers
J1708	SAE	Truck and Bus Practice. Serial Data Communications between Microcomputer Systems in Heavy Duty Vehicle Applications.	Serial Data Communications Between Microcomputer Systems in Heavy Duty Vehicle Applications. Details the hardware interface and outlines the communications protocol.	A	Vehicle Area Network	Vehicle area network	Society of Automotive Engineers
J2313	SAE	Standard for On-Board Land Vehicle MAYDAY Reporting Interface	This standard describes the message protocol between an on board mayday detection system and the external response center (E911 center).	D	Emergency Services	Emergency services	Society of Automotive Engineers
MIL-STD 1777	U.S.DOD	Internet Protocol (IP)	Internet protocol supports the interconnection of networks, using an internal datagram service to determine the shortest time distance to the end connection.	A	Communications	Communications	United States Department of Defense
MIL-STD 1778	U.S.DOD	Transport Control Protocol (TCP)	Transport control protocol provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May be replaced by ISO 8072 and 8073.	A	Communications	Communications	United States Department of Defense
MIL-STD 1780	U.S.DOD	File Transport Protocol	File transport protocol is the "upper-layer protocol" that commands the transport control protocol issuing 'service requests' and receiving 'service responses'.	A	Communications	Communications	United States Department of Defense
MIL-STD 1781	U.S.DOD	Simple Mail Transfer Protocol	an "upper layer protocol" for mail transfer through a network based on transfer control protocol (TCP) and Internet protocol (IP).	A	Communications	Communications	United States Department of Defense
MIL-STD 1782	U.S.DOD	TELNET Protocol	TELNET is a virtual circuit switching system (CCITT X.75) similar to Internet.	A	Communications	Communications	United States Department of Defense

Vehicle to Vehicle and In-Vehicle Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
NAD 27	USGS	North American Datum - 1927.	Geodetic datum for the North American Continent per 1927. Most US maps are based on NAD 27 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NAD 83	USGS	North American Datum - 1983.	Geodetic datum for the North American Continent per 1983. Some US maps are based on NAD 83 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NP 10.2	ISO	Traffic Message Coding for Traffic and Traveler Information.	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Communications	Communications	International Standards Organization
NP 10.5	ISO	Medium-Range Pre-Information	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Communications	Communications	International Standards Organization
RBDS	NAB-R	United States Radio Broadcast Data System (RBDS) Standard - FM subcarrier data transmission.	Proposed FM subcarrier signaling for wide area data transfer to vehicles.	D	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
RDS	NAB-R	United States Radio Data System (RDS) Standard - FM subcarrier data transmission. Approximately 1000 bits per second (bps)		A	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
TIA/EIA/IS-95	TIA	Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System.	Code Division Multiple Access (CDMA). A cellular telecommunications scheme in which multiple users may simultaneously share a frequency as each is using a different code for their information transfer.	D	Communications	Communications	Telecommunications Industry Association
VDV 300	VDV	Integrated On-Board Information systems (IBIS)	Defines physical characteristics of on-board transit computers, peripherals, interconnecting wiring and connectors, protocols and message structures for busses and light rail. (German Association of Public Transport Operators)	A	Automated Vehicle Location	AVL, control	Verbund Deutscher Verkehrsunternehmen

A.5.4.5 Listing of possible Center-to-Remote Access Communication Standards

Center to Remote Access Subsystem Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
ANSI X3.4	ANSI	American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See FIPS-1)	A	Computers	Message transfer	American National Standards Institute
EIA-462	EIA	Electrical Performance Standards for Television Broadcast Demodulators.	Television receivers, performance standards.	A	Communications	Communications	Electronics Industries Association

Center to Remote Access Subsystem Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
EIA/TIA-250-C	TIA	Electrical Performance Standards for Television Relay Facilities.		A	Communications	Communications	Telecommunications Industry Association
EIA/TIA-553	TIA	Mobile Station-Land Station Compatibility Specification.	A compatibility standard for cellular mobile telecommunications systems.	A	Communications	Communications	Telecommunications Industry Association
FHWA-STD-WP-11	Nat'l Arch.	Information Service Provider Wireless Interfaces Standards Requirements Package	Describes the wireless communications messages / interfaces between the Information Provider and users. Provides message sequences, contents and data dictionary.	P	Traveler Information	Traveler information	National Architecture Team
FHWA-STD-WP-14	Nat'l Arch.	Traffic Management Subsystem to Other Centers Standards Requirements Package.	Describes the communications messages required between a traffic management center and a host of other centers (Traveler information, transit, traffic, CVO, etc.) Includes message sequencing, content and data dictionary.	P	Traffic Control	Traffic control	National Architecture Team
FIPS 1	NIST	Federal Information Processing Standard, American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See ANSI X3.4)	A	Computers	Message transfer	National Institute of Science and Technology
FIPS 148	NIST	Federal Information Processing Standard, Government Open System Interface Procedures.	U.S. Government standard for ISO Open System Interconnection.	A	Communications	Communications	National Institute of Science and Technology
IEEE 1228	IEEE	Software Safety Plans	Software safety.	A	Safety	Human factors, Safety	Institute of Electrical and Electronics Engineers
IEEE C95.1-1992	J-A/I	Safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz.	Standard specifies maximum power densities tolerable in a 30 minute time period.	A	Communications	Communications, Safety	Joint ANSI / IEEE
ISO 3309:1991	ISO	Data Communications - HDLC Procedures - Frame Structure.	High level digital data link control - Link protocols.	A	Packet Switching	Packet switching	International Standards Organization
ISO 4335:1991	ISO	Data Communications - High Level Data Link Control (HDLC) Procedures.	HDLC procedures (Link protocols.)	A	Packet Switching	Packet switching	International Standards Organization
ISO 7498:1990	ISO	Information Processing Systems - Open System Interconnect - Basic Reference Model.	ISO OSI model of seven layer data communications model.	A	Data Communications	Data communications	International Standards Organization
ISO 8072:1984	ISO	Information Processing Systems - Open System Interconnection - Transport Service Definition	Defines the transport layer (layer 4) requirements for network service. Class 4, Type C is similar to, and based on MIL-STD 1778 Transport Control Protocol.	A	Communications	Communications	International Standards Organization
ISO 8073:1984	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Transport Protocol Specification.	Defines the transport layer (layer 4) protocol requirements for network service. Class 4, Type C is similar to, and based on MIL-STD 1778 Transport Control Protocol.	A	Communications	Communications	International Standards Organization

Center to Remote Access Subsystem Communications Standards

Number	*Abbr.*	*Title*	*Abstract*	*Status*	*Projected Application*	*User*	*Developing Organization*
ISO 8208:1990	ISO	Information Technology - Data Communications X.25 Packet Layer Protocol for Data Terminal Equipment.	Network protocol for data communications.	A	Packet Switching	Packet switching	International Standards Organization
ISO 8822	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Definition	Defines service for connection (circuit) presentation.	A	Communications	Communications	International Standards Organization
ISO 8823	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Protocol Specification	Protocol requirements for connection-oriented presentation service.	A	Communications	Communications	International Standards Organization
ISO 9075:1988	ISO	Structured Query Language.	Structured Query Language is a standardized set of commands for accessing and updating databases.	A	Database Queries	Database queries	International Standards Organization
ISO 9595	ISO	Information Technology - Open System Interconnect- Common Management Information Service Definition	Defines the common management information protocol (CMIP, analogous to TCP) and service.	A	Communications	Communications	International Standards Organization
ISO 9596	ISO	Information Technology - Open System Interconnect - Common Management Information Protocol (CMIP) Specification	CMIP is similar to TCP. CMIP provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May replace TCP about 2001.	A	Communications	Communications	International Standards Organization
ISO 9735	ISO	Electronic data interchange for administration, commerce and transportation (EDIFACT).	Application of EDIFACT syntax.	A	Data Interchange	Data interchange	International Standards Organization
ITE-96-02	ITE	Transit Communications Interface Protocols (TCIP)	Transit protocols and messages for use with the vehicles, operations, maintenance and public information.	P	Transit	Transit	Institute of Transportation Engineers
MIL-STD 1777	U.S.DOD	Internet Protocol (IP)	Internet protocol supports the interconnection of networks, using an internal datagram service to determine the shortest time distance to the end connection.	A	Communications	Communications	United States Department of Defense
MIL-STD 1778	U.S.DOD	Transport Control Protocol (TCP)	Transport control protocol provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May be replaced by ISO 8072 and 8073.	A	Communications	Communications	United States Department of Defense
MIL-STD 1780	U.S.DOD	File Transport Protocol	File transport protocol is the "upper-layer protocol" that commands the transport control protocol issuing 'service requests' and receiving 'service responses'.	A	Communications	Communications	United States Department of Defense
MIL-STD 1781	U.S.DOD	Simple Mail Transfer Protocol	an "upper layer protocol" for mail transfer through a network based on transfer control protocol (TCP) and Internet protocol (IP).	A	Communications	Communications	United States Department of Defense
MIL-STD 1782	U.S.DOD	TELNET Protocol	TELNET is a virtual circuit switching system (CCITT X.75) similar to Internet.	A	Communications	Communications	United States Department of

Center to Remote Access Subsystem Communications Standards

Number	Abbr.	Title	Abstract	Status	Projected Application	User	Developing Organization
							Defense
NAD 27	USGS	North American Datum - 1927.	Geodetic datum for the North American Continent per 1927. Most US maps are based on NAD 27 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NAD 83	USGS	North American Datum - 1983.	Geodetic datum for the North American Continent per 1983. Some US maps are based on NAD 83 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NP 10.2	ISO	Traffic Message Coding for Traffic and Traveler Information.	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Communications	Communications	International Standards Organization
NP 10.5	ISO	Medium-Range Pre-Information	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Communications	Communications	International Standards Organization
RBDS	NAB-R	United States Radio Broadcast Data System (RBDS) Standard - FM subcarrier data transmission.	Proposed FM subcarrier signaling for wide area data transfer to vehicles.	D	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
RDS	NAB-R	United States Radio Data System (RDS) Standard - FM subcarrier data transmission. Approximately 1000 bits per second (bps)		A	Communications	Traffic data communications	National Radio Systems Committee [NRSC] (EIA and NAB)
TIA/EIA/IS-95	TIA	Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System.	Code Division Multiple Access (CDMA). A cellular telecommunications scheme in which multiple users may simultaneously share a frequency as each is using a different code for their information transfer.	D	Communications	Communications	Telecommunications Industry Association
V.28	ITU	Electrical characteristics for interface circuits.	Characteristics of electrical circuits used between terminal and communications devices.	A	Communications	Communications	International Telecommunications Union
V.35	ITU	Transmission of 48 kilobits/second data using 60 to 108 kiloHertz group bank circuits.	Transmission of 48 kilobits per second digital data over telephone group circuits with bandwidths of 60 to 108 kiloHertz (kHz).	A	Communications	Communications	International Telecommunications Union
X-11	MIT	X-Windows, Version 11.	Standard for MIT X-windows. X-windows is a terminal based graphical user interface.	A	Terminal User Interface	Terminal MMI	Massachusetts Institute of Technology
X.21	ITU	General-purpose interface between data terminal equipment and data circuit-terminating equipment for start-stop transmission services on public networks.	Defines the physical characteristics and control procedures for a synchronous digital transmission between the user machine and network. Provides end-to-end digital transmission.	A	Communications	Communications	International Telecommunications Union
X.25	ITU	Interface Between Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE) for Terminals Operating in the Packet Mode on Public Data Networks.	Interface protocol standard specifying physical control (layer 1), link control (layer 2) and network control (layer 3) for packet format data transfer connection to a network.	A	Communications	Communications	International Telecommunications Union

Center to Remote Access Subsystem Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
X.400	ITU	Message Handling Systems: System Model-Service Elements	"Upper Level Protocols" for Message and Mail transfer on networks.	A	Communications	Communications	International Telecommunications Union

A.5.4.6 Listing of possible Center-to-Vehicle Communication Standards

Center to Vehicle Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
ANSI X3.4	ANSI	American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See FIPS-1)	A	Computers	Message transfer	American National Standards Institute
EIA/TIA-553	TIA	Mobile Station-Land Station Compatibility Specification.	A compatibility standard for cellular mobile telecommunications systems.	A	Communications	Communications	Telecommunications Industry Association
ETTM	ITSA	Electronic Toll & Traffic Management (ETTM) User Requirements for Future National Interoperability	White paper defining electronic tag requirements, for toll collection and traffic management.	A	ETTM	Electronic toll, traffic mgmt.	Intelligent Transportation Society - America
FHWA-STD-WP-10	Nat'l Arch.	Transit Management to Transit Vehicle and Remote Traveler Service Interfaces Standards Requirements Package	Describes the communications messages between transit management and the remote traveler (kiosk) and between transit management and the transit vehicle. Includes message sequencing, content and data dictionary.	P	Traveler Information	Traveler information	National Architecture Team
FHWA-STD-WP-11	Nat'l Arch.	Information Service Provider Wireless Interfaces Standards Requirements Package	Describes the wireless communications messages / interfaces between the Information Provider and users. Provides message sequences, contents and data dictionary.	P	Traveler Information	Traveler information	National Architecture Team
FHWA-STD-WP-14	Nat'l Arch.	Traffic Management Subsystem to Other Centers Standards Requirements Package.	Describes the communications messages required between a traffic management center and a host of other centers (Traveler information, transit, traffic, CVO, etc.) Includes message sequencing, content and data dictionary.	P	Traffic Control	Traffic control	National Architecture Team
FHWA-STD-WP-15	Nat'l Arch.	Signal Priority for Emergency and Transit Vehicles Standards Requirements Package	Describes the communications messages between traffic management and emergency and transit vehicle for signal control. Includes message sequencing, content and data dictionary.	P	Traffic Control	Traffic control, MAYDAY, Transit	National Architecture Team
FIPS 1	NIST	Federal Information Processing Standard, American National Standard Code for Information Interchange (ASCII).	Computer eight bit code for 256 character set of printing and control characters. (See ANSI X3.4)	A	Computers	Message transfer	National Institute of Science and Technology
FIPS 148	NIST	Federal Information Processing Standard, Government Open System Interface Procedures.	U.S. Government standard for ISO Open System Interconnection.	A	Comm	Comm	NIST
IEEE 1228	IEEE	Software Safety Plans	Software safety.	A	Safety	Human factors, Safety	IEEE

Center to Vehicle Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
IEEE C95.1-1992	J-A/I	Safety levels with respect to human exposure to radio frequency electromagnetic fields, 3 kHz to 300 GHz.	Standard specifies maximum power densities tolerable in a 30 minute time period.	A	Comm	Comm, Safety	Joint ANSI / IEEE
ISO 3309:1991	ISO	Data Communications - HDLC Procedures - Frame Structure.	High level digital data link control - Link protocols.	A	Packet Switching	Packet switching	International Standards Organization
ISO 4335:1991	ISO	Data Communications - High Level Data Link Control (HDLC) Procedures.	HDLC procedures (Link protocols.)	A	Packet Switching	Packet switching	International Standards Organization
ISO 7498:1990	ISO	Information Processing Systems - Open System Interconnect - Basic Reference Model.	ISO OSI model of seven layer data communications model.	A	Data Communications	Data communications	International Standards Organization
ISO 8072:1984	ISO	Information Processing Systems - Open System Interconnection - Transport Service Definition	Defines the transport layer (layer 4) requirements for network service. Class 4, Type C is similar to, and based on MIL-STD 1778 Transport Control Protocol.	A	Comm	Comm	International Standards Organization
ISO 8073:1984	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Transport Protocol Specification.	Defines the transport layer (layer 4) protocol requirements for network service. Class 4, Type C is similar to, and based on MIL-STD 1778 Transport Control Protocol.	A	Comm	Comm	International Standards Organization
ISO 8208:1990	ISO	Information Technology - Data Communications X.25 Packet Layer Protocol for Data Terminal Equipment.	Network protocol for data communications.	A	Packet Switching	Packet switching	International Standards Organization
ISO 8822	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Definition	Defines service for connection (circuit) presentation.	A	Comm	Comm	International Standards Organization
ISO 8823	ISO	Information Processing Systems - Open System Interconnection - Connection-Oriented Presentation Service Protocol Specification	Protocol requirements for connection-oriented presentation service.	A	Comm	Comm	International Standards Organization
ISO 9075:1988	ISO	Structured Query Language.	Structured Query Language is a standardized set of commands for accessing and updating databases.	A	Database Queries	Database queries	International Standards Organization
ISO 9595	ISO	Information Technology - Open System Interconnect- Common Management Information Service Definition	Defines the common management information protocol (CMIP, analogous to TCP) and service.	A	Comm	Comm	International Standards Organization
ISO 9596	ISO	Information Technology - Open System Interconnect - Common Management Information Protocol (CMIP) Specification	CMIP is similar to TCP. CMIP provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May replace TCP about 2001.	A	Comm	Comm	International Standards Organization
ISO 9735	ISO	Electronic data interchange for administration, commerce and transportation (EDIFACT).	Application of EDIFACT syntax.	A	Data Interchange	Data interchange	International Standards Organization
ITE-96-02	ITE	Transit Communications Interface Protocols (TCIP)	Transit protocols and messages for use with the vehicles, operations, maintenance and public	P	Transit	Transit	Institute of Transportation

Center to Vehicle Communications Standards

Number	Abbr.	Title	Abstract	Status	Projected Application	User	Developing Organization
			information.				Engineers
MIL-STD 1472D	U.S.DOD	Human Engineering Design Criteria for Military Systems, Equipment and Facilities	Human engineering design criteria, principles and practices to integrate the human into the system; and achieve effectiveness and safety of operations and maintenance.	A	Human Factors	Human factors	United States Department of Defense
MIL-STD 1777	U.S.DOD	Internet Protocol (IP)	Internet protocol supports the interconnection of networks, using an internal datagram service to determine the shortest time distance to the end connection.	A	Comm	Comm	United States Department of Defense
MIL-STD 1778	U.S.DOD	Transport Control Protocol (TCP)	Transport control protocol provides a connection-oriented data-transfer service between users in order to overcome damage, loss, duplication and misordering of packets during transmission through multiple networks. May be replaced by ISO 8072 and 8073.	A	Comm	Comm	United States Department of Defense
MIL-STD 1780	U.S.DOD	File Transport Protocol	File transport protocol is the "upper-layer protocol" that commands the transport control protocol issuing 'service requests' and receiving 'service responses'.	A	Comm	Comm	United States Department of Defense
MIL-STD 1781	U.S.DOD	Simple Mail Transfer Protocol	an "upper layer protocol" for mail transfer through a network based on transfer control protocol (TCP) and Internet protocol (IP).	A	Comm	Comm	United States Department of Defense
MIL-STD 1782	U.S.DOD	TELNET Protocol	TELNET is a virtual circuit switching system (CCITT X.75) similar to Internet.	A	Comm	Comm	United States Department of Defense
NAD 27	USGS	North American Datum - 1927.	Geodetic datum for the North American Continent per 1927. Most US maps are based on NAD 27 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NAD 83	USGS	North American Datum - 1983.	Geodetic datum for the North American Continent per 1983. Some US maps are based on NAD 83 geodetic constants.	A	Navigation	Navigation	United States Geodetic Service
NP 10.2	ISO	Traffic Message Coding for Traffic and Traveler Information.	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Comm	Comm	International Standards Organization
NP 10.5	ISO	Medium-Range Pre-Information	ISO TC 204 Working Group 10 Traveler Information Systems effort.	P	Comm	Comm	International Standards Organization
P1404	IEEE	Microwave Communications Systems Development: Design, Procurement, Construction, Maintenance and Operation	A guide to microwave communications systems procurement for the non-communications manager.	D	Comm	Comm	Institute of Electrical and Electronics Engineers
P1483	IEEE	Standard for Safety for Software Used in Rail Transit Systems		P	Safety	Safety	Institute of Electrical and Electronics Engineers

Center to Vehicle Communications Standards							
Number	***Abbr.***	***Title***	***Abstract***	***Status***	***Projected Application***	***User***	***Developing Organization***
RBDS	NAB-R	United States Radio Broadcast Data System (RBDS) Standard - FM subcarrier data transmission.	Proposed FM subcarrier signaling for wide area data transfer to vehicles.	D	Comm	Traffic data comm	National Radio Systems Committee [NRSC] (EIA and NAB)
RDS	NAB-R	United States Radio Data System (RDS) Standard - FM subcarrier data transmission. Approximately 1000 bits per second (bps)		A	Comm	Traffic data comm	National Radio Systems Committee [NRSC] (EIA and NAB)
TIA/EIA/IS-124	TIA	Cellular Radio Telecommunications Intersystem Non-Signaling Data Communications	Interim standard describes procedures to provide non-signaling data communications.	D	Comm	Comm	Telecommunications Industry Association
TIA/EIA/IS-95	TIA	Mobile Station-Base Station Compatibility Standard for Dual-Mode Wideband Spread Spectrum Cellular System.	Code Division Multiple Access (CDMA). A cellular telecommunications scheme in which multiple users may simultaneously share a frequency as each is using a different code for their information transfer.	D	Comm	Comm	Telecommunications Industry Association
VDV 04.05.5	VDV	Radio Data Interface	Defines protocols and data formats to be used in interface between the central computer and radio system in transit AVL/Control (fleet management) system. (German Association of Public Transport)	A	Automated Vehicle Location	AVL	Verbund Deutscher Verkehrsunternehmen
VDV 420	VDV	Technical Requirements for AVL/Control Systems - Radio Data Interface	Protocols and message structure for public transit fleet management. Communications between vehicle to/from transit control center. (German Association of Public Transport)	A	comm	comm., transit	Verbund Deutscher Verkehrsunternehmen

A.6 References

1) U.S. DOT, "National ITS Architecture"- VARIOUS DOCUMENTS, *January 1997*
2) TCIP Status Report to the Joint NTCIP Committee, *December 1996*
3) ITS International Journal, *November 1996*
4) Dedicated Short Range Communications (DSRC) Draft Document, *November 1996*
5) White Paper on the National ITS System Architecture: Data Dictionary for Transit Use, Final Draft, Sandia National Laboratories, *October 1996*
6) Description/listing of SAE Standards to describe SAE J1708 and J1587, provided Kristy Hanson of SAE, Troy
7) NEMA TS-2 Traffic Controller Assemblies, *1992*
8) NEMA TS-3.2 NTCIP - Simple Transportation Management Framework (STMF), *1996*
9) NEMA TS-3.1 NTCIP - Class B Profile, *1996*
10) Computer Networks, Second Edition, Tanenbaum, A.S., Prentice-Hall, *1988*
11) Concept of Operations for Dedicated Short Range Communications (DSRC) - U.S. DOT, *March 1997*

Appendix B: Sample ITS Procurement Language

Appendix B contains excerpts from procurement documents of proven, real-world transit ITS applications. This sample procurement language provides a model for transit agencies embarking on transit ITS projects. The excerpts are taken from RFPs of the following agencies:

+ Ann Arbor Transit Authority
  - Intelligent Transportation System (ITS)
+ King County Department of Transportation
  - Automatic Passenger Counter (APC) System
  - Automatic Vehicle Identification (AVI) System for Transit Signal Priority
+ Milwaukee County
  - Radio System
+ Tri-County Metropolitan Transportation District of Oregon
  - Trip Planning System

During interviews, a majority of transit agencies recommended that a competitive negotiation process be used for most ITS procurements. Transit agencies also identified several areas that require special attention when procuring ITS applications. The sample procurement language contained in this appendix is organized according to these areas, as shown below:

Proposal Format / Procurement Method — Section B.1

+ ITS
+ APC System
+ AVI System for Traffic Signal Priority
+ Radio System
+ Trip Planning System

ITS Specifications — Section B.2

+ ITS
+ APC System
+ AVI System for Traffic Signal Priority
+ Radio System
+ Trip Planning System

Drawings / Documentation — Section B.3

+ ITS

Software / Source Code — Section 8.4

+ ITS

Interface Criteria	**Section B.5**
+ ITS	
Installation	**Section 8.6**
+ ITS	
+ Radio System	
Acceptance Tests	**Section B.7**
+ ITS	
+ Radio System	
Instruction and Training	**Section B.8**
+ ITS	
+ Radio System	
Warranties	**Section B.9**
+ ITS	
+ APC System	
+ AVI System for Traffic Signal Priority	
+ Radio System	

Some of the categories listed above are contained in an ITS specification. For example, the specification for the Trip Planning System contains requirements for configuration and hardware, software, testing, and training, and the specification for the Radio System contains requirements for software, training, and testing. These sections were not removed from the specification to be placed in the respective category above.

Some of the material from specifications were not included in this appendix in their entirety. For specifications that are incomplete, the table of contents for that specification was provided to give the reader a sense of the topics covered.

Note: Addenda to the RFPs are not included in this appendix.

B. 1. PROPOSAL FORMAT / PROCUREMENT METHOD

Intelligent Transportation System

1.5 PROPOSAL FORMAT

Proposals shall be submitted in the format outlined below. Proposals submitted in any other form may be considered non-responsive and may be rejected:

Proposals shall be submitted in two (2) separate sealed packages consisting of:

PACKAGE 1: **Technical Proposal (1 *original, 3 copies)***

PACKAGE 2: Price and Delivery **Proposal (2 *original, 1 copy)***

Each package shall be sealed and clearly reflect the RFP Number, Package Number and Contents, and the Proposer's name. For a proposal to be considered responsive, each package must include the following information or executed forms, in the format stated:

A. PACKAGE 1 - TECHNICAL PROPOSAL

Each section of the proposal must be clearly identified with appropriate headings:

i. Technical Proposal

Refer to Part 4, Specifications, for desired performance and features of the AATA's Intelligent Transportation System.

ii. Background

Provide a concise history of your firm, list corporate officers, general experience and specific capabilities.

iii. Related Project Experience

Provide descriptions of your firm's completed projects which are similar to the project being described in this RFP. Include a list of references from among your firm's most recent clients, preferably governmental agencies, with contact names, addresses and up-to-date telephone numbers, and installation dates. Proof of successful installation within the past t-three years of a system similar to that being specified in this RFP is required in order for a proposer to be considered qualified for participation in this project.

iv. Schedule

Provide a progress schedule demonstrating the time elements in weekly intervals for accomplishing the Deliverables as presented in Part 4, Specifications, of this RFP. This progress schedule must consider all elements and their relations, as described in the Specifications. Include projected impact upon AATA operations due to expected modification of vehicles in the AATA's fleet.

v. Location

State the location of the proposer's facility or office from which the majority of the work on the AATA's project will be directed.

vi. AATA Participation

Describe as precisely as possible the expectations for AATA's participation in the work, by indicating the number and types of AATA Personnel expected to participate, and for each type, the estimated number of hours involved and the nature of the assistance expected.

B. **Package** II - Price Proposal

Each section of the proposal must be clearly identified with appropriate headings:

i. **Itemized and Total Costs for all required elements.**

ii. **Cost for each optional element as proposed.**

iii. Proof of Responsibility

iv. **Forms (APPENDIX), as follows:**

- *DISCLOSURE OF OWNERSHIP* FORM
- *BIDDER CERTIFICATE STATEMENT*
- *"BUY AMERICA" CERTIFICATE FOR ROLLING STOCK*
- *ATTACHMENT A: CERTIFICATION OF PRIMARY PARTICIPANT REGARDING DEBARMENT, SUSPENSION, AND OTHER RESPONSIBILITY MATTERS*
- *ATTACHMENT C: CERTIFICATION OF LOWER-TIER PARTICIPANTS REGARDING DEBARMENT, SUSPENSION, AND OTHER INELIGIBILITY AND VOLUNTARY EXCLUSION*
- *LOBBYING RESTRICTIONS COMPLIANCE CERTIFICATE*
- ADDENDA RECEIPT CERTIFICATE
- ATTACHMENT A: AFFIRMATIVE ACTION REQUIREMENTS including:
  - *Equal Opportunity Compliance Report Form*
  - *Certification of Compliance with Federal Affirmative Action Requirements Form*
- ATTACHMENT B: *Disadvantaged Business Enterprises Program*

1.15 PROPOSAL ACCEPTANCE OR REJECTION

The AATA reserves the right to:

1. Accept any proposals;
2. Reject any or all proposals;
3. Negotiate with all proposers whose proposals are considered to be within the "competitive range";
4. Reject proposals which are not considered to be within the competitive range, or which show evidence of poor past performance, or which have major deviations from the AATA's specifications; and accept a proposal which has only minor deviations;
5. Postpone the proposal due date or and cancel the solicitation; or
6. To contract on such basis as it deems to be in its best interest, including splitting the award between two or more proposers.

PART 2
Procurement Process

2 1 METHOD OF PROCUREMENT: COMPETITIVE NEGOTIATION

1. Procurement will be made on a "competitive negotiated" basis. The Competitive Negotiation method of procurement is an acknowledgement that, in addition to price and responsiveness to technical specifications, there are other factors which should be considered in the procurement process in order to determine which offer is in the best interest of the AATA and allows the most efficient and economical use of public funds. It should also be understood that the Competitive Negotiation" process is designed to ensure, to the maximum extent possible, that award will be made on a competitive basis.

2. The contract will be awarded to the proposer whose proposal will be the most advantageous to the AATA in terms of all evaluation criteria stated elsewhere in the RFP.

3. Proposals will not be publicly opened and are strictly confidential. Detailed procedures for proposal evaluations and the steps leading to award follow.

4. The basic steps in the competitive negotiation process are as follows:

   a. AATA determines the relative importance of all the evaluation factors pertinent to the RFP and lists them in order of priority. This has been done and is reflected as the criteria provided in Part 3 of this RFP.

   b. AATA issues a Request For Proposals (RFP) containing specifications that describe the actual minimum needs and advising prospective offerors of the criteria upon which the proposals will be evaluated.

   c. By the date specified in the RFP, qualified offerors submit sealed proposals in two (2) parts: Package 1- Technical Proposal, Package 2- Price Proposal.

d. Package 1 - Technical Proposals are opened in private by the AATA. Package 2 - Price Proposals are not opened at this time.

e. The AATA reviews the Technical Proposals to determine proposal compliance.

f. AATA evaluates all compliant Technical Proposals in accordance with the evaluation criteria. Technical information is kept strictly confidential.

g. Price Proposals are opened in private by the AATA. Pricing information is kept strictly confidential.

h. The AATA determines the "Competitive Range". The Competitive Range includes all proposals which have a reasonable chance of being selected for award, based upon a preliminary screening against the previously established evaluation criteria. When there is a doubt as to whether a proposal is within the competitive range, that doubt shall be resolved by the proposal's inclusion.

i. The AATA determines whether or not to carry out discussions with those offerors whose proposals are within the competitive range or to recommend an award of the contract without further discussion.

NOTE: The AATA may elect to award a contract without further discussions or negotiations if the AATA determines that the best technically acceptable proposal has been received and that acceptance of this initial proposal would result in a fair and reasonable price.

j. If an award is to be made pending further discussion or negotiation, all offerors whose proposals are within the competitive range will be formally notified in writing, of the AATA's intentions to hold discussions with them and the required steps leading to "Best And Final Offers" (BAFO's). A meeting will be held with each such offeror. Offerors may then modify their proposals, accordingly, and may submit their BAFO after all meetings and discussions have been completed. No evaluation and/or price comparisons are allowed between proposals. Discussions will not include disclosure of the strengths and weaknesses of competing proposals-

k. The sealed BAFO's are submitted by a common closing time, of which all offerors within the competitive range will be formally notified.

l. The AATA evaluates these BAFO's, and unless all proposals are rejected, recommends award to the offeror whose offer, conforming to the solicitation, will be most advantageous to the AATA, price and other factors considered.

m The award recommendation is submitted to the AATA's Board of Directors and DBE Liason/EEOC Officer, if required, for their consideration and approval.

n. All proposers are advised in writing of the AATA's final decision.

o. The non-proprietary portions of the proposal and contract documents are not made public until the evaluation and award processes have been completed.

PART 3:
Evaluation Criteria and Award

3.1 EVALUATION CRITERIA

The specifications, and any addenda thereto, set forth the minimum requirements of the equipment, parts, service, and other deliverables the AATA requires through this procurement.

The award for this contract will be made to the proposer whose proposal, in the opinion of the AATA, best meets the established criteria listed below. The AATA is committed to providing high-quality public transportation service. The Ann Arbor community provides a high level of financial support to this end. In the procurement of this product and service, as with all products and services procured by the AATA, cost is an important but not overriding consideration. That is, it is the AATA's intention to contract for the "best value" product and service which offers the desired level of quality at a reasonable price rather than a product and service that just meet minimum specifications at the lowest price. The selection process is designed to serve this purpose.

Weights for the different evaluation criteria listed below, to be used for scoring purposes, will be assigned by the AATA's evaluating committees prior to the acceptance of proposals. The criteria weights will remain confidential at all times. The proposal scoring the highest number of points for the combined criteria will be the one recommended for award of contract.

Technical proposals will be evaluated by the following aiteria:

A. TECHNICAL

1. Ability of the proposed ITS to support performance requirement-s as outlined in this RFP.

2. Features of the proposed ITS

   a. Percentage of existing demonstrable software and hardware
   b. Previous success with similar projects

3. Performance characteristics and reliability of components of the proposed ITS.

   a. Identification of real-time versus non-real-time requirements and allocation of system resources to reflect this.
   b.' Identification of throughput bottleneck and expansion Limitations.
   c. Ability of the ITS to continue (possibly degraded) operations in the event of a system or component failure.

4. Ergonomics and Human Factors

   a. Operations Control Information System
   b. Motor Coach Operator (MCO) Man Machine Interface (MMI)

B. MANAGEMENT'

The managerial capability and qualifications of a potential contractor will be evaluated by the following criteria:

1. Related Experience of Firm and Staff

   a. With APTS technology.
   b. With the proposed ITS.

2. Schedule

   a. Time constraints.
   b. Projected completion dates.
   c. Sequence of work to be performed.
   d. Demonstration that schedule can be met

3. Background

   a. History / Years of experience.
   b. Ownership / Management of the firm.
   c. Project descriptions of the firm's related projects.

4. Experience in working with local government.

C. MANAGEMENT CONCEPT AND ORGANIZATION

The AATA recognizes that it is unlikely that any single organization is capable of providing all the components specified in the functional description. However, it is looking for a commitment on the part of the proposer to reduce the risk inherent in management of this project Thus, it is looking for a single entity that will accept full responsibility for completion of the project.

Some conceptual and management alternatives for responsive proposals (not necessarily inclusive) are as follows:

Tumkev Concept

Under the turnkey concept a single entity who may be both a System Designer/Integrator and a Subsystem Supplier, would be the Prime Contractor responsible for the definition, design, development, implementation and test of the entire system. The Prime Turnkey Contractor may assemble a team of subcontractors for the various subsystems that are outside of the Prime Turnkey Contractors competence. System performance responsibility, however, would reside with the Prime Turnkey Contractor.

Consortia or Joint Venture

Under this concept **a** new entity would be created for the purpose of responding to this solicitation among suppliers who represent capabilities, know-how and subsystem products to provide the entire system with clearly defined individual responsibilities of each contributing participant, as well as an understanding among the participants for full system performance responsibility to be explicitly assigned to a single entity.

When the Evaluation Committee has completed its evaluation of each proposal in relation to the above non--financial criteria, the technical scores will then be weighed relative to the competitiveness, fairness and reasonableness of price.

Price proposals will be evaluated using the following criteria:

1. Competitiveness, fairness and reasonableness of proposed price for the total svstem.
2. Impact of expected operating costs (for up to three years) on total cost of ownership.
3. Cost effectiveness of use of existing equipment.

In terms of importance, responsiveness to the technical requirements will be given greater weight than price.

The contract shall be awarded only to a “responsible” prospective contractor. No award shall be made unless the AATA’s Contracting Officer makes an affirmative determination of responsibility. To be determined “responsible”, a prospective contractor must:

(a) Have adequate financial resources to perform the contract, or the ability to obtain them;

(b) Be able to comply with the required or proposed delivery or performance schedule, taking into consideration all existing commercial and governmental business commitments;

(c) Have a satisfactory performance record:
  1. Satisfactory customer references.
  2. Satisfactory past performance with the AATA;

(d) Have a satisfactory record of integrity and business ethics;

(e) Have the necessary organization, experience, accounting and operational skills, or the ability to obtain them (including, as appropriate, such elements as production control procedures, property control systems, and quality assurance measures applicable to materials to be produced or services to be performed by the prospective contractor and subcontractors);

(f) Have the necessary production, construction, and technical equipment and facilities, or the ability to obtain them; and

(g) Be otherwise qualified and eligible to receive an award under applicable laws and regulations.

[REFERENCE: FAR 9.104]

Automatic Passenger Counter System

1-14 Proposal Requirements

A. The Proposal shall contain the following items and follow the exact sequence outlined below:

1. Exhibits
   No. 1: Corporate Profile
   No. 2: Corporate References

2. Scoring (See Sections 2-5 and 7-2, C through F)

3. Attachments
   A- Proposal Response Form
   B- Price Proposal
   E- Affidavit and Certificate of Compliance Regarding Equal Employment Opportunity - Sign and submit with Proposal
   F- Sworn Statement Regarding Minority and Women Business Enterprise and Disadvantaged Business Enterprise Commitment - Sign and submit with Proposal
   G- Current or Former County Employee Disclosure Form. Complete and submit as part of the Proposal.
   M- Agreement - Sign and submit with Proposal

B. Submit six (6) copies of the Proposal and attachments. One copy shall be unbound to facilitate reproduction.

SECTION 2 - PROPOSAL EVALUATION AND CONTRACT AWARD

2-l General

The PEB will evaluate the Proposals submitted in response to the RFP, conduct fact finding and determine which Proposal, if any, is most appropriate for the contract award. The PEB will make such investigations as it considers necessary for evaluation of Proposals.

2-2 Changes in Requirements

When, either before or after receipt of Proposals, the County changes, raises, increases, or otherwise modifies its requirements, the County shall issue a written addendum to the RFP. In considering which firms to notify of a change, the County will consider the stage in the procurement process at which the change occurs and the magnitude of the change, as follows:

A. If Proposals are not yet due, the addendum will be sent to all firms that have received the RFP.

B. If the time for receipt of Proposals has passed but Proposals have not been evaluated, the addendum will be sent only to Proposers responding to the RFP.

C. If the Proposals have been evaluated and classified, only those Proposals classified as potentially acceptable will be sent the addendum.

D. If a change is so substantial that it warrants substantial revision of the RFP, the County may cancel the original RFP and issue a new one, regardless of the state of the procurement process. The new solicitation will be issued to all firms originally solicited and to any firms added to the original list.

2-3 Proposal Evaluation

The PEB will evaluate each Proposal using the criteria set forth in Sections 2 and 7 of this RFP. If deemed necessary by the PEB, written or oral discussions may be conducted with those Proposers whose Proposals are found to be potentially acceptable. Identified deficiencies, technical requirements, terms and conditions of the RFP, costs or prices, and suspected mistakes may be included among the items for discussion. The discussions are intended to give Proposers a reasonable opportunity to resolve deficiencies, uncertainties and suspected mistakes as requested by the PEB and to make the cost, pricing or technical revisions required by the resulting changes.

Upon completion of discussions, the PEB may issue to all remaining potentially acceptable Proposers a request for Best and Final Offers. The request will include notice that discussions are concluded, an invitation to submit a revised Proposal with a Best and Final offer, and a new submittal date and time. This submittal shall be evaluated in accordance with Section 2-4 of this RFP.

The County reserves the right to make a contract award withoutwritten and/or oral discussions with the Proposers and without an opportunity to submit Best and Final Offers when deemed to be in the County's best interests:

2-4 Evaluation of the Best and Final Offer

After receiving Best and Final Offers, if requested, the PEB will evaluate the Proposal or Proposals which have been preliminarily identified as most advantageous through analysis of information derived from the Proposal, the County's records, other relevant sources and information provided by the Proposer. The

PEB may request that the Proposer provide additional information, explanation and documentation such as the following:

A. <u>Responsiveness</u>

The County will consider all the material submitted by the Proposer to determine whether the Proposer's offering is in compliance with the terms and conditions set forth in this RFP.

B. <u>Responsibility</u>

1. The County will consider all the material submitted by the Proposer, and other evidence it may obtain otherwise, to determine whether the Proposer is capable of, and has a history of, successfully completing contracts of this type. This may include requiring the Proposer to provide references from customers who have been provided the same or equivalent goods or services. References shall include the names and addresses of the parties to whom such goods or services were provided and the name and phone number of contact persons with such parties.

2. The following elements will be given consideration by the County in determining whether a Proposer is responsible:

   a. the ability, capacity and skill of the Proposer to perform the contract or provide the service required;

   b. the character, integrity, reputation, judgment and efficiency of the Proposer;

   c. whether the Proposer has the financial resources and experience to perform the contract properly and within the times specified;

   d. the quality and timeliness of performance by the Proposer on previous contracts with the County and with other local governments and state and federal agencies, including, but, not limited to, the relative costs, burdens, time and effort necessarily expended by the County and such governments and agencies in securing satisfactory performance and resolving claims;

   e. the previous and existing compliance by the Proposer with laws relating to public contracts or services, including, but not limited to, minority and women business enterprise and equal employment opportunity requirements;

   f. the' history of the Proposer in filing claims and litigation on prior projects involving the County or on other public or private projects; and

   g. such other information as may be secured having a bearing on the decision to award the contract.

Proposers shall furnish acceptable evidence of the Proposer's ability to perform such as firm commitments by subcontractors, equipment, supplies and facilities, and the Proposer's ability to obtain the necessary personnel, when requested by the County. Refusal to provide such information when requested will cause the Proposal to be rejected.

c. <u>Financial Resources</u> (See section 7-2E)

The County is requesting proposers to submit the following financial information with their proposal.

1. certification by the principal financial officer of or an independent accountant for the Proposer, stating that the Proposer has adequate financial resources for the prosecution and completion of the work called for hereunder, and

2. the names, addresses and telephone numbers of at least one contact in the company's principal financial or banking organization and its independent auditor.

The PEB may find that the Proposer appears fully qualified to perform the contract or it may require additional information or actions from the Proposer. In the event the PEB determines that there are problems of such a nature or magnitude that it is advantageous to the County to bypass the highest scored Proposal, the PEB shall evaluate the qualifications of the next ranked Proposer for award of the contract. A Proposer bypassed for award by the PEB for whatever reason shall have no claim for costs incurred including, but not limited to, presentation costs, Proposal preparation, the cost of providing additional information requested, or modification made either to its Proposal or internal structure or systems of the Proposer or its organization.

D. Financial Reporting

The Proposer shall provide a current copy of its Dun and Bradstreet report if requested by the county.

2-5 Scoring

Each Proposal has a total possible score of 1000 points with the points assigned as follows:

SUBSECTION	TITLE	POINTS
Exhibits No. 1& 2	Corporate Profile/Reference	50
7-2C	Business Plan	100
7-2D	Technical Proposal	400
7-2E	Financial Resources	50
7-2F	MA&BE Participation	50
Attachment B:	Price Proposal	275
Attachment B:	Options (items 5 through 8)	75
	TOTAL POINTS AVAILABLE	1,000

2-6 Evaluation Criteria

Proposals will be evaluated on their meeting the needs of King County as identified by the criteria listed below. The inability to meet any one criteria may disqualify or significantly reduce a proposal's score. The following criteria are listed in descending order of importance:

A. Working Product
Proposals will be evaluated on the maturity and stability of the product. Product must be complete and available immediately for production use. Beta products will not be considered.

B. Schedule
Proposals will be screened based on the vendor's ability to provide the products and services in time to meet the project schedule as outlined in this document.

C. Technical Capability
The Proposals will be evaluated to determine their ability to meet the business and technical requirements outlined in this document.

D. Cost
Proposals will be evaluated for the cost of the products, the cost of the services, the cost of maintenance and support, and other costs that King County would incur as a result of the proposal. For example: a proposal might require expensive equipment which King County doesn't have available and is not experienced with.

E. Vendor Viability
Proposals will be evaluated on the company's financial and business viability, their expected ability to be able to succeed in the marketplace and keep their products supported and improving.

F. Services
This project will require several services be provided by the vendor. The vendor will need to be able to train King County staff on the use of the product. The vendor will be needed to help design an effective way to use their product . Then help install and configure the product.

G. References
References will be checked to determine that the products are in use by other companies and that those companies are satisfied with the product, support and services provided by the vendor. Special consideration will be given to products that have been used in applications as proposed in this project.

H. Demonstration/Testing
As part of the Proposal Evaluation Criteria, the selected vendor may be asked to provide King County with a demonstration of its system, which shall include but not limited to the operational and functional requirements,

2-7 Negotiations

The County may enter negotiations with one or more Proposers to finalize contract terms and conditions. In the event negotiations are not successful, the County may initiate negotiations with the next ranking Proposers or reject Proposals.

Negotiation of a contract will be in conformance with applicable federal, state and local laws, regulations and procedures. The objective of the negotiations will be to reach agreement on all provisions of the proposed contract.

2-8 Contract Award

Contract award, if any, will be made by the County to the responsible Proposer whose Proposal meets the requirements of the RFP, and will be the most advantageous to the County with respect to price, quality and other factors as evaluated by the County. The County is not required to award a contract to the Proposer offering the lowest price. The County shall have no obligations until a contract is signed between the Proposer and the County. The County reserves the right to award one or more contracts as it determines to be in its best interest.

Automatic Vehicle Identification System for Transit Signal Priority

SECTION 1
PROPOSAL PREPARATION

1.1 Introduction

The Department of Metropolitan Services (Metro), formerly known as the Municipality of Metropolitan Seattle, is a department of King County, Washington, responsible for building and operating transit and sewage treatment systems in the greater Seattle metropolitan area. Metro has a fleet of 1,300 transit coaches, including diesel buses, electric trolleys, dual-powered (electrical and diesel) buses, and electric streetcars. Metro currently operates coaches from six bus and trolley bases and the Waterfront Street Car Barn, and it may resume operations from a seventh base in the next few years. Metro forecasts indicate that there will be approximately 75.5 million riders in 1994.

Metro is requesting proposals from qualified vendors to design, procure, deploy, and test an Automatic Vehicle Identification (AVI) system to support transit signal priority (TSP) on arterial streets. The TSP system will provide green time advantage to specific transit coaches at specified street intersections. The hardware and software included in this procurement will provide the data transmission, vehicle detection, vehicle identification, and the necessary output to the traffic signal controller.

Each local traffic signal operating agency will be responsible for providing the traffic controller equipment to affect the signal timing at the intersection..

A. Project Goals

The AVI procurement is intended to support the following Metro goals:

1. Select and develop a successful AVI system to support TSP projects on Rainier Avenue South and Highway 99 North.
2. Reach a regional consensus on an AVI system in King, Pierce, and Snohomish Counties.
3. Select an AVI system that supports non-proprietary, open interfaces.
4. Select an AVI system that is simple, reliable, and easy to maintain.

The TSP program supports the following Metro goals:

5. Support the movement of people at congested intersections.
6. Improve the competitiveness of transit travel time with non-transit modes.
7. Develop partnerships with the local traffic control community.

The contract for this AVI procurement supports the following Metro goals:

8. Execute a contract for supply, installation, and deployment of an AVI system.
9. Execute a contract that affords other political jurisdictions pursuing TSP projects access to similar prices, terms, and conditions.
10. Execute a contract with an acceptable cost escalation index to ensure competitive equipment pricing to support future projects.

B. Project Locations

Metro has identified Rainier Avenue South and Highway 99 North as two arterial corridors for installing and testing an AVI system to support TSP treatments.

Rainier Avenue South is a 2.5-mile corridor with five signalized intersections for TSP treatments. The City of Seattle manages the public right-of-way and traffic control system.

The AVI system will support TSP treatments for both northbound and southbound transit movements. The only exception will be the intersection of South Jackson Street and Rainier Avenue South. At this location, signal priority will be provided from eastbound South Jackson Street to southbound Rainier Avenue South.

Highway 99 North, Winona Avenue North to North 205th Street, is a 6.5-mile corridor with 22 intersections identified for TSP treatments. Portions of the public right-of-way are managed by the City of Seattle and the Washington State Department of Transportation.

The AVI system will support TSP treatments for both northbound-and southbound transit movements. The only exception will be the intersection of North 200th Street. At this location, signal priority will be provided from northbound Highway 99 North to eastbound North 200th Street, from westbound 200th Street to northbound Highway 99 North, from southbound Highway 99 North to eastbound North 200th Street, and from westbound 200th Street to southbound Highway 99 North. Also, note that the intersection identified as North 112th Street is the access to the Washelli Cemetery and the intersection identified as North 120th Street will be the access to a proposed commercial development.

C. Regional Implications

A primary goal of this Request for Proposal (RFP) process is to foster the acceptance of a regional AVI system. In addition to Metro, Community Transit, Everett Transit, and Pierce Transit are presently evaluating AVI and TSP systems. Community Transit has a fleet of two hundred (200) transit vehicles serving greater Snohomish County. Everett Transit has a fleet of sixty (60) transit vehicles serving the City of Everett. Pierce Transit has a fleet of one hundred and sixty-eight (168) transit vehicles serving Pierce County. Community Transit, Everett Transit, and Pierce Transit have participated in the development of the RFP. All four transit agencies will participate in the Proposal evaluations.

D. Additional TSP Initiatives

While not currently planned as part of this procurement, Metro is presently evaluating the potential for additional AVI equipment to support TSP projects in the City of Bellevue and along Highway 99 South. A successful AVI procurement should have a positive impact on the schedule and development of additional installations.

1.9 Proposal Requirements Checklist

The Proposer shall submit fifteen (15) copies of the Proposal including Supplemental Material and Attachments in accordance with Subsection 1.2. One copy shall be unbound to facilitate reproduction, Proposals will be evaluated in a three (3)-phase process which is described in Subsections 2.4 and 2.5.

A. For the Phase I Submittal, the Proposal shall contain the following in the format and sequence listed. Note that subsection references are provided in parenthesis.

1. Description not to exceed five (5) pages of how the Proposal meets Metro's goals (Subsection 1.1)

2. Proposal Response Form (Attachment A)

3. Price Proposal (Attachment B, B-l through B-9)

4. Letter of Commitment to Bond (Subsection 3.39)

5. Proposed software licensing agreement reasonably consistent with Attachment N (Subsection 6.6-C)

6. Technical Proposal (Section 6)

   a. System Overview (Subsection 6.1)
   b. Hardware Requirement Details - Common Features (Subsection 6.2)
   c. Product Viability (Subsection 6.3)
   d. Installation Requirements (Subsection 6.4)
   e. Training Requirements (Subsection 6.5)
   f. Documentation (Subsection 6.6)
   g. System Testing and Acceptance (Subsection 6.7)
   h. Warranty (Subsection 6.8)
   i. Regional AVI Procurement Document (Subsection 6.9)
   j. AVI System Options (Subsection 6.10)

The following elements of the Technical Proposal will be identified as Supplemental Material and shall be provided in a separate volume:

7. Independent, operational test data documenting the following:

   a. Transmission rate of one frame of data between the on-vehicle device and antenna/reader (Subsection 6.2.A)

   b. System capture rate of ninety-nine percent (99%) accuracy for similar AVI application (Subsection 6.2.B)

   c. Ability to accommodate multiple reads of the same transponder within a fixed time frame with protection against cross direction reads (Subsection 6.2.B)

   d. Operational speed range for the on-vehicle device with percentage of devices read at O-20 mph, 20-30 mph, 30-50 mph, and greater than 50 mph (Subsection 6.2.B)

   e. Equipment meantime between failures and meantime to repair (Subsection 6.3.H)

8. Sample AVI system reports to support Metro's AVI system application (Subsection 6.2.B)

9. Copy of manufacturer's standard published literature (Subsection 6.3.D)

10. Sample AVI system operations manual (Subsection 6.6.A)

11. Sample AVI system maintenance manual (Subsection 6.6.B)

12. Current AVI parts list (Subsection 6.6.D)

The Technical Proposals shall be limited to 100 pages of text. The Technical Proposal shall provide a complete and clear description of the proposed AVI system and subsystem in sufficient detail to enable Metro to evaluate its compliance with Section 6. The Technical Proposal shall be organized following the same paragraph titles and numbering system in Section 6. The Technical Proposal shall describe how the proposed system will meet all functional requirements of Section 6. The Proposer is cautioned against providing a reprinted copy of the RFP in the Proposal. The Proposal shall include only relevant technical design details. The Proposer's submittal of examples of program plans or catalog cuts of components, etc., should be submitted as part of the Supplemental Material. The Supplemental Material will not be included in the 100-page Technical Proposal limit.

B. For the Phase II Submittal, the Proposal shall contain the following in the format and sequence listed:

1. Proposal Response Form, if needed (Attachment A). Revisions of or supplements to as required by addenda.

2. Price Proposal Form, if needed (Attachment B, B-l through B-9). Revisions of and supplements to as required by addenda.

3. Sworn Statement Regarding Equal Employment Opportunity (Attachment E)

4. Certificate of Insurance (Guidelines in Attachment F)

5. Buy America Certificate (Attachment H)

6. Certificate of Lobbying Activities (Attachment I)

7. Disclosure Form to Report Lobbying and Instruction (Attachment J). Complete as appropriate.

8. Former Metro Employee Disclosure Form (Attachment M)

The Proposal shall contain a detailed description of the following:

9. Financial Resources (Subsection 2.6.A)

   a. Audited financial statements
   b. Documentation of credit arrangement
   c. Certification of adequate financial resources
   d. Contact person from principal financial or banking organization

10. Business Plan (Subsection 2.6.B)

   a. Experience and Expertise of Project Team
   b. Project Management Plan
   c. Disadvantaged Business Enterprise (DBE) Participation
   d. Commitment to Business Relationship

11. Technical Proposal (Section 6). Revisions of or supplements to as required by addenda.

12. Metro Equipment Price List (Subsection 2.7). Format to be provided by addenda.

13. Other material, as may be required by addenda.

C. For the Phase III Submittal, the Proposer shall provide a Best and Final Offer (BAFO) to include the following:

   1. Final Proposal. Contents, format, and final evaluation criteria, as required by addenda.

D. The following elements shall be signed and submitted when requested at the time of contract award:

   1. Performance Payment Bond (Attachment D)

   2. Agreement (Attachment G)

   3. Certification of Primary Participants regarding Debarment, Suspension and Other Responsibility Matters (Attachment K)

   4. Certification of Lower-Tier Participants Regarding Debarment, Suspension, and Other Ineligibility and Voluntary Exclusion (Attachment L)

SECTION 2
PROPOSAL EVALUATION AND CONTRACT AWARD

2.1 General

Metro is requesting Proposals and conducting the procurement process. Proposals will be evaluated and ranked by the Proposal Selection Board (PSB) on the basis of the criteria established in this section of the RFP. The PSB membership includes Metro, King County, Washington Department of Transportation, the City of Seattle, Community Transit, City of Edmonds, City of Everett, Pierce Transit, the City of Lynnwood, Snohomish County, the City of Bellevue, the City of SeaTac, and the City of Federal Way. The PSB will evaluate the proposals submitted in response to the RFP, score them and make recommendations to Metro. Metro will determine which proposal, if any, is most appropriate for recommendation of contract award. The PSB's recommendations are subject to the review and approval of Metro's Executive Director. The PSB and Metro will make such investigations as it considers necessary for evaluation of the proposals.

2.2 Changes in Requirements

When, either before or after receipt of proposals, Metro changes, revises, increases, or otherwise modifies its requirements, Metro shall issue a written addendum to the RFP. In considering which firms to notify of a change, Metro will consider the stage in the procurement process at which the change occurs, as follows:

A. If proposals are not yet due, the addendum will be sent to all firms that have received the RFP.

B. At the close of the Phase I evaluation, Metro will 'send the addendum to those Proposers who have passed the Phase I evaluation The Phase I evaluation process is described in Subsection 2.4.A.

C. At the close of the Phase II evaluation, Metro will send the addendum to those Proposers who are determined to be in the competitive range. Phase II evaluation is described in Subsection 2.4.B.

D. As part of the Phase III evaluation, Metro will issue an invitation to submit BAFOs to all Proposers in the competitive range. Phase III evaluation is described in Subsection 2.4-C.

2.3 Changes, Errors, and Omissions

Metro 'will not be responsible for any errors in proposals. Proposers will not be allowed to alter proposals after submission except as specifically permitted herein.

Metro reserves the right **to** allow corrections or amendments to be made that are due to minor administrative errors or irregularities. Corrections or amendments may be allowed for such errors in typing, transposition, or similar administrative errors. Errors and corrections will be confirmed with the Proposer and must be authorized by Metro's purchasing agent. Proposers are responsible for all errors or omissions contained in their proposals.

2.4 Proposal Evaluation

The Proposal evaluation process is structured to require the submittal of information when needed and to assess whether the proposed AVI system successfully accomplishes the project goals. The Proposals will be evaluated in a three (3)-phase process. The required elements of the Proposal for each of the three (3)-phases are identified in Subsection 1.9.

A. Phase I Submittal-Minimum Requirements

The required elements of the Phase I Submittal are listed in Subsection 1.9.A. In Phase I, all Proposals will be evaluated and scored pass/fail on the following minimum requirements:

1. Letter of commitment to bond for one hundred percent (100%) of the contract price (Subsection 3.39)

2. Demonstrated ability to precisely locate a specific vehicle within twenty-five (25) feet of the point of first detection (Subsection 6.1)

3. Demonstrated ability to transmit the minimum required data packet (Subsection 6.2.A)

4. Commitment to provide dynamic programming of transponder via SAE-J1708 standards (Subsection 6.2.A)

5. Commitment to provide common and non-proprietary hardware and software interfaces between the interface module and traffic signal controller (Subsection 6.2.D), between interface module and portable personal computer (PC) (Subsection 6.2.D), between the interface module and base computer (Subsection 6.2.D), and between the reader and the portable PC (Subsection 6.2.B)

6. Commitment to providing an interface module with the ability to reside within the traffic signal controller cabinet (Subsection 6.2.D)

7. Ability to document an AVI system capture rate of ninety-nine percent (99%) accuracy (Subsection 6.2.B)

8. Commitment to provide a software licensing agreement reasonably consistent . with Attachment N (Subsection 6.6.C)

9. Completeness of the Price Proposal '(Section 2.7)

The PSB will evaluate the Proposal's ability to meet the minimum pass/fail requirements. Proposals must pass all of the minimum pass/fail requirements in order to receive further evaluation in Phase II.

B. Phase II Submittal-Establishment of the Competitive Range

In Phase II, Metro will issue addenda to Proposers meeting the minimum pass/fail requirements. The addenda will further refine the requirements of the RFP and establish the submittal date for Phase II. If deemed necessary and at the discretion of the PSB and/or Metro, written and/or oral discussions may be conducted with the Proposers. The discussions are intended to give Proposers a reasonable opportunity to resolve deficiencies, uncertainties, and suspected mistakes, as requested by the PSB and/or Metro, and to make the cost, pricing, or technical revisions required by the resulting changes.

The required elements for the Phase II Submittal are listed in Subsection 1.9.B. The PSB will evaluate, rank, and score each Proposal. The final score for Phase II will be the sum of the points awarded consistent with Subsection 2.8. Proposals with the highest scores will be judged in the competitive range and will be eligible for further evaluation in

Phase III. A Proposal will be allowed in the competitive range if the PSB determines the Proposal has a reasonable chance of being selected for award based on the factors set forth in the RFP.

Metro will conduct written and/or oral discussions with the Proposers in the competitive range. These discussions will further clarify uncertainties, refine requirements, and as requested by Metro, provide necessary revisions to the proposals.

Information received or reviewed during the discussions shall not be shared with other Proposers or made available as a public record to extent protectible under Washington State or federal law. Changes or clarification in Metro's requirements resulting from discussions with Proposers shall be identified to all Proposers within the competitive range through the issuance of addenda.

C. Phase III-Best and Final Offer (BAFO)

Each Proposer remaining within the competitive range at the close of discussions will be allowed to submit a final proposal denominated the BAFO.

Metro will issue to Proposers in the competitive range a final addenda to the RFP and request a BAFO. The request will include an opportunity to submit a Proposal with revisions and supplements as may be required by addenda with a BAFO. The required elements for submittal of a BAFO are identified in Subsection 1.9.C. BAFO evaluation criteria will be provided by addenda. BAFO scoring shall not include the scoring results from the Phase II evaluation.

Metro shall have the right to consider all submissions from Proposers as part of the. Proposal. BAFOs submitted to Metro shall constitute an irrevocable offer to contract with Metro under the terms of this RFP. BAFOs may not be withdrawn prior to Metro's award decision.

Metro reserves the right to make a contract award without written and/or oral discussions with the Proposers and without an opportunity to submit BAFOs when deemed in Metro's best interest.

25 Cost/Price Analysis

Metro will enter into negotiations with the highest scored Proposer based upon the BAFO evaluation criteria. If Metro concludes that a cost and/or price analysis is necessary, Metro will request cost and/or price data from all Proposers in the competitive range. Each Proposer must submit such data as specified by Metro. Allowability of costs and reasonableness of price will be determined in accordance with the Federal Acquisition Regulations. Metro may re-open discussions with all Proposers within the competitive range to the extent necessary to address issues raised by cost and price analysis.

2.6 Proposer Capability

The following will be used by Metro in evaluating the capability of the Proposer to successfully develop, install, and support an AVI system on schedule and within budget: the ability, capacity, skill of the Proposer to perform the Contract or provide the service required, whether the Proposer can satisfactorily perform the Contract within the time specified, the quality of performance on previous and similar contracts; the character, judgment, reputation, and efficiency; financial resources, management, scheduling capability, experience, and understanding of the required work or services; the previous and existing compliance with laws relating to public contracts or services; and such other information as may be secured having a bearing on the decision to award the contract.

To enable Metro to evaluate the Proposer's capability, Proposals shall include Financial Resources and Business Plan sections.

A. Financial Resources

The Proposer shall submit proof of adequate financial resources that would be available to the Proposer for the prosecution and completion of the work as required. Required financial information shall include, but not be limited to the following:

1. Audited financial statements (balance sheets, statements of income and stockholders' equity, and statements of cash flows) for each of the most recently completed three fiscal years (1993, 1992, and 1991), including notes to financial statements, independent auditors' reports, and annual reports to stockholders, and SEC Form 10K reports (for publicly held corporations)

2. Documentation of an open line of credit or other credit arrangement with an established bank under which adequate financing would be available for prosecution and completion of the work called for hereunder

3. Certification by the chief financial officer or the Proposer's independent auditor stating that the Proposer has adequate financial resources for the prosecution and completion of the work called for hereunder

4. The names, addresses, telephone and fax numbers of at least one contact person from the Proposer's principal financial or banking organization and the Proposer's independent auditor. The contact persons shall be duly authorized by the Proposer to provide information and discuss the adequacy of the Proposer's financial resources. Upon Metro's request, the Proposer shall provide written authorization permitting Metro or its designee access to information documenting the adequacy of the Proposer's financial resources

B. Business Plan

The Proposal shall describe the Business Plan for ensuring successful completion of the project on schedule. The four (4) elements of the Business Plan include experience and expertise of the project team, project management plan, M/WBE participation, and commitment to ongoing business relationships.

1. Experience and Expertise of the Project Team

   a. The Proposal shall identify the Project Manager. Provide a current resume for this individual, no more than three pages in length. The resume should clearly demonstrate both experience with AVI projects and an ability to work successfully in a complex, multi-jurisdictional, decision-making environment. Experience with traffic control systems is desirable. Provide names, addresses, and phone numbers for the client representatives for each of the last five contracts that the Project Manager has overseen. It is highly desirable that the same Project Manager be available for the duration of the five (5)-year contract

b. The Proposal shall identify key project personnel, including current resume and job history. Metro is seeking a proposal team that has the ability to design, procure, install, commission, and test an AVI system.

The Proposal shall identify all of the firms on the proposal team. Indicate which firm(s) will be responsible for each aspect of the AVI project, including overall project management and project control, cost estimating, quality control, system integration, hardware, software support and development, and all aspects of installation, testing and acceptance, and training. Include letters of commitment from firms included in the project team. This description of team composition should be limited to no more than five pages and should include a project organization chart that identifies the role/function of each firm, key personnel from each firm, and M/WBE status.

c. The Proposal shall provide at least five project/client references for the Proposer and for each member on the Proposer's team. References should be directly applicable to the functions that each firm will be expected to perform for the proposal team. Transit or transportation references are preferred, if possible. References must include the name, title, and current phone number for the client contact.

2. Project Management Plan

Metro is interested in evaluating the Proposer's ability to manage the development and implementation of the AVI system for both the initial project scope as well as possible future expansions of the system. The project is unique because of the requirements to work with multiple agencies and to meet the needs of the many diverse agencies. Demonstrated ability to address the requirements of the various owners is essential.

The Proposer shall submit a Project Management Plan with the Proposal. The plan should clearly outline the Proposer's capability to implement a fully functional AVI system within the Highway 99 North and the Rainier Avenue corridors. The Project Management Plan should include the following:

a Description of the proposed organization of the project team.

b. Definition of the key individuals and their roles and responsibilities"

c. Identification of the project manager, who will be the prime point of contact with Metro and other agencies.

d. Description of your plan for developing, managing, and coordinating the various activities required to implement the project.

e. A project schedule that identifies the various activities, their duration, logic sequence, and milestones, which may define completion of key project components or define significant duties that are critical to the successful completion and coordination of the work. The preliminary Production, Delivery, and Installation Schedule is identified in Exhibit E, and should be used as the template for the schedule.

If awarded a contract, project management efforts will be required. The scope of work for this effort is described as follows for the initial work effort:

f. Submit a Project Management Plan, which shall include a detailed project schedule, verification of the project team and organizational structure, the scope of services to be managed, and invoicing procedures. Schedule information shall conform to the following requirements:

(1) Construction bar charts identifying activities, including their early start/finish period

(2) In preparing the schedule, organize the work into activities such that the duration of each activity shall not exceed ten (10) working days and activity values shall not exceed fifty thousand dollars ($50,000) unless approved by Metro. Non-construction activities (submittals, software development, fabrication, etc.) may have durations in excess of 10 working days, and $50,000 of value.

(3) Submittal and procurement activities, including preparation and submittal of shop drawings, product data, samples, fabrication, delivery, as-built drawings, and operation and maintenance manuals

(4) A list of the holidays and non-work days applicable to the schedule

(5) Metro operator training, operation and maintenance manuals, and other milestone dates

(6) Scheduling software approved by Metro

g. Provide as part or supplemental to the Project Management Plan, the following information:

(1) Software Development Plan, which incorporates user needs analysis and review phase

(2) Quantity Control/Quality Assurance program

h. Provide monthly updates of the schedule, progressing activities to show revisions to the planned completion dates.

i Attend biweekly meetings with Metro. A total of twenty-six (26) meetings are anticipated.

j. Prepare monthly status reports with the invoice. A total of twenty-four (24) reports are anticipated.

k. Prepare monthly invoice.

L Meetings with local regulatory authorities to coordinate perrnits and onsite installation contractors. A total of ten (10) meetings are anticipated.

3. Disadvantaged Business Enterprise (DBE) Participation

Submit a DBE utilization plan, two pages or less, outlining how DBE firms will be utilized on the team. As noted in Subsection 1.20, Metro has not yet established specific DBE participation goals for this contract, but Proposers that include DBE firms on their teams and provide opportunities for meaningful participation will be awarded additional points. The DBE utilization plan should identify the DBE firms, their task assignments, their roles as either support or lead, and the percentage of each task they are expected to perform. The information in this plan shall be consistent with the Project Plan submittal. Metro may identify specific DBE participation requirements by addenda following the Phase II or the Phase III evaluation.

4. Commitment to Ongoing Business Relationship

a The Proposal shall describe in detail how field support will be provided during testing and acceptance, and during the one (1)-year warranty period. For each of these two time periods, describe the location and staffing to support the contract. Identify the technical staff that will be available to support sales and marketing personnel. Identify the testing and repair facilities to be provided. Identify the sources for replacement components and the turnaround time for delivery of replacement parts or new components.

b. The Proposal shall identify all litigation to which each firm, its subconsultants, and its AVI vendor were party for the past five (5) years. If the litigation specifically dealt with the procurement, installation, proprietary or patent rights associated with an AVI technology, identify the plaintiff, the cause of action, the dispensation if the matter has been settled, or the current status if it is unresolved.

c. The Proposal shall describe the Proposer's ability to guarantee the availability of the items shown in Attachment B, Bid Items 3 and 4, and Subsection 2.7.E. The Proposal shall also describe the Proposer's ability to continue to provide these items for the term of the contract if the Proposer introduces upgrades or replacement components. Metro reserves the right to continue to purchase equipment as specified in the Price Proposal form or to purchase upgraded components as they become available. Discuss any discounts that the Proposer would be willing to provide to Metro to purchase hardware and software upgrades as they become available.

d. The ability to competitively procure AVI systems over the long-term is essential. Metro will be reluctant to make a substantial investment in a proprietary AVI product, either hardware or software, without adequate assurances that long-term support from the vendor for hardware and software with protection from excessive price increases. Indicate how your proposal will meet this requirement. Address whether your firm will be willing to establish an escrow account for all proprietary technology, an account which Metro could access in the event that the vendor could no longer perform. Describe the commitments the Proposer is willing to make to assure that long-term prices will remain fair and reasonable.

e. The Proposal shall identify any proposed new technology, including hardware or software, not previously installed in AVI systems. Describe how the Proposer will manage the design and production of the new system elements to ensure that Metro is provided with the desired capabilities within budget and on schedule,

f The Proposal shall provide a chart that identifies all proprietary components and patented materials included in the AVI system. The Proposal shall list the holder of proprietary and patent rights.

2.7 Price Proposal Contents

A. Overview

The successful Proposer will design, test, and install an AVI system at 27 intersections along Rainier Avenue South and Highway 99 North within King County and will equip one hundred and sixty (160) Metro transit vehicles with transponders in order to initiate testing and installation. Metro expects to procure additional AVI equipment from the successful Proposer under the terms of a subsequent one (1) year contract, renewable up to four (4) times for a potential subsequent contract duration of five (5) years. The first subsequent contract is to commence upon Metro's final acceptance of the first 27-intersection, 160-bus installations, pursuant to the current contract.

Metro proposes to purchase this additional AVI equipment under subsequent contracts for additional transit signal priority projects using a Metro Equipment Parts List (MEPL) and Price Escalation Index (PEI), which will be established through the current procurement. Metro will also make this purchasing mechanism available to any public agency who requests it within the State of Washington through contract assignment. The successful proposer must agree to these contract assignments throughout the additional five (5)-year time period of the subsequent contract(s).

The Price Proposal has been designed to allow Metro **to** evaluate the cost effectiveness of each Proposal both for the initial 27-intersection/l60-bus project and for subsequent AVI projects that may follow.

The current Price Proposal will address three (3) areas, as described below, which shall be submitted with each proposal.

1. A price to furnish, install, and test AVI equipment at twenty-seven (27) specific installations on Rainier Avenue South and Highway 99 North; furnish, install and test transponders on one hundred and sixty (160) Metro coaches; and provide Spare Parts for the first 27 AVI installations and for the first 160 transit coaches.

2. A PEI for adjusting the MEPL over the duration of the subsequent contract, which will be up to a maximum of five (5) years. Metro has proposed an index by which the costs of parts will be adjusted over time. Proposers must accept this index or propose an alternate index.

3. Price Proposals to supply the optional features described in Subsection 6.10. Proposers must identify the incremental cost to supply each option with the initial system.

   Cost will be a factor in the selection of a vendor, both for the initial project and for subsequent projects.

   Metro will use the proposal process to refine its requirements, which may result in revisions to Metro's specifications. Metro reserves the right to require each vendor to submit an MEPL for all hardware and software specifically developed to comply with Metro's specifications and to incorporate this MEPL into its evaluation of price. However, the MEPL is not a required submittal at this time during Phase I of the Proposal evaluation.

B. Price Proposal Form

The Price Proposal Form in Attachment B consists of nine elements. A description of each element of the Price Proposal Form is provided below:

1. Bid Items

Bid Item 1-A Lump Sum Price for Project Management: All fees required to implement the Project Management Plan from Subsection 2.6.B, and inclusive of, but not limited to, all contract administration, project management, travel, per diem, home office expenses, cost of communication, meetings, supplying information to subconsultants and or subcontractors, scheduling, cost estimating, value engineering, construction analysis, permits, bonding, insurance, any markups or expenses not included in any other bid item. Bid Item 1 should also include all overhead and profit, except for the overhead and profit associated with the work in Bid Items 3,4, and the Additive Alternates, for which Guaranteed Maximum Prices (GMPs) have been submitted.

Bid Item 2-A Lump Sum Price for System Design and Product Development: All direct costs required to design and develop 'the initial system, as defined in Section 6, including software applications, interface module development, system integration and in-house testing, and regional AVI Procurement Specification document.

Bid Item 3-A GMP for Installation of AVI System at 27 Intersections: All materials,' equipment, and labor (subcontracted or self-performed), and associated overhead and profit, required to install the initial AVI system at 27 intersections, as outlined in Subsection 6.4, to provide a fifteen percent (15%) spares ratio for all hardware and related software licenses for the intersections for the initial system, and to supply five (5) test benches, four (4) portable reader devices, four (4) programmer devices, and as-builts.

Bid Item 4-A GMP for Installation of AVI System on One Hundred and Sixty (160) Transit Coaches: All materials, equipment, and labor (subcontracted or self-performed), and associated profit and overhead required to install Transponder A, as outlined in Subsection 6.4, and provide twenty (20) spare transponders and twenty (20) sets of all other equipment required for each coach installation.

Bid Item 5-A Lump Sum Price for System Testing, Acceptance, and Training: All direct costs required to test the system, as defined in Subsection 6.7, Factory Acceptance Test, Pre-Installation Checkout, 30-Day Installation Acceptance Test, and 90-Day Installation Acceptance Test, to correct any and all deficiencies, to train designated personnel per Subsection 6.5, and to supply required system documentation per Subsection 6.6.

Bid Item 6-A Lump Sum Price for Warranty: All direct costs for materials, equipment, and labor required to provide the one (1)-year warranty on the system, as outlined in Subsection 6.8.

Bid Item 7-The Total Cost of the Initial System: The sum of the bids for Bid Items 1 through 6 shall constitute the cost of the initial system. The Proposer's price for each section shall be treated as a discrete bid and any ensuing contract award shall be based on these individual bids.

2. Other Price Information Regarding Subsequent Contract(s)-Price Escalation Index: The index by which the cost of AVI equipment will be adjusted over time.

3. Additive Alternative: The incremental cost to provide one or more of the optional features from Subsection 6.10 with the initial system.

   Metro reserves the right to ask Proposers to submit an AVI MEPL during Phase II specific to Metro's specifications. with associated prices and quantity discounts and to analyze this as one element of the Price Proposal.

c. Guaranteed Maximum Price (GMP) Mechanism for Bid Items 3, 4, and the Additive Alternates.

1. Metro recognizes that there is more uncertainty in pricing the installation work. Therefore, Proposers will be allowed to submit a GMP for these activities as opposed to the fixed Lump Sum bid. This GMP will be subject to future adjustment as described in this section.

   It is understood that the GMP for Bid Items 3 and 4 will be developed on the basis of a combination of design and performance specifications and that all drawings and specifications cannot be completed prior to submittal of the GMP. However, the Proposer will be required to develop the GMP based on its experience, expertise, good judgment, unit pricing, and any other means at its disposal.

2. Costs eligible for reimbursement for the GMP include the following: all direct on-site supervisory, professional labor, craft labor costs, overhead and profit, provided that none of these charges shall duplicate any items covered in the Project Management Price in Bid Item 1 of Price Proposal Form; subcontract costs include payments made to subcontractors as well as any premium costs for bonding provided to these subcontractors; and all self-performed work inclusive of all costs of labor, equipment, and materials; and other materials and equipment.

   Costs not to be reimbursed under the GMP include any cost that would cause the GMP to be exceeded and any costs due to the fault or negligence of the Contractor, subcontractors, suppliers, and any one directly or indirectly employed by them, or for whose acts any of them may be liable, including but not limited to costs for the correction of damages, defective or non-conforming work, disposal and replacement of materials and equipment incorrectly ordered or supplied, and making good damage to property not forming part of the work or warranty.

   The GMP for Bid Items 3 and 4 may be revised by change order for modifications to the Contract or by adjustments in the price of the work to install the AVI system, as described below.

3. The Cost of Work (CW) for Bid Items 3 and 4 includes all allowable costs necessary to perform the work. The Proposer guarantees that the CW will not exceed the GMP.

4. The reimbursement mechanism for CW for Bid Items 3 and 4 will be as follows:

   a. Subcontractable Work: The Contractor must procure at least three (3) bids for all subcontractable work required for installation of the AVI equipment. Metro will pay the actual costs of the lowest, responsive, responsible bidder, plus overhead and profit, as identified in Bid Items 3 and 4 of Attachment B provided these costs do not cause the GMP to be exceeded. Any costs in excess of the GMP will be borne by the contractor.

b. Self-Performed Work: Metro and the Contractor shall agree upon the specific work to be self-performed by the Contractor. Self-performance is defined as work in which the labor is performed by employees of the Contractor. Work so identified for self-performance shall be normally and customarily performed by the Contractor or the Contractor's subsidiary. Metro will pay for self-performed work in accordance with a schedule of values of Direct Costs to be negotiated by Metro and the contractor, plus overhead and profit, as identified in Bid Items 3 and 4 of the Price Proposal submittal, so long as these costs do not cause the GMP to be exceeded. Any costs in excess of the GMP will be borne by the Contractor.

c. Overhead and Profit: Reasonable overhead and profit markups will be allowed as identified in Bid Items 3 and 4 in Attachment B. However, there must be no duplication of charges between Bid Item 1 and Bid Items 3 and 4. Any overhead factor that is utilized must be verifiable by audit.

D. Price Escalation Index (PEI)

The PEI will be a factor in determining which Proposers are deemed to be in the competitive range. As previously described, Metro proposes to make the first adjustment to the MEPL concurrent with final acceptance of the initial system. At that time, Metro proposes to base this adjustment on the Producers Price Index (PPI). The percent change in the PPI that has occurred between the date Proposals were first submitted and the date of final acceptance will be applied to every price in the MEPL.

Thereafter, the annual percent change in the PPI will be used to adjust the MEPL, on the anniversary date of final acceptance for the initial system.

In the event that. Proposers do not accept Metro's proposed index, based on the PPI, they must propose an alternate PEI. Failure to supply an alternate index will commit the Proposer to accept Metro's index. Proposers must affirmatively state their intent with respect to the PEI by completing the applicable portion of Attachment B. Any alternate index that is proposed must provide assurances that Metro and its assigns will pay commercially reasonable prices. Indexes that lack an economic rationale, that are difficult to understand or administer, that are capricious, that would lead to excess profits, or that fail to satisfy prudent public procurement policy, will be rejected. Federal regulations also require that the index must allow for both price increases and price decreases. Since federal monies will be expended to purchase AVI equipment, any alternate index that is proposed must meet this requirement.

Metro reserves the right to disqualify Proposers with whom they fail to reach an agreement on an alternate PEI that protects the economic interests of both parties.

E. Prices for Additive Alternates

The Proposer shall supply prices for the five (5) AVI additive alternates described in Subsection 6.10. For Options A, B, C, and D, prices should reflect the incremental cost above the cost of the basic system. The price supplied should be a GMP to supply a production version of the option with the initial system according to the Production Delivery and Implementation Schedule shown in Exhibit E.

If Metro elects to purchase any of Options A, B, C or D, Metro and the successful Proposer will negotiate a process for determining the actual CW performed to supply a particular option. Reimbursement of all eligible costs will be made up to the value of the GMP. Payments will be made based on a schedule of values of direct costs, plus overhead and profit, to be negotiated by Metro and the Contractor. Proposers are encouraged to supply prices for all Options A, B, C and D, but Proposers will not be deemed non-responsive if they fail to provide them.

For Option E, Extended Warranty, the Proposer should supply a Lump Sum Price for each of four (4) additional one (1)-year warranties. Metro wants the ability to extend the one (I)-year warranty for the initial system for up to four (4) additional years, and reserves the right to purchase all or a part of this extended warranty. Proposers are required to submit the Lump Sum Prices for Option E, as outlined in Attachment B, in order for their proposal to be considered complete and responsive to this solicitation.

F. Metro Equipment Price List (MEPL)

Each Proposer is required to submit their AVI Current Parts List (CPL) for the technology they propose to supply, as outlined in Subsection 6.6.D. This initial submittal should be based on the Proposer's current products. Proposers should include the prices and quantity discounts they presently offer. Proposers are required to identify any new components or products that they will have to develop specifically to respond to the Metro RFP. These products or components should be named and then functionally described. If these products replace or supersede existing equipment, this should be noted. If the products represent an entirely new piece of hardware, this should also be noted. This information will assist Metro in refining its requirements and specifications.

As part of Phase 2 of the evaluation, Metro reserves the right to reconcile proposals by soliciting by addendum from all Proposers who have been determined to meet minimum qualifications, an MEPL specific to all the hardware and software associated with Metro's revised specifications. At that time, Metro would require that Proposers to supply pricing information for specific order quantities, to be defined by Metro. This MEPL, complete with pricing and quantity discounts, would be evaluated as part of each Price Proposal.

The format in which this Phase 2 MEPL submittal would be requested may be determined, in part, by the CPL provided with each Proposal. Proposers are encouraged to provide input on how an equipment parts list should be structured to allow for fair comparisons between Proposers with the Proposals.

For the successful Proposer, the MEPL will remain in effect from the date the current contract is executed through final acceptance of the initial system. The MEPL will then be subject to an initial price adjustment using a PEI that will be established by this procurement. The date of the first adjustment will become the anniversary date for each annual price adjustment of the MEPL for the duration of the subsequent contract(s). Metro reserves the right to extend or terminate its contract with the successful Proposer at each of the five (5) anniversary dates.

2.8 Proposal Scoring

Each proposal has a total possible score of 1000 points with the points assigned as follows:

Subsection Reference	Title	Score
Subsection 2.6.A	Financial Resources	150 points
Subsection 2.6.B	Business Plan	250 points
Section 6	Technical Specifications	400 points
Attachment B	Price Proposal for RFP	200 points
		Total available points: 1000

The PSB will score each proposal on the completeness and adequacy of the Proposer's responses, described in RFP, Subsection 1.9, Proposal Requirements Checklist, and Subsection 2.4, Proposal Evaluation Checklist.

2.9 Proposal Selection

The PSB will evaluate the proposal that has been preliminarily identified as most advantageous through analysis of information derived from the Proposal, Metro records, other relevant sources, and information provided by the Proposer.

2.10 Ability to Perform

Proposers shall furnish acceptable evidence of the Proposer's ability to perform, such as firm commitments by subcontractors, equipment, supplies and facilities, and the Proposer's ability to obtain the necessary personnel when requested by Metro. Refusal to provide such information upon request may cause the proposal to be rejected.

The PSB may find that the Proposer appears fully qualified to perform the contract, or it may require additional information or actions from the Proposer. In the event the PSB determines that the problems found are of such a nature or magnitude that it is in Metro's best interest to bypass the highest scored proposal, the PSB shall evaluate the qualifications of the next ranked Proposer for award of the contract. A Proposer bypassed for award by the PSB for whatever reason shall have no claim for costs incurred including, but not limited to, presentation costs, proposal preparation, the cost of providing additional information requested, or modification made either to its Proposal or internal structure or systems of the Proposer or its organization.

2.11 Negotiations

Metro may enter negotiations with one or more Proposers to finalize contract terms and conditions. In the event negotiations are not successful, Metro may initiate negotiations with the next ranking Proposers or reject proposals as required.

Negotiation of a contract will be in conformance with applicable federal, state and local laws, regulations and procedures. The objective of the negotiations will be to reach agreement on all provisions of the proposed contract.

Upon successful completion of negotiations, the Executive Director of Metro will authorize contract award.

2.12 Contract Award

Contract award, if any, will be made by Metro to the responsible Proposer whose proposal meets the requirements of the RFP and will be the most advantageous to Metro with respect to price, quality and other factors as evaluated by Metro. Metro is not required to award a contact to the Proposer offering the lowest price. Metro shall have no obligations until a contract is signed between the Proposer and Metro. Metro reserves the right to award one or more contracts as it determines to be in its best interest.

2.13 Execution of Contract and Notice to Proceed

The Proposer to whom Metro intends to award the contact shall sign the Agreement form set forth in Attachment G prior to contract award and shall return it to Metro. Upon authorization by the Executive Director, a contract will be issued. Upon receipt by Metro of any required documentation and submittals, a Notice to Proceed may be issued.

Radio System

6. CONSIDERATION OF PROPOSAL

6.1 Partial Proposals

Partial proposals will not be considered. No proposal will be accepted unless individual costs are listed on the Proposal Form where requested. Purpose of this requirement is to permit increase or decrease of quantities of like items to be maintained over the life of the contract.

6.2 Method of Award

Award will be made to the proposer which, in the sole judgement of the Owner, offers the best value to the County for all departments when the completed system (which will serve most county radio communication requirements) is considered. Proposals will be evaluated and ranked by a committee according to the following criteria:

a) Technical and functional capability of the radio system to carry plain voice, encrypted voice, canned and text data message traffic together with vehicle location data in the trunked mode. **(15%)**

b) Transit CAD and schedule adherence software and system. **(15%)**

c) Anticipated cost of the fully implemented trunked radio system. (15%)

d) Anticipated reliability, system integrity, and maintenance cost. **(15%)**

e) Cost of the instant procurement. (10%)

f) Vehicle tracking equipment, technology, software, and resultant traffic load imposed on the radio system. **(10%)**

g) Experience of the proposer with similar systems to that proposed here. **(10%)**

h) Adherence to time lines for contract execution specified in this invitation. (10%)

Trip Planning System

1.3 Proposal Content and Format

(a) Proposers shall submit seven (7) complete copies of the Proposal documents required below.

(b) The Proposal forms (Section 6) (Yellow Pages) shall be submitted_ in a sealed envelope, separate and apart from the proposal document and must be clearly marked "PROPOSAL FORMS".

(c) Proposal documents shall be sectionalized as described below. Each section should be preceded by a blank page with an index tab extending beyond the far right side of the page. The index tab should have the appropriate section number typed thereon. At a minimum, the items described in each section below should be addressed.

(d) Proposers must fully describe their qualifications to undertake a project of this size and scope. All information requested must be submitted. Missing or incomplete information may render the proposal technically unacceptable.

SECTION 1 - Introduction of the Offeror. Include an introduction of all members of a joint venture if a joint venture relationship is involved, and/or an introduction of all major subcontractors who may be involved in the performance of the work. For each firm described herein discuss primary business experience, the firm(s) overall mission statement, length of time in business; ownership, the location of offices, pertinent telephone numbers and other matters offerors might deem pertinent and introductory in nature.

SECTION 2 - Qualifications of the Firm. The proposer's history and experience relevant to Tri-Met's needs should be discussed including a description of the proposer's direct experience on projects of similar size, scope and complexity; including-dates, locations, character, costs of assignments, project managers, and names, addresses, contact persons and telephone numbers of clients. No fewer than three (3) client references shall be provided. Proposers shall similarly discuss the qualifications of all other firms proposed to be utilized in the performance of the work (including joint venture members or major subcontractors) and shall clearly differentiate which qualifications listed relate to which firm.

Proposers shall provide a detailed listing customer references including contact person and telephone number. Proposers shall include in this section, an audited financial statement with specif-ic information pertinent to the group or division, if applicable, providing the proposal.

References shall consist of client's sites where a system of similar sise and scope has been installed-or is in the process of installation. The following information shall be submitted with the proposal:

- o The project name and a brief description of the size, scope, and functional capabilities of the system.
- o Average number of trip requests processed daily.
- o Number of personnel supported by the system, identified by job category.
- o The name and phone number of the client's project manager.

The above information shall be considered proprietary and will not be disclosed except as required by law. The contractor, by submission of- a proposal authorizes Tri-Met staff to contact the references listed in the proposal.

SECTION 3 - Qualifications of Staff. This section shall contain the proposer's staffing plan, which shall identify the project manager(s) and any other key personnel who will be assigned to the project, and shall discuss the direct qualifications and experience of each key individual. This section shall also identify the number of hours each team member is expected to spend on each major work task. Resumes of key staff shall be provided in this section.

SECTION 4 - Technical Proposal.

The technical section of the proposal shall be specific and complete in all respects. It shall demonstrate a thorough understanding of the specifications and provide a logical plan for solving the problems presented. The technical proposal is the primary focus in the selection process; legibility, clarity and completeness are important factors. The technical proposal shall not contain any reference to cost or prices.

Provide a date specific project completion schedule using the signing of the contract (on or about January 1, 1994) as the project's start date base, reference events prior to base as minus days/months, events following the base, plus days/months into the schedule. Include all major tasks and milestones, along with resource descriptions and estimated number of hours required for each task. Be sure to include time for Tri-Met staff review of deliverables and status meetings.

At a minimum, the technical proposal shall include the following:

(a) A complete, detailed, and clear description of the system and services being proposed to meet the specification requirements.

(b) A user's manual for the proposer% standard Trip Planning System.

(c) An itemized list of all hardware to be- provided including manufacturer, model number, and quantity. (This list shall not relieve the proposer from supplying **all** hardware necessary to meet the specification requirements.)

(d) Data sheets for all proposed hardware.

(e) An itemized list of all software to be provided including supplier name, program name, revision level and a description of any customization or new development required to meet the specification requirements. (This list shall not relieve the proposer from supplying all software necessary to meet the specification requirements.)

(f) A system configuration drawing.

(g) A description of any major planned product improvements and the expected release dates for these improvements.

(h) A system demonstration disk (if available) which demonstrates the major functions and user interface of the proposed system.

(i) Printouts. of the primary displays provided in the proposed system (unless these displays are documented in the user's manual or demonstration disk).

(j) Answers to the questions listed in Appendix E of the specification.

(k) Table of Conformance referencing each numbered paragraph of the specification and indicating for each numbered paragraph whether the proposed offering will conform to the specified requirements or whether the Proposer takes exception to the requirements. (A numbered paragraph includes all material in both numbered and un-numbered paragraphs up to the next numbered paragraph). The Proposer shall provide details of nonconformance. The only acceptable classifications in the Table of Conformance are:

Conform: The Proposer's offering meets the requirements in the manner indicated by the Specification and any addenda thereto.

Exception: The Proposer's offering uses an approach at variance with the Specification, or addenda thereto or the Proposer declines to meet the Specification requirements. All differences between the proposed offering and the Specification requirements must be described in detail. The reason for a Proposer declination shall be specified.

Any classifications besides "Conform" and "Exception" may be interpreted as non-conformance on the part of the proposer. Ambiguous responses such as "read and understood" are unacceptable. Specific references to proposal sections containing supporting information may be provided.

The Table of Conformance shall be provided in the format shown below and containing the types of information shown below.

Specification Paragraph No.	Title/ Subject	Conform/ Exception	Comments

As part of the technical proposal, the proposer is requested to identify any specification requirements which, in the proposer's opinion, unnecessarily increase the cost or customization required for the system. Proposers should explain the problems, proposed alternative approaches, and suggested specification rewording.

1.4 Price Proposal

Tri-Met may perform or have performed a Cost/Price Analysis for each proposal being considered for award. Cost/Price information must be submitted with each proposal on the form(s) provided in Section Six (6). All pricing information shall be submitted separate and apart from the technical proposal.

To comply with federal guidelines proposers may be required to supply (in addition to the pricing forms required by Section Six (6)) cost data to support prices. Additional information which may be required by Tri-Met may include personnel cost elements; including direct salary (hourly rates by individual position), overhead on salary (expressed as a verifiable rate), direct non-salary (travel, or sub-contractor work directly related to this contract), and proposed fees. By submission of a proposal under this RFP, the Proposer certifies it's intent to comply with this clause and submit information in a format to be determined by the District.

Cost/Price information will be evaluated to determine allowability, reasonableness and proper allocability-according to federal cost/price principles, and in accordance with the evaluation criteria-set forth elsewhere in this solicitation.

Failure to submit accurate cost data upon request, including any requested breakdown, or to allow Tri-Met to verify the same, may result in rejection of the proposal. Tri-Met will consider all cost data privileged, and will receive and hold all such information in confidence as allowed by law.

ALL PRICING INFORMATION SHALL BE SUBMITTED IN A SEALED ENVELOPE, SEPARATE AND APART FROM THE TECHNICAL PROPOSAL.

SECTION 2 EVALUATION OF PROPOSALS

2.1 Evaluation Procedure - Non A & E Proposal

Tri-Met's General Manager will appoint an Evaluation Committee to evaluate the Proposals.

The Evaluation Committee will determine which proposals are within the competitive range in accordance with the evaluation criteria set forth below at 2.2 Evaluation of Proposal, Price Evaluated after Technical. Only those proposals determined to be within the competitive range will be considered for award. In all instances, the proposed price will be evaluated when determining the competitive range. After determination of the competitive range, the Committee- shall determine whether acceptance of the most favorable initial proposal without discussion is appropriate, or whether discussion should be conducted with all proposers submitting proposals within the competitive range.

If the Committee determines to award based on the most favorable initial proposal, the Committee shall perform or have performed a Cost/Price Analysis of that proposal. If the analysis is acceptable to Tri-Met, the Committee shall make a recommendation for award to Tri-Met's General Manager.

If the Committee decides to enter into discussions, the Committee shall submit to proposers any questions regarding their proposals which it feels are appropriate for discussion. Proposers should be prepared to respond in writing or by oral interview as required by the Committee.

When discussions have -been completed, proposers will be requested to submit Best and Final Offers by a specified date. The Committee will evaluate the Best and Final Offers in accordance with the evaluation criteria set forth at 3.2; and select a proposal for contract award. The Committee shall make a recommendation for award to Tri-Met's General Manager.

2.2 Evaluation of Proposal, Price Evaluated after Technical

(a) All proposals shall be initially evaluated and ranked on the basis of the following factors, the weights of which are shown in parenthesis:

A. Feasibility, clarity and organization of the proposal. Demonstrated understanding of Tri-Met requirements and the ability to communicate often complex technical information clearly and concisely.

(10 points)

B. Experience level and availability of personnel proposed for this project. Consideration given to firms with experienced staff members available for assignment to this project through completion.

(5 points)

C. Transportation applications, specifically Trip Planning System experience, of the same or similar type required by Tri-Met. Proposers should provide a history of two (2) years of experience involving similar projects.

(10 points)

D. Company stability, capabilities; well established business. Verifiable documentation of successful completion of projects of similar size and scope, on time and within budget.---

(15 points)

E. Capability of the proposed application system to meet the specified requirements. Does the system proposed,meet required functions with a minimum of customization and cost.

(65 points)

F. Capability of the proposed system to meet optional. requirements.

(20 points)

(b) Following an, initial evaluation and ranking of the technical proposals submitted, Tri-Met shall select those firms technically qualified to perform the work irrespective **of** price. If a determination is made that a Proposal is <u>not</u> technically qualified, the Proposer will be notified in writing and the Proposal Price will be returned unopened. Tri-Met shall open the price proposal of only those firms technically qualified to perform the work and each price proposal shall be evaluated and scored on the basis of a 75 point maximum for the most fair and reasonable price. The sum total points scored on both the technical (125 point maximum) and price (75 point maximum) will be considered in determining the competitive range and/or-award of contract.

(c) Tri-Met reserves the right to investigate the qualifications of all proposers under consideration and to confirm any part of the information furnished by a proposer, or to require other evidence of--managerial,financial or technical capabilities which are considered necessary for the successful performance of the work. Tri-Met reserves the right to visit sites where work of a similar nature has been performed by the Proposer.

(d) The committee will employ only those evaluation criteria set forth in this RFP or in addenda that may be issued. An evaluation criterion is deemed to include any unstated "subcriterion" that logically might be included within the scope of the stated criterion.

(e) The committee or designated members of the committee will negotiate separately with each proposer whose proposal falls within the competitive range based upon the contents of their individual proposal. Each proposer remaining within the competitive range at the close of negotiations will be allowed to submit a final supplement denominated the "best and final offer." The best and final offer shall contain all information and documents necessary to state the proposer's entire proposal without reference to the original proposal or to any supplements that may have been submitted during negotiations. All proposers that submit best and final offers will be evaluated by the committee based upon those best and final offers. The committee will recommend one proposer for contract award. If that proposer is acceptable to Tri-Met's General Manager and Board-of Directors, Tri-Met will award the contract to that proposer.

(f) Tri-Met reserves the right to hold individual interviews and/or discussions with the proposers deemed to be within the competitive range. Tri-Met personnel may visit the contractor's work facility during the evaluation period.

B.2. ITS SPECIFICATIONS

Intelligent Transportation System

ITS Functional Requirements

The functional requirements, as stated herein, are to be interpreted as the minimum requirements of the equipment to be furnished under this acquisition. These specifications have been prepared to reflect the needs of the AATA with an eye to future expansion utilizing emerging technologies. Various methods for accomplishing the tasks described will be considered provided that the necessary environmental, operational and reliability requirements are met.
Some of the functional requirements are for limited operational tests or as optional functions based on cost/benefit analysis. Such functional requirements will be clearly identified. It is not intended that these functions are of less importance but rather that they must fall within a priority schedule and therefore must be broken out for costing purposes. AATA priorities are to replace current communications equipment and control center, replace the fare collection system with both cash and cashless systems, a single onboard logic unit with a single human interface, interface to existing equipment (i.e., external signs) and interface to new peripheral equipment (i.e., internal signs). It is intended that each proposer meet each and every requirement of this specification as a total system.

The Proposer shall include in the Technical Proposal the type of equipment and services being proposed to meet the specification. Such items shall include:

1. A listing of each major item of hardware or software equipment being offered identifying the manufacturer, brand name and model number as appropriate. Indication of equipment under development versus in deployment shall be included with a time line indicating steps leading to deployment. Equipment in deployment shall indicate location and a contact source.
2. Description of installation location and of mounting hardware for equipment to be installed in vehicles.
3. Descriptive material, as may be appropriate, such as photographs, brochures, operations manuals and/or drawings that will illustrate the equipment being offered.
4. A narrative technical description and block diagram of the operation of the system, indicating the specific interfaces between the various items of equipment being proposed.

A reminder is made to the proposers that the material submitted will be evaluated against the Evaluation Criteria described earlier in this RFP. It is the obligation of the proposer to provide sufficient information to allow the evaluation against these Criteria.

Introduction

The AATA believes that technologies exist for automating many of the functions currently performed by manual operations. Furthermore these technologies also enable additional and more accurate and timely information services than are currently provided. However, many of these technologies have not been integrated into a full system operating with one another.
It is the primary goal of this project to evaluate and hopefully confirm the operation of these technologies integrated together in an operational transit system.
The key to the use of these technologies is a support infrastructure, particularly on the transit vehicle that will provide management of the various components implementing these technologies that will enable the collection and transmission of various data among the buses components. Therefore, a central item in the overall ITS is that of the network contained within the transit vehicle. Once that network is provided, it will be possible to attach additional peripheral devices (communications, monitors, controls, etc.) for use within the transit vehicle as well as with external components (the OCIS and Traveler system). (Non-AATA transit vehicles used in demand situations will require only limited infrastructure support Currently, only fare collection are anticipated.)
As currently envisioned, the ITS would have a structure similar to todays” operations. (Names and titles have changed, in part, to differentiate between existing and planned operations.) Instead of a Supervisor, the ITS will have an Operations Controller (OC) running the OCIS. The transit vehicles will remain, driven by the MCOs. The objective of the activities of both sets of personnel will still be to service the transportation needs of the public.
Consequently, the following sections describe each of these components of the ITS transit operations:

> OCIS
>Vehicle
>Fare Collection

Operations Center Information System - Phase I

The Operations Center Information System (OCIS), or sometimes just the Operations Center, is at the core of the ITS. It will provide facilities for communications, computer aided dispatch, operator management, bus management, bus maintenance and information systems. I t is anticipated that the OCIS be installed in the existing raised floor facility currently being used as the Control Center. The current Operations Center is staffed by a single individual. It is expected that no additional personnel -will be required to operate the OCIS.

Communications

This section describes the communications requirements for the OCIS. It includes both those internal to ITS (between OCIS and the vehicle and traveler systems) as well as those external to ITS (such as to emergency organizations).

Internal Communications

The current AATA communications consists of an 800 MHZ Motorola Centracom, using two radio channels with communication utilizing land lines between the antenna and base station. One channel is shared for voice and data and one is for supervisory use. Features exist within the radio control head on each vehicle to indicate status changes (emergency / accident, in service, out of service, returning to garage and transfer request) and are automatically exchanged over the current radio system. Support personnel are equipped with either portable radios or two way walkie talkies.
The current system originally consisted of the following Motorola equipment:

- (68) 35 watt four frequency Mitrak mobile radio with MDC 600 status message control head
- (8) 35 watt frequency synthesized Syntor X mobile radio with system 90 control module
- (3) Tone remote consoles with MDC 600 selective call encoder
- (3) 70 watt Micor repeaters
- (2) GCC-80 General communications controller
- (1) GSP-300 General status processor
- (1) Centracom control center

Currently there are 81 mobile and 9 portable radios in operation. The frequencies now in operation are 852.53750, 852.51250, 807.51250, 852.51250. Leased landlines from Ameritech going through two exchanges connect the Operations Center to the antennae site. With increased reliance on data transmissions the repeaters have been replaced by digital capable, solid state microprocessor controlled repeaters (Motorola MF5000).

The ITS shall provide reliable point-to-point communications for voice and data transmissions between the OCIS and other systems. Coverage shall include the entire AATA service area (all of Washtenaw County) during all service hours. An analysis of communications throughput shall be performed and indication of any sources of contention or limitations shall be provided. The communications shall allow the OC to specify reception or transmission from or to all available communications devices on the vehicle. The procedure for communicating with support personnel shall be via the same interface as for MCOs.

To ensure reliable communications, replacement radios are required that will operate in a two channel conventional 800MHz frequency and meet Mil. Std. 810D. Utilization of the two radio channels may be designed in such a way as to best utilize existing bandwidth.

External Communications

The current AATA system allows communication with external entities (fire, police, and other emergency personnel) via separate telephone. Necessary telephone numbers are maintained manually. Additionally, A-Ride and demand service daily reservations are transferred to the service provider at the end of a business day for the following days reservations.

The ITS shall integrate external communications and shall provide a mechanism to connect external sources to internal channels so as to provide two-way communication between external entities and all ITS components.

The City of AM Arbor, the State of Michigan and the AATA are interested in demonstrating adaptive signal retiming on a limited trial basis. The proposed trial is contingent on the City of Ann Arbbor purchasing and installing EPAC3 608 Ml0 traffic signal controllers and the MONARC System supplied by Eagle Signal. The trial would be along Washtenaw Avenue and include six signals. The ITS shall provide a mechanism to exchange data with the adaptive signal timing system being installed by the City of Ann Arbor and other jurisdictions. This function should be priced separately.

Information Storage and Retrieval

Information storage and retrieval requirements fall into two categories : the realtime and the non-realtime. Realtime information is that which must be processed when available and upon which a particular and immediate course of action may be dependent. Non-realtime information is that which is either static, not in a constantly changing state, or which can be processed offline, after the fact.

Currently the AATA has a token ring local area network using Netware 4.1 as a network operating system using SPX/IPX as the protocol stack. An AS400 is a node on the network that runs the maintenance, operational and payroll systems. These systems are developed in-house and written in RPG. There is one Compaq ProLiant file server for print and file services and a Shiva LanRover/T Plus, a multi-protocol remote access server, for dial-in, dial-out and tan-to-Lan communications. Operational systems currently implemented on the AS400 are anticipated to become part of the proposed OCIS or re-engineered in the network/PC environment The OCIS shall integrate seamlessly with the existing network so that OCIS databases are available to users on the existing network. Currently several applications utilize the Btrieve DBMS running as a NLM on the Compaq file server.

The OCIS shall have capabilities for processing both realtime and non-realtime information as appropriate and for being able to store and retrieve such information. It shall provide seamless integration with the existing local area network.

Realtime Information

In the current AATA system the only realtime information displayed on the On-line Supervisor's Centracom console is the bus status indicator (one of: in service, out of service, returning to garage, emergency / accident, or transfer request). Any other information that could be considered realtime (such as vehicle location) would be transferred by voice communication between the MC0 and the Supervisor. Vehicle location is displayed as scheduled based on time of day and transfer location.

In the OCIS, vehicle location and operating / maintenance condition shall be ascertained on a realtime basis. A graphic display shall be updated to reflect any change from previous location or condition. Display updates of changing conditions shall occur no less than every thirty seconds and be accurate to within 400 meters. Updates on both fixed route and paratransit / demand response vehicles shall be performed.

The OCIS shall be capable of displaying information on the headway/pacing of vehicles by different runs of the same route, groups of routes or based on transfer location.

Non-Realtime Information

In the current AATA system, there are several pieces of non-realtime information. These include such items as MCO assignments, duty roster and hours worked, Supervisor schedule, and bus assignment to routes. The actual routes and route schedules are also non-realtime information. Within the demand response service, the collection of reservations for future transportation is anon-realtime requirement AATA is using UMA Trapeze (currently network version 2.99) and Map Edit for route and schedule development AATA is in the process of implementing UMA Trapeze QV for paratransit scheduling and dispatching.

The OCIS shall provide a mechanism for non-realtime data interchange with outside systems. In particular, it shall be able to accept the output of run cutting software and MCO assignment from existing software systems and support preparation of input data acceptable for the payroll system. Currently the payroll system is an application on the AS400. At a minimum, standard data formats such as ASCII can be used for import/export via the PC Support router.

The OCIS shall maintain a database of all MCO and vehicle activity and shall obtain, by the end of the vehicles service day, all vehicle logs of location, transaction and maintenance / operating data for each vehicle in operation during that day.

The OCIS shall maintain and make available, as needed, information such as digital map data, routes and schedules, emergency contact information, etc. Map data used within OCIS shall be consistent with USGS Quadrangle maps or Bureau of the Census TIGER / Line files. The AATA is currently using UMA's Map Edit that provides a license for an ETAC map of Washtenaw County. The AATA will shortly be provided, from the Southeast Michigan Council of Government (SEMCOG), the Washtenaw County MIRUS map that the State of Michigan uses for its road network. SEMCOG has merged Tiger file attributes with the MIRUS file. This map will replace the ETAC map when it becomes available. This map is available to AATA for use in the OCIS.

Computer Aided Dispatch

Computer Aided Dispatch (CAD) is the use of computer technology to manage the information flow associated with transit operations in the assignment of vehicles and MCOs to routes. This area includes information storage and retrieval, MCO management and vehicle management-

Visual Display and Aural Feedback

In the current AATA system, the Supervisor has two consoles providing information on the system status. The first console is an interface to the radio system, providing lists of buses and their statuses and mechanisms for managing the buses with transfer between statuses. The second console is an interface to a PC computer that is used for logging purposes. Logs are maintained on the AS400 for vehicle assignment, lift checks and payroll exception hours. Also vehicle's scheduled locations can be scrolled through chronologically for the days operation. Logs are maintained in Paradox databases on the Netware file server for lost service, vehicle break downs, sick and late calls, incidents, detours and accidents.

The OCIS shall provide an integrated display interface for the Operations Controller (OC). The display shall have graphics capabilities sufficient for display of map information, vehicle routes, locations and status conditions, and shall utilize both graphic symbols and color notations to distinguish different features and aural capabilities sufficient to provide emergency notification. Event information and information logs shall be displayed using a graphical user interface such as but not limited to Microsoft Windows, X Windows or Motif.

Vehicle Management

The current AATA system provides vehicle management by a collection of manual and computer supported procedures. The manual procedures include actions such as assignment of vehicles to routes, performance of special requests (such as wheelchair requests), and logging of activities. The computer support procedures include status tracking of vehicles in operation and assignment of MCOs to vehicles. Demand response vehicle management for paratransit requiring lifts is performed by manual procedures and voice communications with such vehicles.

Specific bus management functions to be supported in the ITS are described in the following sections.

Ve hicie Status

In the current AATA system a list of vehicles and their status is maintained and displayed on the Supervisor's console. An MCO indicates a change in status by depressing the appropriate push button on the vehicle radio control head followed by Supervisory Action. Any additional status information (schedule adherence, vehicle location, wheelchair lift and lockdown utilization and bus mechanics indication) is exchanged between the MCO and the Supervisor by voice communication as needed.

The OCIS shall maintain a database of all vehicles and their current operating status. It shall use appropriate graphics to display pertinent information on the OC console in conjunction with the Information Storage and Retrieval Requirements. A visual indication of the buses location relative to its schedule shall be displayed.

Transfer Coordination

Transfer coordination is the holding of one or more vehicles by a late or connecting vehicle to allow passengers to make timely transfers.

In the current AATA system, there are two types of transfer coordination. There are timed transfers at the downtown centers (specifically supported by the existing vehicle schedules) and intersecting route transfers. Transfer coordination is performed upon passenger request. Once requested, usually when the customer boards or the MCO asks prior to reaching the transfer location, MCO initiates a status change condition indicating a transfer request to the Supervisor, which, after acknowledgement is followed by a voice communication indicating the requested vehicle or vehicles to be held for transfer. The Supervisor then initiates a voice communication with the vehicles to be held for transfer to determine whether an acceptable delay (currently no greater than five minutes) can be accomplished. No feedback is provided to the requesting vehicle regarding the results of the request

The ITS shall support transfer coordination without requiring manual intervention by the OC. The OCIS shall be made aware of all requests and results and be capable of distinguishing a vehicle in a delayed condition awaiting such a transfer. Logs of the individual vehicles shall indicate any interaction involving coordinated transfers (requesting or responding) and the results of such requests. The requesting vehicle shall be notified of the acceptance of the transfer request.

Emergency Situations

In the current AATA system, an MCO can covertly indicate an emergency situation to the Supervisor by use of a hidden switch. Activation of this switch is intended to initiate a series of Supervisor actions, including a call to an appropriate emergency services entity (police, fire, ambulance, etc.)

The OCIS shall support indication and resolution of emergency situations by providing automatic graphic indication of a vehicle requesting emergency action and shall prompt the OC with a check list of activities to be performed and information relevant to such situations.

Flexible Routing

In the current AATA system, paratransit demand response service is provided via manual procedures requesting paratransit vehicle location through voice communication. This allows paratransit vehicles to deviate from their pre-assigned routes to make additional pickups or deliveries.

The ITS shall permit the realtime addition of pickups and deliveries to existing paratransit demand response routes and allow the OC to confirm selection of the vehicle to be re-routed via an interface to UMA Trapeze QV. The ITS shall also permit the realtime modifications of fixed routes.

MCO Management
Checkin and Checkout

In the current AATA system, the MCOs can checkin at any transit center. The MCO signs **a** time sheet and obtains the days assignment from information printed and made available at the checkin location. If the vehicle that the MCO is to be assigned is in service, the MCO arranges to be at the location to begin service. Once in possession of the vehicle, the MCO will carry out vehicle inspection (both for vehicles departing garage locations and in service), and will input data into the farebox indicating fare structure and MCO operation. Upon completion of the days activity the MCO initiates voice communications if the need exists to adjust scheduled pay hours. If returning to a main facility the MCO receives a parking assignment and fills out a Vehicle Condition Card which is then placed in the maintenance area.

The OCIS shall automate MCO checkin and checkout and vehicle possession by use of a smart card device to uniquely identify each MCO. The smart card device shall maintain information on the MCOs assigned schedule and a record of hours in operation of a vehicle. The OCIS shall accept data from the existing route scheduling software to provide the basis for the days vehicle and MCO assignments.

Relief and Extra **Assignment**

In the current AATA system, there are two situations in which the Supervisor must act in order to ensure continued vehicle operation because of an MCO missing an assignment These situations occur either during the initial start of a vehicle's operation or when a relief MCO has failed to arrive at the location for relief of an inservice MCO . In these situations, the Supervisor must determine the appropriate course of action to provide continued service. This can include assigning a standby MCO, extending the unrelieved MCOs service, placing another vehicle into service, etc.

The OCIS shall provide a mechanism to support modifying an MCO's scheduled assignment and assigning MCOs to vehicles during the daily operation. (That is, it shall be capable of modifying the MCO assignment information received from the existing route scheduling software.) It shall be capable of displaying appropriate information (available MCOs, current pay status, vehicle availability, etc.) to determine the course of action.

Cable Television

A majority of the households in the AATA service area are subscribers to cable television. Community access channels are available to the AATA to broadcast route information. A communications link will be established with the cable television center to broadcast real-time route information. The ITS shall provide information on those vehicles that are not on schedule and can update the system map. Messages (textual and/or graphical) to the cable television viewers shall indicate the system routes real running time. The system should be designed to allow addition of interactive cable services in the future. This is an optional system.

Vehicle Sys tern

The Vehicle System in the ITS will take advantage of electronics technologies to manage the flow of information among devices used on the vehicle and to automate much of the MCOs support as possible. The system will require an onboard network to connect the various devices a processing system to perform computational tasks, and a Man Machine Interface (MMl) to allow the MCO to operate the Vehicle System.

Devices attached to the network will provide for automatic vehicle location, fare collection, system condition and communication. The onboard processor will utilize information from these devices to perform additional management functions.

Some of these devices and functionality exist on the current vehicle and will only need to be integrated, while others will need to be modified and some installed new. The basic component set for the Vehicle System is a vehicle area network (VAN) that minimally meets the SAE J1708 standards and a vehicle logic unit (VLU) that is capable of arbitrating and controlling vehicle specific peripheral devices. The function of a vehicle will determine the necessary peripheral devices to be connected to the VAN (and VAN installation) and/or the VLU.
AATA vehicle functions are broken down as follows:

- AATA Supervisory Vehicles • Three (3) Jeep Cherokees used for road supervision
- AATA Support Vehicles • Two (2) Dodge pickup trucks used for shelter, facility and bus stop maintenance
- AATA Transit Vehicle • Sixty-five accessible motor coaches
- AATA operated accessible para-transit vehicle • Currently the sixteen (16) Orion II vehicles function in both a Transit Vehicle and para-transit vehicle mode
- Child and Family Services accessible para-transit vehicle • Four (4) xxxxxx vans
- Taxi operated accessible para-transit vehicle • Two (2) Chrysler mini-vans
- Taxi operated para-transit service • On average fifty-five (55) different taxis carry AATA subsidized trips

The functional requirements that peripheral components may provide are described in the following sections. The following matrix is intended for clarity when assessing quantities for bidding purposes and indicate the types of functions the different vehicle types require.

Function Vehicle Type Matrix

	Supervisory	Support	Transit	Orion II	CFS	Accessible Taxi	Taxi
voice/data communication	x	x	x	x	x		
fixed route vehicle location			x	x			
flexible vehicle location	x	x	x	x	x		
cash collection			x	x			
smart **card** reader			x	x	x	x	x (future)
high speed printer			x	x	x	x	x (future)
DDEC interface			x				
external sign interface			x	x			
internal display			x	x			
internal anunciator			x	x			
internal **PA** interface			x	x			
external anuncia tor			x	x			
external PA interface			x	x			
Lift/Ramp monitor			x	x			
Future expansion for video interface			x	x			
signal retiming			x (10)				

Vehicle Network System (VNS)

The primary components of the Vehicle Network System (VNS) include the physical network wiring, the On Board Processing System (OBPS) and the MMI.

All components shall be appropriate for the operating environment of the ITS.

Physical Network

The physical network shall consist of wiring that is installed throughout the transit vehicle for attachment of peripheral devices. A protocol, such as SAE J1708, shall be used that provides for reliable transmission of data packets between attached peripherals on the network. All devices used in the vehicle system shall be capable of exchanging data packets across this physical network.

On Board Processing System **(OBPS)**

The On Board Processing System (OBPS) shall consist of a central processing unit (CPU) and sufficient memory capacity to operate required software programs to manage the vehicle's operation and maintain a log of the vehicle's daily activities. The MCO interface to the OBPS shall be through the MMI (described below) which may be directly connected to the OBPS.

Man **Machine Interface (MMI)**

The current AATA system requires the MCO to operate several independent devices to control various components of the transit vehicle during operation. For example, the farebox has a keypad that must be used to select fare schedule, input route number, employee number, fare per class and end of trip code as well as individual fare transactions. The radio control head contains several buttons, used to indicate status changes. External displays have thumbwheels or keypads used to select the appropriate route displays for the front and side panels.

The VNS shall provide a single Man Machine Interface (MMI) to the various components of the vehicle and shall automate the operation of such components to the extent possible during the vehicles operation. Appropriate visual and aural interfaces for the vehicles operating environment shall be used.

Peripheral Devices

The VNS will have various peripheral devices attached to perform additional functions. These devices will provide mechanisms for communication, automatic vehicle location, fare collection, video monitoring and proximity detection and operating condition.

Communication

The VNS shall provide for voice and data communications within the vehicle, with the OCIS and between individual vehicles as appropriate.

Voice

AATA vehicles currently include a 35 watt Mitrek moble radio with the MDC 600 status/message contol head. The current AATA system includes a handset and cradle for radio and allows for communication local to the vehicle via Public Address system consisting of **a** MobilPage amplifier, a gooseneck microphone, volume control and speakers (internal and external).

The VNS shall provide a hands-free method of communication and allow the MCO to specify the destination via the MMI as internal, external, or to the OCIS.

The ITS shall also allow the OC to perform a "listen in" one way communication with covert notification to the MCO of its activation.

Automatic Vehicle Location

In the current AATA system, vehicle location is known by the MCO recognizing landmarks and street signs. The Supervisor may only determine an individual vehicle's location through voice communication with the MCO of **a** vehicle.

The VNS shall have a mechanism that can automatically determine the vehicles location to within ten meter accuracy. This information shall be continuously provided to the vehicle's OBPS. The ability to determine location shall be independent of the vehicle route and type of use (fixed route, demand response, or paratransit).

Operating Condition

In the current AATA vehicles, the MCO is informed of the operating condition of the vehicles mechanical systems (brakes, oil pressure, fuel level, etc.) by a collection of meters and indicator lights. The MCO is responsible for forwarding any information on mechanical systems operation to the Supervisor or maintenance personnel as appropriate for corrective action.

The Vehicle System shall monitor the condition of the vehicle's mechanical systems and maintain a log of all significant and the previous three minutes data in these conditions within the OBPS. Monitoring shall begin at vehicle checkout and terminate at vehicle return. Logs shall be transferred to the OCIS no later than concurrent with vehicle return and be available for immediate download to a Field Service Mechanic.

Vehicle Status

The current AATA system provides no support for automated feedback on the status of items of interest. This section describes some such status indicators to be performed by the OBPS, including pacing and headway, passenger capacity, and management of visual displays. A block diagram of vehicle status components is given in Figure 7.

Pacing and Headway

In the current AATA system, time points have been established along the individual routes and schedules have been posted for trips of these routes at these time points. If a bus travels between two time points in less time that allotted in the schedule, it waits at the second time point to return to the schedule. Schedule is not provided at individual bus stops between time points.

The ITS shall accommodate an increase in time points equivalent to making each bus stop a time point and provide pacing information to the MCO via the MMI for each segment of a route.

The OBPS shall inform the OCIS when a vehicle is outside its pacing threshold (currently 5 minutes). The OBPS shall also indicate headway between the vehicle and the ones just ahead and behind it in the instance that one of these vehicles is out of schedule.

Passenger Capacity

In the current AATA system, passenger capacity is informally measured by the MCO performing a visual scan of the vehicle. When the vehicle approaches full capacity and the MCO anticipates additional passengers, the Supervisor is notified of the situation. The Supervisor can then take appropriate action (dispatching an additional vehicle, route or schedule modification, etc.)

The OBPS shall ascertain and record passenger capacity at each vehicle stop. The data shall be timestamped and geocoded and maintained in the OBPS log. The OCIS shall be notified when the passenger capacity reaches a specifiable threshold and when it drops below a separately specifiable threshold. This function should be priced separately.

Displays and Annunciators

All AATA vehicles have mechanisms for display of route and other information as well as vocal announcements. The MCOs change the external route display panels through use of a thumbwheel or keypad device to select the appropriate code for the vehicle's current route. An internal display is available that lights up in response to a passenger request for the vehicle to stop at the next bus stop. The MCO makes a vocal announcement of the upcoming stop prior to arrival at each time point

The OBPS shall automate internal and external display and announcement functions. Data for these functions shall primarily be stored in the OBPS at vehicle checkout time and shall also be capable of being modified by the OCIS and / or MCO as appropriate during the vehicle's operation. Pre-recorded messages and visual displays shall announce upcoming time point stops and any requested stops. The MCO and OC shall be able to make vocal announcements.

The ITS shall provide a mechanism for local creation of all necessary messages and display information.

Wayside Information

Customers waiting at stops currently have no information regarding the status of the bus upon which they are waiting.

As a limited demonstration the ITS shall provide a mechanism at each stop on one route (approximately 20 bus stops) that will provide information on the amount of time remaining before the arrival of the next vehicle on routes serviced by that stop- This is an optional function.

FARE COLLECTION - Phase II

Current System Description

Currently the AATA uses GFI electronic registering fareboxes to collect cash fares. Paper stock ID cards are issued to customers eligible for reduced fares to be shown to drivers at the time of boarding. It is the operators reponsibility to press the appropriate key to distinguish all cash fare types. Tokens are available to the customer and are the only fare media the driver isn't required to press a key.

Transfers are issued by drivers to customers upon request Transfer are pre-printed books of 100 transfers. Drivers insert the books into a cutter and move the book throughout the day to indicate time of day by the length of the transfer.

The farebox is opened by an hardwired handheld electronic probe by the service crew in a remote unsupervised area at the time the vehicle is being fueled and cleaned. While the probe is opening the access door to the cashbox an electronic download of the data stored in the farebox is passed over to a hardwired personal computer. The computer has software that colectsand stores all farebox data and produces daily and monthly reports. The cash box is removed and dumped by inserting the cashbox into a receiver, securing the door to the receiver and turning a crank. Coins and bills are divided in separate areas within the cash box. The money is dropped into a vault to be opened and counted by the finance counting team at a later time. Coins and bills are stored in separate areas within the vault.

Coins are dropped onto a conveyor belt and moved into a MoneySystem Technology Inc. model 822 sorter/counter machine. Bills and tickets are removed, sorted and counted separately by hand.

Fare Collection System General Description

The Fare Collection System integrates smart cards, high speed printers, electronic dump fareboxes and coin vault/counting system through the utilization of the OBPS and the OCIS central system. Driver procedures are simplified by a single keypad, smart cards used for discounted fare identification, transfers printed on request with appropriate data and a single point for data collection.

Cash Collection

The farebox is to be at a minimum an electronic dump farebox. This allows the driver to press a key(s) on the OBPS designated to dump the inspection plate. An electronic mechanism will accept a signal and the coin inspection plate will tip, causing any coins, bills, tokens and/or tickets in the inspection area(s) to be advanced into the cashbox. It will accept fares in the form of U.S. coins, tokens, dollar bills, and tickets. The farebox shall be equipped with standard connector(s) to connect to the vehicle area network. Protocols for data in and data out will be made available. The farebox must function under the environmental and operational conditions of the transit vehicle and operate quickly and quietly so as to not interfere or degrade current practices in regards to customer boarding or driver comfort It will be manufactured to provide a high degree of security against forced entry and/or unauthorized manipulation.

The farebox must permit the passenger to easily and rapidly insert the required fare and the driver to readily ascertain that the correct fare has been paid, regardless of the fare media employed. Subsequent to insertion, coins, tokens, paper currency and tickets will be directed to an illuminated inspection plate on the farebox, where they may be viewed by the driver. Coins and tokens visible in this inspection area will be advanced to the cashbox in the lower portion of the farebox when the driver depresses a dump pushbutton(s).

The farebox and its electronic logic must be designed to provide trouble reporting and self testing and diagnosis when interogated by the onboard logic unit at start-up of vehicle and at other times as requested.

The farebox and its mounting fixtures must be built to discourage vandalism and theft. Finishes must resist corrosion, abrasion and scratching. All exterior surfaces will be clean with all comers rounded. There will be no exposed bolt heads, nuts, sharp edges or cracks on the outside surfaces. The entire farebox will be made of satin finish stainless steel. The compartment housing the cashbox will have a door attached by a full length hinge. There will be no gaps that would allow the door to be easily pried or broken open.

Keys and/or locks that are “captive” to the lower portion of the farebox and used to interface with the cashbox must be securely fastened and removable only in an authorized manner. Guides will be employed within the cashbox compartment to assure that the cashbox is properly aligned. Wires and cables which are run through the lower portion of the farebox to the upper portion will be run in a protected channel and/or raceway. No wires will be visible inside the cashbox compartment.

The bottom of the farebox will have a cast iron base plate to permit mounting to the bus floor. The dimensions and construction of this base plate will provide the necessary lateral stability, without secondary anchorages. The base plate will be affixed to the floor by means of stainless carriage bolts from the interior of the bus, with the stainless washers and stainless nuts on the underside of the floor.

The cashbox will fit within the cashbox compartment in the lower portion of the farebox. The cashbox will have a useful interior volume capable of holding approximately $500 in mixed coins and $300 in unfolded “street money” dollar bills, or paper equivalent.

It will be provided with a handle to permit its being carried by a person with a gloved hand. Removal of the cashbox from the farebox will require opening of the cashbox door in the lower portion of the farebox. The mechanism and operation of the cashbox will be positive and will at no time during the collection or transfer of revenue expose the interior of the cashbox or its contents at any point. The cashbox will fit into the farebox in a unique correct position and will be placed into the ready position to collect revenue by a continuous single motion. The farebox will remain inoperable until the cashbox is properly inserted and ready to accept revenue and the cashbox access door is closed and locked. The cashbox will not have removable lids, covers or other elements which may be detached from the cashbox. The operation of the cashbox will be such that it will be locked and sealed unless it is in a farebox or vault receiver for revenue transfer. There will be no unauthorized means of gaining entry to the cashbox other than physical destruction of the cashbox, which will be immediately noticeable through visual inspection. The locks and keys used on the cashbox will be of the high security type as specified below. The operation of any keys within the locks will not require excessive torque that may damage either the key or the lock.

The mechanism employed to open and/or close the cashbox shall be positive and smooth in operation. Internal locking mechanisms shall be constructed of strong and durable materials. The term “internal locking mechanisms” refers to all components, including levers, slides, cams, etc., that are required to release the cashbox from the farebox or lock it in place in the farebox The cashbox shall be made of stainless steel, 20 gauge minimum. It shall be of welded construction with no exposed external fasteners. The parts of the cashbox that come in direct contact with the farebox shall be abrasion-resistant.

Locks and Keys

All locks and keys used in the farebox exterior and the cashbox shall be of the high security type defined as follows. A high security lock is pick resistant and of the multi-tumbler type. It employs hidden and/or complex keyways to require the insertion and/or removal of the key in a uniquely correct position. Making an unauthorized duplicate of the key for a high security lock by means of impressions or similar technique would present a high degree of difficulty. Security keys are registered and new or additional keys are available only from the manufacturer or authorized agent by authorized personnel.

Vaults

The garage equipment used in transferring revenue from the farebox shall include, as a minimum, a fixed vault through the counting room wall with a receiver(s). accessible from the service area side of the wall. There shall be at least access to two receivers in the case of failure one receiver. There shall be a secure method for openeing farebox access doors to remove the cashbox.

Environmental Conditions

The garage equipment shall be able to function in accordance with the requirements herein and not suffer any degradation of performance under the following environmental conditions:

Temperature Range	30” to +120^{o} F ambient temperature; surfaces may be heated by direct sunlight to +150^{o} F
Humidity, Range	5 percent to 95 percent R.H. (non-condensing)
Precipitation	exterior condensation and wind gusts
Contaminants	Airborne dust particles, diesel oil, lubricating oil, diesel engine exhaust
Interference	EM1 from bus equipment and other electrical equipment in the vicinity.

Cashbox Receiver

The cashbox shall be inserted into the receiver for revenue transfer. The cashbox shall be inserted into the receiver in a uniquely correct position. A heavy duty interlocked door shall be provided. When closed, the door shall be locked with a lever that shall start the revenue transfer process. The door shall remain locked until the revenue transfer process is complete. Once the door is closed and locked, an internal mechanism shall open the cashbox and securely transfer the contents into the collection vault At no time is the interior of the cashbox or the collection vault to be visible or accessible in any way, by unauthorized means. When the cashbox is completely closed, interlocks shall unlock the door, permitting the cashbox to be removed. Appropriate indicators shall be provided, at a location adjacent to the receiver door, to signify a “ready” condition and a “process” condition.

The receiver shall be provided with appropriate maintenance apertures. Each of these shall be secured with a high security locking system. Keys to this locking system shall be different from those employed elsewhere in the system and shall be of the high security type. All elements of the receiver shall be self-contained and integral to the receiver; operation of the receiver shall not require loose keys. All engagements and/or alignments shall be positive and automatic.

Through-wall Revenue Collection Vaults

The vault structure containing the receiver and bins shall be designed to be built into an exterior wall of the counting room. The vault shall hold a minimum of $20,000 in “street” money, with a coin capacity of $10,000 and bill capacity of $10,000. Revenue discharge door(s) shall be secured by a high security lock. Coins and tokens shall be discharged from the coin compartment by gravity; sloped stainless steel bottom surfaces shall aid in this process.

The receiver and vault shall operate in the following manner:

- Revenue shall not be transferred from cashbox to vault until the cashbox has been properly inserted in the receiver and the receiver door has been locked closed.

- The revenue transfer process, once started, shall be irreversible. A full cycle shall be completed before the cashbox can be removed.

- The receiver door shall not lock closed nor shall the transfer crank operate without **a** properly inserted cashbox.

- The receiver and vault shall remain secure when a jam occurs except for access by authorized personnel. Security features for overriding the interlocks under such conditions shall be subject to approval by AATA.

The revenue collection vault housing shall allow no entry to the vault other than through authorized apertures. The through-wall vault shall be installed so that the receiver faces the service lane and the revenue discharge outlets face the counting area. The cashbox door on the receiver shall be approximately 48 inches from the lowest point of the collection vault for ease of cashbox insertion.

The receiver, its enclosure, and the vault structure shall be solidly built of substantial materials to ensure maximum security. All parts of the vault shall be made of non-corroding or plated materials or, to the extent cold rolled steel is used, shall have been cleaned, prepared, and powder coated or base coat/clear coat painted. The front surface, door and interior of the receiver shall be made of stainless steel for corrosion protection and wear. All locks used on the vault shall be of the high security type.

Coins and Tickets/Bills Separation

It is important during the revenue collection process and prior to counting the revenue that coins be separated from tickets and bills.

High Speed Printer

The electronic highspeed printer will be equipped with SAE J1708 connector(s) to connect to the vehicle area network. Protocols for data in and data out will be made available.

The printer will be capable of printing transfers on demand. By pressing the transfer issue button(s) on the onboard logic unit the driver will initiate the printing of a transfer. Printing will last roughly one (1) second for an ordinary transfer. When the transfer is ejected it will be pre-cut to a majority of its width. The remaining piece will prevent wind and drafts from displacing the transfer.

The printer will be integrated into the Vehicle System and the onboard logic unit. The AATA can define information to be printed on the transfer. Examples of such information, but not limited to, are busstop location, time of boarding, time of issue. Transfer issue events will be recorded with route, run, driver, time of issue and location data derived from daily initialization of onboard logic unit and vehicle location system and stored in the onboard logic unit.

The printer will be capable of printing receipts and customer smart card transaction logs of recent activity when appropriate onboard logic unit button(s) are pressed.

The printer will be housed in a sturdy high impact housing with a weather sealed design. It will mount into the vehicle by a self locating, key locked cradle. It will operate with 12 or 24 volts.

Cashless Payment - Smart Card

The proximity smart card will be the preferred media for AATA traveler identification and fare payment in the ITS. It will be capable of supporting multiple fare determinations and payment strategies. However, the University of Michigan is implementing **a** smart card program with the First of America Bank. This program includes 60,000 insert chip *cards.* The card will act as an electronic purse that can hold up to $50.00 for small anonymous purchases (less than $50.00). The card is also tied to a bank account for larger purchases. Large purchases require a realtime connection to the bank. Local merchants as well as the university community are welcome to participate in the program. AATA is planning to a limited “Mcard” demonstration project on six vehicles in November 1995 through First of America, University of Michigan and Schlumberger/Danyl.. Therefore, it is important that the ITS be able to participate with the UM “MCard” electronic purse as well as a proximity smart card for the transit customers.

Traveler Identification

In order to ensure that the appropriate fare is being charged for each use, the transit smart card must be capable of uniquely identifying the traveler to whom it is issued. The system shall be capable of maintaining a list of cards reported lost or stolen and taking appropriate actions when such cards are presented for payment- The current AATA system provides for fifteen types of fare categories (student, senior citizen, low income, AATA employee, etc.). In addition, monthly passes can be purchased in advance and pricing for demand response transportation (normal or paratransit) provides for different fare amounts. The ITS shall support transit smart cards with different fare categories and of changing fare schedules for different categories. The ITS shall have the capability to support various pricing approaches, including multiple use discounts, time-of-day usage, etc.

Automatic Passenger Counter System

SECTION 6

PROPOSAL TECHNICAL REQUIREMENTS

Note that with respect to time and date, the system must be able to automatically adjust for changes due to daylight savings time and leap year. Dates from current year, as well as including and beyond the year 2000, should be able to be accommodated.

Specific record formats (Exhibit No. 3) are required to be provided (output) by the system. It is not necessary that the data be recorded and stored in this format on the bus, so long as the stated record formats are provided to the County after data retrieval, whether using the portable data retrieval unit or a wireless retrieval method Any software or special hardware required to convert the data into the required formats must be provided by the Contractor, including the source code.

The contractor must also provide the capability to create, display and/or print an ASCII file of the internal data records, in a format which can be easily understood.

The bidder may propose other formats which must be approved by the County.

6-3 Type of Buses for System Installation

The APC systems purchased under this contract shall be able to be installed in a variety of transit vehicles, including small buses or vans, standard 40' buses, articulated buses, and electric trolley buses. The initial installations will be in GiIlig 35' and 40' buses and Champion 25 passenger vans. The installed equipment must allow for the particular space limitations of each vehicle.

All systems should be operable on bus voltage which may range from 12 to 24 volts

Listed below are the current buses King County presently operates. APC's shall be able to fit any of these transit coaches and any other transit buses and mini vans that the County may purchase in the future.

TYPE	YEAR
AM General Model 10240B-8	1976
AM General Model 10240B-8	1978
M.A.N. SG220-18-2	1978/1979
Flyer D 10230 C	1979/1980
Flyer D 10235 C	1980
M.A.N. SG 3 10-18-2	1982
M.A.N. SL 401021	1986/1987
AM General Model 10240T	1979/Trolley
M.A.N. SGT3 10-18-3	1987/Trolley
Breda ADPB 350	1990/1991 Dual Mode Bus
Gillig Phantom 35' and 40' Ml l-T40-102	1996

6-4 Equipment Description

Each APC system to be instaIled on each bus shall incorporate at least the following features:

A: Passenger counter sensors at each doorway.

The County currently has about 145 APC systems which use mat sensors, and desires initially to continue using this technique. However, the APC systems provided under this contract shall be adaptable, for future application, at a minimum to IR beam sensors and possibly to other types of sensor inputs, with only firmware changes and/or parameter changes.

Mat sensors must use London Mat Industries, or equivalent, stairwell mats. Any other type of mat must have been proven in a passenger counting application in revenue bus service for at least one year and must be approved by the County.

Mats must be provided with a 3-inch 'safety yellow' leading edge, with the color molded directly into the mat material. Prior to installation, the Contractor may be required to apply a non-skid material to the leading edge of the mats. The County will supply this material.

On some vehicles the front upper mat is on the floor and front lower mat is on the top step.

Mats with four switches must be supplied in two pieces, each piece with two switches. The two pieces should fit together for a neat appearance on the step. The County reserves the right to procure these mats directly from the manufacturer.

B. Radio/AVL (ARI) Interface:

Bach APC system shall be capable of interfacing on the vehicle with the County's ARI. This can be accomplished in one of three ways:

I. With a direct connection to the ARI Echelon LONworks net. The net uses twisted pair wires and operates at 1.25 mbps; or

2. Using a Lonworks device that provides an RS-232 port;

3. Using an APC Interface Unit(AIU), available from Northwest Technologies, Inc., that is being used to interface to King County's current APC systems. The AIU provides au RS-232 port for connecting to other devices. Note that some modifications to this unit may be needed to accommodate the proposers APC equipment.

The interface shall provide for two way communication and data must be available for offloading in real time. Any device put on the net must maintain net connectivity via an open net port The following information is currently available on the net to the APC unit:

1. <u>signpost</u>: each useable signpost reception by the AVL.

2. <u>odometer</u>: an odometer signal approx. every 5.6 feet.

3. <u>routerun</u>: the assignment that the driver has keyed into the radio keypad at the start of this routerun

4. <u>clock</u>: the AVL system time is continuously available on the net. The contractor should describe how this could be used by the APC either to update the APC clock, or in lieu of the APC clock (See E on the next page.)

The APC unit must also be capable of sending the stored APC data back across the interface for storage in the interface memory unit (Event Log) and subsequent downloading via an IR unit. (Provided separately.) However, offloading of data in this manner shall not automatically remove the data from the APC unit's memory.

The contractor may also propose a separate IR download capability specifically for the APC system.

1. Complete diagrams

2. Illustrations

3. Instructions for operation of the system, including normal operating and communications procedures

4. Diagnostic procedures

5. Restart/recovery procedures

6. Other necessary procedures for operating the system

7. Complete descriptions of functions necessary for generating reports

The Proposal shall include a sample System Operations Manual. The manual will not be included in the one hundred (l00)-page limit.

B. System Maintenance Manual

Seventy (70) copies of the System Maintenance Manual shall be provided. This document shall be comprehensive and shall provide complete detailed technical descriptions of maintenance operations, including, but not limited to, the following:

1. General descriptions
2. Theory of operations
3. Preventive maintenance schedule and activities
4. Troubleshooting techniques
5. Corrective measures, both temporary and permanent
6. Location and availability of support services for all major components
7. Point-to-point component wiring schematics
8. Assembly and disassembly drawings
9. Installation guidelines
10. List of required maintenance tools

The Proposal shall include a sample System Maintenance Manual. The manual will not be included in the one hundred (lOO)-page limit.

C. Software Documentation

Software documentation for the specific application software/firmware developed for this project shall include, but not be limited to, the following:

1. Overview description of software/firmware for each system and subsystem, including data flow and other diagrams as necessary to demonstrate software structure

2. Commented source code listings of all application software/firmware

The Proposer shall agree to a software licensing agreement reasonably consistent with Attachment N.

The Proposal shall include a proposed software licensing agreement consistent with Attachment N.

C. Independent Data Storage

Memory must be non-volatile for at least 72 hours with respect to the power supplied by the bus to the APC system Memory should be cleared by logic and not by a power loss. As a minimum, memory should allow for data storage for up to 5,000 STOP records, 1000 SIGNPOST records, 300 SPECIAL EVENT records, 1000 DISTANCE records, 500 IDLE records, 200 SWITCH DIAGNOSTIC records and 100 HANGUP DIAGNOSTIC Records. Memory should also allow for storage of other system diagnostic messages that could be used to identify and troubleshoot problems.

D. Internal Batteries

Any internal batteries used should be long-life, rechargeable batteries. The batteries should incorporate a test feature with a special diagnostic generated (part of SWITCH DIAGNOSTIC record) before the battery level reaches a level which could adversely impact system operations. The batteries should provide a low impedance sink for any RFI on the input voltage.

E. Real Time Clock

Each system must be capable of providing real time, to the nearest second, and date of specific events as described in Section 6-2. The time must be accurate to within 5 seconds per month. The system must not require an excessive amount of clock setting. The data retrieval system may involve a clock that can automatically update the APC clock.

F. Logic

All APCs must be microprocessor controlled to allow for ease of logic changes for any of the functions performed by the APC including passenger counting logic and record generation The microprocessor must be readily available and supported in the U.S. marketplace such that the County could easily acquire test/programming equipment for the microprocessor for the purposes of future functional modifications.

All firmware should use Flash Memory EEPROMS, to allow the system firmware to be changeable via the ARI interface through a laptop computer or via the infrared.

G. Interchangeability

Each APC system, except for some mats, must be interchangeable among all vehicles. The system should be capable of being programmed for which type of vehicle it is installed in so that the appropriate logic is used For example, some stairwells are two stream, while others are one-stream, and the counting logic must know which type of stairwell it is receiving information from.

H. Interconnecting Cables; Connetors and Related Hardware

All connectors and terminals shall be MIL spec grade. Any exceptions to this must be approved by the County. Certain plastic connectors may be acceptable, subject to prior approval by the County. All interconnecting cables shall be shielded Any external connectors must not have any exposed pins, but should use the socket end of the connector and have an easily removable cover that is permanently attached. All integrated circuits (IC) sockets shall be gold machined pin and either a) locking or b) the IC's shall be capable of being strapped to the socket. All connector pins and sockets shall be gold plated.

I. Door Open Sensor

Each APC system must be capable of determining when each doorway of the bus is open or closed. Since passenger on and off activity must be provided separately for each doorway, the door open/close sensor must be capable of differentiating between each doorway.

The door open sensor should utilize the signal from either a) the bus drivers door opening switch, or b) a signal from a switch at each doorway. If a separate switch is required, the door open or close logic must be accomplished by the use of a switch provided by the contractor. (A suqqested switch is Hamlin- 300 series, mercury wetted, all position switch, with contact resistance of 0.2 ohms, or equivalent.)

J. Odometer calibration

Each APC system should have the capability to calibrate the odometer input provided by the API. This calibration should be accomplished with user settable parameters in the MPPU, discussed below. .

6-5 **Multipurpose** (MPPU) Unit

A single unit should be provided that has the capabilities as described below. This unit shall be a DOS/Windows based portable computer, preferably a laptop with a long life battery, easy to change in the field

The MPPU should connect to the APC system with an umbilical cable of at least 10 feet in length, using a quick connect connector, and should obtain its power from the APC system and/or from a battery that can power the unit for at least 4 hours in the field The connector on the bus should be located for convenient access and its location must be approved by the County. It should not be necessary to remove or disconnect any connectors or cables in order to use the MPPU. In order to monitor the rear stairwells of vehicles, a separate 40”extension cable should be provided and/or a connector should be provided near the rear stairwell(s), in an approved location, for this purpose.

The functionality should be programmable using readily available software, such that additional diagnostic functions could be added at a later date without significant design changes.

Use of the MPPU should not adversely affect the operation or accuracy of any other system equipment. The MPPU should be appropriately packaged for the harsh bus environment. Operation of the devices should **not** be adversely affected by occasional rough handling. All displays shall be clearly visible in bright daylight. The County must approve all functionality of the MPPU and a prototypt must be available for testing and approved prior to final design and production

These functions should be accessible by password only to authorized personnel.

A. **External Record Generation** - Enter the eight extra input values (alphanumeric) and generate a SPECIAL EVENT record

B. **Memory Clear -** In the case of a manual download, memory should not be cleared automatically, but should require a separate command from this unit.

C. **Setting Time and Date-**

D. **Setting of Variable/Parameter Data Input -** This includes at least the following parameters: parameter 1 (see STOP record), parameter 2 (see SIGNPOST record), and odometer calibration. The proposal should discuss other parameters.

E. **Information Display Mode -** The unit should be capable of displaying at least the following information:

1. Time, date, device ID, vehicle ID, software version.

2. Passengers on and off at each doorway.

3. Odometer reading to ,001 miles, for both a cumulative odometer reading, since memory was last cleared, and a resettable 'trip' odometer.

4. Signpost code for last signpost received

5. **Indication, using a blinking** light **or** display for each signpost reception, of when the bus is receiving a signpost signal. The signpost code shall remain displayed until a new code is received.

Reset keys should be available to reset the passenger **on/off** counts at each **doorway,** and to reset the 'trip' odometer to zero (0).

F. Monitoring Mode - In this mode, a person would ride the bus and enter at each bus stop the number of passengers getting on and off at each doorway. The unit would store this data in a stop record, together with the counts for that stop from the APC unit. This file could be easily offloaded from the MPPU for tabulation, or the MPPU could be easily programmed to include software to tabulate the results of the accuracy check.

G. **System Maintenance/Diagnostic Mode - The** purpose of this mode is to test various system functions, and to provide diagnostic information on system operation. The MPPU should be capable of displaying/indicating at least the following information:

1. <u>Mat Status</u> - For each switch in each mat(or other individual sensor such as a IR beam), the MPPU shall be capable of indicating whether the switch or sensor is open or closed, based on logic thresholds required for correct system operation The test shall be capable of indicating when a mat is "spongy" and when a switch remains shorted or partially shorted when someone steps off it. In other words, **a** switch that does not open and close cleanly would be detected.

2. <u>Door Switch Status</u> - The MPPU shall be capable of displaying door open/close status in each doorway.

3. <u>Odometer Status</u> - The MPPU shall be capable of indicating when an odometer pulse is received.

4. <u>APC Svstem</u> Self Check - The system self-check should be a procedure that indicates the APC system is functioning properly when the system is reset such as with a warmstart. System malfunctions would display appropriate messages which could be used to diagnose and troubleshoot the problems.

5. <u>Memory Utilization</u> - The MPPU shah be able to display the amount of memory remaining in the APC unit, in terms of percent available and bytes available.

6. Input Device Status - The MPPU shall be capable of indicating, and modifying the status of various external input devices being used (active), such as mat switch inputs v. Beams.

7. Other - The MPPU shall provide other diagnostic and status information which may be appropriate for troubleshooting the system and diagnosing the location of a particular problem The bidder should include other recommended diagnostics with the proposal.

The MPPU should use alphanumeric displays to provide the above information An audible sound with a volume control should also be used to indicate certain conditions, such as a mat switch, or door switch open or closed.

H, **Data Retrieval Mode** - (see also 6-6 below). The MPPU shall have the capability to download the APC data from the APC unit's memory and/or from the Event Log. This download must include a cabled option, wherein a cable connection would be required between the APC and MPPU. The Contractor shall also propose a wireless option for this download using the MPPU, such as an infrared link.

The unit shall be capable of storing data from at least ten (10) full APC systems. The method of data storage should use non-volatile memory media such as a hard drive or PCMCIA card The unit should display diagnostic information regarding data transfer/retrieval status.

As in the case of on-board storage, it is not necessary that the data be stored in the record formats stated in Section 6-2; however, the Contractor must provide any software or hardware required to convert the data to the required formats and communicate with The County's computer. Standard ASCII code should be used. The Contractor must provide The County with complete software protocol requirements and descriptions for this interface, including all details necessary for communication between the unit and a host computer.

Sufficient error checking should be involved in the data retrieval process to determine whether the data has been recorded successfully and without error. If problems are found, an indication of such should be indicated on the MPPU to the MPPU operator, and a special diagnostic record generated. The MPPU operator will then have the option of re-initiating the data retrieval request,

L **Simulator Mode** - The MPPU should be capable of being used as a simulator to simulate all external inputs to the APC unit, including at least individual counting sensors, passenger ons and offs, odometer, signpost, clock, routerun. This capability should be programmable so tbat an input file of one or more events could be prepared and run through the system for testing purposes.

6-6 ARI Method of Data Retrieval

In addition to offloading the data using the MPPU, the proposer should include in the proposal a data retrieval option that does not require a person to go to the bus (e.g., an infrared link between the bus and the base). This capability could allow the APC data to be off-loaded through ARI Event Log together with any other data stored in the Event Log or it could be a direct link between the APC unit and the base, or both.

The Contractor shall provide King County with complete software protocol requirements, hardware . requirements and descriptions for this interface, including all details necessary for communication between the equipment provided herein and the ARI.

6 - 7 Accuracy

A. Passenger Counter Accuracy

As a minimum, the passenger counter shall demonstrate the following accuracy for a series of data recording events where such event is defined as a complete stop cycle.

1. Accumulated Count

An accumulated count for both boarding and alighting passengers to within 5 percent for each 100 consecutive boarding and alighting passengers. That is, for every 100 consecutive boarding (alighting) passengers, the system 'on' ('off') count must be within the range of 95 to 105.

2. stop-by-stop

For 85 percent of all stops, the 'on' and 'off' count shall be exact. This shall include stops for which there was either an 'on' or 'off activity or both 'on'/'off' activity. If a stop had no 'on' activity, and the counter recorded no 'on' activity, this would be considered a correct count.

For 90 percent of all stops, the 'on' and 'off count shall be within +1 of actual.

For 97 percent of all stops, the 'on' and, 'off count shall be within +2 .of actual.

All accuracy tests shall be conducted during revenue service by the County. Actual counts shall be determined by the County personnel riding the bus. Passenger counter counts shall be based on either the counts displayed on the portable display unit or the recorded data, or both.

A valid test of the above conditions shall contain a minimum of 500 events (stops), with an average number of boardings per stop of at least 1.75. The tests shall be conducted for each vehicle installation prior to acceptance. (See Sections 6-22.)

The accuracy of the passenger counter shall not be adversely affected by normal passenger behavior, such as standing in stairwells while the bus is in motion and hesitance while inserting fares into the farebox when entering/leaving the bus.

Because of wide doorways in some of the buses, the counter must be capable of counting simultaneous 'ons' and 'offs' in a two-stream operation That is, two persons entering or exiting in parallel or one person entering and one exiting simultaneously.

B. Location Accuracy

The system must provide the signpost code, time, and odometer value as required in the signpost record. For the GPS option, the proposer should include a discussion of how this would be used to determine location and the resulting accuracy. (See Sections 6-14.)

6-8 Packaging

All equipment provided under this contract shall be packaged in a non-corrosive casing and be such that it can be installed in the bus in a location convenient to personnel who must interact with it The County must approve the packaging prior to production. Any cables or connectors required must be provided.

6-9 Installation

Installation cost of equipment shall be shown as a separate line item on Attachment B. Installation shah include all labor, supervision, equipment, and materials required to place the equipment properly in compliance with ail specifications and standards. Acceptance of the equipment is contingent upon the installation of the equipment meeting ail applicable codes and standards and functions according to the King County's specifications. Equipment shall be installed in buses and mini vans designated by the King County. The exact location for system installation in each vehicle must be approved by the County prior to installation.

The Contractor shall proceed with the installation of all the above equipment upon written notice by the County within ten working days of the notification to install. The County will provide a facility for installation.

The passenger counter system shall be installed so that the flow of passengers will not be impeded or restricted. Any form of barrier or turnstile is not permitted. The equipment must not result in a decrease in seating capacity of the bus. Equipment, electrical connections, and wiring shall be protected and concealed from view as much as possible and shall be designed so that there is no hazard to the passenger in the event of accidental contact Potential damage to passengers' clothing shall be minimized. The equipment shall be firmly secured on the bus to prohibit tampering and to avoid damage by accidental abuse of the equipment.

The bidder must include in his proposal an estimate of the amount of time required per system installation.

6-10 Operating Environment

All on-board equipment shall be capable of operating in the working environment of a diesel bus or electric trolley bus. It is especially critical to note the likelihood of interference from TV, radio or other broadcast media, and also from internal or external noise generated by the trolleys through arcing of brushes, chopper commutation, etc. The equipment shall be capable of withstanding indirect exposure to such climatic conditions as rain, snow, and sleet. Operation in specific adverse climates, such as corrosive atmospheres (those containing high salt or other chemical content), or atmospheres containing concentrations of dust or smoke, will be required

The following data represent typical values during normal bus operation At a minimum, the design of the equipment shall conform to these values:

A. minimum temperature (storage) -34 degrees F

B. minimum temperature (operation) 0 degrees F

C. maximum temperature (storage and operation) +110 degrees F*

D. minimum humidity 5% RH

E. maximum humidity 95% RH

F. maximum vibration 3g. RMS

G. vibration spectrum 1.0-2000 HZ

H. shock 5g.

*Note that some equipment may be exposed to higher temperatures, depending on its installation location.

The equipment shah withstand thermal shock due to rapid change in temperature. The design shall take into consideration conditions of temperature and humidity that would promote condensation on equipment components.

6-l 1 Electronic Design Considerations

All equipment shall be designed to operate from 9 to 39 volts, DC. All equipment provided shah be designed to be unaffected by RFI, EMI and power surges and must minimally satisfy the criteria outlined below. All cables used shall be appropriately shielded. Any cable connectors used shall be of a twist, positive connect type.

EMI/RFI

The equipment shall not malfunction when subjected to EMI MIL-STD-461B test as follows:

A CS02 Conducted susceptibility - power leads

B. CS06 Spikes - power and input leads 600V, l0us, both positive and negative polarity.

C. RS03 Radiated Susceptibility,

. up to 30 MHZ @ 10V/M

. 30 MHZ to 500 mHz @ 5V/M

450 MHZ @ 10 V/M

D. UM05 Emissions test

The Contractor shall test a minimum of one production unit in accordance with MIL-STD-46 1B and provide certified test results to King County for approval prior to shipping any units.

Electrical Transients

The on-board equipment must withstand long-term voltage transients on the power leads of 80 volts for 10 msec. from a 1 ohm source.

6-12 Training

The Contractor shah provide, at no additional cost to the County, three days of training for up to ten County personnel including troubleshooting, maintenance, and operation of all equipment to the component level. The dates of this training shall be mutually agreed to by the County and the Contractor. The location of this training shah be at a King County facility.

6-13 Documentation

Complete documentation, including schematics, shall be provided for troubleshooting the equipment down to the component level. Procedures' manuals shah be provided which describe all system functions and parameters and their operations. Five (5) copies of all documentation shall be provided. In addition, all documentation shall be provided in Word 6.0 format on 3.5' diskettes. (See Sections 6-21.)

6-14 Global Positioning Satellite (GPS) Option

The proposer shall include in the proposal an optional capability to include GPS data for use in vehicle location. The proposal should include a discussion about how this data would be recorded, how it would be included in the current output data structures, how it could be used, and what additional equipment will be needed, and its cost.'

6-15 Payment Schedule

Payment(s) to the Contractor shall be as follows:

The Contractor shall bill King County for all work that has been completed, delivered, installed and partially or fully accepted by King County. King County shall pay the Contractor 80% of all billings (invoice amount) within 30 days as required by law or within the discount period if applicable. (See Section 1-12.) The remaining 20% of each invoice/billing shall be paid by King County to the Contractor upon satisfactory installation and completion of all requirements for a period of not less than 60 days. King County shall not be bound by prices contained in an invoice that are higher than those approved.

All invoices or billings for services which have been delivered or provided to the County shall be mailed to:

Mr. Tom Friedman, Project Manager
King county
Research and Market Strategy, Mail Stop 53
821 Second Avenue
Seattle, WA 98104-1598

6-16 Pricing

Pricing for the initial order of APC's Radio Interface System underthis agreement shall remain firm as proposed or as negotiated and agreed to by both parties prior to contract award. King County will be buying additional units on an as-needed basis to be installed in selected buses and mini vans over a five year period. As a result, reasonable price changes for subsequent orders installed after the initial order may be made by the contractor for quantities indicated in Attachment B. Annual price adjustment with regard to any price increase or decrease in costs for additional APC units purchased by the County, shah be Limited to changes in the Producer Price Index (PPI) SIC #3669, published by the U.S. Department of Labor Bureau of Statistics. The Contractor shall supply satisfactory documentation within thirty (30) days in advance of any price changes to King County Buyer or Project Manager for their review and approval prior to approving any price changes.

King County will evaluate this information to determine whether the Contractor's request for a price adjustment is considered fair and reasonable. Any, agreed-to change shall take effect at the time of the contract extension and shall remain in effect throughout the extension period.

6-17 System Compatibility

The Contractor shall be responsible for the procurement of the hardware and software components of the system. The Contractor will be responsible for the whole system integration and guarantees the functionality of the integrated system as a whole.This provision will constitute an express warranty on the part of the Contractor.

A. Guarantee of Functionality

Functionality shall mean that the configuration. as specified by the Contractor, i.e., software, software updates, hardware, specifications of the communications network and services shall operate together efficiently in light of industry standards, so long as the system is maintained in accordance with the manufacturer's specifications. 'The Contractor warrants and represents that the unmodified configuration identified in the contract document has been specifically selected and designed for the County as being an operationally efficient integration of hardware, software, communications network and services, in light of the County's current identified specifications and project expansion.

B. Guarantee of System Integration

System integration means the installation and operation of all hardware, software and communications components so that they function in an operational environment and in conjunction with each other. By executing this Agreement, the Contractor acknowledges its commitment to successful integration of hardware/software/communications capabilities and warrants that the capabilities being supplied under this contract will be successfully integrated.

The Contractor shall coordinate the resolution of the problems with the hardware or software supplied under this Agreement, which arise upon delivery or at any time during the warranty or maintenance periods contained in this or other agreements between the parties Problems shall be resolved by the Contractor to the County's satisfaction and in accordance with the specifications.

6-18 Desire and Phase 1 Equipment Delivery

The Contractor shall deliver a preliminary design and concept of operations within thirty (30) days of NTP. The County will review this document and may request a presentation by the Contractor. The County may approve or require revisions to this document.

Phase 1 shall consist of the following items:

A. 2 complete APC systems with the capabilities described in Section 6, and as agreed to in the Final Design Document.

B.; 1 MPPU with the capabilities described in Section 6-5, and as agreed to in the Final Design Document.

C. 1 preliminary operations and maintenance manual, as described in Section 6-21.

Phase1 equipment shall be delivered and installed within 120 days of NTP.

6-19 Notice to Proceed - Phase 2 Delivery

Upon successful performance of Phase 1 equipment, the County will give a NTP with Phase 2 to the Contractor for the production/delivery of the remaining equipment.

Phase 2 equipment shall be delivered and installed beginning within 90 days after NTP to Phase 2, at the rate of at least 15 systems every 30 days.

6-20 Delivery of Test Output Data

Not later than 30 days prior to delivery of the first Phase 1 APC system, the Contractor shall provide the County with sample output data, which contains at least several hours of real or simulated in-service data including at least 20 records of each type. The data shall be provided in both hard copy and computer readable form, in a medium to be mutually agreed to between the County and the Contractor.

6-2 1 Delivery of Documentation

A. Within 30 days of initial equipment delivery

Not later than 30 days prior to delivery of the first Phase 1 APC system, the Contractor shall provide the County with a preliminary installation manual. The installation manual shall include at least the following information: mounting location diagrams, cable runs, wiring diagrams for all interfacing equipment (including that provided by the County), and any modifications to the vehicle to accommodate the equipment- Installation procedures must be approved by the County.

The contractor shall revise the installation manual, as needed, based on actual installation procedures and deliver the revised manual to the County not later than the first delivery of Phase 2 equipment.

At this same time the Contractor shall also provide the County with information as to what special equipment is required to do any routine preventative maintenance, tests, or troubleshooting and subsequent repair.

B. With Phase 1 Equipment

The Contractor shall deliver to the County a preliminary Operation and Maintenance (O&M) Manual including at least the following information:

- Theory of operations
- Operating procedures
- Full description of the operation of the systems provided to the component level.
- Circuit and logic diagrams and schematics
- Tolerances allowed
- Check-out procedures
- Troubleshooting Procedures
- Methods/tests to demonstrate that systems are functioning properly
- Maintenance equipment required
- Information on parts replacement, including an illustrated parts breakdown, with trade names and part numbers of all components used.
- Complete software protocol requirements and descriptions for interfaces.

The Contractor shall revise the O&M manual as needed and deliver a revised manual to the County not later than with delivery of the first Phase 2 Equipment.

6-22 Acceptance

Each APC system and other equipment provided by the Contractor shall be partially accepted after delivery, installation, and initial check-out. Partial acceptance shall be based on satisfactory installation, including workmanship and materials used, and satisfactory performance of all system functions for seventy-two (72) hours. At that time, the County shall notify the Contractor that the equipment is partially acceptable or reasons for non-acceptance. If not acceptable, the Contractor shall begin correcting deficiencies within 10 working days of such notification by the County.

Automatic Vehicle Identification System for Transit Signal Priority

SECTION 6
TECHNICAL SPECIFICATIONS

6.1 System Overview

This section identifies Metro's desired functional characteristics for an **AVI** technology system for signal priority requests at street intersections. Included in these specifications are requirements for AVI hardware, an interface module, product viability issues, installation requirements, training, system acceptance testing, and warranty. The Proposal must meet or exceed all minimum requirements contained herein.

Metro is interested in obtaining the most efficient and most cost-effective system to meet the requirements listed herein. Proposers shall clearly identify the technology and design proposed and shall provide objective data to demonstrate how the proposed AVI system meets these requirements. Each Proposer shall be responsible for providing Metro with proof of its ability to perform all functions as specified.

The Technical Specifications provide an outline for an AVI system to be installed at designated locations in the City of Seattle and King County, Washington. The AVI system shall incorporate communications between field devices installed on transit vehicles and traffic signal controllers located at selected intersections. Exhibit B identifies the Transit Priority Signal System Configuration.

The generic method of operation is as follows: A device (commonly referred to as a transponder or functional equivalent) is affixed to a vehicle and has data stored within its memory. At selected locations along the arterial system, sensing equipment shall be installed. The sensing equipment (also known as a reader) communicates with the transponder, determines the unique bit stream message, and then sends the messages to an interface module. The interface module sends a signal to the low priority input of the traffic signal controller. The reader and the interface module date and time stamp the data; then they store the data, and transmit the data to a portable computer, and to a remote base computer via a telephone linkup, twisted pair, or fiber interconnect cable. The Contractor shall offer a solution which precisely locates a specific vehicle and that is within twenty-five (25) feet of the point of first detection. For the purposes of this procurement, the point of first detection is defined as five hundred (500) to one thousand (1,000) feet from the intersection. The purpose of this distance range is to provide vehicle detection at a minimum of twenty (20) seconds from the traffic signal in order to adequately affect the signal timing control strategy. Exhibit C details the typical intersection configuration.

6.2 Hardware Requirement Details-Common Features

The Proposer shall provide a functional overview indicating its understanding of the equipment and data interfaces and protocols.

A. Equipping Transit Vehicles with AVI Electronic Devices

The AVI system shall provide for an on-vehicle device commonly referred to as a transponder.

The system shall be capable of handling up to ten thousand (10,000) vehicles without requiring additional hardware or software modifications other than additional transponders.

The Proposer shall provide an identification number for each transponder.

The Proposer shall provide technical data on the tamper-resistant features of the transponder.

The Proposer shall describe the method of interrogation and response between the on-vehicle device and the antenna/reader station. The transmission rate of the data packet between the on-vehicle device and the antenna/reader shall be provided and substantiated with independent, operational test data. Test data shall not be included in the 100-page Technical Proposal limit.

The Proposer shall detail the method by which the transponder is programmed with data. The technology shall have the capability to have static data and also to be dynamically programmed. Exhibit D defines the format of the data packet.

The Proposal shall detail the method by which the transponder is programmed for the following scenarios:

1. Transponder A shall provide read/write capability, full data packet, with dynamic data programmed using SAE-J1708 standards. This transponder shall be mounted on transit coaches.

2. Transponder B shall provide read-only capability and be compatible with Transponder A systems. This transponder shall be used on vehicle probes for future congestion management purposes.

The Proposer shall define the transponder memory capacity for both read-only and read/write capabilities.

The Contractor shall initially program the static portion of the data packet during installation. Subsequent to the initial programming of static data, Metro shall be provided with the ability to reprogram static and dynamic data.

B. Monitoring Vehicles Equipped with AVI Electronic Devices-Common Features

The AVI system shall provide field equipment near intersections that reads and stores information as the AVI transponders pass through the detection zone. The information will be transmitted from the AVI reader to an interface module that, in turn, sends a signal to the traffic controller. The transmission rate from point of first detection to interface module shall be less than or equal to zero point three (0.3) seconds.

The Proposer shall provide independent, operational test data detailing a system capture rate of ninety-nine percent (99%) accuracy for a similar application. The source and methodology of the test must be acceptable to Metro. Examples of acceptable sources of test data include public agencies, such as federal and state departments of transportation that will certify that the test is independent and non-biased. The test data will not be included in the 100-page Technical Proposal limit.

The AVI reader shall also have the ability to communicate directly by an open, non-proprietary method with a PC-based computer system or a portable laptop computer. The Proposer must provide information regarding the format of the data from the AVI reader to a computer. Diagnostic and reporting software shall be provided, with the Proposer detailing existing off-the-shelf software packages that could be utilized.

The Proposer shall provide a unique identification number for each reader.

The Proposer shall provide sample reports consistent with this AVI application. The sample reports shall not be included in the 100-page Technical Proposal limit.

The Proposer shall provide a field test device for diagnostic support of the AVI system. The Proposer shall describe the functions and capabilities of the field test unit.

The reader shall retain transmitted data, vehicle identification, antenna location, reader location, time of day, and date for the reader to the nearest second for a minimum of sixty (60) days.

The reader shall retain stored data in the event of a power interruption. Any power failure will be logged and only that data being logged at the time of power failure will be lost. The reader shall log the time of power-up.

The Proposer shall provide detailed technical data as to how the readers will collect, verify, retain, and transfer transponder data to the interface module, the central computer, and a portable PC. Only one record per vehicle per reader shall be accepted or recorded. The Proposer shall specify the equipment required for transferring data to a computer.

The Proposer shall provide an AVI technology which can accurately accommodate multiple reads of the same transponder within a fixed time frame and which has protection against cross-direction reads for vehicles traveling in the opposite direction. The Proposer shall substantiate these claims with test data in their bid.

The Proposer shall describe the operational speed range for the on-vehicle device to be successfully read. Describe the percentage of devices read at O-20 mph, 20-30 mph, 30-50 mph, and >50 mph. The Proposer shall substantiate these claims with independent, operational test data with the Proposal.

The Proposer shall describe the probability of decoding and/or reporting an incorrect vehicle identification and the details of security provisions.

The AVI system shall provide a test message that can be signaled to any reader site so that end-to-end completed systems tests can be performed from a base computer.

C. Portable Reading Devices-Common Features

The AVI system shall include portable hand-held reading devices capable of verifying the status of individual transponders in the field. The portable reading device shall be powered from a battery system and from a twelve (12)-volt cigarette lighter.

D. AVI Interface Module-Common Features

The interface module shall be a programmable logic unit capable of performing different tasks. The interface module shall receive the data packet transmitted from the vehicle via the AVI reader.

The interface module shall issue a signal to the low priority input of the traffic signal controller upon receipt of a valid data packet subject to conditional statements.

The following example conditional statement functionality shall be included in, but not limited to, the software used to initialize the interface module:

1. If valid transponder is detected, issue priority signal.

2. If valid transponder is detected within sixty (60) seconds of previous priority signal being issued, do not issue the priority signal to the signal controller. Note that this is an arbitrary period of time to be used to test this capability.

3. If valid transponder is detected, and data packet indicates that the trip is not eligible for priority, do not issue priority to the signal controller.

The Proposer shall detail the method by which the interface module is programmed for the above conditional statements.

The interface module shall have the capability of communicating via an open protocol with both NEMA and Type 170 traffic signal controllers and current software revisions. The Contractor shall provide copies of all interface protocols free of all restrictions.

The interface module shall be an input/output microprocessor-based device with sufficient available memory to create, record, and store the event log elements listed below for a minimum of sixty (60) days. It is anticipated that the AVI system application will include up to 1,000 events per day.'

4. Data Packet

   The interface module shall log the entire contents of the data packet, and the date and time it was received from the AVI reader.

5. Date Stamp

   The interface module shall log the date on which a low priority signal was sent.

6. Time Stamp

   The interface module shall log the time of day when the signal to the low priority input of the traffic controller was sent.

The interface module shall have an EIA232C Asynchronous serial port to communicate by a common, non-proprietary method, via a portable PC and/or modem or hardwire connection to a remote location. The port shall be used for monitoring the interface module's event log, for downloading data files, and for a user interface to create the conditional statements. The Proposer shall detail the ability to interconnect the interface modules for communication to a central computer.

The Proposal shall define memory capacity of the interface module. The interface module shall have a power supply compatible with the local intersection traffic signal controller. Input power shall be 95-l 35 VAC, 60 Hz, single phase, with nominal power requirement of thirty (30) watts.

The interface module shall retain stored data in the event of a power interruption. Any power failure will be logged, and only that data being logged at the time of power failure shall be lost. The interface module shall log the time of power-up.

The interface module shall have a time clock which will be capable of being resynchronized by each local signal operating agency's time of day resync point and an external source such as a WWV signal. The time clock shall be capable of automatically compensating for daylight savings time and leap years. The AVI reader will, in turn, be resynchronized from the interface module.

The interface module shall be adaptable for either rack or shelf mounting in NEMA and Type 170 controller cabinets. The dimensions of the interface module shall not exceed three (3) inches wide by nine (9) inches high by twelve (12) inches deep.

The interface module shall employ a single mating, minimum 25-pin connector to the traffic signal controller (or via a back panel termination) to accommodate the required data input and output.

The interface module programmable logic unit shall handle up to eight points of detection corresponding to the eight phases of a standard quad controller configuration and issue up to eight corresponding priority input signals.

E. Data Packet Description

The data packet to be stored on the AVI transponder for the various jurisdictions shall be as indicated in Exhibit D. The static portion shall initially be programmed by the Contractor during installation.

F. Programmer Device

The Proposer shall provide a desktop programmer device capable of programming a transponder via SAE-J1708 standards with the static data and dynamic data listed in Exhibit D.

G. Base Computer

The Proposer shall define the requirements of the base PC-based computer with sufficient memory, speed, and communications ability to support remote diagnostic and reporting software for this AVI application.

The information will be transmitted from the five (5) Rainier Avenue intersections and five (5) Highway 99 North intersections (Winona, North 85th Street, North 105th Street, North 145th Street, and North 200th Street) to a base computer located at Metro's office over dial-up telephone lines. The AVI system shall have sufficient numbers of telephone modems, telephone lines, and automatic dial-up capabilities to transmit the information on a one (l) minute interval from selected intersections. The AVI system shall have the capability of reading, storing, and transmitting information from transponders per intersection per hour.

The base computer shall be an IBM or compatible 486 PC running at 33 MHZ with 8 Mbytes of memory. The PC shall include, as a minimum, a keyboard, 14-inch super VGA color monitor, three serial and two parallel I/O ports, one 1.44 Mbyte 3.5-inch floppy disk drive, one 1.2 Mbyte 5.25-inch floppy disk drive, and 100 Mbyte hard disk drive storage unit. One spare card slot shall be made available.

The Contractor shall provide software that performs the following functions:

1. Collects each on-line interface module station base information at a minimum of one (1)-minute intervals. This time interval shall be adjustable for longer time intervals. The- base information shall include, as a minimum, date, time reader location, and transponder data packet. Additional information that may be included is as follows: antenna identification and reader status information.

2. Displays the base information on the AVI computer monitor as it is received from the field and stores it in a report for later printing. The format of the display shall be organized by intersection.

3. Monitors the AVI system for proper operation. Software for diagnostic programs, maintenance records, and system malfunctions shall be provided with the base computer.

H. Portable PC

The Proposer shall define the requirements of the portable PC devices with sufficient memory and speed capability to support diagnostic and reporting software for this AVI application.

The portable PC shall be an IBM or compatible 486 PC running at 33 MHz with 8 Mbytes of memory. The portable PC shall use an active color matrix screen.

This information will be transmitted from the field to a portable computer directly connected to the interface module. The Contractor shall provide software that performs the following functions:

1. Collects interface module station base information whenever polled by a portable PC. The base information shall include, as a minimum, date, time reader location, and transponder data packet. Additional information that may be included is: antenna identification and reader status information.

2. Displays the base information on the AVI computer monitor as it is received from the field. The format of the display shall be organized by intersection.

3. Monitors the AVI system for proper operation. Software for diagnostic programs, maintenance records, and system malfunctions shall be provided with the portable computer.

6.3 Product Viability

A. Workmanship

The hardware furnished under these specifications shall be the latest improved model in current production, as offered to commercial trade, and shall be of quality workmanship and material. The successful bidder must represent that all equipment offered under these specifications is new. Used, shopworn, demonstrator, prototype, re-manufactured, reconditioned, or discontinued models are not acceptable.

Equipment shall conform to the specifications and applicable requirements of the specifications of the Underwriters Laboratories Incorporated (UL), the Institute of Transportation Engineers (ITE), the National Electrical Manufacturers Association (NEMA TS-I), and the regulations of the State of Washington and the City of Seattle.

All external screws, nuts, and locking washers shall be stainless steel; no self-tapping screws shall be used unless specifically approved by Metro.

All parts shall be made of corrosive resistant material, such as plastic, stainless steel, anodized aluminum or brass. Additional requirements for on-vehicle components are defined in Paragraph C of this subsection.

B. Standard Parts

All parts, even if not specified in this document, but which are necessary for the equipment to be complete and ready for operation, or which are normally furnished as standard equipment, shall be furnished at installation time by the successful bidder. All parts shall conform in strength, quality, and workmanship to the accepted standards of the industry.

C. Additional Performance Characteristics-Vehicle Mounted Equipment

1. Durability

Describe the materials, construction methods, design details, and other characteristics employed to ensure the equipment is durable and can withstand the rigors of normal operation in Metro's service environment for a minimum useful life of ten (10) years.

2, Equipment Interfaces

Verify each interface's compliance with the requirements of SAE Recommended Practice J 1708.

3. Operating Environment

Verify equipment compliance with SAE Recommended Practice 51455 and its ability to operate and not suffer any degradation in performance, corrosion, deterioration, or abnormal wear under the following conditions:

Storage temperature	-25 to +150 degrees Fahrenheit, ambient
Operating temperature	-10 to +l 10 degrees Fahrenheit, ambient
Ambient humidity range	20 to 95 percent relative humidity (noncondensing)
Inclination	0 to 18 degrees off vertical
Dust	Airborne particles and dust encountered in revenue service and caused by interior bus cleaning with use of cyclone-type vacuum machines
Moisture/Water	Moisture/water from wind-blown rain, passengers, water from interior and exterior bus/car wash equipment
Vibration/Shock	Requirements as specified in Factory Acceptance Test
Electromagnetic effects	Requirements as specified in Factory Acceptance Test

Verify that the equipment will not be subject to interference from Metro's radio system and other onboard devices, nor will it interfere with Metro's radio system and other onboard devices.

4. Vehicle Power Supply

Verify the ability of the equipment to operate, if required, under the following electrical conditions:

Nominal voltage	12 and 24 volts dc nominal (car or bus battery)
Operating range	9 to 39 volts dc

In addition to the, above electrical characteristics, the equipment shall be able to withstand sustained voltage levels of up to 48 Vdc for periods of up to ten (10) minutes. The equipment shall not suffer damage or lose data in memory when the supply is increased to 48 Vdc.

The equipment shall not suffer corruption of data when the power dips below 9 Vdc. The equipment shall not be damaged by very high (twenty [20] times nominal voltage) short duration (up to ten [l0] milliseconds) peak voltage.

Indicate full operation and quiescent power drain of each type of onboard equipment proposed. Discuss how provision will be made fo r EMI/RFI protection and power conditioning for operation of the equipment on various vehicles, particularly in the tunnel environment.

5. Circuit Boards/Connectors/Wiring Harnesses

The circuit boards within the equipment shall have through-hole plating, solder masking, and component-identification silk screening. Circuit cards shall employ pin/socket connectors of the form, and shall not utilize printed card-edge fingers. All socketed devices and all connectors, whether physically on the circuit boards or in other wire harnesses, shall employ some type of positive lock and shall utilize machined pins with gold plating. Devices in non-locking IC sockets shall be "tie -wrapped" in place.

D. Copies of Literature and Specifications

The Proposer shall provide a copy of the manufacturer's standard published literature in their bid package for each item bid. Technical and standard published literature submitted will be used to determine compliance with all relevant specifications contained in this document. Omission of this item may disqualify the bid.

The Proposer shall supply independent operational test data which details product performance with the bid.

E. Equipment Acceptance Testing

The Proposer shall supply any equipment necessary to conduct the acceptance testing. For additional details on this testing, refer to Subsection 6.7, System Testing and Acceptance.

F. Long-Term Parts Availability

The Proposer shall guarantee that replacement parts are available through the life of this contract. If it is necessary for the Contractor to request substitutions of any equipment previously approved by Metro, the Contractor shall do so in writing and may be requested to submit samples of such equipment substitutions for testing prior to approval of the substitution by Metro.

G. Diagnostic Considerations

Software for diagnostic programs, maintenance records, and system malfunctions shall be provided with the AVI system. The software shall be capable of residing on a 486 laptop computer and a base PC-based computer system.

H. Maintenance Considerations

The Proposer shall detail the equipment meantime between failures (MTBF) and meantime to repair (MTTR) specifications, and substantiate this information with test data.

I. Potential Impact of System Growth (or Expansion)

The Proposer shall describe how the AVI system hardware and/or software would need to be changed as more vehicles are added to the system.

The Proposer shall describe how the AVI system could be expanded if other agencies were to utilize AVI technology in the region.

The Proposer shall describe if the technology has the ability to transfer additional information and the quantity of such additional information.

6.4 Installation Requirements

The Proposer shall install any features necessary for the hardware to operate properly.

The Proposer shall procure all permits and licenses.

The Proposer shall furnish all labor, tools, equipment, and incidentals necessary to complete the installation in an efficient and workmanlike manner.

In cases where equipment is to be mounted on existing structures, the Proposer shall review the structure and submit the mounting details to Metro or its assigned representative for approval.

The Proposer shall deliver two sets of “as built” drawing packages for each reader site in the latest version of AutoCAD. Packages shall be of good quality, readable, and reproducible.

The Proposer must have sufficient staff to perform hardware and software installations according to the Production, Delivery, and Installation Schedule (shown in Exhibit E). Metro reserves the right to set allowable working hours. These hours may require the Proposer to perform installations at other than normal business hours (Monday through Friday, 8:00 a.m. to 5:00 p.m.). Metro will not pay any additional monies for after-hour charges during installation.

The Proposer shall install the equipment and cabling in a professional manner that is least disruptive to traffic operations. This includes providing adequate protection from installation debris and providing necessary warning and guide signing of traffic in and around the installation sites. The Proposer shall submit traffic control plans (which follow manuals concerning safety for in-street work), sixty (60) days before installation begins, for approval by the appropriate jurisdiction.

The Proposer shall provide block diagrams with Proposals illustrating the full range of installation types that may be encountered.

The Proposer shall describe the method of construction used as the basis for the Price Proposal (Subsection 2.7), including utility hookups, location of in-ground work, location of above-ground installation, sidewalk replacement, restoration, and contingencies. The Proposer shall assume that all work is being done within the public right-of-way. The Proposer shall provide this description for two (2) construction scenarios, the first being for work with existing sidewalk and curb and gutter. The second scenario is for work with open ditch and no sidewalk.

The Proposer shall be aware that there may be other work at or near the site with other forces than those of the Proposer. The Proposer shall cooperate with all other contractors or forces. The coordinator of the work shall be taken into account as part of Section 2.7. Any resulting costs shall be incidental and included within Section 2.7.

Metro reserves the right to change or delete any or all installations prior to installation. The Contractor will be notified in writing of any changes or deletions as they occur. Upon the deletion of an installation site, there will be no equipment costs or installation costs charged to Metro associated with the deletion.

The Contractor shall recommend a location and mounting method to install the transponder on each vehicle type listed in Exhibit F and detail implications of the location such as the following:

A. If modifications to the vehicle chassis are required

B. If the location is accessible to the driver or to the general public

C. If the device installation is permanent, semi-permanent, or removable

D. If the device must be installed by the manufacturer

E. If the orientation of the device is a concern

F. If the issue of metallized windshields is a concern

The Contractor shall install and program the transponders on all designated vehicles before acceptance testing can begin.

6 5 Training Requirements

The Contractor shall provide operational and maintenance training to personnel designated by Metro during installation, testing, and debugging This training shall be provided through practical demonstrations, seminars, and other related technical procedures. Training will be limited to approximately seventy (70) people and shall be provided at times and locations in the Seattle area approved by Metro. Metro reserves the right to tape the training sessions.

Operations and maintenance manuals, detailed in Subsections 6.6.A and 6.6.B, shall be provided for each trainee.

The training shall include, but not be limited to, the following:

A Hands-on operation for each type of equipment

B. Explanation of system commands, their function, and their usage

C. Required preventive maintenance procedures

D. Servicing procedures

E. System troubleshooting or problem identification procedures

F. Recommended spare parts

A minimum of twenty (20) hours of instruction shall be provided for each person to be trained in the operational aspects of the system and for each person to be trained in maintenance procedures. The Contractor shall submit an outline of the proposed training material to Metro at least thirty (30) days before the training is to begin.

6.6 Documentation

Documentation in the form of manuals and electronic media in a form acceptable to Metro shall be provided. Preliminary versions are to be delivered according to the schedule in Exhibit E. Final versions shall be delivered after successful completion of testing. The manuals and/or documentation to be delivered shall include the following:

A System Operations Manual

Seventy (70) copies of the System Operations Manual shall be provided. The Proposer shall include one (1) copy on an electronic file. The document shall include the following:

D. Current Parts List (CPL)

The Proposal shall provide a comprehensive and detailed Current Parts List (CPL) for each and every component included in the system. Parts shall be numerically coded for inventory purposes. The CPL shall be categorized and related to particular system components. The CPL shall contain the source vendor's name, identification numbers and codes, or other means to identify the manufacturer of each component. The CPL shall include prices and quantity discounts offered. The CPL shall identify new component and products that will be developed for this application, as well as note which products are replacing existing equipment.

6.7 System Testing and Acceptance

A. General

The objective of the Equipment Test Program is to ensure that the equipment furnished under this Contract shall meet all the requirements specified in this document, including operation under environmental stress conditions. Testing and Acceptance shall be conducted to satisfy production and delivery schedule requirements. The tests to be conducted shall be the following:

1. Factory Acceptance Test (FAT)
2. Pre-Installation Checkout (PIC)
3. Installation Acceptance Test (IAT)

B. Methodology

The following steps define the methodology for conducting the Equipment Test Program:

1. The Factory Acceptance Equipment shall be subjected to the Factory Acceptance Test (FAT) at a factory or independent test lab with Metro-selected observers. This test shall be comprised of the following series of tests:

   a. Functional Test
   b. Environmental Test
   c. Shock and Vibration Test
   d. Electromagnetic Interference Effects Test
   e. Radiated Electromagnetic Energy Test
   f. NEMA TS-1 Test
   g. Maintainability Test
   h. Interface Test

   The first article shall be representative of the final production item. The purpose of this test shall be to demonstrate that for all items of equipment to be furnished under this Contract, the functions specified in this document shall be met.

   FAT details are specified in Paragraph F of this subsection. Should a design change be made after the FAT results have been approved, the performance of the modified equipment shall be demonstrated as conforming to the specifications and the test results submitted to Metro for approval.

2. The successful completion of the FAT shall be a prerequisite to produce the equipment to be furnished for the Pre-Installation Checkout (PIC). The purpose of the PIC shall be to demonstrate that the equipment performs its functions in the

manner specified prior to go ahead for the Installation Acceptance Test (IAT). The PIC shall include an onsite demonstration at a Metro-designated intersection. Tests shall verify proper installation and interfacing of the equipment. PIC details are specified in Paragraph G of this subsection.

3. Upon successful completion of the PIC, Metro production release for twenty-seven (27) intersections and one hundred and sixty (160) transit vehicles installation will be issued. IAT, Phase 1, shall be conducted for a period of thirty (30) days. IAT, Phase 1, will test the accuracy of the system.

4. Upon completion of the IAT, Phase 1, the IAT, Phase 2 shall be conducted for a period of ninety (90) days. Metro's final acceptance of the system is contingent upon successful completion of the IAT. Warranty period shall begin upon successful completion of all tests. IAT details are specified in Paragraph H of this section.

   The Contractor shall furnish all spares and consumables and perform all maintenance functions until the IAT is passed.

C. Test Plan

For all tests to be conducted, a test plan and test procedures shall be submitted for Metro approval at least thirty (30) days prior to the start of each test.

The Contractor shall prepare a test plan and applicable procedures, which shall govern the conduct of activity, surveillance, direction, and methods of observing and recording the pertinent data. Metro shall approve the test plan prior to proceeding with testing. At least the following elements shall be included in the test plan:

1. Dates, times, and locations of testing
2. Support and calibration tools and instrumentation to be used
3. Technical publications to be referenced
4. Spares and consumables to be available
5. Maintenance facilities needed
6. Staffing requirements to be met
7. Scheduling of personnel
8. The format and specific data to be collected during the test period together with the method used to report the test results
9. Preventive maintenance tasks to be performed during the test

D. Test Procedure Outline

1. The test procedure shall include, as a minimum, the following requirements:
   a. Objective of test
   b. Test environmental conditions

c. Detailed description of test specimens including drawings, part numbers, inspection and test records, maintenance records, and calibration records

d. Detailed procedure of test

e. Test equipment to be used. Include any measuring equipment and/or any equipment aiding in the performance of the tests.

f. The level and schedule of preventive maintenance during the test

g. Pass/Fail criteria

h. Retest procedure

i. Test data sheet format

j. Test notification to engineer

k. Test Reports

2. Test Failure Resolution

The test procedures shall describe the process to be followed for the resolution of test problems, failure recurrence control, and general test conduct ground rules.

E. Test Reporting

The Contractor shall provide a complete report documenting the operation and reliability during the Acceptance Testing. The report shall be in a form acceptable to Metro.

F. Factory Acceptance Tests (FAT)

On-vehicle equipment shall be subject to Subparagraphs 1 through 6 and Subparagraphs 8 through 10. On-street equipment shall be subject to Subparagraphs 7 through 10.

One item of each equipment type shall be tested as described below or shall have been previously tested to these requirements as provided for in Subsection 6.7.F.10.

If the Contractor can prove by certification of using authority, property, or independent testing organization that equipment manifestly similar to that specified here has been subjected to testing to the extent specified, the Environmental, Vibration, Shock, Electromagnetic Interference Effects, and Radiated Electromagnetic Energy may be waived, subject to Metro's approval. Proposers shall submit independently verified tests with the Proposal. This test information shall not be included in the 100-page Technical Proposal limit.

1. Functional Test

The purpose of this test shall be to demonstrate that for each individual component of the AVI system, the functions specified throughout this document, including all limiting conditions, shall be met. Each item of equipment shall be required to execute all hardware and software functions as detailed in these specifications and to meet the performance criteria requirements. The procedures for handling maintenance (troubleshooting and correcting faults) and service functions shall also be written and demonstrated.

The Contractor shall be responsible for developing a functional test procedure that satisfactorily demonstrates all equipment functions and shall submit this test procedure to Metro for approval thirty (30) days in advance of the test.

Each function specified shall be tested at least ten (10) times prior to confirming success or failure. Each piece of equipment shall have passed the functional test before the environmental tests listed below are started.

2. Environmental Test

The AVI system components shall be allowed to stabilize for a period of two (2) hours at each of the given environmental condition settings.

3. Vibration Test

The Contractor shall ensure that Metro vehicle fleet vibration conditions expected in the area of transponder installation are taken into account to ensure that proper isolation/protection is built into the transponder design to accommodate the range of frequencies anticipated for the vehicle fleet. In addition, the following requirements shall be met.

The transponder shall be tested per the procedure of MIL-STD-810C, Method 514.2, Category f, Curve V (1.5g, 5.5 to 200 Hz) with the following changes:

a. The cycling time shall be two (2) hours on each axis for a total of six (6) hours. The transponder shall operate normally during and after this acceleration test, and the transponder shall not experience broken or loosened parts from this vibration.

b. At the conclusion of each axis frequency sweep cycle, the transponder shall be subjected to a vibration of 3 g-forces at a frequency sweep between 7 and 14 Hz for a period of one (1) minute and 4 g-forces at a frequency sweep between 70 and 140 Hz for a period of one (1) minute. The transponder shall operate normally after these acceleration tests and shall not experience broken or loosened parts from this vibration.

4. Shock Test

The transponder shall be tested per Procedure I of MIL-STD-810C with the following changes:

a. The half sine shock pulse shall have a peak value (A) of 5g and a duration (D) of 20 milliseconds.

b. The transponder shall operate normally after the shock tests and shall not have experienced broken or loosened components as a consequence of these tests.

5. Electromagnetic Interference Effects Test

   a. Susceptibility to Radiated Electromagnetic Energy

      The transponder shall be tested for susceptibility to radiated electromagnetic energy per the procedures of SAMA Standard PMC 33.1.1978, Class 2 (10 volts per meter), Frequency Bands a, b, and c, including Paragraph 5.3.3, Digital Equipment Modulation Test, and Paragraph 5.3.4, Keying Test.

      The transponder shall not sustain any permanent damage as a result of the exposure to these electromagnetic fields nor shall it lose its data.

   b. Susceptibility to Conducted Electromagnetic Energy

      The transponder shall be tested for susceptibility to conducted electromagnetic energy per the procedures of MIL-STD-461B, Requirement CS06, utilizing the 400-volt, 5-microsecond pulse of both positive and negative polarity.

      This testing shall take into account the conditions existing at Metro bases and street intersections.

      The AVI system components shall not sustain any permanent damage as a result of application of the pulse energy nor shall it lose its data in RAM storage.

6. Radiated Electromagnetic Energy Test

   The Contractor shall be responsible for compliance with applicable Federal Communication Commission (FCC) regulations (i.e., FCC Rules, Part 15, Subpart J) concerning conducted and radiated radio frequency energy.

7. NEMA TS-1 Test

   The interface module and reader shall be subjected to testing to ensure performance characteristics, including operating environment, cabinet requirements, and component specifications in conformance with NEMA Standard Publication No. TS-1-1983 or latest version. This testing shall occur at the Washington State Department of Transportation Lab in Olympia, Washington. Prior to testing, the Contractor shall provide a product informational presentation to testing staff. The tests shall be conducted over a thirty (30)-day period.

8. Maintainability Test

   Upon successful completion of the previous tests specified in Subsectio n 6.7.F.l through 7, the Contractor shall conduct a Maintainability Test of the equipment.

   The purpose of this test is to determine that the equipment tested conforms to the maintainability'requirements provided in the Proposal. This will be accomplished by introducing faults into the equipment and then measuring the time required for a technician to correct the fault.

   Thirty (30) days prior to the FAT, the Contractor shall submit to Metro a test outline, which shall be prepared in accordance with a Metro-approved Maintainability Test plan and shall show the basis of sample size selection and list of faults to be introduced into the equipment. This list shall represent every known failure mode for each unit of equipment. Next to each fault, the Contractor shall identify a reasonable time limit for repair performed by an average technician, based on field experience with the equipment. Metro must approve this list and the repair times prior to conducting the Maintainability Test.

The Maintainability Test shall be conducted in the following steps:

a. The Contractor shall provide several units of the equipment to Metro to introduce failed components, misadjustments, and incorrect settings. The simulated failures shall be introduced in proportion to their expected failure rate.

b. The Contractor's maintenance personnel shall be unaware of the simulated failures and shall be assigned to troubleshoot the equipment.

c. The repair times shall be recorded and the MTTR shall be compared with the advance list provided by the Contractor. All results will need to be approved by Metro.

9. Interface Test

The following equipment interfaces shall be evaluated for hardware, software, and data transmission. These tests shall be performed under ambient conditions and shall demonstrate all functions specified for the interfaces.

a. Between transponder and reader
b. Between reader and interface module
c. Between interface module and each signal controller type
d. Between interface module and portable PC
e. Between interface module and base computer

10. Test Certification

The Contractor shall supply certification for those tests for which exemption is requested. This shall include actual test data documenting the appropriate tests performed on the AVI system equipment to meet the requirements specified.

The Contractor shall supply to Metro the name, address, and phone number of all testing facilities used to perform such testing.

G. Pre-Installation Checkout (PIC)

Upon successful completion of the FAT, Metro will issue a production release to the Contractor to deliver all equipment specified for the PIC. Prior to installation, a PIC Test will be conducted in two phases. The Contractor shall provide and install five (5) test benches, which will be set in such a manner as to permit the evaluation of subject equipment to the following PIC test objectives:

1. To visually inspect a random sample of AVI system components for conformance with specifications

2. To confirm that there was no visible damage in delivery of equipment

3. To verify that the AVI system components work as expected by exercising them to check their operating functions

4. To ensure that all simulated data reports are produced

5. To determine if installation can begin or if corrections and/or adjustments are needed, followed by a retest, before installation can begin

The PIC test will be conducted in the following two (2) phases:

1. Phase 1--Onsite Shop Testing

   The following sequence of tests shall be conducted as a minimum. Phase 1 shall be conducted at a transit base and at signal operation shops selected by Metro.

   a. When required, each transponder type will be powered using a converter furnished by the Contractor.

   b. The transponder shall be programmed with static data using the programmer device.

   c. The transponder shall be programmed with dynamic data via SAE-J 1708 protocols.

   d. The interface module shall be programmed to perform the conditional functions as identified in Subsection 6.2.D.

   e. The interface module shall create the event log.

   f. The interface module shall send the low priority input that will be accepted by each controller type.

   g. Visual inspection of the AVI system will be made to ensure that there is no physical damage and that all specific displays, messages, and prompting sequences occur as specified.

   The schedule for Phase I testing shall be over a period of thirty (30) days.

2. Phase 2-Onsite Demonstration

   Upon completion, Phase 2 shall consist of an onsite demonstration with transit vehicle types and a single street intersection determined by Metro.

   A two-week test period shall begin when Metro receives notification from the Contractor that the following has been accomplished:

   a. All field equipment is installed and operational.

   b. All data transmission equipment is installed and operational.

   c. All AVI transponders are mounted on each transit vehicle type.

Phase 2 testing shall verify that the information from the AVI transponders can be read, transmitted to a portable computer, displayed on the portable computer, and stored in the base computer and the portable PC.

Phase 2 testing shall also verify that all information from the AVI transponders can be transmitted to the interface module, the proper signal is sent to the signal controller, and the event log information is stored and downloaded to a portable computer from the interface module.

Successful completion of PIC shall be a prerequisite for start of the IAT. Satisfactory performance shall be approved by Metro.

H. Installation Acceptance Test (IAT)

The IAT shall start after a fourteen (14)-day settling period when the AVI system base computer system has been installed and installation checkout is complete at a designated Metro location and all equipment is functioning in the manner specified. During this period, the Failure Review Board (FRB) shall be established in conformance with . guidelines specified in Subparagraph I.

The IAT shall be conducted in two parts: a thirty (30)-day test to verify the accuracy of the system and a ninety (90)-day test to verify the reliability of the system. The 90-Day Test period can include the 30-Day Test period at the discretion of Metro,

1. Priority of Tests

The IAT shall be performed at twenty-seven (27) intersections identified in Appendix I, Exhibit A. The 30-Day Test period shall begin when Metro receives notification from the Contractor that the following has been accomplished:

a. All field equipment is installed and operational.

b. All data transmission equipment is installed and operational.

c. All AVI transponders are mounted on one hundred(100) designated transit vehicles at Metro's Central Base and sixty (60) transit vehicles at Metro's North Base, and the information from the AVI transponders can be read, transmitted to, displayed on, and stored in the base and portable computer.

d. All information from the AVI transponders can be transmitted to the interface module, the proper signal is sent to the signal controller, and the event log information can be downloaded to a portable laptop PC from the interface module.

2" Responsibility of Equipment During Tests

The Contractor shall be responsible for all equipment maintenance before and during all testing. The Contractor shall provide adequate spare modules, parts, and assemblies to complete the IAT.

Should the vendor-supplied equipment fail the acceptance testing, Metro will notify the vendor and require the vendor to supply and install replacement equipment. The replacement equipment shall pass all acceptance testing as defined in this document. The replacement equipment shall be provided at no additional cost to Metro.

3. Thirty (30)-Day Test Period

The length of the test period shall be 30 calendar days. The entire AVI system shall be operational and shall have successfully recorded ninety-nine percent (99%) of the transponders that passed through the detection zones during a 30-day period. The AVI system shall have accurately logged and transmitted the signal to the low priority input of the traffic signal controller at a ninety-nine percent (99%) accuracy rate. At the discretion of Metro, time shall be suspended or restarted if the system fails to operate correctly.

4. Ninety (90)-Day Test Period

The length of the test period shall be 90 calendar days. The test shall be over a 90-day period (which, at the discretion of Metro, may include the 30-Day Test period) during which time the entire AVI system shall be operational and shall have successfully recorded more than ninety-nine percent (99%) of the transponders that passed through the detection zones. The AVI system will have accurately logged and transmitted the signal to the low priority input of the traffic controller at a ninety-nine percent (99%) accuracy rate. At the discretion of Metro, time shall be suspended or restarted if the system fails to operate correctly.

5. Testing Criteria

During the 30- and 90-day periods, it is assumed that there will be a minimum of one hundred (100) test transit vehicles on Rainier Avenue South and Highway 99 North, equipped with transponders traveling through the detection zones.

a. The Contractor shall record, on a portable PC, the transponder information for each trip at each of the reader stations passed by the vehicles. The Contractor shall provide a written copy of the daily records in the portable PC to Metro within twenty-four (24) hours.

b. Metro will compare the records of AVI data with scheduled route information that lists each of the test vehicles and their expected routes of travel as defined by the reader stations that are normally passed on their daily trip. The comparison will note any discrepancies between the expected and the actual travel routes. Each discrepancy noted will be examined by Metro to determine if the AVI system failed to read a transponder. If Metro confirms that the vehicle passed through a detection zone and the corresponding record is not recorded on the AVI computer, the event will be noted as a missed transponder read and will be charged against the accuracy requirement of the system.

c. Metro will provide the Contractor with a list of missed transponder readings within 24 hours of receiving the AVI data. It shall be the Contractor's responsibility to determine if there is a failure of the AVI system, its probable cause, and the time it will take to correct the problem.

d. The Contractor shall provide Metro with a written explanation of the probable cause for the failure and the time it will take to correct the problem. Metro will then decide if it is warranted to suspend time (see Paragraph 6.a. below) or if it will be necessary to restart the test period (see Paragraph 6.b. below).

e. The exact number of test vehicles and the number of transponder reads per vehicle will not be known until the installation contract is underway. For example, for a fleet of one hundred (100) vehicles and a route that passes five (5) read stations, each vehicle would generate five (5) reads per day. For ninety (90) work days, this would result in forty-five thousand (45,000) reads. For this assumed usage, and applying the criteria of ninety-nine percent (99%) accuracy, the AVI system shall not miss more than four hundred and fifty (450) reads during ninety (90) days of operation.

f. If part of the AVI system is malfunctioning such that the time is to be suspended, then the testing for the entire AVI system shall be suspended. If part of the AVI system is malfunctioning such that the testing period is restarted, the testing period for the entire AVI system shall be restarted.

6. Adjustments To Test Periods

The types of test period adjustments to be enforced in this project are as follows:

a. Suspension of Time --When the failure and the correction may require a short time to implement. Time suspension shall begin when the failure is first noticed, and it shall extend only as long as required to correct. Once corrected, the time of the test shall resume with the number of days completed at the time of the failure.

b. Restart of Time-When the failure may be more serious and require more time to correct. Once corrected, the time of the test shall start at zero for the 30-Day Test period and at 30 for the 90-Day Test period.

When determining the adjustments to make to the acceptance testing time periods, failures in the operation of the AVI System will be grouped into two categories:

a. Type 1 Failures-Those that involve conditions that are beyond the control of the Contractor, failures of a minor nature that are easily and quickly corrected, or failures that are expected of a new installation

b. Type 2 Failures-Those that involve conditions that are within the control of the Contractor, failures that are related to system design, or failures that may be of a minor nature but have not been easily or quickly corrected

Type 1 Failures shall result in the test period being suspended for the time necessary to make the corrections, and the testing shall begin again at the point in time of the failure; Type 2 Failures shall result in the test period being restarted at time zero for the 30-Day Test period after the corrections are made, and at time 30 days for the 90-Day Test period after the corrections are made. The costs for repairing, replacing, or correcting the malfunctioning equipment shall be the responsibility of the Contractor. The definition of the types of failures will differ with the two test periods.

The definition of failures for the 30-Day Test period are as follows:

a. Type 1 Failures-Electrical power outages, telephone line outages, adjustments to antenna alignment, and equipment malfunctions. If a second equipment failure occurs in the same device, the Contractor shall prove that the failures were different in order to be classified as a Type 1 Failure.

b. Type 2 Failures- If a second equipment failure is determined to be the same failure as the first; a third failure of any description occurs in the same device, then after the repair or replacement is made and the system is made operational; design deficiencies; interferences due to ambient conditions; software problems; any other failures that can not be classified as Type 1 Failures; and the AVI system failing to meet ninety-nine percent (99%) accuracy criteria.

For the 90-Day Test, the definition of failures for the first 30 days are the same as the definition of failures for the 30-Day Test. The definition of failures for the next **60** days are as follows:

a. Type 1 Failures-Telephone line outages attributed to third party communications failures; electrical power outages; adjustments of sensing equipment shall be a Type 1 Failure until the number of adjustments equal three (3) for the same antenna.

b. Type 2 Failures-Electrical component failure, multiple adjustments to the same sensing equipment in excess of three (3); any disruption to service that cannot be classified as a Type 1 Failure; and the AVI system failing to meet the ninety-nine percent (99%) accuracy criteria.

I. The Failure Review Board (FRB) shall include four members selected by Metro, a member from Metro's Consultant, and a member from the Contractor. The FRB shall determine what constitutes a failure and what the satisfactory corrective actions shall be to prevent recurrence. Failures shall be established in conformance with guidelines specified in Paragraph 6.7.H.6.

6.8 Warranty

A. WarrantyCoverage

Warranties in this Contract are in addition to any statutory warranties or remedies. The Contractor hereby warrants and guarantees to Metro that all work performed or furnished under this Contract shall be free from all defects and related defects under normal operating use and service, including without limitation defects in design, material, and workmanship. "Work" means and includes anything and everything to be done and provided for in the execution, completion and fulfillment of the Contract.

B. WarrantyPeriod

1. The Contractor shall provide the warranty for a period of twelve (12) months following successful completion of Section 6.7. The warranty shall cover all parts and labor costs associated with the repair of the work during the twelve (12) month period.

2. The warranty period shall be extended to cover the completion of all remedial work to correct any and all deficiencies under warranty. No warranty shall expire until all warranty obligations of this Contract are met.

C. Complete or Partial Unit Replacement

In the event of any defect in design, material or workmanship of a unit, component or subassembly under warranty, Metro shall consider (in consultation with the Contractor when possible) whether the unit, component or subassembly is to be replaced in its entirety or whether it is to be repaired and the defective parts replaced. Metro's decision as to which alternative will' be used will be based upon minimizing downtime and total repair costs of the unit, component or subassembly and as to whether or not the failure may be detrimental to the life of the total assembly.

D. Warranty Conditions

1. No warranty period shall end unless the complete finished documentation specified herein is provided by the Contractor and is approved by Metro.

2. Metro's maintenance, use and operation of the work or any part thereof, including all equipment and systems listed above, shall not defeat, limit or in any way affect the warranties of this Contract if the Contractor has not provided adequate, correct and complete training, maintenance manuals, operating manuals, electrical and electronic schematics, mechanical diagrams and documentation of microprocessor and microcomputer programs.

E. Negligence

The warranty shall not apply to any equipment which has been damaged through accident or negligence, or which has been subjected to other than normal use. Temperature, humidity, vehicle vibration and ambient electrical conditions described herein shall be considered normal operating conditions for this equipment.

F. Consumable Items

The warranty shall not cover the replacement of normal consumable items or items which are replaced in usual and scheduled preventive maintenance programs, such as light bulbs and wear-related items, unless they fail due to defective manufacture, improper installation by the Contractor, or defects in design of the part or the system within which the part functions.

G. Reliability Requirements

The equipment reliability shall be in accordance with the criteria identified in Subsection 6.7.

H. Design Defects

If during the said warranty period the rate of failure of any part or component, from any one cause or from various causes, exceeds twelve percent (12%) of the mean quantity of such item delivered to Metro, then the entire quantity of such item shall be considered to have failed, and shall be repaired, corrected, or replaced as hereinafter provided.

The warranty on items determined to be design defects shall be extended for the time of the original warranty. This extended warranty shall begin on the repair/replacement date for the corrected items.

I. WarrantyRepair

1. The Contractor shall be responsible for all costs associated with the repair and/or replacement of components removed from the equipment supplied under this Contract, and which has been found to be defective in terms of design, material, workmanship, or function under the terms of the warranty.

2. The Contractor shall reimburse Metro for parts used in a warranty repair at the price indicated on the MEPL, and shall include any applicable taxes. The Contractor shall be responsible for shipping charges for shipment of components from Metro to the Contractor and shipments of returns, replacements, or new components to Metro facilities, even if it is determined that returned components were not covered by warranty.

3. All repairs will be performed by **Metro or a** representative assigned by Metro. Repairs performed by Metro or its representative will be made by the method **which,** in the judgment of Metro, is best given the existing conditions unless Metro and the Contractor have agreed to a specific repair. [The warranty labor rate charged to the Contractor by Metro will be two times the hourly wage rate of a Mechanic, Step E. This rate is subject to adjustment per the applicable collective bargaining agreement. As of November 1, 1993 to October 1, 1994, the warranty rate is $55.94 per hour, with an overtime rate of $58.74. The number of hours paid may be determined by a flat number of hours per type of failure which shall be negotiated between the Contractor and Metro.]

4. At its sole discretion, Metro may require the Contractor or its designated representative to perform warranty repairs that cannot be easily accommodated in the facilities of Metro. Metro shall make the system components available to complete repairs in a timely manner consistent with the Contractor's repair schedule. The Contractor shall provide at its own expense all required parts, tools, and work space required to complete the repairs. The Contractor is responsible for reimbursing Metro for all expenses incurred in the removal and reinstallation costs incurred by Metro or its representative in providing the defective component(s) to the Contractor or designated vendor worksite.

5. Metro will add ten percent (10%) to the total of parts and labor for all warranty claims to cover overhead and processing costs.

J. Repair Time and Liquidated Damages

Test repair and warranty repair must be performed by the Contractor in a maximum of fourteen (14) calendar days after the receipt of the defective part or module. The Contractor shall make available adequate resources for replacement including test repair and warranty repair, spare modules and spare components to support one hundred percent (100%) availability daily.

K. Compensation for Unresponsiveness

In the event. the Contractor fails to comply promptly with its obligations under these specifications or with a request by Metro to repair, replace, or correct failed components, devices, equipment, and/or materials, Metro shall, upon written notice to the Contractor, have the authority to deduct the cost of labor and materials from any compensation due or to become due to the Contractor. In the event the Contractor has been paid, the Contractor agrees to compensate Metro for the costs thereof.

L. Access to Equipment in Service

The Contractor shall follow the proper Metro security procedures for gaining access to field equipment and locations.

M. Repair Reporting

During the entire warranty period, any and all repairs/adjustments of equipment by the Contractor shall be documented by the Contractor. A repair report shall be submitted at the end of each week. Each repair or adjustment shall be documented by time, day, component, type of failure, type of repair, or adjustment made and by whom.

N. Warranty Claims

The Contractor shall resolve all claims made by Metro for warranty within sixty (60) days after receipt of the claim; all warranty claims unpaid on the sixty-first (61) day from the date the Contractor received the claim from the warranty administrator shall be subject to a one percent (1%) per month charge for non-payment until the claim is paid.

Denials of claims must be presented to Metro in writing and must contain the reason for denial. Payment of warranty claims shall be by check. Metro will add ten percent (10%) to the net amount of each claim to compensate Metro for overhead and processing.

0. Additional Warranties

If any vendor to the Contractor offers a warranty on a component or subsystem that is longer than the required warranties stated herein, the Contractor shall inform Metro of this additional warranty period and pass said period through to Metro.

6.9 Regional AVI Procurement Specifications Document

This procurement is to be utilized to support the Metro goal of executing a contract that affords other political jurisdictions within the State of Washington pursuing transit signal priority projects access to similar prices, terms, and conditions for the AVI system hardware and software. To facilitate the pursuit of similar systems by other agencies, at the successful conclusion of system testing for this project, the Contractor shall deliver a document outlining the technical specifications and process that another agency could utilize as a guideline or “cookbook’* for system procurement. Items to address include the following:

A. Sample step-by-step project plan
B. Hardware specifications
C. Interface requirements
D. Software capabilities
E. Maintenance provisions
F. Ordering information
G. Price list

6.10 Description of AVI System Options

Proposals must address five (5) optional features to the AVI system. If any of the options are exercised, Metro desires concurrent development with the initial system. These optional features include two-way communication capability between interface module and the traffic signal controller, two-way communication capability between transponder and the reader, an on-board keypad to program the dynamic portion of data packet, an on-vehicle on/off switch to disengage signal priority capability of the transponder, and four (4) additional one (1)-year warranty periods.

A. Two-Way Communication Capability-Interface Module and Traffic Signal Controller

The Proposal shall describe the capability of the interface module to log information provided by the traffic signal controller. The Proposal shall detail the method by which each function occurs. The Proposer shall describe the ability to log the following elements:

1. Signal Condition

The interface module shall recognize the current traffic signal display at the time of issuance of the priority signal input and shall log that condition.

2. Next Phase

The interface module shall log the time of day when the traffic signal makes its next phase change after the priority signal has been processed.

3. Override

In the event of a high level emergency preemption call being placed at the local traffic signal controller or the priority signal being overridden by the signal operating agency, the interface module shall log that event.

B. Two-Way Communication-Transponder and Reader

The Proposer shall describe the two-way communications capability between transponder and reader. Detail the method by which this function occurs. Describe the method and rate of communication. Describe the memory capacity of the transponder.

C. On-Board Keypad

The Proposer shall describe the capability for providing an on-board keypad to program the dynamic data to the transponder. This option will provide transit coach operators the ability to program the dynamic data portion of the data packet.

Describe the location and positioning of the keypad on the transit coach and how the location will be consistent with safe and convenient operations.

Describe how the operator will interact with the keypad on the transit coach to ensure proper use. Detail features to assist the operator in logging in, logging out, and recording data packet information.

D. On/Off Switch

The Proposer shall describe the capability of the AVI system to provide an on-vehicle on/off switch to disengage the signal priority capability of the transponder. This function will provide the transit operator the capability of having the vehicle detected and recorded by the interface module, and log information transmitted from the interface module to the base computer. However, the priority signal input would not be provided from the interface module to the traffic signal controller.

E. Extended Warranty

The Proposal shall provide an extended warranty agreement consistent with the terms of Subsection 6.8, Warranty. The term of the contract shall be for one (1) year, commencing with the expiration of the initial warranty. Metro reserves the right to the warranty for four (4) additional one (1)-year periods following expiration of the original extended warrantyagreement. Metro reserves the right to cancel all or part of the extended warranty agreement for any reason with thirty (30) days' written notice to the vendor. Metro reserves the option to add or delete equipment on the agreement upon thirty (30) days' written notice. The contract is subject to cancellation by Metro, without penalty, either in whole or in part, if funds are not made available.

Radio System

Section 1

SYSTEM

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Section 1

SYSTEM

1 GENERAL

1.1 Overview

This is a solicitation for proposals for an 800 mHz trunked radio system which is licensed for slow growth. The complete system will encompass 15 channels using four transmitter/receiver sites operating in the simulcast mode with receiver voting. The complete project, which extends beyond the instant purchase, will combine clear and encrypted voice plus alpha/numeric text messages, canned data messages, computer aided dispatch (CAD), special schedule adherence software for CAD at the Transit communications center, and automatic vehicle location (AVL) within the single radio system. This purchase includes only six channels at one transmitter/receiver site, CAD for Transit operations, AVL, and mobile radios for just the Milwaukee County Transit System (MCTS). The instant system will carry clear voice, alpha/numeric text and canned data messages, plus AVL data traffic. Repeaters purchased now will be controlled through new consoles included in this work to be located at Transit System offices, 1942 North 17th Street, Milwaukee. Expansion of system capability in later purchases will add three more transmitter/receiver sites, simulcast operation, a new dispatch center with CAD for the Sheriff Department and perhaps two additional dispatch centers at undefined locations, mobile/portable radios with voice encryption capability, and mobile data terminals.

1.2 System Backbone

Three of the four 800 mHz transmitter/receiver sites to be used in the trunked radio system, including the single transmitter/receiver site to be implemented within the instant project, are linked together by an existing Motorola *2* gHz *Starpoint* microwave system using *Starplex* analog mux. Part of the microwave system is configured as a loop. The Muirdale water tank and Brown Deer sites are on the loop (see Pl.5 Radio *Sites,* below). Transit General Office and House of Corrections sites are on stubs off the loop. The First Wisconsin site is not presently served by county microwave.

1.3 Microwave System Modifications

Because the existing MCTS 450 mHz radio system must be kept on the air while the new 800 mHz trunked radio system is installed and tested, the trunked system will have to use mux channels which are currently unassigned. New modems will be purchased and installed by the Owner apart from this contract to accommodate the trunked radio system, As part of the submittal for this bid, Bidder shall provide explicit detail on: a) number and characteristics of microwave channels required to link the Muirdale site with the Operations Center at Transit headquarters with Muirdale operating as a single site system; b) number and characteristics of microwave channels, including modifications to the microwave system, required to implement simulcast using four sites with additional dispatch consoles at the Sheriff Department; c) number and characteristics of microwave channels to add one or two other console sites.

1.4 New Work - Radio System

Equipment purchased as part of *this* solicitation will only implement six channels at a single site - the Muirdale water tank. Trunking equipment furnished now shall be installed in contemplation of later addition of three more transmitter/receiver sites operating in the simulcast mode with the Muirdale site. *Nothing* furnished now shall require replacement or significant modification when simulcasting and voice encryption is added. However, this requirement anticipates additional apparatus will be *added* to equipment purchased here which is not required now as long as Muirdale operates in the single site mode without voice encryption. System manager terminal for the radio system, dispatch consoles, and central computer/display equipment related to schedule adherence and transit computer aided dispatch will be located at the Transit System Administration Building, 1942 North 17th Street. Approxima~~tely 556 buses plus approximately 61 cars and trucks will be equipped with trunked radios in the instant purchase. An additional 33 radios will be purchased for spares and expansion making a total of 650 mobile radios for Transit operations. Of this number, approximately 643 are expected to be purchased with AVL capability for Transit operations, funds permitting~~ Approximately 582 buses and 55 non revenue cars and trucks will-be equipped with trunked radio and the AVL adiunct. Six spare radios with AVL adiunct are scheduled for purchase as spares. Additionally, approximately 6 "standard" mobile two-way radios and a *spare* will be purchased for passenger cars for a total of 650 trunked mobile radios of both kinds. About 30 portable radios are also expected to be purchased now for Transit personnel.

1.4.1 ***Expansion***

The trunked radio system purchased here shall have capability to be expanded to accommodate dispatch consoles at three additional widely separated locations in the city which have 12 additional work stations in aggregate; three additional transmitter sites with which equipment furnished now shall operate in the simulcast mode; expansion to 15 trunked channels with capability for 20 channels; and expansion to 1800 mobile and portable radios.

1.5 Radio Sites

The four transmitter/receiver sites are:

1. Muirdale Water Tank (implemented as part of this purchase)
   10325 Watertown Plank Road
   Wauwatosa, Wisconsin
   43°02'41" north latitude
   88°02"30" west longitude
   site 734' msl
   195' agl water tank
   Typical antenna coaxial cable run 310'

2. First Wisconsin Building
   717 East Wisconsin Avenue
   Milwaukee, Wisconsin
   43°02'18" north latitude
   87°54'05" west longitude
   site 617' msl
   penthouse roof 588' agl
   Typical antenna coaxial cable run 100'

3. House of Corrections Water Tank
   8885 South 68th Street
   Franklin, Wisconsin
   42°52'48" north latitude
   88°00'10" west longitude
   site 759' msl
   173' agl water tank
   Typical antenna coaxial cable run 210'

4. Brown Deer Park
   Near intersection of Bradley & North Cedarburg Roads
   Brown Deer, Wisconsin
   43°09 '43" north latitude
   87°57'33" west longitude
   site 696' msl
   180' self supporting tower
   Typical antenna coaxial cable run at maximum mounting height 210'

1.6 New Work - CAD/AVL

Transit CAD/AVL equipment and software purchased as part of *this* procurement will only track municipal buses and related cars and trucks. Initial installation of schedule adherence equipment is expected to include the complete CAD/AVL fixed end apparatus with displays and AVL equipment for 15 coaches. After a demonstration of compliance with CAD/AVL specifications, including prompt system response- for the various features under simulated worst case traffic loading,. the Contractor shall proceed to complete the work. All Transit System vehicle monitoring will occur at Transit Headquarters, Using equipment and software furnished with this project, the Owner shall be able to track transit vehicles which do not have route assignments plus, for vehicles which do operate on routes, expand, modify, add, and delete routes and time points at the convenience of the Owner. The ultimate tracking system shall simultaneously accommodate not fewer than:

a) 1000 vehicles in service;
b) 650 vehicles operating on routes;
c) 400 time points within the route structure;
d) 350 vehicles operating without routes;
e) 3 dispatcher work stations; 1 supervisor work station; and one programmer work station at MCTS headquarters;
f) 12 dispatcher work stations distributed among three other locations in the city which may be installed in the future.

2 SYSTEM ARCHITECTURE

System architecture and operating capability shall be based on recommendations of the Associated Public Safety Communication Officers, Inc. (APCO) "Project 16A". The system shall include the following features:

1. Support not fewer than 4000 discrete addresses on 15 radio channels, field expandable to 20 radio channels.

2. Support an organizational hierarchy of'individual radios, subfleets, and fleets as suits the convenience of the Owner within the 4000 available addresses.

3. Support console work stations installed as part of the instant project, plus for future expansion, at least three other widely separated sites in the county.

4. When a radio channel is idle, establish the complete transmit/receive path between caller and listener within 400 milliseconds of push-to-talk function, regardless of traffic loading on the system, even if the system grows to 20 channels and more than 2,000 mobile/portable radios.

5. When all channels are busy, place new callers in a busy queue according to priority on a first-in-first-out basis and then automatically signal each queued radio when communication may begin.

6. Support at least eight levels of system access priority.

7. Identify each caller. Software capability shall be furnished and implemented to compare each caller's ID to a subscriber list; callers not listed shall be denied system access.

8. Identify type of request from calling radio, i.e. individual call, subfleet call, fleet call, telephone interconnect call, etc.

9. Offer two-way communication between any combination of individual dispatch positions, groups of dispatch positions, individual mobile/portable radios, and groups of mobile/portable radios (except as modified by the Transit CAD system).

10. Forward ID of transmitting field radio to appropriate console(s) displaying that group either as selected or unselected audio, where the ID of the selected group shall be displayed as an up to 8 character alpha numeric ID, or alias ID, programmed into the system in the field (except as modified by the Transit CAD system).

11. Assign a channel to calling radio or dispatcher plus identify, collect, and assign the same channel to other members of the same subfleet or fleet, as the case may be.

12. Accept dynamic assignment of field radios to subfleets or fleets on an individual or subfleet basis.

13. Continuously update all field radios for channel assignment.

14. *Carry* clear and digitally encrypted voice.

15. Carry alpha/numeric text, canned, and schedule adherence (AVL) data messages in the trunked mode.

16. Operate in the message or transmission trunked mode as programmed by the System Manager. When operating in the message trunked mode, use channel drop-out time programmed by the System Manager.

17. Provide recent user priority for at least two seconds after repeater drops off the air.

18. Provide transmission of emergency alarm to dispatcher within 0.5 seconds, even if all voice channels are busy:

19. Become transmission trunked and provide voice access at first break in traffic on any voice channel for emergency (highest priority) calls, regardless of queue.

20. Assign two or more subfleets to the same RF channel when patched together at the console bythe dispatcher.

21. Provide "Call Alert paging to individual mobile radios.

22. Provide visual and/or audible signal to caller when field radio fails to gain system access (out of range).

23. Provide radio inhibit function to "put radio to sleep" to deny system monitoring or system access to lost or stolen radios.

24. Detect certain out-of-limits repeater operation, display alarm at System Manager Terminal, and remove repeater from system. Make no assignments to failed repeater.

25. Detect control channel failure, display failure alarm at System Manager Terminal, and automatically assign control tasks to another channel.

26. Accept assignment of control channel from the System Manager terminal to not fewer than four channels in the system.

27. Detect Trunking Controller failure, display failure alarm at System Manager Terminal, and either (a) continue trunking or (b) automatically assign system control functions to redundant Trunking Controller in a manner which is transparent to users.

28. At all times identify operational status of the Trunking Controller(s) locally and at the System Manager terminal.

29. Automatically default to pre-programmed conventional system operation if trunking capability fails.

30. Accumulate system activity in a data file.

31. Not require circuits with performance higher than Bell System 3002 circuits for communications of every type between dispatch console locations, system manager terminals, and site controller(s).

32. Not require more than one type 3002 channel on the microwave system to carry one digitally encrypted voice message.

3 COMMUNICATIONS PERFORMANCE

3.1 Hardware Performance

The Contractor will be held responsible for performance of all equipment furnished by him whether manufactured, modified, or only resold to the County, in that it must meet manufacturer% advertised performance or performance specified in this document, whichever is higher.

3.2 Coverage

Contractor is not responsible for radio coverage. However, Contractor shall furnish coverage contours as an exhibit to his bid predicated on the dest 800 mHz propagation algorithms, experience with similar systems, urban features, and local terrain. Each contour shall represent that signal required for 20 dB quieting in a receiver at 95% of all locations within the contour 95% of the time (95/95) using equipment proposed in this bid. System gain shall be based upon the worst channel in the 15 channel system considering loss in the transmitter combiner and receiver coupler. Coverage shall be computed for path losses under the following assumptions:

a) Talk-out range from the Muirdale water tank operating in single site configuration and talk-out range from all four sites operating as a simulcast system to a mobile radio with typical 0 dB gain roof mounted vehicular antenna appropriate for transit bus installation.

b) Talk-out range from all four sites operating as a simulcast system to a portable radio on the street carried against the body at waist level.

c) Talk-out range from all four sites operating as a simulcast system to portable radio carried against the body in a commercial building (30 dB building loss).

d) Talk-back range to Muirdale water tank operating in single site configuration and talk-back range to all four sites operating with receiver voting from a 12 watt mobile radio with typical 0 dB gain roof mounted vehicular antenna.

e) Talk-back range to all four sites operating with receiver voting from 1 watt portable radio on the street held at head height.

f) Talk-back range to all four sites operating with receiver voting from 1 watt portable radio held at head height in a commercial building as described above.

Coverage plots for talk-out range shall extend east across Lake Michigan as far as necessary to show specified signal limits, except exhibits for in-building coverage over Lake Michigan may be omitted. Maps will be used for information purposes only; no contractual liability will attach to the submittal.

4 RADIO SYSTEM MANAGER

4.1 Basic Capability

The trunked radio System Manager Terminal shall be installed as part of the Supervisory Dispatcher work station at the Communications Center in the MCTS office building, 1742 North 17th Street, The terminal shall be furnished with a printer. System Manager data shall include system clock information, screen ID (Owner assigned alias) and serial number of each radio in the system, screen ID of fleets and subfleets, names of persons with system terminal access including log-on password and software level of authorized access, plus fleets and subfleets accessible to that person. System manager terminals used by operators with appropriate authorized level of access shall be able to:

a) reprogram subfleet assignment of permitted radio or group of radios without intervention by the radio user;

b) inhibit transmit and receive voice access to a radio in the system. and to reverse the process. It shall be possible to identify the target radio by alias ID assigned by the Owner, native ID used by the system, or serial number assigned by the manufacturer;

c) add, delete, and edit a positive subscriber list of member radios for system access and level of telephone interconnect access for permitted radios;

d) change priority level of fleets, subfleets, and individual radios;

e) enable/disable individual repeaters and/or RF channels and key any repeater or combination of repeaters for diagnostic purposes;

f) program system timing parameters;

g) adjust the shared service algorithm for telephone interconnect feature;

h) enter airtime billing rate information for telephone interconnect management;

i) generate pseudo telephone bills for interconnect service by individual radio or subfleet;

j) display and/or print, with time stamp, real time processing of incoming trunked radio ID's with highlighted emergency messages, organized by subfleet. Messages shall be displayed in English with ID's displayed as Owner assigned aliases;

k) create, edit and display (or print) system configuration including positive and negative subscriber list, subscriber attributes, and fleet map.

4.2 Password Security

Each terminal on the system manager network shall be password protected using a printable character string of not Less than 8 characters, none of which can be a space. No more than three attempts at correct password entry shall be permitted before generating and recording an alarm at the network manager terminal which shows time, date, ID of victim terminal, and failed passwords, Successful access to a terminal shall be similarly recorded plus sign-off time and date,

4.3 Database

The system manager network shall use a single data base accessible to all terminals as permitted by the network manager. Only one terminal shall have access to the radio system control channel at a time from a queue managed on a first-in-first-out basis.

4.4 Activity Log

A system activity log shall be maintained by the System Manager. The log shall include radio ID (with alias if assigned), time stamp and call type. Log shall be saved to disk with hard copy available upon command. The terminal shall generate an alarm with appropriate error message when the file reaches approximately 90% of maximum allowable size. It will be permissible to lose file overflow. Equipment and software shall be furnished to transfer system activity files to tape. All reports shall carry a date and time stamp plus legend to indicate time interval covered by the report. It shall be possible to display or print:

a) chronological report of system activity over a defined period of time;
b) system activity by type of transaction over a defined period of time;
c) airtime per radio over a defined period of time;
d) airtime per subfleet over a defined period of time;
e) airtime per channel over a defined period of time;
f) telephone interconnect activity and billing data;
e) test and diagnostic data;
f) alarm data.

4.5 Trunking Controller Status

The System Manager shall always log, and display upon command, operational status of the trunking controller(s). If redundant controllers are required to assure continued trunking capability, ID of the active controller shall be available at this terminal. If only one controller out of two is available for service, it shall not be possible to switch controllers from the system manager terminal. Nor shall the terminal display indicate the controller has been switched if such action does not occur. Any attempt to shut down the only operational controller or transfer system operation to the controller out-of-service shall generate an error signal plus clear and obvious warning message on the CRT to the effect that no back-up controller is available.

4.6 Electronic Mail

The system manager network shall permit terminal operators to exchange and store electronic mail.

4.7 System Diagnostics

It shall be possible to run complete radio System diagnostics from a system manager terminal to include not less than trunking functions, telephone interconnect, repeater operation, and alarms. Test results shall be time stamped and logged to the system printer.

4.8 Help Screens

On-line Help screens shall be available to assist terminal operators to correctly execute'all programs available to that operator and terminal. In addition to conventional Help screens, an operator shall be able to recall a table of authorizations showing those functions and system operating parameters for which the operator is authorized to add, delete, edit and use.

4.9 System Manager Back-up

Bidder Proposer shall include a discussion with his proposal concerning possible failures of the system manager and how these failures affect system operation. The discussion shall include recommendations for back-up equipment and/or software not included by the Bidder Proposer in his prime ~~bid~~ proposal to make the various failures transparent to users and dispatchers. Each recommendation shall include an itemized list of additional hardware and software with prices.

7 RELIABILITY

7.1 General

All failures and switches between fixed station equipment shall be logged to the System Manager with time, date, nature/of failure and, if appropriate, notation of system response. The System Manager operator shall have the option to drop one or more repeaters from service without removing the channel from service at all sites.

7.1.1
Contractor shall furnish a detailed discussion with his bid describing the effect of various hardware and/or software failures. Particular attention shall be given to failures which affect basic trunking capability and system operation during such a period. Topics shall at least include:

a) if one trunking controller fails when the other is not operational (using redundant controllers) or desired switching to back-up controller does not occur, how does this affect system operation and how is failure perceived by field units;

b) if the trunking controller fails (no back-up controller), how does this affect system operation and how is this failure perceived by field units;

c) what is perceived by users during any failure in fixed equipment, besides controller failure, which affects trunking capability;

d) what is perceived by users when a repeater at one of the four sites goes off the air or operates beyond normal parameters, including off frequency operation;

e) what is perceived by users when the loop microwave switches at any site when the radio system is operating in the simulcast mode?

f) what limitations are imposed on system capability by any of the failure modes described above;

g) what is the required action on the part of dispatchers and field users to optimize communications during any failure described above;

h) what recovery procedure is required by dispatch&s and field users after the failure has been corrected.

7.1.2
If any failure to full trunking capability, microwave system, or central electronics malfunction requires re-booting the system, the discussion shall give particular attention to probable failure mode and recovery procedure, 'including elapsed time to effect recovery. If any activity at any console work station, System Manager Terminal, or field radio during the re-boot process will scramble or is likely to scramble prompt and expedi-. tious restart, the Contractor shall specifically mention this characteristic in his discussion.

7.2 Repeater Failure

A repeater shall be dropped from service which exhibits:

a) reduced power output below a programmed threshold;
b) increased reflected power above a programmed threshold;
c) carrier on the channel not assigned by the trunking controller. Channel shall be returned to service after the unwanted carrier is no longer heard.

Repeater failure shall be alarmed locally and to the system manager network.

7.3 Site Controller Failure

Controller failure in a two controller system shall cause operation to automatically transfer to the other controller. The two controllers shall continuously update each other so a switch can be made which is transparent to system users. Switching caused by controller failure shall not be affected by loss of communications link between console central electronics and the repeater site. Controller failure shall be alarmed locally and to the system manager network.

7.4 Link Failure

Failure of the communications link between console central electronics and trunking controller shall be alarmed and logged to the system manager. Trunking operation shall continue without interruption to users who do not depend upon the failed link for communication with each other. If fault sensing and switchover to a redundant link is optionally available to the Owner, this option shall be discussed in the proposal with cost cited for additional equipment.

7.5 Control Channel Failure

Failure of the control channel shall be alarmed locally and to the system manager. The Trunking Controller shall bring up a new control channel in not more than 10 seconds from detection of failure.

7.6 Fault Maintenance

Alarmed events shall be automatically logged to disk and displayed by the system manager. The log shall include time and date of the event plus identity of the alarm with sufficient detail to locate the failed module.

7.7 Maintenance Communications

It shall be possible for a technician at any repeater site to directly communicate with any dispatcher, control station, mobile, or portable radio, anywhere in the system.

10 SOFTWARE

10.1 License

Contractor shall furnish latest version of software when equipment is installed. Contractor shall include a license in his price to the Owner to use, modify, and copy all software for his own use without additional cost so long as any related equipment remains in service by the Owner. Modifications to software developed by the Owner, with or without assistance from the Contractor, suppliers, or contractors to the Contractor, shall be the exclusive property of the Owner. Owner shall have no responsibility to the Contractor for software or information about software in its possession prior to this contract or which subsequently comes into its possession through channels independent of the Contractor, or is independently developed by the Owner.

10.2 Warranty

Contractor shall warrant that software furnished under this contract is free from error and defects in material and workmanship for twelve months from date of System Acceptance by the Owner of the instant procurement and will operate under normal use and service as a system which conforms to these specifications. Any software which fails to meet this warranty shall be promptly corrected or replaced at Contractor's sole cost and expense.

10.2.1

Contractor will not be held responsible for performance of software which is modified or altered by the Owner other than pursuant to directions of the Contractor.

10.3 Updates **and Maintenance**

Contractor shall promptly furnish updates of all software used in this system without additional charge to the *Owner* for two years from date of successful completion of the Thirty Day Acceptance Test specified in 312.10, ***Thirty Day Acceptance Test,*** below. Upgrade and maintenance policy shall be described for all software initially furnished with this project after the two year period, above.

10.4 Software and PROM Programming Support

Contractor shall make software and PROM programming consulting available to Owner and contract maintenance personnel for all products furnished. Besides training specified in P11, Training, of this chapter, unlimited telephone consulting shall be available at no additional cost for two years from date of successful completion of the Thirty Day Acceptance Test, and thereafter on a pay-for-service basis,both by telephone and on-site assistance. Service shall be available during regular business hours at Milwaukee for on-site visits and in the time zone of the Contractor for telephone calls. Contractor shall include an exhibit with his bid listing cost of this service.

10.4.1 Software Documentation

Programming documentation shall be furnished in three copies of sufficient detail to assure a fully functional and acceptable trunked radio system for Transit operations. Contractor shall furnish two sets of all equipment, cables, adapters fixtures, and related apparatus required to implement available field programming within specified. performance options for equipment furnished on this project.

10.4.2 Software Support and Upgrades

Contractor shall guarantee to actively support software furnished on this project for not less than ten years from date of system acceptance. The Owner shall be promptly notified in writing if the Contractor discontinues software support after that time. After expiration of the two year free upgrade service for software required above, Contractor shall make further upgrades available on a fee basis. Contractor shall include an exhibit with his proposal describing past upgrade practice, including fees, and anticipated practice for future years. If, after ten or more years, software support is terminated while Owner continues to use this system, Contractor shall furnish source code to the Owner with complete documentation in two copies. No charge shall be made for the submittal.

11 TRAINING

The proposal shall include cost of field training at Milwaukee for MIS personnel, users, and dispatchers. Full training shall be provided as follows:

Personnel,		Description
6	MIS personnel, System Manager, CAD & AVL	40 hours minimum: trunked radio system operation and programming, including programming related to data

Personnel	Description
	base maintenance, schedules and schedule adherence, console operation.
6	MIS personnel, 40 hours minimum: database maintenance.
30	Dispatchers: system operation, CAD & AVL, console operation.
6	Mechanics: do's and don'ts when working on vehicles to avoid radio damage; AVL for non route vehicles.
10	Drivers/Supervisors: train the trainer on/system operation, mobile/portable radio operation, capability of CAD and AVL for both route and non route vehicles.

11.1 Instructor Qualifications

Instructors shall be regular, full time employees of the Contractor who are fully qualified with products furnished on this project through experience and factory training. Instructors shall be thoroughly familiar with topics appropriate to operation and maintenance of this equipment and have previously conducted equivalent training sessions. This requirement probably means local sales and/or maintenance people do not have the level of fluency and teaching skills expected by the Owner for this task.

11.2 Student Proficiency

Bidder shall include a section in his proposal which describes student testing or other measuring methods that shall be applied to each person during the course of instruction and at completion of the training program to assure required level of skill has been attained. This discussion shall include a statement of how the Bidder intends to assist students who do not achieve required proficiency after routine instruction.

11.3 Timing

All field training shall be completed prior to commencement of acceptance testing described in P12.9, Second Phase of Acceptance Test of this section,

11.4 On-Site Training

The Owner will furnish accommodations in Milwaukee for classroom training activity. Included is chalk board, overhead projector, screen, and similar generic instructional tools, plus equipment items already supplied but not yet installed by the Contractor. Where appropriate, training should occur at the site of installed equipment for "hands-on" instruction. Contractor. shall furnish student textbooks, pamphlets, notes, and/or other written material which cover topics to be studied. Student materials will become property of the Owner for continued reference by students. The Contractor shall furnish instructor plus all travel, lodging, and per diem expense,

11.5 Recording

Owner reserves the right to make audio and/or visual recordings of any and all training sessions in Milwaukee for later use by the Owner. Contractor shall cooperate with the Owner to make these recordings.

11.6 Training

Classes shall be organized for dispatchers/supervisors and train-the-trainer for coach operators. Subject material shall be appropriate to required level of understanding by participants. Topics must include at least:

> System organization and trunking methodology
> System capability
> Equipment sites
> Transit CAD program
> AVL and schedule adherence program
> Fleet map and dynamic reconfiguration
> Priority levels
> Telephone interconnect
> Description and use of all mobile and portable radios
> Failure sensing and recovery
> Operation during partial system or equipment failure
> Report generation

11.6.1
For persons who will staff the System Manager terminals, these additional topics shall also be covered:

> Role of System Manager
> Screen formats and description of usage
> System codes and mnemonic abbreviations
> System configuration and reconfiguration
> Subscriber lists
> Error messages and handling procedures
> Diagnostics, alarms, failure modes, and recovery
> Logging and retrieval of system activity data
> Create, edit, and delete schedule files
> Edit map displays

11.6.2

Course material for MIS personnel shall be furnished in **6 copies; for** dispatchers, supervisors, and system managers course **material shall** be furnished in illustrated books or pamphlets in **50** copies. **Course material for coach operators** shall be furnished in **1500** copies. **The** books shall be **organized to be** used for self teaching.

Section 2

TRANSIT OPERATIONS

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Section 3

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Trip Planning System

TRI-COUNTY METROPOLITAN TRANSPORTATION DISTRICT OF OREGON

TRIP PLANNING SYSTEM SPECIFICATION

Section 4

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SECTION 4 - SPECIFICATION

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APPENDICES

42 Functions

This section describes the application functions to be performed by the TPS. System software and -software utility functions are described in Section 4.4. The system shall be capable of handling the volume of activity specified in Appendix D.

Although specific implementation methods are sometimes suggested in this section, Tri-Met desires that the Contractor use as much standard software as possible. Cost-effective alternative features and methods that. satisfy the intent of the specification are solicited.

The following requirements apply to all functions:

(a) The system functions and displays shall be organized in a hierarchy so that a new ATP can perform the system functions by starting from a master menu and selecting the appropriate options from each succeeding display in the hierarchy. Keyboard commands shall be available for the experienced ATP to proceed directly to frequently used information from any other display without having to start at the master menu.

(b) TPS users shall be required to log in and log out. The system shall not initiate a function unless a user authorized for that function is logged into the requesting workstation. A means shall be provided for the network manager to change the authorization levels of system users:

(c) Each time a function is performed by an ATP, the system shall calculate the elapsed time required to complete the function.

(d) X.1 functions shall properly account for changes between standard time and daylight saving time.

4.3 Configuration/Hardware

This section describes general hardware and configuration requirements for the TPS. The Contractor, however, has the responsibility for assuring that the hardware has adequate capability and flexibility to meet the requirements of this section and the functional requirements defined in other sections of this specification.

4.4 Software

This section defines the general requirements for software to be. included in the TPS. Details of the functional requirements of application software are defined in Section 4.2.

Due to the vuious design approaches used by system suppliers, it is neither intended nor possible to list all software or all characteristics of the software required in the TPS. The Contractor, however, is responsible for including all the necessary software to-satisfy the functional and performance requirements described in this specification.

All software included in the system shall be the latest field-proven v&ion available as of a software cut-off date mutually selected by the Contractor and Tri-Met,

B.5. INTERFACE CRITERIA

Intelligent Transportation System

5.19 INTERFACE CRITERIA/RESPONSIBILITIES

A. SCOPE

The Successful Contractor shall be responsible for the correct interfacing of the systems, subsystems, facilities and equipment that are provided under this contract with existing communications systems, subsvstems, and facilities, and with the facilities and equipment furnished by the AATA and other contractors. If any incompatibility is discovered, this Contractor shall correct the incompatibility by modifying the equipment provided and/or by providing additional required equipment and material at no additional cost to the AATA. Unless otherwise specified, modifications to the equipment of existing systems, subsystems and facilities and to equipment provided by other contractors will generally not be permitted.

If no other solution exist, and the Contractor has to modify other system(s), this will require approval of the AATA and the supplier of the other system.

B. INTERFACES

An interface point is defined as the line(s) of demarcation between the various Contractor-furnished and/or installed systems, subsystems, equipment and materials and AATA bus communications systems and other equipment The Contractor shall identify these interface points on all submitted documentation.

1. Electrical/Mechanical Inter-face Compatibilitv

Electrical and mechanical interface compatibility is defined as the electrical and mechanical characteristics required to ensure that separate systems, subsystems, equipment and materials and existing systems, subsystems, equipment and materials are compatible, retain their specified function, and perform the service in the specified manner in conjunction with facilities to which they are connected; and do not impair or have any adverse effect on the operation of any system, subsystem or equipment to which they are directly or indirectly connected, or that may be influenced by them or their electromagnetic field(s).

2. Physical Interface Compatibilitv

Physical interface compatibility is defined as the physical form and fit required to ensure that all items of equipment and materials are fully compatible with all other equipment, materials, facilities and structures with which they interface, including: those furnished in accordance with this Specification; those furnished by others; and those owned or occupied by the

AATA and/or others.

3. . Schedule Compatibility

Schedule compatibility is defined as the scheduling of contract work on an essentially non-interfering basis with the work of all others and AATA. The AATA's determination of what constitutes an "essentially non-interfering basis" shall be required whenever any degree of interference to the work of others or the AATA is anticipated.

4. Adherence to FCC Regulations & Licenses

The Contractor shall ensure that all additions, modifications, interfaces, and interconnections of equipment conform to all existing FCC regulations governing the AATA radio operating licenses; or the Contractor shall assist the Authority in modifying existing AATA radio operating licenses to cover the new ITS.

8.6. INSTALLATION

5.40 SOFIWARE LICENSES

A. With respect to all software delivered by Contractor as a part of the contract which may ensue from this solicitation, Contractor g-rants AATA the right to use the software for internal purposes, including the right to: load and execute the software; to reproduce copies of the software (such as for archival and back-up purposes, for running parallel computing operations, and for operating the ITS from more than one Central Processing Unit), the aforementioned in compliance with the terms and conditions of the software licenses provided for in the Contractor's Proposal; to modify the software (such as through enhancements, upgrades, bug fixes, and conversion to other operating platforms); to integrate with other software; and to otherwise utilize the software for purposes relating to the ITS. These rights include all elements relating to the software, including the audio, visual, graphic, and textual elements, in any form or medium now known or later developed and in all formats, such as electronic, magnetic, digital, laser, or optical. These rights are perpetual, nonexclusive, transferable, and royalty-free.

B. Except as provided above, software and other written materials created as a part of the contract which may ensue under this solicitation are owned by the AATA, including documentation and specifications. All works of original authorship created in connection with said contract are "works for hire" as that term is used in connection with the U.S. Copyright Act To the extent that, by operation of law, the AATA would not own the intellectual property rights in such works, Contractor hereby assigns its right, title, and interest to the AA.TA.

5.41 SOURCE CODE

A. Customized Software for AATA's Applications

Contractor shall deposit with the AATA, at the time of installation of Contractor's customized software developed for the AATA's particular application, or upon the AATA's request, whichever comes first, a copy of the source code, and all updates, as they become available. The AATA shall have the right to use and adapt the source code in connection with its use of the system, including ports to other systems. The AATA shall not have the right to publicly distribute copies of the source code.

B. Proprietary Software

Contractor shall deposit, with First of America Bank, Inc., Ann Arbor, Michigan, USA, agent for the AATA's source code escrow account, a copy of its source code(s) for its proprietary software per the sample "Source Code Escrow Agreement" (attached). Contractor agrees to supply updates to the source code whenever changes are made to the software. Contractor shall perform this obligation at no charge to the AATA or First of America Bank, Inc.

4.5 Testing

No TPS hardware and software shall be shipped until all required inspections and tests have been completed and Tri-Met has approved the shipment . Approval of inspection and test results or the waiving of inspection or tests shall in no way relieve the Contractor of the responsibility for furnishing a complete.-system that meets the requirements of this specification.

If any inspection or test indicates that specific hardware, software, or documentation does not meet the specification requirements, the Contractor shall replace, modify, or add the appropriate items necessary to correct noted deficiencies, at no cost to Tri-Met.

Tri-Met representatives shall have free entry into any of the Contractor's facilities where the system is being produced to verify that the system is being fabricated in accordance with the specification.

4.6 Training and Support Services

4.6.1 Training

The Contractor shall offer training courses that- provide Tri-Met personnel with a thorough understanding of the TPS capabilities and instruction in the operation of the hardware and software.

All training except the Automated Trip Planner training shall be conducted at either the Contractor's site-or-at Tri-Met depending on which is most cost-effective to Tri-Met. The Automated Trip Planner training shall be conducted at Tri-Met.

4.7 Project Management, Standards, and Documentation

4.7.1 Project Management

In the proposal, the Contractor shall designate a project manager and shall provide an organization chart showing the make-up of the project team. Tri-Met will assign a project manager to coordinate all Tri-Met activities related to the TPS project. All communications-between Tri-Met and the Contractor shall be through the respective project managers.

4.7.2 Standards

The work covered by this specification shall be guided by the latest applicable standards of:

(a) American National Standards Institute (ANSI)
(b) Institute of Electrical and Electronics Engineers (IEEE)
(c) Electronic Industries Association (EIA)
(d) International Standards Organization (ISO)
(e) Underwriters Laboratories Inc. (5)
(f) National Electrical Code
(g) Occupational Safety and Health Administration (OSHA).

Where the standards of the above organizations differ, the most stringent standard shall apply.

The TPS shall use non-proprietary, open system hardware and software to the greatest extent possible. For example: industry-standard peripheral device interfaces shall be provided; the LAN shall comply with IEEE standard 802-x; and UNIX operating systems, if provided, shall comply with the IEEE POSIX standard.

4.73 Documentation

The Contractor shall provide complete documentation for the TPS. An inventory of all documentation to be delivered shall be submitted by the Contractor within four weeks of the contract award. This inventory shall include for each document: document name, document number, revision level, and date for submittal to Tri-Met.

8.3. DRAWINGS / DOCUMENTATION

Intelligent Transportation System

5.16 SHOP DRAWINGS, BROCHURES AND SAMPLES

A. The Successful Contractor shall submit for approval prior to preparation of shop drawings, a list of proposed submittals and a tentative schedule of all proposed shop drawings, brochures and samples called for under the Contract or requested by the Authority in accordance with the Successful Contractor's "ITS Project Schedule of Deliverables and Payments", as approved by the AATA.

All drawings submitted shall be in English only and shall use inches and feet, as well as meters, for all measurements.

B. The Successful Contractor shall prepare shop drawings that establish the actual detail of the work: The location and method of attachment of the equipment on the buses shall be approved by the AATA's Project Manager and should be replaceable with "plug-in" feature allowing rapid change-out.

8.4. SOFTWARE / SOURCE CODE

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5.20 INSTALLATION CRITERIA

The installation of all equipment and material shall be in accordance with City of Ann Arbor codes, accepted practices and standards specified by, but not limited to, the Federal Communications Commission (FCC), the National Electrical Code (NEC), the National Fire Prevention Association (NFPA), the Federal Motor Vehicle Safety Standard (FMVSS), the Society of Automotive Engineers Project Management (SAE), the EIA and other local governing agencies and/or jurisdictional authorities. The installation shall conform with the standards specified in the ITS Functional Specifications, when applicable.

The Contractor shall furnish and install interfaces, antennas, transmission Lines, terminals, hardware, connectors, wire and cabling, conduits and fittings, and all connections and cross-connections required to provide a complete, operational ITS that meets all the requirements of the Functional Specification.

A. Work To Be Performed Bv Contractor

1. The Contractor shall be responsible for all work and expenses relating to the proper design, manufacture, delivery, storage and total installation of the equipment at the AATA bus garage, transmitter and receiver sites and on all buses.

2. For those items of equipment to be installed by the Contractor, he shall provide all items of hardware and the required personnel and supervision for this installation work in accordance with the AATA-approved "Schedule of Deliverables and Payments".

3. The Contractor shall provide, at all times during installation, a qualified English speaking representative who shall be responsible for the installation, testing and adjustments of equipment to meet the requirements of this Specification.

4. AATA shall maintain full bus operations at all times during the installation. The Contractor shall not interfere with AATA garage operations.

5. All equipment proposed shall be at the Contractor's latest engineering change level including modifications to correct all known operational problems. The Contractor shall retrofit all new modifications and engineering changes into equipment to be installed, as well as non-compliant equipment already installed prior to approval of the change.

6. Commercial power for the kiosks (if necessary) will be obtained by the AATA, but the Contractor shall design, draft permit application, furnish and install all of the required equipment.

7. The installation of equipment on each type of bus currently in service must be approved by the AATA's Manager of Maintenance prior to installation. The Manager of Maintenance will assist the Contractor in determining the location and type of mounting required for the various pieces of equipment to be installed on a bus. The Contractor shall submit drawings of each type of equipment to be installed on a bus for approval by the Manager of Maintenance.

8. For mobile installation, Contractor shall design a standard mounting method for each type of bus. Design shall provide non-interference with normal passenger and driver functions, be theft and vandal-resistant, have a good appearance, and shall not affect the structural, electrical and ventilation system integrity of the bus.

9. Contractor shall notify the Project Manager, a minimum of 72 hours in advance of proposed schedule, to enter upon the property for the performance of any work during this Contract

B. Work To Be Performed Bv AATA

1. AATA will coordinate availability of its buses. AATA will provide a Maintenance Mechanic representative for a total of forty hours (2 mechanics at 20 hours each) per week. The Contractor and AATA will develop a schedule for daily bus availability.

2. Space for work on one bus will be made available at the AATA bus garage. Drivers to drive the buses in and out of the designated work stations will also be provided by the AATA.

3. AATA will make one (1) bus at a time available for installation.

4. The AATA will provide space as necessary for the installation of the operations center work stations.

5. The Contractor shall be responsible for the storage and disposal of all Contractor-owned equipment which it removes.

6. For testing and system validation, the Authority will provide a bus and driver to the Contractor.

7. The AATA will provide technical assistance on all of their data and software in use that is needed or required by the Contractor.

C. Evaluation

1. The AATA shall be responsible for evaluating the system. The Contractor may be requested to provide explanations concerning the validity of data. AATA's decision on the validity of the data will be final.

2. The Contractor shall not repair, replace or modify any piece of equipment without the knowledge and approval of the AATA. All work performed by the Contractor shall be reported and documented by the Contractor.

3. The evaluation will be conducted with the Contractor's system in actual revenue service.

4. The system shall be evaluated as follows:

   a) Hardware: That components operate as designed.

   b) Software: That the design and application provides the functionality contained in the Contractor's technical proposal.

D. ITS Installation Plan

The Contractor shall design and submit for approval an ITS installation plan at least 15 days prior to any planned work. This requirement does not apply to prototype installations. The ITS installation plan shall address at least the following:

1. Rate of installation (buses per day)

2. Composition of installation crew(s)

3. Approximate dates at bus garage

4. Cut-over scheme.

The buses must be radio capable when returned to service.

E. ITS Installation Scheme

The Contractor shall design an installation scheme for the ITS equipment that will optimize the operation, service life, reliability, availability, and maintainability of the equipment without interference to passenger movement or driver functions. The Contractor shall consider the following information when designing the equipment installation scheme for the ITS equipment:

1. The only electronic installations that have remained dry are those above the floor level of the bus.

2. The location(s) on the buses proposed by the Contractor for

installation of ITS components shall operate reliably in the bus environment with its susceptibility to vibration, shock, electromagnetic interference, water, and bus cleaning operations.

3. Security of bus radio components is a continuing problem; therefore, every exposed ITS component shall be designed to resist vandalism. Vandal-resistant fasteners, microphone cords, control heads, and cabinets shall be designed into the ITS installations.

F. Installation on New Buses

In the event that the AATA purchases new buses, the AATA may elect to negotiate with the ITS Contractor for the provision and installation of additional ITS vehicle units during the building of its bus orders at the bus manufacturers' plants. This might include installation of wiring (including the Vehicle-BUS) and connection to all peripherals and on-board processor. The ITS Contractor would be required to deliver the ITS equipment F.O.B. the bus manufacturers' plants and provide technical assistance, as needed, to permit the bus manufacturers to fully test the ITS hardware before the buses are delivered to the AATA.

H. ITS Svstem Cut-over Plan

The Contractor shall insure that the installation of the new KS does not affect normal bus operations. The Contractor shall prepare an ITS cut-over plan and submit it to the AATA's Project Manager at least 15 days prior to the planned cut-over of any ITS equipment. No work shall be undertaken to implement the ITS cut-over plan until it is approved by the AATA. The plan will detail the maintenance of radio service for the bus system during the entire cut-over period.

L Removal Of Existing Equipment

The security of new and old equipment during the installation, removal, and transport period shall be the responsibility of the Contractor unless otherwise notified by the AATA in writing. The Contractor shall deliver a complete inventory list detailing the equipment removed. The inventory list shall include at least the following information:

1. Inventory Item Number (if any)

2. Equipment Type

3. Model Number

4. Serial Number

The Contractor shall also remove existing “stop requested” signs and install blank plates where required, providing touch-up paint to all exposed areas.

J. Wire And Cable

Nylon straps shall be furnished and installed for bundling and cabling of conductors where two or more single conductors of the same circuit are run exposed in cable trays. Straps shall be installed approximately every 5 feet along the cable run. Wires of multi-conductor cables exposed by the stripping of the cable jacket for termination shall be trimmed in a neat, workmanlike manner and tied approximately every three inches with nylon straps. Care shall be taken in terminating or splicing cable.

Cables shall be permanently tagged with plastic tags at each entry to and exit from all junction boxes, cable trays, cable ladders, equipment . enclosures, conduits, ducts and pipe. Appropriate identification shall be permanently marked on each tag. These plastic tags shall be provided in two forms: Sleeve and fiat The sleeve form shall be of the heat shrinkable type and shall be properly sized to fit the cable for which it is intended. The sleeve form type may be used on cables with an outer diameter of 0.5 inch or less. The fiat form type shall be made of flat sheet stock with slots for installation with nylon tie-wrap fasteners. The markings on the tags shall be provided in a color that will contrast sharply with the color of the associated tags. The plastic tags shall be properly installed.

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10. INSTALLATION AND CONSTRUCTION PRACTICES

All installations are to be made in a neat and workmanlike manner. Each installation is not specified in every detail. Rather, the Contractor shall be required to use workers experienced in their trades who can follow procedures required by these specifications to produce a finished communication system which is a credit to both the Contractor and Owner.

10.1 Coaxial Cable

Coaxial cable jumpers for fixed stations shall be Andrew Heliax, or equal. All connectors shall be type N, BNC, TNC, or constant impedance approved equal. Cable connections exposed to the weather shall be weatherproofed by wrapping with butyl rubber tape and "Scotch" brand #88 all weather vinyl tape per Andrew Bulletin #237133. Each bandage shall be carefully painted with "Scotchkote" brand electrical coating;avoid voids and bubbles in the coating. Use of other grades of "Scotch" tape or their equivalents is prohibited.

10.2 Identification

Coaxial cable shall be identified at the building exit with a permanent metal or plastic tag which displays antenna model number, frequency(ies) and location on the tower of the connected antenna.

10.3 Crimp Connections

Crimp connections between wires shall use a non-reversing press and dies recommended by the connector manufacturer. All mating surfaces shall be absolutely clean, bright, and treated with an anti oxidant compound such as NO-OX or equal. Lugs shall have two holes for bolting in place; star washers shall be used under bolt heads and nuts to insure good electrical connection.

10.4 Welded Connections

Connections outdoors to ground rods, radio tower, water tower, and all buried connections shall be made by the "Cadweld" exothermic process, or approved equal. After welding, each weld shall receive a sharp blow with a hammer to test weld integrity.

10.5 Electric Service

Three wire service shall always be supplied for 117 VAC primary power where the third (green) wire is ground of the electrical distribution system. All wiring shall meet all requirements of the National Electrical and local codes.

10.6 Surge Protection

Surge protectors for power and signal circuits at each site shall use a common ground point which is bonded to the neutral connecting point of the electrical distribution system, water pipe and/or made ground in a manner consistent with the/National Electrical Code and Bell Telephone System practice.

10.6.1 AC Power Circuits

Each power supply or apparatus connected to the 60 Hz electrical distribution system shall be furnished with a Thyrector, gas discharge device, or equal surge protector on the line side of its primary power circuit. Alternately, surge protectors may be installed on the distribution circuit serving the equipment.

10.6.2 Signal Circuits

Each wireline signal circuit which extends beyond the building where the equipment is located shall be protected by Polyphaser twisted pair impulse suppressor, Porta Systems 581P-2 terminal block with Porta Systems 95BCDX suppressor, or approved equal. The ground buss shall be #6 copper wire or copper strap connected to halo ground, nearby metallic water pipe or ground of the electrical distribution system, using the most direct route with fewest bends in the ground buss consistent with neat installation work. Bends in ground wires of less than 12" radius shall be avoided.

10.6.3 Coaxial Cable

Each coaxial cable shall be grounded at the antenna supporting structure with Andrew grounding strap kits per Andrew Bulletin 1386A. Grounding kits shall be used at both the top and bottom on vertical runs more than 50' total height. Unless specified otherwise, each coaxial cable shall be fitted with a Polyphaser, Reliance Electric, or approved equal, coaxial surge suppressor at the grounding window (cable entrance) to the equipment room where available or at the equipment cabinet or cavity nearest to the antenna.

10.7 Equipment Cabinets

Equipment cabinets, racks, chassis, associated cavities, and surge protectors shall be bonded together with #10 solid copper wire common to all cabinets and radio devices in the immediate vicinity unless more specific procedure is specified for the site.

8.7. ACCEPTANCE TESTS

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5.21 ACCEPTANCE TESTS

Milestone payments by the AATA to the Contractor will be contingent upon inspection, verification and acceptance of the Contractor's completed Deliverables for each Milestone by the AATA's Project Manager, according to the following minimum testing requirements:

A. Task Responsibilities

1. The Contractor shall establish and implement a test program, that will ensure all mobile, fixed radios and related subsystems, equipment, material and services furnished during the performance of this contract meet the technical requirements and standards, as specified in the AATA's RFP #328, as well as all criteria of performance.

2. The Contractor will be required to perform tests outlined below for this project All tests are to be performed for the completion of the system.

a. Validate that the radio transmission and reception is equal to the current system. (AATA will provide information on the levels to the Contractor)

b. Validate that data messages can be transmitted and acknowledged by the operations control work station.

c. Validate that data messages can be transmitted and acknowledged by buses throughout the coverage area.

d. Validate that each segment of the In-Vehicle Logic Unit (IVLU) functions as specified on each bus.

e. Validate that buses can transmit preemption requests, that messages can be received by signal controllers.

f. Perform an overall system operation validation by utilizing all available data messages to and from a bus and the operations control work station.

g. Verify that interior bus signs and synthesized voice modules perform accurately and reliably; and receive data messages from the operations control work station for special announcements, and display/vocalize these announcements.

h. Verify that fare collection systems perform accurately and reliably; and that stored data is available daily for reporting purposes.

i. Validate that bus exterior signs can be controlled reliably and accurately from the on-board processor, and remotely by data messages from the operations control work station.

j. Validate that the transfer feature functions as required by the Specification.

3. The following task requirements are the Contractor's responsibility for the test program:

a. Develop comprehensive test plans detailing methods and test procedures to be utilized to ensure compliance-with all applicable requirements.

b. Develop detailed test procedures for each individual test within each category of testing.

c. Submit the test plans and all test procedures to the AATA for evaluation, review.

e. Furnish personnel, calibrated test equipment, tools, and miscellaneous supplies as necessary to perform all tests and retests, and to maintain all systems and equipment during the test period and until acceptance by the AATA.

f. Coordinate unified test program activities with the schedules and activities of other contractors, if applicable, and with the AATA to avoid conflicts with operational requirements.

g. Perform test and inspections as detailed in all test procedures.

h. Prepare detailed test reports, summary reports and progress reports, beginning within 30 days after the AATA's receipt of test plans.

i. Submit all raw test data, test results, evaluations, and summary reports for review by the AATA.

j. Prepare and submit revised test procedures and test plans to correct procedural and technical errors or omissions discovered in those documents after their initial AATA review.

k. Furnish labor and material to correct and/or effect Specification compliance.

1. Participate in AATA final acceptance activities. Except for the equipment already installed on the buses, clean the equipment and worksite, secure the equipment, and remain responsible for prompt repair or replacement in the event of loss or damage, until acceptance by the AATA. Furnish inventory services and demonstrate system or equipment operation in support of requests by the AATA. Provide support and access so that the AATA technicians and mechanics can inspect and test any potion of the work during normal work hours.

4. The Contractor shall advise the AATA, in writing, two weeks prior to the date(s) of scheduled tests and inspections. The AATA will witness these tests. TWO certified copies of installation completion test and inspection data shall be submitted to the AATA within 7 days after test completion for review and acceptance.

5. The AATA reserves the right to perform additional non-destructive tests and inspections at any time during the course of the contract work. Results indicating deficiencies involving non-compliance with Specification requirements will be reported to the Contractor for corrective action.

B. Deficiencies

If the AATA determines from test data acquired from any category of test(s) that the system, equipment, materials, technical documentation, or services furnished do not conform to any Specification requirement(s), the Contractor shall begin appropriate remedial action based on an analysis of test results within fifteen days after receipt of the AATA's notice of deficiency. When such recommendations relate to engineering deficiencies, the Contractor shall, upon receipt of approval, make the necessary changes to all equipment and documentation of that type to be delivered or previously delivered (even if previously accepted) during the course of the contract, at no additional cost.

When recommendations relate to other deficiencies such as quality control and installation workmanship, the Contractor shall correct all deficiencies at no additional cost to the AATA. Retesting after the changes have been completed (factory tests and inspections, installation completion tests and inspections, and technical documentation verifications) shall be required in whole or part; as determined by the AATA, at no additional cost to the AATA.

C. Categories of Tests

1. Tests and inspections shall be required in each of the categories listed below:

a. Custom developed equipment tests and inspections

b. Installation completion tests and inspections

c. System and integration tests

d. Sys tern validation tests (AATA- conducted program)

e. Technical documentation verification inspections

f. Substantial completion acceptance tests and inspections (AATA- conducted program)

g. Final acceptance tests and inspections (AATA- conducted program).

D. Custom Developed Equipment Tests And Inspections

Where required, two copies of test results certified by the manufacturer shall be furnished to the AATA for review.

E. Installation Completion Tests And Inspections

1. Installation completion tests and inspections shall be performed . after installation to ensure that equipment and materials were properly installed and functioning in accordance with this Specification, parameters, and good commercial practice. Installation completion tests and inspections shall consist of:

a. **Visual** inspection to verify the following:

1. Full compliance with requirements detailed in this Specification;

2. Use of only approved products;

3. Installation of equipment in accordance with approved installation Drawings;

4. Location and workmanship of wire and cable terminations, identification, routing, and color code.

b. Detailed testing will be required to demonstrate that material and equipment installed meet the criteria, and possess the characteristics and parameters contained in the contract Specification and in the manufacturer's published specifications

2. The testing of all items of equipment and material will include electrical, mechanical, operational, and functional parameters. Such parameters include, but are not limited to: levels of voltages, currents, power, distortion, noise, cross-talk, insulation resistance, continuity, attenuation (optical and electrical), physical strength, suitability of mounting method, paint and marking quality, graphics quality and style, location of operating controls and adjustments, maintainability, etc.

3. These tests shall be performed after the installation of material and equipment and shall be in addition to any tests and inspections previously performed. The Contractor shall perform all necessary alignments, adjustments, and maintenance, prior to the scheduling of installation completion tests and inspections.

F. **Svstem** And Integration Tests

1. System and integration tests shall be on-site performance tests to verify that all operating parameters and functions perform as specified and **that** each system and subsystem performs as specified in conjunction with each system or subsystem with which it interfaces. The Contractor shall demonstrate that all material and equipment elements of each installed system

function together to meet the system criteria specified. Each major subsystem (excludes vehicle systems) shall be powered a minimum of 40 hours (five eight hour days) prior to commencing system and integration tests.

2. The Contractor shall be responsible for meeting all system and integration test requirements including testing and documenting interface compatibility and integration with existing AATA-owned systems and equipment

3. Each and every interface shall be verified as to operation, functions, levels, and voltages, as specified. The Contractor shall test across the interface points; however, these tests shall only be made under the observation of appropriate AATA personnel. When minor adjustment to, or reconfiguration of, existing equipment is required, the Contractor shall notify the AATA, in writing, of the required adjustment or reconfiguration. An AATA representative will make the adjustment or reconfiguration in the presence of the Contractor. The Contractor shall be responsible for the necessary adjustments or reconfiguration of Contractor-furnished equipment to ensure proper functioning as specified.

4. The successful completion of all specified tests and inspections, including installation completion tests and inspections, and the correction of all outstanding discrepancies and subsequent retesting, is required as a prerequisite to system and integration tests.

5. The tests will vary with each specific subsystem(and ITS interface with other systems); however, each test shall include all operating parameters and functions. Tests shall be conducted on each subsystem installed, including vehicle installations with all failures and discrepancies noted. The Contractor shall not engage in further testing until the AATA has verified that the Contractor has taken necessary corrective action with respect to those failures and discrepancies. The Contractor shall retest after each successive failure and corrective action to verify specification compliance.

G. Specific Required System and Integration Tests

In addition to other testing requirements, the Contractor shall conduct the following specific system and integration tests:

1. Bus Stop Communications Test

This bus stop communications test is intended to demonstrate uniform radio system coverage over the entire AATA operating area. In this test, 2-way data communications will be demonstrated between the ITS and each bus stop on each bus route in the AATA operating area. The Contractor shall record relative signal quality between a typical bus and the operations control work station.

2. Voice Channel Access test

The voice channel access test is intended to provide a measurement and record of the time required by a bus operator to access a voice channel at various times during a normal operating weekday. The Contractor shall measure and record the time required to access a radio voice channel every 15 minutes over the period from OS30 to 2300 hours on a single normal business weekday.

3. Voice Channel Priority Access Test

The Contractor shall test the ability of the bus drivers to transmit an emergency signal and automatically access a voice channel during the time of the day that the radio channels are busiest. The times required for emergency access to the radio system shall be measured every 15 minutes for at least six (6) hours of the day when the radio channels are busiest

H. System Validation (AATA Conducted Test)

System validation will be performed by the AATA, to verify performance at each installation, as follows:

1. System Validation

A. The subsystem validation is an AATA program and will be scheduled and performed for the Vehicle, OCIS, and Traveler subsystems. The Contractor may furnish a representative for the duration of such tests. If the Contractor elects not to furnish a representative or the representative is absent during scheduled test(s), the AATA will not accept claims of discrepancies in the test(s) results. The AATA will evaluate subsystem validation results. In the event that the test results are unacceptable, the Contractor shall correct all deficiencies. The AATA may retest when the Contractor's correction of deficient work is completed.

2. Test Conditions

a. The test period shall be a minimum duration of 50 consecutive days, extended by corrective maintenance, or at the discretion of the AATA for a maximum period of 70 test days (subject to contract scheduled limitations). Each test day shall nominally consist of 8 consecutive hours. Exact test starting and finishing times shall be designated by the AATA. ITS shall be continuously powered on an operational-day basis for the entire system validation period, unless otherwise directed herein or by the AATA.

b. The AATA shall endeavor to perform at least the minimum of test operations specified during each test day. A test operation failure shall be recorded in the test data when a detected cessation or error in the specified response of the system being tested occurs. The failure of the system to furnish all correct responses to a test operation in accordance with each and every applicable specification requirement shall result in the recording of a test operation failure for that entire test operation.

c. Limited preventative and corrective maintenance actions in the form of repairs involving specific component parts, wiring, or minor internal equipment assemblies and adjustments, shall be allowed during test operations. The replacement or interchanging of whole equipment units, plug-in subassemblies, or major material items shall be allowed once during each test operation.

d. An AATA designated representative shall witness each test operation attempt and resulting system response throughout the test period.

e. Optionally, the AATA may perform more than the specified minimum number of test operations per day, total test operations, and number of test days, so long as all data collected is recorded and included in the test computations. A maximum test period as specified shall be allowed. The Contractor may be allowed to start, stop, and restart, the system validation tests. The AATA will report a test failure, discontinue testing, and after the Contractor completes the correction, the testing begins. After the second such attempt, the AATA will require a detailed examination of Contractor discrepancy correction efforts and all specification compliance related actions to date, prior to further testing. Equipment replacement or other extensive corrective measures may be required in accordance with all applicable specification provisions.

3. IVLU Subsystem Test Operation

Multiple network radio transmissions originating from the ITS operations control work station and transmitted through the transmitter(s) shall be received on an IVLU at the required percentage of locations, not to exceed (70) vehicles and not to exceed number of bus stops, within the coverage areas. The reception shall comply with the specified characteristics and grade of service for a period of 10 minutes. Multiple reply transmissions from the IVLU at each location shall be received with specified quality at the ITS operations control work station. IVLU units shall be operated from various locations designated by the AATA during a 10 minute period.

I. Final Acceptance

1. Final acceptance is an AATA-conducted program. The AATA accepts the systems, equipment, and material furnished, as being complete and in accordance with this Specification. All discrepancies (if any) documented at substantial completion and any other discrepancies discovered thereafter, shall be corrected prior to final acceptance.

2. The Contractor shall participate in AATA final acceptance

activities by providing support, as follows:

a. Produce records, copies of documentation, etc. for inspection

b. Furnish the original copy of all test logs and data to the AATA

c. Correct all discrepancies that are not in compliance with this Specification.

5.22 ACCEPTANCE OF SYSTEM AS WHOLE

If the system as a whole does not perform in accordance with the agreed-upon Specifications, even where the AATA has previously paid for Deliverables, the AATA reserves the right to either reject the whole system and get a complete refund from the Contractor, and/or accept the system (with its defects) and be reimbursed by Contractor for all costs necessary to bring the system to a level that will meet the AATA's needs.

Radio System

40. TESTING OF EQUIPMENT AND ALL CONSTRUCTION

40.1 Access

The Owner shall be permitted access to the project at all times to make inspections and tests of materials and equipment. The Contractor shall provide assistance to the Owner to perform all necessary operation and quality tests on the site. The Contractor will not be required to furnish personnel for tests conducted off the site.

40.2 Notice

If the specifications, Engineer's instructions, laws, ordinances or any public authority require any work to be specially tested or approved, the Contractor shall give the Engineer timely notice of its readiness for inspection, and if the inspection is by an authority other than the Engineer, the date for such inspection. Inspection by the Engineer will be promptly made. If any work is covered without approval of the Engineer, it must, if required by the Engineer, be uncovered for examination at the Contractor's expense.

40.3 Re-Testing

Re-examination of questioned work may be ordered by the Engineer and if so ordered it must be uncovered by the Contractor. If such work is found to conform to Contract Requirements, the Owner will pay the cost of reexamination and replacement. If such work is found not to conform to Contract Requirements, the Contractor shall pay such cost, unless he can show that the defect was caused by another Contractor.

40.4 Final Inspection

The Contractor shall make all tests, inspections, and checks necessary to place equipment in operation and to determine the system operates satisfactorily. When notified by the Contractor that, in his opinion,all work required by the contract as been completed, he shall notify the Engineer and request a date for final inspection of the work, including any test of operation. The Contractor shall have on hand at each installation site adequate test equipment to properly evaluate system operation, All test equipment shall have been calibrated within one year of final inspection date in a method representing the best trade practice for similar equipment and applications. In presence of the Engineer, the Contractor shall conduct complete functional performance tests of the system to demonstrate it meets performance guarantees and contract specifications.

40.5 Acceptance

Acceptance of the work will be on a project basis. Final payment will not be made until the last discrepancy has been corrected. However, nothing shall prohibit the Owner from taking possession or using unaccepted portions of the system or the entire system prior to completion in accordance with terms of the contract. If such prior possession causes delay to the Contractor, an equitable adjustment to the contract price or completion deadline will be made in writing. During such times the Contractor shall cooperate with the Owner to avoid unnecessary system interruptions. System acceptance will not be delayed because of loss of installed equipment by abuse or negligence of the Owner.

40.6 Certificate of Completion

After completion of this inspection and these tests the Owner shall, if all things are satisfactory, issue to the Contractor a certtificateof final completion certifying that, in his opinion, the work required by the contract has been completed in accordance with the contract drawings and specifications. However, the certificate shall not operate to release the Contractor from any obligations under the contract or from any guarantees, warranties, or maintenance bonds required in the contract documents.

40.7 Latent Defects

Notwithstanding the one year unconditional maintenance requirement of these specifications, the Contractor shall, for three years from date of final acceptance, correct all hidden defects in equipment, software, installation, or operation, not discovered at time of installation which result from incomplete or incorrect work not in compliance with specifications.

B.8. INSTRUCTION AND TRAINING

Intelligent Transportation System

5.23 INSTRUCTION AND TRAINING

Contractor shall perform training per the following minimum requirements:

A. PURPOSE

The objective of the training program shall be to train AATA mechanics, technicians and operating personnel to properly operate, diagnose, troubleshoot and maintain the ITS equipment provided in accordance with this Contract.

The Contractor shall furnish operating instruction manuals. Each manual shall contain the procedures for the normal use of the installed equipment showing step-by-step cause and effect results of each action taken by the user. Equipment troubleshooting and reversion to manual modes will be included in the training process. The Contractor will prepare such written and practical (hands-on) tests that will assure system fluency. The Contractor shall use demonstrations and visual aids (including working models, where practical) for training; however, adequate handouts shall be available for each student attending the classes.

B. SCOPE OF TRAINING PROGRAM

The training program shall be devoted primarily to instruction on key items of equipment The training shall be a combination of formal and hands-on training, including demonstrations. Formal classroom and hands-on training will be conducted at the AATA's Main Facility, while hands-on training and demonstrations will be conducted in the bus garage or other designated locations.

Maintenance training shall be provided in two levels: field and shop. Field maintenance covers configuration, interconnection and alignment, and "quick-fix" troubleshooting techniques utilizing the concept of lowest unit replacement. Shop maintenance shall be equipment oriented and include subsystem testing, equipment and component troubleshooting techniques and equipment and component repair, calibration and final testing.

Operations training shall be provided at bus operator, field supervisor, operations controller and management levels. "Train the trainer" strategies may be utilized to deliver training to some levels as approved by the AATA.

The Contractor shall submit a training concept plan/program for approval. It shall include the subject matter to be covered, a tabulation of the hours of instruction to be provided and the equipment to be included in the training program.

The Contractor shall furnish all required training aids and material necessary for the training program. The Contractor shall provide copies of each course outline, instructor's guide(s), student work books, models for hands-on demonstration, and hardware cut-aways. All material used for training shall become property of the AATA after training is completed. Printed training materials shall be prepared on personal computer word processing equipment, as practical, and digital data files for all materials shall be delivered on 3.5 inch "floppy discs." Digital files shall be in the current Microsoft "Word For Windows" format.

C. TRAINER'S EXPERIENCE

The Contractor's training program shall be conducted by fully qualified instructors, fluent in the English language. The instructors shall have thoroughly mastered the specific specialized subject matter involved and shall have the ability to impart equipment and system technical information to others in easily understood terms.

D. TRAINING AIDS AND MATERIALS

The Contractor shall furnish all required training aids and materials necessary for the training program. All material used for training, such as lesson plans, study guides, student handouts, etc. and training aids such as VCR tapes, transparencies, slides, photographs, dynamic mockups, test fixtures and test equipment, models for hands-on demonstration, training and hardware cut-aways shall become property of the AATA after training is completed. Printed training materials shall be prepared on personal computer word processing equipment, as practical, and digital data files for all materials shall be delivered on 3.5 inch “floppy discs.”

E. TRAINING DELIVERABLES

1. Instructor’s Guide

An instructor’s guide shall be provided which contains the information and directions necessary for an effective presentation. It shall include adequate guidelines to conduct a comprehensive training program. Individual lessons within the course shall be organized as separate blocks (or modules) which may be taught as a unit The instructor guide shall contain, at a minimum:

a. A discussion of student prerequisites (if any)

b. Program overview

c. A statement of overall program goals

d. Lesson plans (a session by session outline) containing the following:

- Student learning objectives, stated in measurable terms;
- Overview of each lesson;

- Suggested instructional methods/learning activities;
- Required equipment and/or resources.

2. Student Workbooks

Student workbooks shall be provided that include all materials for the student to interact in the learning situation. It shall contain, as a minimum:

a. Program overview/introduction

b. Statement of overall program goals

c. Learning objectives, stated in measurable terms, that specifically describe desired behaviors or knowledge to be gained

d. A fully developed prose treatment (not outline format) of content presentation, developed in the same modular format as the instructor's guide

e. Illustrations, charts, or graphics, as needed to enhance content presentation

f. Problems/questions related to lesson content, as appropriate

g. The repair guide in checklist format, showing all tools, parts (with part numbers), and steps in operation.

3. Audio-Visual Aids

The Contractor shall provide all necessary handouts, transparencies, slides, films, VCR tape (in VHS format), and mock-ups.

F. INSTRUCTIONAL DELIVERY

1. Instructor Qualifications

A description of instructor qualifications, a resume or other description of instructor qualifications must be submitted to the AATA at least 15 days prior to the presentation of training. The description shall document a thorough knowledge of the equipment being taught, an understanding of the adult learning process, and demonstrated experience in vocational instruction.

2 Course Len&

a. As mentioned in the Contractor's letter of l/13/94 to the AATA, the Contractor shall provide 68 hours of training to one group consisting of controllers/supervisors/dispatchers and totalling no more than three persons, to acquaint them with the functions and features of the ITS work station.

b. As mentioned in the Contractor's letter of l/13/94 to the AATA, the Contractor shall provide 24 hours of instructor training to the Authority's designated personnel ("train the trainer") to familiarize each participant with the ITS mobile equipment and fixed terminal interfaces. Instructors will be responsible for the training of operating personnel.

c. The Contractor shall provide training for the Authority's information systems and technical support personnel adequate to acquaint them with system interfaces and software functionality.

d. The Contractor shall provide training for the Authority's maintenance personnel adequate to enable them to perform routine maintenance tasks on the system.

3. Student Qualifications

The Contractor, for the purposes of course development and presentation, shall assume all AATA students are high school graduates (or equivalent), and that maintenance personnel will possess the ability to use basic hand tools and electronic test equipment

4. Testing

Instructors must give written and/or practical tests as a measuring device to determine knowledge transference. Tests shall use a multiple-choice or short answer format, and have been validated in a pilot course or by some other means agreed to by the AATA. Whenever possible, a practical hands-on test shall be developed to demonstrate the transference or operational/mechanical skills.

5. Training Schedule

The Contractor shall submit proposed training schedules, offers of training to be provided, instructor qualifications and proposed assignment of instructors for the various portions of the training program to the AATA for review and approval. Training shall be scheduled on a non-interfering basis to AATA operations and maintenance requirements. Therefore, the AATA will exercise wide latitude in approving or directing changes to Contractor training schedule submissions at no additional cost to the AATA.

The AATA requires that the Contractor supply system training' the quantity and quality of which is sufficient to fully train the AATA's personnel in the complete operation of the system. Though, as a part of this document, AATA specifies numbers of days or hours of required training in this regard, the number of days or hours so stated shall be understood to be suggested minimums. The actual number of days or hours required shall be whatever is necessary in order to provide sufficient training as judged by the AATA.

Radio System

11. SYSTEM MANUAL

11.1 Documentation

Six copies of a "System Manual" shall be furnished which documents all equipment as installed. Drawings and text shall be neatly prepared and suitable for reproduction. The entire manual shall be furnished in a durable binder or notebook for easy reference. Five copies shall be furnished to the Owner and one copy to the Engineer. The System Manual shall include:

11.1.1 Site Plan

A simple diagram showing the location of all equipment.

11.1.2 Block Diagram

Diagram showing inter relationship between principal pieces of equipment, including directly connected items not furnished by the Contractor. Items shall be identified by manufacturer, common name and model number.

11.1.3 System Description

Summary of system operation which briefly states the purpose of each item and how it relates to the whole system.

11.1.4 Intercabling Diagrams

A diagram identifying all wiring between equipment furnished by the Contractor plus other equipment connected to these items. Identification shall include common trade description of wire or cable, vendor name and catalog number, and color codes where appropriate. Connectors, tie points, and connecting blocks shall be identified by common trade name if applicable, and location on the premises. It shall be possible to trace each function from its origin to each and every connecting point in a continuous manner. The use of wire lists requiring jumping from page to page is prohibited.

11.2 Cost of Documentation

Documentation is considered an installation cost and shall be included as part of the same. The project will not be complete until correct and complete copies of the System Manual have been delivered as specified above. Cost of updating these manuals shall be included in installation cost of additional sites and repeaters as further specified in Sections 1 and 3.

11.3 Delivery

Complete documentation shall be delivered to the Owner and Engineer prior to or concurrent with commencement of the Final Inspection. Any change made in equipment or operation resulting from modifications flowing from the Final Inspection shall be promptly reflected in all copies of the System Manual.

12. CLEAN UP

Remove from buildings and sites as it accumulates all containers and debris resulting from work done under this contract. and' leave all materials and equipment spaces occupied by them absolutely clean and ready for use.

13. MAINTENANCE MANUALS AND PARTS LISTS

Three copies of a paper Maintenance Manual and Parts List for each type of fixed station equipment shall be furnished to the Owner before System Acceptance which document hardware as installed plus one copy of each relevant manual shall be kept on site with each equipment. Ten copies of each kind of mobile and portable radio manuals shall be furnished to the Owner. Maintenance manuals shall be prepared to be easily understandable by any technician familiar with communications equipment and accessories but without specific knowledge of this system or equipment proposed by the proposer.

B.9. WARRANTIES

Intelligent Transportation System

5.27 WARRANTY

A. Coverage

The Successful Contractor shall warrant that the Deliverables, whether supplied by it or its subcontractors, shall meet the AATA's Functional Specifications as specified in its RFP #328, shall conform to their description set forth in the relevant scope of work documents, shall be free from defects in materials and workmanship under normal operating use and service.

B. Warranty of Fitness For A Particular Purpose

The Successful Contractor shall agree that it has had the opportunity to assess the transportation computing systems needs of the AATA, and represents and warrants that the system delivered in connection with the Contract shall meet the particular needs of the AATA.

C. Warranty For Total Svstem

The Successful Contractor shall represent and warrant that it shall deliver a total system which will meet the functional needs and requirements of the AATA, as specified in the AATA's RFP #328 and the Contractor's Best **and** Final Offer, and that no additional equipment, software, cabling, or system components need be acquired in order for the system to perform all of the functions identified in RFP #328 and Contractor's technical proposal.

D. Warrantv Period

The Successful Contractor shall warrant that each of the Deliverables, as well as the entire ITS system, shall meet the AATA's Functional Specifications, shall conform to their description set forth in the relevant scope of work documents, shall be free from defects in materials and workmanship, and shall operate without defects for a period of twelve (12) months from the date of Acceptance of the entire system by the AATA for service operations. Contractor further warrants that all software provided with, or as a part of, the system shall contain no viruses or worms. Contractor further guarantees that the AATA will be given the most favorable warranty terms offered by the Original Manufacturers (O.E.M.'s) of the equipment, hardware and software to be provided.

Each piece of equipment, hardware and software shall be conditionally accepted for revenue service after being individually tested and approved by AATA. The warranty shall cover 100% parts and labor costs associated with the test, removal, repair, reinstallation, retest, and certification of the equipment and software from the time of installation through the end of the warranty period.

The warranty period shall be extended to cover the completion of all remedial work to correct any and all deficiencies under warranty.

E. Remedial Work

The remedial work to correct any and all deficiencies shall include the repair or replacement, at the AATA's determination of equipment, components, devices, materials and/or software.

F. Warranty Conditions

The AATA shall operate and maintain (or have maintained) the equipment in accordance with the Contractor's specific instructions in order to maintain this warranty.

1. The AATA shall be held harmless from operating and maintaining the equipment properly if the Contractor has not provided the AATA with complete operating manuals, maintenance manuals, electrical and electronic schematics, mechanical diagrams and complete micro-processor program documentation which includes full source codes.

   All of the above shall be required for the complete system.

2. No warranty period shall end unless the complete, finished documentation is provided by the Contractor and approved by the AATA.

G. Negligence

The warranty shall not apply to any equipment which has been damaged through accident or negligence, or which has been subjected to other than normal use. Temperature, humidity, bus vibration and ambient electrical conditions shall be considered normal operating conditions for this equipment

H. Consumable Items

The warranty shall not cover the replacement of normal consumable items or items which are replaced in usual and scheduled preventative maintenance programs, such as light bulbs and wear-related items.

I. Reliabilitv Requirements

The mean-time between failure of the Intelligent Transportation System equipment shall be no more than the following:

MTITS = One (1) failure per vehicle per year

A "Failure" is defined as the non-functioning of a component of a system as originally designed, or when such a component's operation poses **a** threat to the driver, passengers, or equipment

A "malfunction" is defined as a random fault that causes the equipment to be partially inoperable and would normally require some form of maintenance attention to be rendered. Every three (3) malfunctions shall be considered one "failure." Consumable items will only be considered a malfunction if they do not achieve their life expectancy.

AATA's decision as to what constitutes a failure or malfunction will be final.

J. Fleet Defects

A fleet defect is defined as the failure of items covered by the warranty and occurring in the warranty period exceeding the agreed failure rate limit of the equipment delivered under this contract A fleet defect for the Intelligent Transportation System shall include:

1. In the event that failures exceed the "MTITS" specified in Section 31.0, 1, of the Contract, by ten percent (10%) or more, for any reason in any six (6) month period of the warranty, the Contractor shall extend the base warranty by six (6) months, but not to exceed a maximum extension of twelve (12) months.

2. In the event that, during the life of the contract, failures of the buses equipped with ITS are exceeded by twenty-five percent (25%) or more, and are caused by any single component failure, the Contractor shall effect a redesign to correct this fleet defect After correcting the defect, the Contractor shall promptly undertake and complete a work program to implement this change in all other equipment purchased under this contract

K. Warranty Personnel

1. The Contractor shall provide, as needed, a minimum of one (1) warranty person at the AATA's main facility to perform contract

warranty repair work during the entire warranty period.

2, The Contractor shall provide the support equipment necessary to assist the warranty personnel in performing the major portion of warranty work on AATA's premises.

3. The Contractor's warranty personnel shall work in conjunction with AATA personnel in the repair and maintenance of the Contractor-supplied equipment The Contractor shall assist the AATA by providing on-the-job training such that by the end of the warranty period, AATA personnel shall be experienced enough to take over the repair and maintenance of the equipment

4. AATA shall provide a work area for each warranty person. The area will be heated inside a building or a garage. There also will be a secure area for the warranty personnel to store equipment

5. Warranty personnel will be required to work - under all weather conditions -a minimum of eight (8) hours per day, five (5) days a week on the warranty and repair of the equipment provided under this Contract When there is uncompleted warranty work to be performed, the warranty personnel will be required to work to complete the backlog.

Automatic Passenger Counter System

4-5 Guarantee/Warranty

The Contractor guarantees the goods and services furnished under this contract will be free from defects in material and workmanship, and will conform with all requirements of this contract, for a period of one (1) year from date of final acceptance of such goods and/or services by the County. The Contractor is responsible for all costs of replacement, including shipping charges, for goods or services found defective within that period, regardless of who actually corrects the defect.

The County shall give written notice of any defect to the Contractor. If the Contractor has not corrected the defect within thirty (30) calendar days after receiving the written notice, the County, in its sole discretion, may correct the defect itself. In the case of an emergency, the County may waive the written notice and correct the defect itself, if the County believes delay could cause serious injury, loss or damage.

The Contractor shall ensure that the warranty requirements of this contract are enforceable through and against the Contractor's suppliers. vendors, distributors and subcontractors. The Contractor is responsible for liability and expense caused by any inconsistencies or differences between the warranties extended to the County by the Contractor and those extended to the Contractor by its suppliers, vendors, distributors and subcontractors. Such inconsistency or difference will not excuse the Contractor's full compliance with its obligations under this contract.

The Contractor, upon notice of award of the contract, shah promptly provide to the County complete copies of all written warranties or guarantees and/or documentation of any other arrangement relating to such warranties or guarantees extended to the Contractor by the Contractor's suppliers, vendors, distributors and subcontractors covering parts, components, subcomponents and systems procured through this contract. The Contractor shall cooperate with the County in facilitating warranty related work by such suppliers, vendors, distributors and subcontractors.

If the original parts or equipment manufacturer provides a warranty that is greater in scope or duration than the Contractor's warranty to the County, the County shall receive the increased warranty benefits.

The termination of this contract shall in no way relieve the Contractor from its warranty/guarantee responsibility.

Any goods or services corrected shall be subject to this clause to the same extent as the goods or services initially provided.

This guarantee shall be in addition to any other express warranties or any implied warranties or remedies provided by this contract or by law, and in addition to any other rights or remedies available to the County under this contract or by law. No provision in this section shall be construed to limit the liability of the Contractor for work not done in accordance with the contract. The liability for such failure to perform shall extend as far as the appropriate periods of limitation provided by law.

The Contractor shall ensure the County receives warranty related work from its, suppliers, distributors, proposers and subcontractors.

Automatic Vehicle Identification System for Transit Signal Priority

3.15 Guarantee/Warranty

The Contractor guarantees the goods and services furnished hereunder will be free from defects in material and workmanship for a period of one (1) year from date of delivery or final acceptance of such goods and/or services to Metro. All goods and/or services found defective within that period shall be replaced, and reinstalled, with all cost of replacement, including shipping charges, to be borne by the Contractor. Metro, in its sole discretion, is hereby authorized to make corrections and repairs to or remove and replace said goods and/or services if, within ten (10) days after giving of written notice to the Contractor, the Contractor has failed to make or undertake with due diligence a cure of the defect(s); provided, however, that in the case of an emergency, where in the opinion of Metro, delay could cause serious injury, loss or damage, then repairs, removal or replacement may be made without notice being sent to the Contractor; and all reasonable expense in connection herewith shall be charged to the Contractor.

The Contractor shall not be relieved of its guarantee responsibility on goods and/or services that have been accepted by Metro on the date of termination of this Contract. The termination of the Contract shall in no way relieve the Contractor from any of its covenants, undertakings,, duties, and obligations under this Contract, nor limit the rights and remedies of Metro hereunder in any manner whatsoever.

This guarantee shall be in addition to any other express warranties or any implied warranties or remedies provided by this Contract or by law, and in addition to any other rights or remedies available to Metro under this Contract or by law. No provision in this section shall be construed to limit the liability of the Contractor for work not done in accordance with the Contract. The liability for such work shall extend as far as the appropriate periods of limitation provided by law.

3.16 Original Manufacturer's Warranty/Guarantee

Warranties in this contract are in addition to any remedies or warranties imposed on the Contractor by statute or otherwise by law.

If the original parts or equipment manufacturer provides a greater or extended warranty coverage, Metro shall receive these increased warranty benefits.

The Contractor shall ensure that the warranty requirements of this Contract are enforceable through and against the Contractor's suppliers, Proposers, distributors and subcontractors. The Contractor is responsible for liability and expense caused by any inconsistencies or differences between the warranties extended to Metro by the Contractor and those extended to the Contractor by its suppliers, Proposers, distributors and subcontractors. Such inconsistency or difference will not excuse the Contractor's full compliance with its obligations under this Contract.

The Contractor, upon notice of award of a Contract, shall promptly provide to Metro complete copies of all written warranties or guarantees and/or documentation of any other arrangement relating to such warranties or guarantees extended to the Contractor by the Contractor's suppliers, Proposers, distributors and subcontractors covering parts, components, subcomponents, and systems procured through this Contract.

The Contractor shall cooperate with Metro in facilitating warranty related work by such suppliers, Proposers, and subcontractors.

Radio System

14. GUARANTEE

14.1 General

The Contractor shall guarantee all materials, workmanship, and the successful operation of all equipment and apparatus furnished by him for a period of one year from date of final acceptance by the Owner.

14.2 Initial Warranty

The Contractor shall warrant to the Owner that equipment shall conform to specifications and be free from defects in materials and workmanship. The foregoing warranty is exclusive of all other warranties whether written, oral, or implied. In addition the Contractor shall guarantee the equipment for the following conditions:

a) Free from imperfections in design, materials, or construction which would create hazards, operational difficulties, or failure to meet specified performance quality.

b) Capable of continuous and satisfactory performance under normal operating conditions at ratings and capacities specified herein.

14.3 Failure of Equipment to Perform

If it appears that within one year from date of acceptance the equipment does not meet warranty specified including repeated failures of the same component or unit, the Contractor shall thereupon correct any defect, including non conformance with the specifications, by either repairing or replacing the defective part or parts at his sole cost and expense.

14.4 Future Product Support

The Contractor shall maintain a stock of replacement parts for each item included in this equipment and shall be in a position to promptly replace these parts as may be required for a period of ten years.

End of Section

Appendix C: Logical Architecture Data Flows Associated With Transit

C.1 Logical Data Flows Into and Out of Manage Transit

In order to facilitate the specification of data flows (relevant to transit ITS) in transit ITS procurements, and thus ensure future compatibility with the National ITS Architecture, Tables C1 through C4 present the currently identified data flows in regard to the Manage Transit process as found in the base level data flow diagram (DFD) -- Manage ITS (DFD 0). A simplified view of the Manage ITS DFD is shown in Figure C1. Each circle represents a process, while the rectangle represents a number of terminators. The arrows represent the flow of data in regard to transit. Note that Manage Commercial Vehicles and Provide Vehicle Monitoring and Control do not have any direct data flows with Manage Transit.

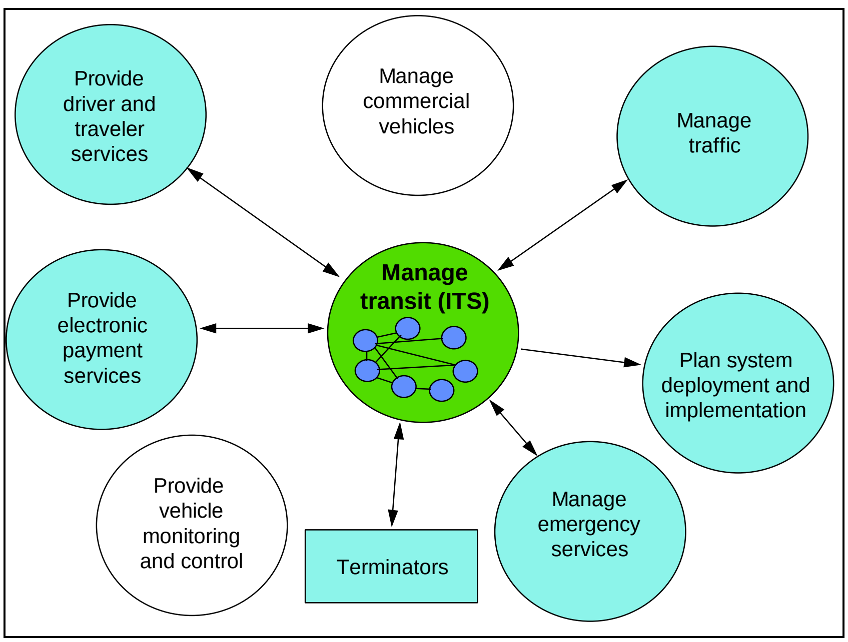

Figure C1 - Simplified Manage ITS Data Flow Diagram

Table C1 - Data Flows Into Manage Transit from Processes

Flow In from Process	Source Process
transit_updates	Manage Traffic
transit_requests	Provide Driver and Traveler Services
transit_payment_results	Provide Electronic Payment Services
transit_emergency_coordination_data	Manage Emergency Services

Table C2 - Data Flows from Manage Transit to Processes

Flow Out to Process	Destination Process
transit_inputs	Manage Traffic
transit_data	Provide Driver and Traveler Services
transit_payment_data	Provide Electronic Payment Services
transit_emergency	Manage Emergency Services
transit_data_transfer	Plan System Deployment and Implementation

Table C3 - Data Flows Into Manage Transit from Terminator

Flow from Terminator	Source Terminator
From_Map_Update_Provider	Map Update Provider
From_Payment_Instrument	Payment Instrument
From_Transit_Fleet_Manager	Transit Fleet Manager
From_Transit_Driver	Transit Driver
From_Transit_Vehicle	Transit Vehicle
From_Transit_User	Transit User
From_Transit_System_Operators	Transit System Operators
From_Intermodal_Transportation_ Service_Provider	Intermodal Transportation Service Provider
From_Other_TRM	Other TRM
From_Transit_Maintenance_Personnel	Transit Maintenance Personnel
From_Secure_Area_Environment	Secure Area Environment

Table C4 - Data Flows from Manage Transit to Terminators

Flow to Terminator	Destination Terminator
To_Media	Media
To_Map_Update_Provider	Map Update Provider
To_Transit_Fleet_Manager	Transit Fleet Manager
To_Transit_Driver	Transit Driver
To_Transit_User	Transit User
To_Transit_System_Operators	Transit System Operators
To_Intermodal_Transportation_Service_ Provider	Intermodal Transportation Service Provider
To_Other_TRM	Other TRM
To_Transit_Maintenance_Personnel	Transit Maintenance Personnel
To_Secure_Area_Environment	Secure Area Environment

The following are the currently identified data flows which flow into or out of the Manage Transit process of the base level data flow diagram (Manage ITS, DFD 0). Each of these flows is composed of other flows which are identified in the Logical Architecture, Volume 3 -- Data Dictionary. When procuring equipment or developing specifications, these data flows need to be addressed and are necessary for the system to conform with the National ITS Architecture.

Data flows from other processes to Manage Transit

transit_updates - traffic data for use in transit operations, requests for information on transit services, or requests for changes to transit services

transit_requests - requests for information about transit services or a request for a paratransit service, plus vehicle location data and transit user tag data

transit_payment_results - results of payment transactions

transit_emergency_coordination_data - contains data necessary to respond and address a transit incident

Data flows from Manage Transit to other processes

transit_inputs - information about the operation of transit vehicles, requests for preemption at signalized intersections, and the response to requests for changes in transit service

transit_data - information that is being provided in response to requests from drivers or travelers

transit_payment_data - data used in payment transactions

transit_emergency - data about incidents within the transit network and fare payment violators

transit_data_transfer - data on the current state of transit operations and transit services

Data flows from Manage Transit to terminators

From_Map_Update_Provider - contains new digitized map data for displays, on-line vehicle and traveler guidance plus system evaluation, transit route generation and static data preparation. The display data is used as the background to outputs of traffic, incident, transit routes and pollution data, while the guidance data is used by the on-line vehicle and traveler guidance facilities.

Fro*m_Payment_Instrument* - data on payments and credits from such sources as parking lots, toll plazas, and electronic tags

From_Transit_Fleet_Manager - contains a variety of inputs. Some are initiated by the manager, while others result from prompts to input data which is additional to that already received by processes within the function. Data includes coordination data, loading updates, requests for vehicle and driver data, and maintenance data.

From_Transit_Driver - contains information on emergency requests, information updates, and transactions

From_Transit_Vehicle - contains data that has been collected on-board the vehicle, and includes availability, maintenance, and trip data

From_Transit_User - contains inputs from the traveler who is at the moment a transit user. Information includes destination data, other services, information requests, and emergency requests

From_Transit_System_Operators - contains acknowledgment of potential incidents, security actions, a request for output of transit fare transaction data and fare data updates

From_Intermodal_Transportation_Service_Provider - contains details of the services available to move travelers by means other than road vehicles, e.g. heavy rail, air, sea, river, etc.

From_Other_TRM - contains data from the other transit centers. Data includes information about services which have an interface in an area covered by services from another center.

From_Transit_Maintenance_Personnel - contains information on maintenance updates

From_Secure_Area_Environment - represents information about conditions in a secure area environment such as that found in a transit network. This information is sensed/detected by sensors contained in the Manage Transit function, and is most probably image data, but switches such as a panic button are also represented by this flow.

Data Flows to Manage Transit from terminators

To_Media - provides output of information on traffic flow conditions, traffic incidents and transit incidents, depending on the content of the output request, plus a request for traveler information.

To_Map_Update_Provider - contains requests for updates of the digitized map data used for display maps, as a navigable map database for on-vehicle or personal traveler guidance, and as a source of data for trip planning and transit route generation. The display map data is used as the background for the output of traffic, incident, transit services and pollution data, the guidance data is used for the guidance of drivers and travelers on their selected routes, while the trip planning data is used for routes produced in response to traveler's trip requests. Static data is sent from the Plan System Deployment function to the map update provider for use in preparing the actual digitized map data.

To_Transit_Fleet_Manager - contains output to a transit fleet manager concerning paratransit services, passenger loading, driver information, vehicle information, and transactions

To_Transit_Driver - contains information for the transit driver. This information is particular to this type of driver and is not relevant to drivers of other types of vehicle(s). Information may include route modifications, emergency situations, paratransit data, and route assignments.

To_Transit_User - contains information for a traveler who is at the moment a transit user. The output may be in audio or visual form, with the latter being available in a variety of formats, e.g. displays, VMS, in-vehicle signage, or hardcopy (paper) output.

To_Transit_System_Operators - contains information on potential incidents and fare collection data. The output may be in audio or visual form, with the latter being available in a variety of formats, e.g. displays, VMS, or hardcopy (paper) output.

To_Intermodal_Transportation_Service_Provider - contains either a request for details of the services available to move travelers by means other than road vehicles, e.g. heavy rail, air, sea, river, etc., or changes to the arrival time(s) of transit services caused by schedule deviations

To_Other_TRM - contains data for the other transit centers regarding services provided by the local center which have interfaces in areas served by other centers

To_Transit_Maintenance_Personnel - contains the work schedule for a transit maintenance engineer

To_Secure_Area_Environment - contains information for transit users when they are in part of the transit operations network. Information includes broadcast messages, panic button acknowledgment, and camera control data.

C.2 Logical Data Flows Within Manage Transit

Within the Manage Transit process exists several other levels of data flows. Figure C2 provides a simplified view of the Manage Transit DFD. Each of the arrows represents flow of data, while the circles represent processes. Table C5 presents the data flows of Manage Transit, DFD 4. In addition to these flows, the other flows contained within these flows need to be addressed to be compatible with the National ITS Architecture.

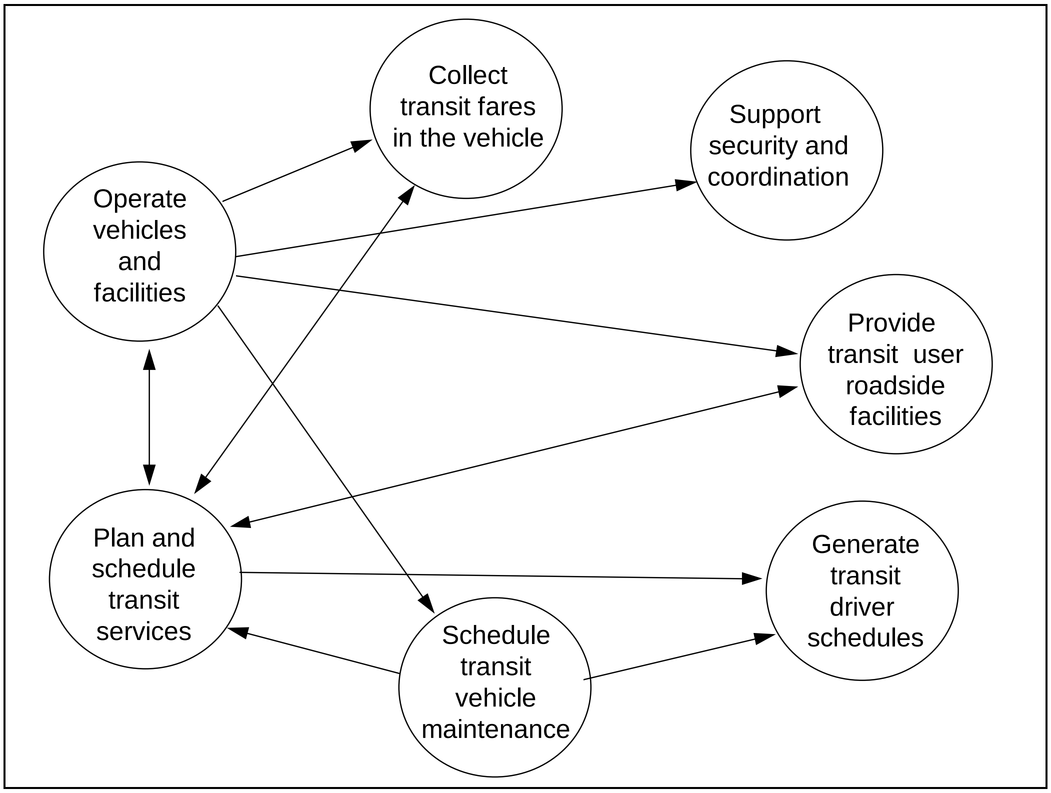

Figure C2 - The Transit Management Components

Table C5 - Data Flows Within Manage Transit, DFD 4

Source Process	Data Flow	Destination Process
Operate Vehicles and Facilities	transit_vehicle_location	Collect Transit Fares in the Vehicle
	transit_vehicle_location	Support Security and Coordination
	transit_vehicle_arrival_time	Provide Transit User Roadside Facilities
	transit_vehicle_user_data	Provide Transit User Roadside Facilities
	transit_vehicle_status	Schedule Transit Vehicle Maintenance
	transit_vehicle_data	Plan and Schedule Transit Services
	transit_services_for_eta_request	Plan and Schedule Transit Services
	transit_vehicle_location	Plan and Schedule Transit Services
Collect Transit Fares in the Vehicle	transit_vehicle_passenger_data	Plan and Schedule Transit Services
Provide Transit User Roadside Facilities	transit_services_travelers_request	Plan and Schedule Transit Services
	transit_roadside_passenger_data	Plan and Schedule Transit Services
Schedule Transit Vehicle Maintenance	transit_vehicle_availability	Plan and Schedule Transit Services
	transit_vehicle_availability	Generate Transit Driver Schedules
Plan and Schedule Transit Services	transit_services_for_eta	Operate Vehicles and Facilities
	transit_services_for_corrections	Operate Vehicles and Facilities
	transit_services_for_scenarios	Operate Vehicles and Facilities
	transit_services_for_vehicle_fares	Collect Transit Fares in the Vehicle
	transit_services_for_travelers	Provide Transit User Roadside Facilities
	transit_services_for_roadside_ fares	Provide Transit User Roadside Facilities
	transit_services_for_transit_ drivers	Generate Transit Driver Schedules
	paratransit_services_for_transit_ drivers	Generate Transit Driver Schedules

The data flows between processes of the Manage Transit level of the data flow diagrams (DFD 4) are briefly described below. They are arranged by the process from which they originate.

Each of these flows may be comprised of several other flows which may be found in the Logical Architecture, Volume 3 -- Data Dictionary.

Operate Vehicles and Facilities

transit_vehicle_location - provides the exact location of the transit vehicle

transit_vehicle_arrival_time - contains the expected time that a transit vehicle will reach the end of segments on its route and is used to determine any schedule deviations. The end of a transit route segment is usually a transit stop and the data is thus the expected arrival time of a transit vehicle at each of the transit stop(s) along the transit route.

transit_vehicle_user_data - contains data about a transit vehicle for automatic output to transit users at transit stops. The data is output at the transit stop as the vehicle approaches and contains information about the vehicle such as the route number.

transit_vehicle_status - contains data that has been collected and processed by sensors on-board the vehicle which is to be sent to the maintenance facility

transit_vehicle_data - contains data about transit vehicles in the fleet. This data is used in the planning of routes and schedules for regular transit services. It is obtained from processing the input to sensors on-board each transit vehicle during the course of their operation.

transit_services_for_eta_request - used to request the details of the current transit service so that a transit vehicle can calculate its current deviation relative to that schedule.

Collect Transit Fares in the Vehicle

transit_vehicle_passenger_data - contains the number of passengers carried by a transit vehicle while in service. It is derived from on-board vehicle fare collection data and may be used for calculating future transit schedules.

Provide Transit User Roadside Facilities

transit_services_travelers_request - used to request the details of the current transit services for a transit user at the roadside. The transit user will have to provide the origin and destination so that the receiving process can determine for which transit route(s) data will be provided.

transit_roadside_passenger_data - contains the number of passengers passing through a transit stop. It is derived from roadside fare collection data and may be used for calculating future transit schedules.

Schedule Transit Vehicle Maintenance

transit_vehicle_availability - contains details of a transit vehicle's availability for work

Plan and Schedule Transit Services

transit_services_for_eta - data is for used in the calculation of transit vehicle estimated times of arrival (ETA) at transit stops. It only contains details of the schedule for the transit route that is currently being operated by the vehicle

transit_services_for_corrections - data is used in the calculation of corrections to transit vehicle routes and schedules to restore a service to normal operation. It contains a complete set of all the transit routes and the services that run upon them, including timings, etc. that are provided by the transit fleet from which the data was requested.

transit_services_for_scenarios - data is used in the calculation of the scenarios for the return of transit vehicles to their published schedules and routes. It contains a complete set of all the transit routes and the services that run upon them, including timings, etc. that are provided by the transit fleet from which the data was requested

transit_services_for_vehicle_fares - contains details of the transit user fares for all the transit routes operated by the transit fleet from which the request was made. This data is for use in processing transit fare payments initiated by transit users on-board a transit vehicle.

transit_services_for_travelers - contains a complete set of all the transit routes and the services that run upon them (e.g., timings) that are provided by the transit fleet from which the data was requested.

transit_services_for_roadside_fares - contains details of the transit users fares for all the transit routes operated by the transit fleet from which the request was made. This data is for use in processing transit fare payments initiated by transit users at the roadside (a transit stop).

transit_services_for_transit_drivers - contains a complete set of all the transit routes and the services that run upon them, including timings, etc. that are provided by the transit fleet from which the data was requested.

paratransit_services_for_transit_drivers - provides data about a confirmed paratransit service to a transit driver.

★ **Useful National ITS Architecture documents: Logical Architecture - Volumes 1, 2, 3**

Appendix D: Physical Architecture Data Flows Associated With Transit

Appendix D lists each of the physical data flows associated with transit (for subsystems, users, providers, and the environment) as identified in the National ITS Architecture. The format of each is as follows:

Heading (bold) - Source subsystem to destination subsystem

Physical Architecture flow name - italics

Brief description of the data flow - line following the Physical Architecture flow name

Logical Architecture Reference Flow (bullets) - Logical data flows which compose the Physical Architecture data flow

Figure D1 provides an illustration of these physical data flows.

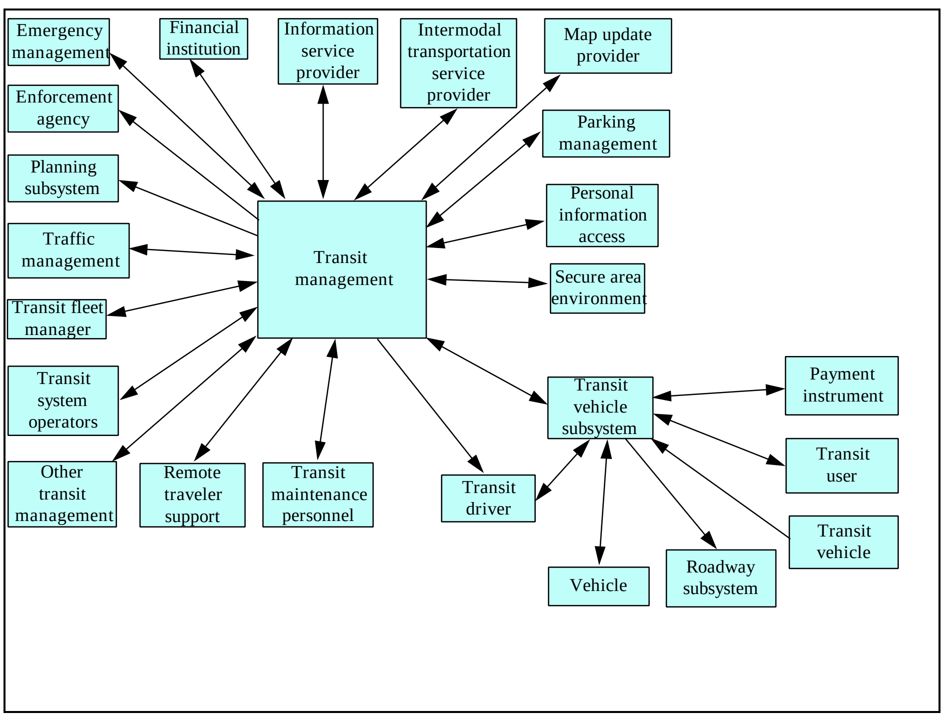

Figure D1 - Physical Data Flows for Transit

Emergency Management -> Transit Management

Physical Architecture Flow Name: transit emergency coordination data

Data exchanged between parties dealing with transit incident

- Logical Architecture Reference Flow: transit_incident_coordination_data

Financial Institution -> Transit Management

Physical Architecture Flow Name: transaction status

Response to transaction request. Normally dealing with request for payment

- Logical Architecture Reference Flow: ffi_bad_fare_payment_updates
- Logical Architecture Reference Flow: ffi_other_services_payment_confirm
- Logical Architecture Reference Flow: ffi_confirm_fare_payment

Information Service Provider -> Transit Management

Physical Architecture Flow Name: demand responsive transit request

Request for paratransit support

- Logical Architecture Reference Flow: paratransit_trip_request

Physical Architecture Flow Name: selected routes

Routes selected by optimization algorithms

- Logical Architecture Reference Flow: paratransit_service_confirmation
- Logical Architecture Reference Flow: advanced_tolls_and_charges_vehicle_confirm

Physical Architecture Flow Name: transit information request

Request for transit schedule information

- Logical Architecture Reference Flow: transit_fare_data_request
- Logical Architecture Reference Flow: transit_services_guidance_request
- Logical Architecture Reference Flow: transit_services_advisories_request
- Logical Architecture Reference Flow: transit_vehicle_deviations_details_request
- Logical Architecture Reference Flow: advanced_other_fares_request
- Logical Architecture Reference Flow: advanced_traveler_fares_request

Intermodal Transportation Service Provider -> Transit Management

Physical Architecture Flow Name: intermodal information

Schedule information for alternate mode transportation providers such as train, ferry, air

- Logical Architecture Reference Flow: fitsp_transit_service_data

Map Update Provider -> Transit Management

Physical Architecture Flow Name: map updates

Either static or real-time map updates

- Logical Architecture Reference Flow: fmup_transit_map_update

Other TRM -> Transit Management

Physical Architecture Flow Name: TRMS coord

Coordination information between local/regional transit organizations including schedule, on-time information and ridership

- Logical Architecture Reference Flow: fotrm_transit_services

Parking Management -> Transit Management

Physical Architecture Flow Name: transit parking coordination

Request for coordinated fare payment and parking lot price data

- Logical Architecture Reference Flow: parking_lot_transit_request

Personal Information Access -> Transit Management

Physical Architecture Flow Name: demand responsive transit request

Request for paratransit support

Logical Architecture Reference Flow: transit_services_portables_request

Remote Traveler Support -> Transit Management

Physical Architecture Flow Name: emergency notification

Mayday notification by a traveler. Could be on foot, or in any vehicle. Routing is eventually to an Emergency Management Center but may be forwarded by any other organization. Message may contain location and nature of emergency

- Logical Architecture Reference Flow: transit_user_roadside_image

Physical Architecture Flow Name: transit request

Request for special transit routing, real-time schedule information, availability information

- Logical Architecture Reference Flow: fare_collection_roadside_violation_information
- Logical Architecture Reference Flow: request_roadside_fare_payment
- Logical Architecture Reference Flow: transit_roadside_fare_payment_confirmation
- Logical Architecture Reference Flow: transit_roadside_passenger_data
- Logical Architecture Reference Flow: transit_services_kiosk_request
- Logical Architecture Reference Flow: transit_services_travelers_request

Physical Architecture Flow Name: traveler information request

Request for any type of traveler information

- Logical Architecture Reference Flow: other_services_roadside_request

Secure Area Environment -> Transit Management

Physical Architecture Flow Name: physical activities

Video or other information for monitoring secure areas and improving traveler safety at public stops or kiosks

- Logical Architecture Reference Flow: fsa_transit_video_image
- Logical Architecture Reference Flow: fsa_transit_panic_button

Traffic Management -> Transit Management

Physical Architecture Flow Name: demand management price change request

Request to change the pricing for road facility use based on demand

- Logical Architecture Reference Flow: transit_conditions_demand_request
- Logical Architecture Reference Flow: transit_services_changes_request
- Logical Architecture Reference Flow: transit_services_demand_request

Physical Architecture Flow Name: signal priority status

Status of signal priority request functions at the roadside (e.g. enabled or disabled)

- Logical Architecture Reference Flow: transit_highway_priority_given
- Logical Architecture Reference Flow: transit_road_priority_given
- Logical Architecture Reference Flow: transit_ramp_priority_given

Physical Architecture Flow Name: traffic information

Congestion, pricing, and incident information

- Logical Architecture Reference Flow: prediction_data

Transit Fleet Manager -> Transit Management

Physical Architecture Flow Name: schedule Guidelines

Instructions to transit management governing schedules

- Logical Architecture Reference Flow: ftfm_technician_information_request
- Logical Architecture Reference Flow: ftfm_technician_information_updates
- Logical Architecture Reference Flow: ftfm_transit_display_update_request
- Logical Architecture Reference Flow: ftfm_transit_driver_information_request
- Logical Architecture Reference Flow: ftfm_transit_driver_route_preferences
- Logical Architecture Reference Flow: ftfm_response_parameters

- Logical Architecture Reference Flow: ftfm_transit_vehicle_maintenance_information_request
- Logical Architecture Reference Flow: ftfm_planning_parameters
- Logical Architecture Reference Flow: ftfm_transit_services_output_request
- Logical Architecture Reference Flow: ftfm_request_transit_vehicle_data
- Logical Architecture Reference Flow: ftfm_transit_vehicle_maintenance_specs
- Logical Architecture Reference Flow: ftfm_planning_parameters_update_request
- Logical Architecture Reference Flow: ftfm_transit_driver_information_updates
- Logical Architecture Reference Flow: ftfm_passenger_loading_updates
- Logical Architecture Reference Flow: ftfm_initiate_service_updates
- Logical Architecture Reference Flow: ftfm_coordination_data
- Logical Architecture Reference Flow: ftfm_approved_corrections
- Logical Architecture Reference Flow: ftfm_request_response_parameter_output

Transit Maintenance Personnel -> Transit Management

Physical Architecture Flow Name: maint Status

Current status of transit system

- Logical Architecture Reference Flow: ftmp_transit_vehicle_maintenance_updates

Transit Management-> Emergency Management

Physical Architecture Flow Name: security alarms

Alarms located in public transit stops or on transit vehicles indicating an incident

- Logical Architecture Reference Flow: transit_emergency_data
- Logical Architecture Reference Flow: transit_coordination_data
- Logical Architecture Reference Flow: transit_incident_details

Transit Management-> Enforcement Agency

Physical Architecture Flow Name: violation notification

Notification to enforcement agency of violation or regulations

- Logical Architecture Reference Flow: tea_fare_collection_vehicle_violation_data
- Logical Architecture Reference Flow: tea_fare_payment_violation_data
- Logical Architecture Reference Flow: tea_fare_collection_roadside_violation_data

Transit Management-> Financial Institution

Physical Architecture Flow Name: payment request

Request for payment from financial institution

- Logical Architecture Reference Flow: tfi_request_fare_payment
- Logical Architecture Reference Flow: tfi_fare_payment_violator_data
- Logical Architecture Reference Flow: tfi_other_services_payment_request

Transit Management-> Information Service Provider

Physical Architecture Flow Name: demand responsive transit plan

Plan regarding overall schedules and deployment of demand responsive system

- Logical Architecture Reference Flow: paratransit_personal_schedule

Physical Architecture Flow Name: transit and fare schedules

Specific schedules from transit management

- Logical Architecture Reference Flow: transit_media_emergency_information
- Logical Architecture Reference Flow: transit_deviation_data_received
- Logical Architecture Reference Flow: transit_fare_data
- Logical Architecture Reference Flow: transit_media_incident_information
- Logical Architecture Reference Flow: transit_services_for_guidance
- Logical Architecture Reference Flow: transit_services_for_advisory_data
- Logical Architecture Reference Flow: transit_vehicle_deviations_details

Physical Architecture Flow Name: transit request confirmation

Confirmation of a request for transit information or service

- Logical Architecture Reference Flow: advanced_tolls_and_charges_vehicle_request
- Logical Architecture Reference Flow: transit_user_payments_transactions
- Logical Architecture Reference Flow: advanced_other_fares_confirm
- Logical Architecture Reference Flow: advanced_traveler_fares_confirm

Transit Management-> Intermodal Transportation Service Provider

Physical Architecture Flow Name: intermodal information

Schedule information for alternate mode transportation providers such as train, ferry, air

- Logical Architecture Reference Flow: titsp_transit_arrival_deviations
- Logical Architecture Reference Flow: titsp_transit_arrival_changes
- Logical Architecture Reference Flow: titsp_transit_service_data

Transit Management-> Map Update Provider

Physical Architecture Flow Name: map update request

Request for a map update

- ♦ Logical Architecture Reference Flow: tmup_transit_map_update_request

Transit Management->   Other TRM

Physical Architecture Flow Name: TRMS coord

Coordination information between local/regional transit organizations including schedule, on-time information and ridership

- ♦ Logical Architecture Reference Flow: totrm_transit_services

Transit Management->   Parking Management

Physical Architecture Flow Name: parking lot transit response

Response to transit occupancy inquiries and coordination with parking lots

- ♦ Logical Architecture Reference Flow: parking_lot_transit_response

Transit Management->   Personal Information Access

Physical Architecture Flow Name: demand responsive transit route

Paratransit response

- ♦ Logical Architecture Reference Flow: transit_services_for_portables

Transit Management->   Planning Subsystem

Physical Architecture Flow Name: operational data

Statistical data used for planning purposes

- ♦ Logical Architecture Reference Flow: transit_services_for_deployment
- ♦ Logical Architecture Reference Flow: transit_passenger_operational_data

Transit Management->   Remote Traveler Support

Physical Architecture Flow Name: emergency acknowledge

Acknowledge request for emergency assistance and provide additional details regarding actions and verification requirements

- ♦ Logical Architecture Reference Flow: request_transit_user_roadside_image
- ♦ Logical Architecture Reference Flow: transit_services_for_kiosks

Physical Architecture Flow Name: transit and fare schedules

Specific schedules from transit management

- ♦ Logical Architecture Reference Flow: transit_services_for_roadside_fares
- ♦ Logical Architecture Reference Flow: transit_services_for_travelers

- Logical Architecture Reference Flow: transit_roadside_fare_payment_debited
- Logical Architecture Reference Flow: transit_services_for_kiosks
- Logical Architecture Reference Flow: transit_roadside_fare_data
- Logical Architecture Reference Flow: transit_vehicle_arrival_time
- Logical Architecture Reference Flow: confirm_roadside_fare_payment

Physical Architecture Flow Name: traveler information

Traveler routing, yellow pages etc.

- Logical Architecture Reference Flow: other_services_roadside_response
- Logical Architecture Reference Flow: transit_roadside_fare_payment_request
- Logical Architecture Reference Flow: transit_vehicle_user_data

Transit Management -> Secure Area Environment

Physical Architecture Flow Name: camera control

Control commands for remote control of security cameras

- Logical Architecture Reference Flow: tsa_broadcast_message

Physical Architecture Flow Name: emergency acknowledge

Acknowledge request for emergency assistance and provide additional details regarding actions and verification requirements

- Logical Architecture Reference Flow: tsa_panic_button_acknowledge

Transit Management -> Traffic Management

Physical Architecture Flow Name: demand management price change response

Response to change request indicating level of compliance with request

- Logical Architecture Reference Flow: transit_services_changes_response

Physical Architecture Flow Name: request for transit signal priority

Request for signal priority either through roadside or directly to TMS

- Logical Architecture Reference Flow: transit_road_overall_priority
- Logical Architecture Reference Flow: transit_ramp_overall_priority
- Logical Architecture Reference Flow: transit_highway_overall_priority

Physical Architecture Flow Name: transit system data

Transit system operational data to be used for demand management within the traffic management functions

- Logical Architecture Reference Flow: transit_running_data_for_demand

- Logical Architecture Reference Flow: transit_services_for_demand

Transit Management -> Transit Driver

Physical Architecture Flow Name: route assignment

Route assignment for transit driver

- Logical Architecture Reference Flow: ttd_route_assignements

Transit Management -> Transit Fleet Manager

Physical Architecture Flow Name: actual schedule and fare info

Real time or batched accumulated schedule and fare information

- Logical Architecture Reference Flow: ttfm_parameters
- Logical Architecture Reference Flow: ttfm_paratransit_service
- Logical Architecture Reference Flow: ttfm_passenger_loading_error
- Logical Architecture Reference Flow: ttfm_coordination_request
- Logical Architecture Reference Flow: ttfm_transit_vehicle_data
- Logical Architecture Reference Flow: ttfm_response_parameter_output
- Logical Architecture Reference Flow: ttfm_technician_information
- Logical Architecture Reference Flow: ttfm_transaction_reports
- Logical Architecture Reference Flow: ttfm_transit_driver_information
- Logical Architecture Reference Flow: ttfm_proposed_corrections
- Logical Architecture Reference Flow: ttfm_transit_services_output
- Logical Architecture Reference Flow: ttfm_transit_vehicle_maintenance_information

Transit Management -> Transit Maintenance Personnel

Physical Architecture Flow Name: work schedule

Orders for maintenance of transit or traffic system

- Logical Architecture Reference Flow: ttmp_work_schedule

Transit Management -> Transit System Operators

Physical Architecture Flow Name: transit operator display

Display for transit operations personnel regarding performance of the transit fleet, current ridership and on-time performance

- Logical Architecture Reference Flow: ttso_transaction_reports
- Logical Architecture Reference Flow: ttso_potential_incidents_alarm
- Logical Architecture Reference Flow: ttso_transit_fare_output

- Logical Architecture Reference Flow: ttso_media_parameters
- Logical Architecture Reference Flow: ttso_emergency_request
- Logical Architecture Reference Flow: ttso_potential_security_problem

Transit Management -> Transit Vehicle Subsystem

Physical Architecture Flow Name: bad tag list

List of invalid charge or value card numbers

- Logical Architecture Reference Flow: bad_tag_list_update

Physical Architecture Flow Name: driver instructions

Instructions for paratransit driver

- Logical Architecture Reference Flow: paratransit_transit_driver_instructions
- Logical Architecture Reference Flow: paratransit_transit_driver_instructions
- Logical Architecture Reference Flow: transit_services_for_corrections
- Logical Architecture Reference Flow: transit_services_for_eta
- Logical Architecture Reference Flow: approved_corrective_plan

Physical Architecture Flow Name: emergency acknowledge

Acknowledge request for emergency assistance and provide additional details regarding actions and verification requirements

- Logical Architecture Reference Flow: request_transit_user_vehicle_image
- Logical Architecture Reference Flow: transit_operator_request_acknowledge

Physical Architecture Flow Name: request for vehicle measures

Request to return vehicle performance and maintenance data

- Logical Architecture Reference Flow: transit_vehicle_collected_maintenance_data_request

Physical Architecture Flow Name: schedules, fare info request

Transit requests

- Logical Architecture Reference Flow: transit_services_for_vehicle_fares
- Logical Architecture Reference Flow: transit_vehicle_advanced_payment_response
- Logical Architecture Reference Flow: transit_vehicle_fare_payment_debited
- Logical Architecture Reference Flow: transit_vehicle_fare_data
- Logical Architecture Reference Flow: transit_vehicle_fare_payment_request
- Logical Architecture Reference Flow: confirm_vehicle_fare_payment

Physical Architecture Flow Name: traveler information

Traveler routing, yellow pages, etc.

- Logical Architecture Reference Flow: other_services_vehicle_response

Transit System Operators -> Transit Management

Physical Architecture Flow Name: transit operator fare schedules

Fare schedule requirements

- Logical Architecture Reference Flow: ftso_security_action
- Logical Architecture Reference Flow: ftso_request_fare_output
- Logical Architecture Reference Flow: ftso_media_parameter_updates
- Logical Architecture Reference Flow: ftso_emergency_request_acknowledge
- Logical Architecture Reference Flow: ftso_fare_updates
- Logical Architecture Reference Flow: ftso_media_parameter_request

Transit Vehicle Subsystem -> Transit Management

Physical Architecture Flow Name: emergency notification

Mayday notification by a traveler could be on foot, or in any vehicle. Routing is eventually to an Emergency Management Center but may be forwarded by any other organization. Message may contain location and nature of emergency.

- Logical Architecture Reference Flow: transit_operator_emergency_request
- Logical Architecture Reference Flow: transit_emergency_details
- Logical Architecture Reference Flow: transit_emergency_information
- Logical Architecture Reference Flow: transit_user_vehicle_image

Physical Architecture Flow Name: fare and payment status

Status of cash box on transit vehicle

- Logical Architecture Reference Flow: fare_collection_vehicle_violation_information
- Logical Architecture Reference Flow: request_vehicle_fare_payment
- Logical Architecture Reference Flow: transit_vehicle_advanced_payment_request
- Logical Architecture Reference Flow: transit_vehicle_fare_payment_confirmation

Physical Architecture Flow Name: request for bad tag list

Request for list of bad fare card id numbers

- Logical Architecture Reference Flow: bad_tag_list_request

Physical Architecture Flow Name: transit vehicle conditions

Conditions of transit vehicle for maintenance

- Logical Architecture Reference Flow: paratransit_transit_vehicle_availability
- Logical Architecture Reference Flow: transit_driver_consideration_inputs
- Logical Architecture Reference Flow: transit_vehicle_collected_maintenance_data
- Logical Architecture Reference Flow: transit_vehicle_collected_trip_data

Physical Architecture Flow Name: transit vehicle passenger and use data

Data collected on board the transit vehicle

- Logical Architecture Reference Flow: transit_vehicle_passenger_data

Physical Architecture Flow Name: traveler information request

Request for any type of traveler information

- Logical Architecture Reference Flow: other_services_vehicle_request
- Logical Architecture Reference Flow: transit_services_for_eta_request

Physical Architecture Flow Name: vehicle probe data

Single vehicle probe data indicating link time and location.

- Logical Architecture Reference Flow: transit_vehicle_arrival_conditions
- Logical Architecture Reference Flow: transit_vehicle_location_for_store
- Logical Architecture Reference Flow: transit_vehicle_location_for_deviation
- Logical Architecture Reference Flow: transit_vehicle_location
- Logical Architecture Reference Flow: transit_vehicle_schedule_deviation
- Logical Architecture Reference Flow: transit_vehicle_deviations_from_schedule
- Logical Architecture Reference Flow: transit_vehicle_eta

Payment Instrument -> Transit Vehicle Subsystem

Physical Architecture Flow Name: payment

Payment of some kind by user

- Logical Architecture Reference Flow: fpi_transit_vehicle_tag_data
- Logical Architecture Reference Flow: fpi_confirm_fare_payment_on_transit_vehicle

Transit Driver-> Transit Vehicle Subsystem

Physical Architecture Flow Name: transit driver inputs

Transit driver instructions to vehicle and management subsystems

- Logical Architecture Reference Flow: ftd_emergency_request
- Logical Architecture Reference Flow: ftd_fare_transaction_mode_set_up
- Logical Architecture Reference Flow: ftd_information_updates

- Logical Architecture Reference Flow: ftd_request_batch_mode_data_transfer

Transit User -> Transit Vehicle Subsystem

Physical Architecture Flow Name: emergency notification

Mayday notification by a traveler. Could be on foot, or in any vehicle. Routing is eventually to an Emergency Management Center but may be forwarded by any other organization. Message may contain location and nature of emergency

- Logical Architecture Reference Flow: ftu_emergency_request
- Logical Architecture Reference Flow: ftu_transit_user_vehicle_image

Physical Architecture Flow Name: transit user inputs

Requests from transit user through on-board traveler information station

- Logical Architecture Reference Flow: ftu_other_services_vehicle_request
- Logical Architecture Reference Flow: ftu_request_advisory_information
- Logical Architecture Reference Flow: ftu_destination_on_vehicle

Transit Vehicle -> Transit Vehicle Subsystem

Physical Architecture Flow Name: vehicle measures

Sensing information from vehicle sensors

- Logical Architecture Reference Flow: ftv_vehicle_maintenance_data
- Logical Architecture Reference Flow: ftv_vehicle_trip_data
- Logical Architecture Reference Flow: ftv_availability

Transit Vehicle Subsystem -> Payment Instrument

Physical Architecture Flow Name: request for payment

Request for individual transaction with user

- Logical Architecture Reference Flow: tpi_request_fare_payment_on_transit_vehicle
- Logical Architecture Reference Flow: tpi_debited_payment_on_transit_vehicle

Transit Vehicle Subsystem -> Roadway Subsystem

Physical Architecture Flow Name: local signal priority request

Request between vehicle and roadside

- Logical Architecture Reference Flow: transit_vehicle_roadway_preemptions

Transit Vehicle Subsystem -> Transit Driver

Physical Architecture Flow Name: transit driver display

Display (either video or audio) to transit driver or status of ITS services

- Logical Architecture Reference Flow: ttd_transit_vehicle_schedule_deviations
- Logical Architecture Reference Flow: ttd_request_fare_transaction_mode_set_up
- Logical Architecture Reference Flow: ttd_paratransit_information
- Logical Architecture Reference Flow: ttd_emergency_information
- Logical Architecture Reference Flow: ttd_corrective_instructions
- Logical Architecture Reference Flow: ttd_batch_mode_data_transfer_status

Transit Vehicle Subsystem -> Transit User

Physical Architecture Flow Name: transit user fare status

Status of fare transaction for transit user

- Logical Architecture Reference Flow: ttu_vehicle_payment_confirmed

Physical Architecture Flow Name: transit user outputs

Information for traveler from on-board traveler information station

- Logical Architecture Reference Flow: ttu_advisory_information
- Logical Architecture Reference Flow: ttu_vehicle_access_message
- Logical Architecture Reference Flow: ttu_other_services_vehicle_confirmed

Transit Vehicle Subsystem -> Vehicle

Physical Architecture Flow Name: traveler advisory request

In vehicle communication between transit and vehicle systems

- Logical Architecture Reference Flow: transit_user_advisory_information_request
- Logical Architecture Reference Flow: transit_user_advanced_payment_on_vehicle

Vehicle -> Transit Vehicle Subsystem

Physical Architecture Flow Name: vehicle location

Location of vehicle which is exchanged between the vehicle subsystems

- Logical Architecture Reference Flow: transit_user_advisory_information
- Logical Architecture Reference Flow: transit_user_vehicle_credit_identity
- Logical Architecture Reference Flow: vehicle_location_for_transit

★ **Useful National ITS Architecture documents: Physical Architecture**