Standards Requirements Document

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1. Standards Requirements Document Executive Summary

The Standards Requirements Document ("*SRD*") collects information from the other National ITS Architecture program documents and reorganizes it in a manner intended to support the development of critical ITS standards. The key results in the SRD are a reference model for the National ITS Architecture, a rating scheme for evaluating the standardization issues associated with individual data flows that make up the architecture interfaces, and then a set of priority groupings of interfaces into standards requirements "packages". These results and the major conclusions are summarized below.

The introductory section explains the structure of the SRD and its intended usage. The strategy is that the reference model provides the overall context for a standards development organization ("*SDO*"). A given SDO can pull a particular package of standards requirements out of the document and then use the reference model as a quick reference to the overall architecture. More detailed needs will require going to the original source documents, such as the Logical or Physical Architectures.

The next section provides the rationale for several different ratings schemes applied to the architecture interconnects and flows. These include interoperability requirements, technology maturity assessments, and stakeholder interest. For Version 1.0 of the National ITS Architecutre, all architecture interconnects were examined with respect to these measures. The stakeholder interest and interoperability requirements in particular were then used as the basis for selecting the standards requirements packages. In general, interfaces associated with mobile systems had both the greatest stakeholder interest and the most stringent interoperability requirements. Following close behind were interfaces associated with Traffic Management and Information Service Provider subsystems.

The Architecture Reference Model is provided next as a high level definition of the components that form the National ITS Architecture. It depicts the interconnectivity of the subsystems and terminators, their definitions, and suitable types of communications strategies. This reference model is an important tool for communicating the full breadth of the architecture at an abstracted level. In the SRD it is intended as a contextual reference, but, as a separate document, the reference model has received international circulation through the International Organization of Standardization (ISO) as a basis for documenting and comparing ITS architectures.

The "meat" of the SRD is the set of standards requirements packages. Each package is a special grouping of standards requirements and contextual information intended to be used in a nearly standalone fashion by an SDO. Thus, packages have been selected that cover the key ITS priorities, maintain the integrity and vision of the National ITS Architecture, and also are perceived as having an interested stakeholder constituency that will help drive standardization. This is a difficult balancing act, but the following 14 packages were identified as covering the high priority standardization needs for the architecture program:

1. Dedicated Short Range Communications (DSRC)
2. Digital Map Data Exchange and Location Referencing Formats
3. Information Service Provider Wireless Interfaces
4. Inter-Center Data Exchange for Commercial Vehicle Operations
5. Personal, Transit, and HAZMAT Maydays
6. Traffic Management Subsystem to Other Centers (except EMS)
7. Traffic Management Subsystem to Roadside Devices and Emissions Monitoring
8. Signal Priority for Transit and Emergency Vehicles
9. Emergency Management Subsystem to Other Centers
10. Information Service Provider Subsystem to Other Centers (except EMS and TMS)
11. Transit Management Subsystem Interfaces
12. Highway-Rail Intersections (HRI)
13. Archived Data Management Interfaces

14. Maintenance and Construction Management Interfaces

These 14 areas cover much of the National ITS Architecture and represent the distillation of stakeholder interests and architecture interoperability requirements. If standardization can be achieved in the near term for all or most of these packages, then ITS will be a long ways towards achieving the original vision captured in the user service requirements.

For this version of the Standards Requirements Packages, some of the changes from Version 3.0 to Version 4.0 of the National ITS Architecture are reflected in the addenda found on the Version 4.0 CD-ROM and website. Addenda were compiled to reflect the smaller changes to affected Standards Requirements Packages that did not necessitate a wholesale rewrite. Addenda have been created for Standards Requirements Packages 1, 2, 3, 5, 6, 7, 9, 10 and 11.

2. Introduction to the Standards Requirements Document

One of the goals of the National ITS Architecture program is to support and promote the process of standardization. Specifically, it is hoped that the Architecture will expedite standards development efforts by providing a technical direction and a stimulus. It is hoped that these ITS standards will, in turn, stimulate public and private sector interest in ITS, by creating a perception of lowered deployment risk and better protection of investments.

The Architecture can support better standards because it has planned a system that covers a full 32 user services (as described in the ITS America *National Program Plan*) over a twenty year time frame. Taking a rigorous system engineering perspective on this process is a luxury few standards efforts would be able to afford. As a result, the Architecture provides a snapshot of a total system in its standards requirements, and not just a piece of the picture. Given this data, a committee developing a standard might not choose to address all the requirements, but at least they would understand all that had bearing on their task and the implications of their actions.

As an example, a standard to support Traffic Management Center (TMC) to roadway device communications might neglect an expansion capability to provide status on railroad crossings or communication with beacons for transit signal priority, if the standards developers were not aware of a long term need for these capabilities. By pointing out the need and the benefits of addressing additional requirements, the Architecture can help produce a standard that will allow a standards-compliant TMC to be upgraded easily over time.

The second benefit, that the Architecture requirements can expedite the standards process, is based on the stimulus that the standards requirements can give to the standardization process. Because standards committees are primarily populated by industry volunteers who usually have other full time responsibilities, it can be difficult to get the first piece of work done that creates a strawman draft. Once that draft is created, though, it is usually easier to find committee members willing to work on the review and tuning process. The standards requirements generated by the Architecture provides a framework for developing a draft, as well as some of the specific information required for the draft. This is a substantial boost to the process. If there is genuine interest in a specific standard, then the standards requirements information will help get a draft formulated and circulating much more quickly.

The systems engineering process behind the Architecture leads to a self-consistent set of documents. That is, traceability is maintained between them, and assumptions are clearly stated and consistently applied across them. The full set of National ITS Architecture documents have been submitted to substantial stakeholder scrutiny and have been revised where needed to reflect the consensus view. The current Architecture documentation is the best available reference set at this time on how a national Intelligent Transportation System can be developed and deployed. The National ITS Architecture will be maintained and updated, to preserve this relevancy in the future

In order to develop standards, it is necessary to understand the readiness and applicability of technologies, the anticipated needs over time of stakeholders, the theory of how a system will work, and many more pieces of information. The Architecture program is targeted directly at creating and documenting this type of information.

By creating this reference material through the Architecture program, it is possible to understand how a hundred varied efforts can be contributing to the development of a seamless interoperable national transportation system. The alternative, that of no National ITS Architecture, would be for standards to be solely driven by market forces. While this would work perfectly well for some areas, it is very unlikely it would converge on a national system or stimulate the type of ITS industry currently envisioned. The Architecture effort provides the keystone for ensuring that the broad picture is preserved as the narrower interests are pursued.

2.1 Scope of this Document

The *Standards Requirements Document* (SRD) is intended to identify the priority standardization needs and gather together the Architecture information that would support developing these priority standards. The supporting material is in the form of an architectural context for the specific standardization activity and then standards requirements applicable to the standard. A standards development organization (SDO) drafting committee would then utilize this information as an input to help develop a draft standard.

The SRD differs from the *Standards Development Plan* (SDP) both in scope and intent. Both the SRD and the SDP are targeted at SDOs and others interested in promoting standards. But the SDP provides a broader view and addresses the implications of standards over time. It is intended to explain how the Architecture supports standardization and how different activities initiated from the Architecture will interrelate to each other. By comparison, the SRD is focused on aiding specific standardization initiatives. It is a document to be pulled apart and worked with, rather than to be consulted and reflected upon, like the SDP.

Another difference between the SRD and the SDP is that the SDP is largely composed of material unique to that document. The SDP deals with previously unaddressed (aside from white papers) standardization considerations. The SRD, on the other hand, is composed primarily of material drawn from other documents and then reorganized and annotated specifically to support the standardization process.

2.1.1 What are "Standards Requirements"

A brief definition of a standard requirement versus a standard is in order, to clarify what it is that this document contains. The material in the Architecture, while comprehensive, is typically not at a sufficient level of detail that it can be transitioned directly into a draft standard. What are present are definitions of interfaces, the semantic content of messages that pass across those interfaces, and some indications of the class of technology suitable for each interface. These items, collectively, represent the requirements that can be derived from the Architecture. An actual standard would dictate a *specific* interface (or interfaces), *specific* message sets and protocols, and *specific* technology for implementation. To satisfy the goals and intent of the National ITS Architecture program, these specifics of a given standard should also satisfy the requirements delineated in the Architecture. These Architecture requirements are collected in this document, as *standards requirements*, to facilitate this process.

The above explains the "*what*" of standards requirements. The Architecture program has also identified where standards are needed to address the issue of interoperability. This is the "*why*" of standards requirements. Interoperability is the key to achieving many of the goals of the Architecture that are dependent on cooperating and communicating systems. Further on in this document we will discuss some of the stakeholder feedback that was used to try to identify the priority areas in the Architecture for standardization.

2.2 Content of the Standards Requirements Document

As shown in Figure 2-1, the SRD has several parts. The key pieces of information are the Architecture Reference Model (ARM) and the packages of standards requirements that are intended to support specific standardization activities. The figure indicates the items included in each of these portions of the SRD. The ARM is discussed in detail in Section 4. The contents of a standards package will be briefly considered here.

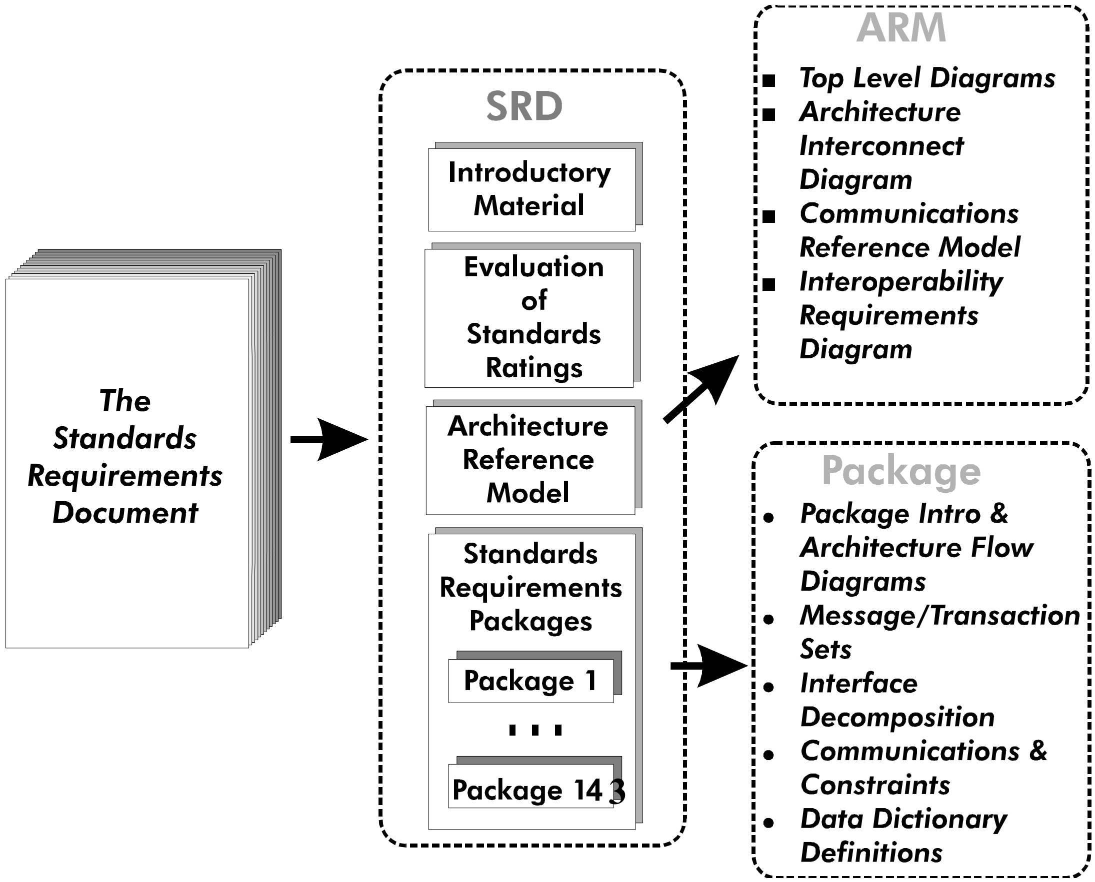

Figure 2-1. The Form and Content of the Standards Requirements Document

Some perspectives that we have used to select what constitutes a standards requirements package:

1. *Total Subsystem Interface*
2. *Technology*
3. *Critical Interface*
4. *User Service or Stakeholder*

These four criteria for grouping together sets of requirements are each appropriate in specific circumstances. This will be developed further in Section 3.

A standards requirements package contains the standards requirements associated with a specific subset of the National ITS Architecture subsystems and data flows. The introductory material in the package will show the subsystems and data flows involved, in an Architecture Flow Diagram (AFD). The remainder of the standards requirements package explains the theory of operation of the interface(s) in the package via the message sets used and offers a collection of information and requirements associated with the data flows.

2.3 Sources of Standards Requirements

Essentially all of the Architecture documents provide pieces of information relevant to the standardization process. Some documents are used directly as sources of standards requirements. Others provide important background on why certain standards are deemed critical or on dependencies between different activities. This subsection will briefly detail some of the roles the documentation plays in the standards recommendations that the Architecture program is developing.

The following list addresses the entire process for identifying and supporting standards through the National ITS Architecture. Area 3 covers the documents that were drawn on in generating the specific content of this document. However, to omit the others would obfuscate the process of selecting what would be presented and how.

1. ***Identifying potential areas for standardization***
   a. Theory of Operation

      Explanation of how a user service is implemented.

   b. Physical Architecture

      Identification of interfaces between physical subsystems and terminators, and explanation of functionality of subsystems.

   c. Market Packages Document

      Identification of pacing/enabling technologies and deployment timing assumptions.

2. ***Prioritizing potential standards***
   a. Market Packages Document

      Identification of technology constraints, user service deployment timing, and stakeholders who operate different subsystems, all of which are required to assess the need and appropriateness of standards.

   b. Theory of Operation

      Identification of subsystems involved in the end-to-end provision of the user services.

   c. Physical Architecture

      Identification of subsystem functionality.

3. ***Developing standards requirements***
   a. Mission Definition

      Operational requirements that dictate system-level performance requirements that apply to interfaces and subsystems.

   b. Theory of Operation

      Explanation of how a user service is implemented and the message set sequences for implementing a service (a transaction set).

   c. Logical Architecture

      Functional requirements from the process specifications, message set requirements, transaction sets of messages, data element definitions, and size estimates from the data dictionary.

   d. Physical Architecture

      The PA specifies the physical subsystems, interfaces, and architecture flows that compose the interfaces.

   e. Market Packages Document

      Identifies critical technology requirements and timing interrelationships between different activities. Also describes market packages, which can be used to identify sets of interfaces that are related through their support of a common user service.

   f. Communications Analysis (not updated for version 4.0)

This augments the data dictionary message set requirements and size estimates with frequency-of-message estimates and overall interface loading information. Also communications requirements for types of service and the operational modes.

4. ***Planning for standards development***

   a. Market Packages Document

      Definition, in "roadmap" style of dependencies and timing of architecture implementation. This in turn dictates the timing of implementing different standards to support specific interfaces or services. Identification of pacing and enabling technologies and time frames. Identification of user/consumer communities for different services. Roll out of user services over time.

   b. Standards Development Plan (not updated for version 4.0)

      Discussion of how the architecture products can facilitate the development of standards.

Not identified in this list are stakeholder workshops, the results of other ITS programs, feedback on the Architecture white papers, and a host of other external interactions. These activities were critical to selecting the format and content of this document. These will be discussed in Section 3.

2.4 Types of Standards

A thorough discussion of types of standards and where they are appropriate is offered in the Standards Development Plan. However, a quick summary is offered here.

There are three types of standards commonly cited:

- *Regulatory Standards* - typically generated under government supervision and enforced by law. These are standards intended to bound the sets of acceptable approaches and to protect the welfare of individuals and society. Product operational safety is sometimes an area of regulatory standardization.
- *Voluntary Standards* - these are standards reached through a consensus process by a standards setting organization. Virtually all industry standards are voluntary standards.
- *De Facto Standards* - these are not actually standards, but rather practices which are accepted by convention. Typically enough documentation exists to allow individuals to build systems to the de facto specification. Often, industry products that are very successful are adopted as de facto standards without going through an actual consensus standardization process.

All of these types of standards will come into play in ITS. Regulatory standards will be required for vehicle control and automated operation, as well as possibly for human interfaces in certain safety-related areas. Most ITS standards will probably be voluntary standards from industry, with perhaps some stimulus from the government. And finally, as early winners in various ITS product arenas emerge, de facto standards will also be recognized.

2.5 From Standards Requirements to Standards

A few words are appropriate in this introductory section about the process of going from the standards requirements packages in this document to a set of standards. The decision by an SDO to develop and maintain a standard is a significant one; it represents both significant work to create the standard and also an ongoing responsibility to maintain and promulgate the standard. Thus no SDO will embark upon a program of work without some certainty that the effort represents the interests of the organization's members or constituency. The SRD has been designed to support the development of programs of work that will address key areas of ITS and to support developing specific standards within those programs of work. The SRD, however, does not provide draft standards or even outline specific programs of work. These are left as the responsibilities of the SDOs.

What the SRD does provide is a distillation of the National ITS Architecture into standalone pieces that have known, interested stakeholders. These pieces, in the form of standards requirements packages, are viewed as appropriate bases for developing a program of work for one or more SDOs. Individual standards would then be defined that represented parts of the particular standards requirements package or that were evolutionary steps in the process of deploying the package. To preserve the integrity and functionality of the National ITS Architecture, though, it is expected that ultimately all the interfaces in the standards requirements packages would be standardized.

What the standards requirements packages primarily capture is information flows; what data must be exchanged to support particular functions. This is far short of a message set and a protocol. This means that “high level” descriptions of the data exchanges are developed in the packages, but these may lead to multiple sets of messages with more complex actual exchanges required to create a full protocol. As examples, the SRD material does not typically distinguish between initialization, on going, and terminating message exchanges; most are simply treated as on going. Beyond the basic request-response exchange, handshaking activities are not depicted. The reason for this is that the Architecture itself is largely implementation-neutral; areas that would require implementation decisions that would tie the Architecture to a particular approach were not specified.

What the standards requirements packages do offer are the interface attributes, information flows, and constraints necessary to realize the National ITS Architecture’s envisioned functionality. By developing a program of work and standards within this framework, an SDO can contribute to the grand vision of creating a national, interoperable Intelligent Transportation System.

3. Standards and Rating the Physical Architecture Data Flows

Note: This section has not been updated for version 4.0. For reference use.

To make decisions about where standardization is required, it is necessary to analyze the Physical Architecture from a number of perspectives. The simplest is, of course, determining where interfaces exist. These interfaces then are focused upon as likely aspects for standardization. This information is captured in the Architecture Interconnect Diagram (AID) that forms part of the Architecture Reference Model.

However, the next level of consideration for standards is the definition of standards requirements and content. This is the primary concern of this document. To meaningfully discuss standards requirements, it is necessary to examine the actual data flows that comprise the architecture interfaces. These data flows are associated with message and transaction sets that are used to accomplish ITS activities. There are often logical groupings of these data flows that share some common attributes, which makes it desirable that they be considered for standardization as a set.

Some perspectives that we have used to group data flows:

1. *Total Subsystem Interface* - the set of all data flows associated with a particular subsystem. Standardizing this defines how this subsystem will interact with all the different entities with which it connects. An example would be all the interfaces to the Traffic Management Subsystem.
2. *Technology* - the set of all data flows which share some distinguishing enabling technology. An example would be all the data flows that require Dedicated Short Range Communications (DSRC).
3. *Critical Interface* - the set of data flows associated with a single interface, or a small number of related interfaces. Standardization for a single interface might be sought when that interface is a critical first step in achieving broader standards and deployment goals. An example would be the wireless Information Service Provider to Traveler interface.
4. *User Service or Stakeholder* - the set of data flows necessary to implement a particular user service, or to accomplish a particular stakeholder's deployment. This may involve a subset of data flows from each of a selection of interfaces. This perspective should track approximately to the market package concept. An example would be the data flows associated with electronic credentialing for Commercial Vehicle Operations.

These four perspectives represent four valid ways that the Architecture can be divided into pieces intended to support standards. Ideally, the process of selecting the appropriate perspectives and defining the standards requirements packages would be a responsive one rather than a normative one. That is, the standards requirements are selected and packaged together in response to stated stakeholder needs, rather than based on possibly abstruse architectural analyses. The current set of standards requirements packages in this document have tried to adhere to the idea of "stakeholder pull" as the basis for identifying the need for a standard.

Some architectural analysis is required, though. The broad perspective of the National Architecture allows us to provide information at a detailed level that can be of use to standards setting organizations trying to determine where to best focus their efforts for maximum benefit. Both this document and the Standards Development Plan offer some insight into scope of need and readiness of different areas of the Architecture for standardization. The next few subsections will discuss some of the analysis that has been performed on the architecture data flows.

3.1 Interoperability Issues

A central concern that drives standardization is the quest for interoperability between products. Typically a focus on interoperability leads to an examination of system interfaces; standardized interfaces can create a modular and expandable deployed system. For a discussion of the general benefits of interoperability, please refer to the Standards Development Plan document.

The Physical Architecture data flows have been examined with respect to the anticipated breadth of the interoperability need. For our purposes, interoperability is said to be required if a service supported by the Architecture is dependent on it. A four level scale has been applied to ranking the data flows, depicting the degree of interoperability necessary to satisfy the Architecture's needs. The levels, from greatest interoperability to least, are:

1. *National Interoperability* - the data flow should have a uniform standard on a national level. Failure to achieve national interoperability may ultimately threaten the service that the data flow supports. An example would be a data flow supplying travel information to a mobile traveler.
2. *Regional Interoperability* - the data flow supports a service that may require regional interoperation. Typically, the impact of adopting a standard that is only regionally recognized would not be great enough to warrant postponing deployment until a national consensus is reached. An example would be the incident alert data flow between a traffic management center and an emergency management center.
3. *Product Interoperability* - the data flow would benefit from standardization by allowing future technology upgrades and competitive selection of products. Virtually all situations benefit from product interoperability. However, product interoperability is viewed as a weaker need than geographic interoperability of some type, since it only constrains a deployer to use a standardized product, rather than to additionally conform to the choices of others in similar situations. An example would be data flows between a vehicle platform and its ITS devices; this is analogous to different radio connections for different car models.
4. *None* - in a few unique cases, stakeholders have expressed a desire to not pursue standardization of interfaces or aspects of interfaces, such as message sets. This is typically the case when there is a concern about protecting proprietary or sensitive information. An example is the assigned route message data flow between a fleet management center and a commercial vehicle.

Every effort has been made to uniformly rate the interoperability needs of the different data flows. However, there is inevitably some "art" in the process. A sample of some of the rules of thumb include:

- Assume the goal is universal payment media. Then most financial payments require *national interoperability*, rather than regional.
- If the data flow is between one center with a regional jurisdiction and another center that also has a regional jurisdiction, then *regional interoperability* is probably needed at a minimum.
- Human to subsystem data flows are rated as requiring *product interoperability*. This is intended as the equivalent of "look-and-feel". However, if the human is likely to encounter many different instances of the subsystem, then a *national interoperability* requirement is cited.
- Data flows to mobile subsystems are rated as requiring *national interoperability*. The exceptions are the data flows to the transit vehicle, which are rated as requiring *regional interoperability*.
- If the data flow is between two subsystems that are wholly owned and controlled by a single entity, then usually only *product interoperability* is specified.
- It is assumed users will ultimately buy digital map data separately from the devices that use it. Therefore this data requires *national interoperability*, based on the need to potentially obtain map updates for any region.
- Proximity interfaces, like vehicle presence or weight, do not receive interoperability ratings.

This interoperability rating is not intended to prioritize data flows for standardization. Rather, it provides a sense of how broad a consensus is required to meet the full service goals, from the standpoint of the National ITS Architecture. This information should definitely not be construed as encouraging "regional standards"; ultimately all standards should be national or even international ones. However, in many cases it may not be necessary to delay action until this level of standardization is reached.

3.2 Technology Issues

Typically a drive to achieve standardization requires both a perceived need for a standard and a set of candidate technologies that provide potential solutions. Standardization that does not address a need is useless, but standardization that is not based in practical technical solutions can actually delay progress. For a discussion of the risks of ill-timed standardization, see the Standards Development Plan document.

The issue for standards requirements definition is to try to determine the technical readiness of various data flows for standardization. This is somewhat subjective, since there are different technical options that some might view as adequate while others might consider them too primitive. In addition, we must define what part of the Architecture we are considering: is it the technology of the data flow itself or is it the technology of the functions that the data flow supports? For our purposes here, the interconnect technology suitable for the data flows is generally technically mature. So it is the functionality associated with the data flows that we are usually rating.

To assess the technical maturity, we use the scale developed in the Implementation Strategy document. There the scale was used to rate the pacing technologies that market packages depended on. Here we attempt to apply it at a much finer level, considering individual data flows. The levels are defined here as follow*s*:

- **Mature:** Current commercially available technology supports the identified ITS requirements associated with this data flow. Deployment of the ITS user services utilizing this data flow are not predicated on further research and development of these technologies.

- **Mature with rapid innovation:** Current commercially available technology supports the identified ITS requirements associated with this data flow. The area is one of rapid technology growth which indicates that the basic support provided by current technologies will likely be superseded within the deployment period. While further research and development are not required to support ITS, future deployments of this data flow may benefit from technology enhancements which should not be precluded by premature standardization or excessive zeal in standards enforcement.

- **Mixed:** Technology is available for the some of the functions associated with this data flow, but others are not supported by current technology. Useful services may be deployed using currently available technologies; however, satisfying all user service requirements will require additional research and development to bolster the identified deficiencies.

- **Immature:** Additional research and development is required before the technologies associated with this data flow can be cost-effectively and reliably applied to support ITS services. In some cases, potentially suitable technologies have been applied in advanced non-consumer applications. Additional research and development is still required in these areas to address the unique producibility, safety, and cost issues associated with larger commercial markets.

By examining the technology rating of the data flows, it is possible to make first order assessments of a number of issues: where to develop near-term standards, where to focus research efforts, what market packages are predominantly composed of mature technologies, etceteras. In particular for standardization, industry consensus will most easily be achieved in areas where there are viable technical solutions, but no entrenched solutions in the marketplace.

For brevity, in the figure depicting the technology maturity ratings, "*innovation*" is used as shorthand for the *mature with rapid innovation* category. This figure is shown in section 4.

3.3 User Interface Issues

Human operators and users of ITS are external to the Architecture system. This means that the National Architecture does not explicitly specify what the humans must do, but it does specify where human-machine interfaces exist and what information is exchanged across these interfaces. From the standpoint of standardization, there are issues that are of unique concern for the human factors aspects of these interfaces.

Safety and training are two areas that were identified as possible drivers for standardization concerns. Some human interfaces, like visual payment status signs at a parking facility, have no strong safety or training component or are adequately supported by de facto industry practices (or both). But some interfaces, like the various interfaces to vehicle drivers, have substantial human factors safety implications. In these areas, standardization may lead to both safer equipment and to a stimulation of markets, by providing guidelines to manufacturers to help limit legal liability.

A more formal statement of these user interface issues that could be used as the basis of an Architecture evaluation follow:

1. *Safety* - this data flow to or from a human user poses safety implications. The human user's responses to the data flow will impact the safety of the user or others that his actions affect.
2. *Training* - the human user of this data flow, typically a subsystem operator, will require significant training to interact with this data flow. Due to job mobility, encountering multiple instances of the relevant subsystem, or frequent changes/upgrades to the subsystem, consideration of standards to minimize training needs will result in improved effectiveness and reduced cost for this data flow.

The nature of the standards (e.g. voluntary, regulatory, etc.) to support human interfaces can fall into any category. However, this is one area where minimum level regulatory standards for the safety impacting data flows might help speed adoption of some mobile technologies. This suggestion should be validated with equipment and vehicle manufacturers.

The Architecture-generated standards requirements in this document do not address the possible need for human interface standards. The rationale for this is presented in Section 5, but the basic issue is that the part that would actually be standardized, the human factors portion, is not covered by the National ITS Architecture analyses and design. It is recommended, however, that the human interfaces be examined, to see if further development and subsequent standardization is warranted.

3.4 Stakeholder Priorities

The information provided above is the result of architectural analyses that include the stakeholder consensus process. However, in examining data flow standardization *needs*, as opposed to ratings or implications, the best source are the affected stakeholder themselves. Based on their day-to-day needs and plans, most stakeholders can clearly articulate at least the near term standards that they view as important.

We discuss below an architecture-specific workshop held to verify the top level Physical Architecture and to collect stakeholder priorities.

3.4.1 The 1995 Standards and Architecture Workshop

The "*1995 Standards and Architecture Workshop*" was held in Schaumberg, IL on July 10th and 11th. Seven stakeholder perspectives were represented in breakout groups with at least six attendees per group. The invite list consisted of both subject matter experts and standards development organization representatives. The breakout groups validated the overall Architecture Reference Model and the Physical Architecture data flows for their stakeholder area. In cases where errors were perceived, these were noted and provided to the Architecture Team.

The breakout groups then went through the data flows relevant to their interests, and selected their top priority choices for standardization. In some cases, items like glossaries of terminology were requested as standards.

This is interpreted as an indication of frustration with the rapid pace and impreciseness that currently characterizes ITS. These priorities are treated as outside the scope of this document, but they are definitely appropriate objects for standards activities.

Below are the seven breakout groups and their standards priority lists. These are edited slightly to conform to the architectural interpretation used in identifying the appropriate data flows and to use the current subsystem notation.

BREAK-OUT GROUP 1 -- PRIVATE VEHICLES AND THEIR EXTERNAL INTERFACES

(PV 1) Message content for VS to EMS
(PV 2) Consistency with 911 policy reporting requirements (VS to EMS)
(PV 3) Transponder for VS to Other Vehicle
(PV 4) Communications protocol for VS to Other Vehicle
(PV 5) ATIS media standard for VS to ISP (Broadcast ATIS reception and interactive ATIS)
(PV 6) Broadcast ATIS media independent applications standard for ISP to VS (Broadcast ATIS reception)
(PV 7) Dynamic toll collection communications
(PV 8) Dynamic toll collection applications
(PV 9) In-vehicle signage communications for Roadway to VS
(PV 10) In-vehicle signage message content

BREAK-OUT GROUP 2 -- FREIGHT MOVEMENT (INTERMODAL) - COMMERCIAL VEHICLES AND THEIR EXTERNAL INTERFACES

(CV 1) VRC air link for CVS to CVCS
(CV 2) Message sets for CVS to CVCS
(CV 3) Transaction sets for CVS to CVCS
(CV 4) Message sets for CVAS to CVCS (clearance authorization)
(CV 5) Transaction sets for CVAS to CVCS (clearance authorization)
(CV 6) Message sets for FMS to CVAS
(CV 7) Transaction sets for FMS to CVAS
(CV 8) HAZMAT MAYDAY message set for CVS to EMS
(CV 9) Wide-area wireless airlink and transmission for CVS to EMS
(CV 10) Message sets for CVAS to Government Agency
(CV 11) Transaction sets for CVAS to Government Agency
(CV 12) Message sets for CVAS to other CVAS
(CV 13) Transaction sets for CVAS to other CVAS
(CV 14) Human factors for visual/audible pass/pull-in/other data for CVS to CV Driver
(CV 15) Message sets for CVAS to CVCS (Event data)
(CV 16) Transaction sets for CVAS to CVCS (Event data)

BREAKOUT GROUP 3 -- EMERGENCY VEHICLES AND THEIR EXTERNAL INTERFACES

(EV 1) Message set for real-time notification of incidents between the Emergency Management System (EMS) and other agencies (Transit Management Center, Traffic Management Center, E-911, Information Service Provider, Fleet Management System, et al)
(EV 2) Real-time communication of incident notifications to travelers via RTS, PIAS, PVS and CVS interfaces
(EV 3) Signal control protocol for emergency vehicle priority

BREAKOUT GROUP 4 -- PUBLIC TRANSIT VEHICLES & THEIR EXTERNAL INTERFACES

(TV 1) Physical layer standard for electronic fee payment between Transit vehicle (TRVS) and electronic payment system
(TV 2) SAE standards J1708 & J1587 should be expanded to account for the TRVS card reader

device

(TV 3) Message sets for data between Transit Management System (TRMS) and Traffic Management System (TMS) - including probe data.

(TV 4) Common glossary of terms and data dictionary for traffic and transit

(TV 5) OSI layers 3, 4, & 5 for NTCIP protocols and the extension to support interaction between the TRVS and RS to support signal priority & operational data exchange

(TV 6) Standards for signal priority and data exchange between Transit Vehicle Subsystem and roadway

(TV 7) Message list for emergency call and notification

(TV 8) Message list for itinerary planning between Transit Management System (TRMS) and Personal Information Access System (PIAS), ISP, Remote Traveler Support (RTS)

(TV 9) Message sets data exchanged between different Transit Management Systems (The main interest in this standard is to facilitate multimodal / interagency transfer connection protection).

(TV 10) Message set for data exchange between ISP and Alternate Transport Service Provider (for reservation and dispatch of demand responsive services)

BREAK-OUT GROUP 5 -- DATA COLLECTION AND DELIVERY FOR TRAFFIC AND ROADSIDE (SENSING-MESSAGING-DATA FUSION)

(RS 1) VRC communication standard
(RS 2) VRC message set protocol
(RS 3) VRC fee collection message set
(RS 4) NTCIP traffic flow/control devices message set
(RS 5) VRC electronic signage
(RS 6) ISP parking management
(RS 7) Signal preemption
(RS 8) NTCIP environmental sensing message set
(RS 9) Multi-modal preemption
(RS 10) VRC access control message set
(RS 11) Standard for AHS
(RS 12) Standard for intersection collision avoidance
(RS 13) Passive location coding

BREAK-OUT GROUP 6 -- TRAFFIC MANAGEMENT

(TMS 1) Message standard (application layer) and format for TMC to ISP
(TMS 2) NTCIP (National Traffic Control/ITS Protocol) for TMC to Roadway
(TMS 3) Human interface standards and terminology guidelines for end users and operators
(TMS 4) Traffic center to traffic center message set format for status, system information, traffic data, access/control, AVI, AVL, and coordination

BREAK-OUT GROUP 7 -- INFORMATION SERVICE PROVIDERS

(ISP 1) Standard message list for ISP to VS/PIAS, traffic management, transit management, etc. (request and response, MAYDAY)
(ISP 2) Transaction Sequences (request and response, MAYDAY)
(ISP 3) Location referencing standard
(ISP 4) Minimum bandwidth capacity for ISP to VS/PIAS
(ISP 5) Message set for ISP to VS/PIAS and other elements (common syntax for ISP messages)
(ISP 6) Message sequencing protocol (transaction sets)
(ISP 7) Message definition (syntax)

The various Physical Architecture data flows that are associated with the standards priorities above have been labeled accordingly, to allow both specific analysis of the standards ratings associated with each data flow and to allow more general analyses, such as identification of equipment or market packages that have high stakeholder interest. These results are summarized in the following table, Table 3-1. This table depicts the mapping of the stakeholder breakout group interests, reported above, to the interfaces in the Physical Architecture. The assignment of interests was actually performed on the data flows and then abstracted up to the interface level for brevity. The priority column in Table 3-1 is encoded to reflect the Workshop breakout groups and their priorities, as presented in the previous list. As an example, the second, third, and fourth priority items for the Commercial Vehicles breakout group is denoted as “CV(2,3,4)”. Although there have been changes to the Physical Architecture Data Flows since the workshop, the set of flows applicable at the time of the workshop are used in this table.

Table 3-1. Stakeholder Interest in Architecture Interfaces

source	destination	Priority	Interface Name
Commercial Vehicle Administration	Commercial Vehicle Check	CV(4,5,15,16)	Database update
Commercial Vehicle Administration	DMV	CV(10,11)	license plate number
Commercial Vehicle Administration	Fleet and Freight Management	CV(6,7)	credentials and compliance reports
Commercial Vehicle Administration	Government Administrators	CV(10,11)	tax-credentials-fees request
Commercial Vehicle Administration	Other CVAS	CV(12,13)	credentials and database information
Commercial Vehicle Check	Commercial Vehicle Administration	CV(4,5,15,16)	inspection reports and problem reports
Commercial Vehicle Check	Commercial Vehicle Subsystem	CV(1,2,3) RS(1,2)	request for tag data and results of screens
Commercial Vehicle Subsystem	Commercial Vehicle Check	CV(1,2,3) RS(1,2)	clearance data on tag
Commercial Vehicle Subsystem	Commercial Vehicle Driver	CV(14)	alerts, messages and pull-in information
DMV	Commercial Vehicle Administration	CV(10,11)	vehicle owner
Emergency Management	Fleet and Freight Management	ISP(1,2,4,5,6,7)	HAZMAT information request
Emergency Management	Personal Information Access	EV(2)	emergency acknowledge
Emergency Management	Remote Traveler Support	EV(2)	emergency acknowledge
Emergency Management	Vehicle	PV(1,2)	emergency acknowledge
Emergency Vehicle Subsystem	Roadway Subsystem	EV(3) RS(1,2,7)	emergency vehicle preemption request
Emissions Management	Traffic Operations Personnel	TM(3)	pollution data display
Fleet and Freight Management	Commercial Vehicle Administration	CV(6,7)	credentials applications
Fleet and Freight Management	Emergency Management	EV(1)	HAZMAT information
Government Administrators	Commercial Vehicle Administration	CV(10,11)	regulations
Information Service Provider	Emergency Management	ISP(1,2,4,5,6,7)	request for information and emergency route info
Information Service Provider	Fleet and Freight Management	ISP(1,2,4,5,6,7)	trip plan
Information Service Provider	Intermodal Transportation Service Provider	TRV(10) ISP(1,2,4,5,6,7)	intermodal information
Information Service Provider	Parking Management	ISP(1,2,4,5,6,7) RS(6)	parking data and reservation request
Information Service Provider	Personal Information Access	EV(2)	trip plans and traveler information
Information Service Provider	Remote Traveler Support	EV(2) ISP(1,2,4,5,6,7)	trip plans and traveler information
Information Service Provider	Toll Administration	ISP(1,2,4,5,6,7)	request for toll schedules
Information Service Provider	Traffic Management	ISP(1,2,4,5,6,7) TM(1)	road use info, req for traffic info, route plans
Information Service Provider	Transit Management	TRV(8) ISP(1,2,4,5,6,7)	transit and paratransit requests, routes
Information Service Provider	Vehicle	PV(5,6) EV(2) ISP(1,2,4,5,6,7)	trip plans and traveler information
Intermodal Transportation Service Provider	Information Service Provider	TRV(10)	intermodal information
Intermodal Transportation Service Provider	Transit Management	TRV(10)	intermodal information
Location Data Source	Personal Information Access	ISP(3)	position fix
Location Data Source	Vehicle	ISP(3) RS(3)	position fix
Map Update Provider	Emergency Management	ISP(3)	map updates

source	destination	Priority	Interface Name
Map Update Provider	Emissions Management	ISP(3)	map updates
Map Update Provider	Information Service Provider	ISP(3)	map updates
Map Update Provider	Personal Information Access	ISP(3)	map updates
Map Update Provider	Remote Traveler Support	ISP(3)	map updates
Map Update Provider	Traffic Management	ISP(3)	map updates
Map Update Provider	Transit Management	ISP(3)	map updates
Map Update Provider	Vehicle	ISP(3)	map updates
Other CVAS	Commercial Vehicle Administration	CV(12,13)	credential information exchange
Other TM	Traffic Management	TM(4)	TMC coord.
Other TRM	Transit Management	TRV(9)	TRMS coord
Other Vehicle	Vehicle	PV(3,4)	vehicle to vehicle coordination
Parking Management	Information Service Provider	ISP(1,2,4,5,6,7) RS(6)	parking lot data
Parking Management	Vehicle	RS(1,2,3,6)	request for payment
Payment Instrument	Transit Vehicle Subsystem	TRV(1,2)	payment
Personal Information Access	Emergency Management	EV(2)	emergency notification
Personal Information Access	Transit Management	TRV(8) ISP(1,2,4,5,6,7)	demand responsive transit request
Remote Traveler Support	Emergency Management	EV(2)	emergency notification
Remote Traveler Support	Information Service Provider	ISP(1,2,4,5,6,7)	trip request, yellow pages request, confirmation
Remote Traveler Support	Transit Management	TRV(8)	transit, traveler requests, emergency notification
Roadway Subsystem	Multimodal Crossings	RS(9)	grant right of way and/or stop traffic
Roadway Subsystem	Traffic Management	RS(4) TM(2)	local traffic flow, requests for right-of-way
Toll Collection	Vehicle	PV(7,8) RS(1,2,3)	request for payment
Traffic Management	Construction and Maintenance	TM(3)	work schedule
Traffic Management	Emergency Management	EV(1)	incident notification and information request
Traffic Management	Emissions Management	RS(4)	pollution state data request
Traffic Management	Information Service Provider	ISP(1,2,4,5,6,7) TM(1)	traffic information
Traffic Management	Other TM	TM(4)	TMC coord.
Traffic Management	Roadway Subsystem	EV(3) TRV(5,6) RS(4) TM(2)	control, signage information
Traffic Management	Traffic Operations Personnel	TM(3)	traffic operations data
Traffic Management	Transit Management	TRV(3)	signal priority status and price change request
Traffic Operations Personnel	Emissions Management	TM(3)	pollution data parameters
Traffic Operations Personnel	Traffic Management	TM(3)	traffic control
Transit Management	Emergency Management	EV(1) TRV(7)	security alarms
Transit Management	Information Service Provider	TRV(8) ISP(1,2,4,5,6,7)	transit fares, schedules, confirmations
Transit Management	Intermodal Transportation Service Provider	TRV(10)	intermodal information
Transit Management	Other TRM	TRV(9)	TRMS coord
Transit Management	Personal Information Access	TRV(8)	demand responsive transit route
Transit Management	Remote Traveler Support	TRV(8)	transit fares, schedules, traveler information
Transit Management	Traffic Management	TRV(3)	request for signal priority, fare information
Transit Vehicle Subsystem	Payment Instrument	TRV(1,2)	request for payment
Transit Vehicle Subsystem	Roadway Subsystem	TRV(5,6) RS(1,2,7)	local signal priority request
Vehicle	Driver	PV(8)	driver updates and transaction status
Vehicle	Emergency Management	PV(1,2)	emergency notification
Vehicle	Information Service Provider	TRV(3)	trip request, yellow pages request, confirmation
Vehicle	Other Vehicle	PV(3,4)	vehicle to vehicle coordination
Vehicle	Parking Management	RS(1,2)	tag data
Vehicle	Roadway Subsystem	RS(1,2)	probe data, AHS vehicle data
Vehicle	Toll Collection	PV(7,8) RS(1,2)	tag data
Weather Service	Traffic Management	RS(8)	weather information

3.5 Additional Issues for Prioritization Consideration

The examinations of possible standards needs have now looked at Architecture-based analyses of interoperability and other concerns, and at stakeholder priorities. A remaining issue worth considering is the standards process itself. In particular, two points are of concern: what standards are already under development and what is the appropriate geographic scope of a standardization effort.

3.5.1 Existing Standardization Efforts

A clear measure of the need and priority for standardization is obviously the active pursuit of a standard. JPL, under the sponsorship of US DOT, has produced an exhaustive catalogue of standards and standards activities relevant to ITS needs. The Architecture Team, has mapped this into the Physical Architecture at the interface level.

This has been augmented by a mapping of the US DOT ITS Standards program activities into the National ITS Architecture. This has been performed at the architecture flow level and below. This mapping effort, coupled with the mapping of the existing standards coverage in the original JPL database, has offered an overall assessment of the progress made to date on "standardizing ITS".

The National ITS Architecture standards requirements have been offered to new ITS standards efforts to provide a baseline of relevant existing material and avoid any redundant efforts. In general, the breadth and complexity of the National Architecture has made coordinating standards to maintain the integrity of the Architecture difficult. Utilization of existing standards and effective standardization efforts will be critical to the rapid development of a portfolio of standards suitable for implementing the National Architecture. Thus, the review of the existing and developing body of standards has been a critical first step in both rapid standardization and the overall coordination process.

A more thorough consideration of this area was offered in the Standards Development Plan document (the version 1.0 release), in Chapter 2 and in the appendices.

3.5.2 National versus International Standardization

The issue of what to standardize is the primary concern of this chapter. The Implementation Strategy document provides additional insight, especially on the question of "when" to standardize. The Standards Development Plan provides good guidance on "how" to standardize using the Architecture products as a base. One question left largely unanswered is "where" to standardize. This section considers the issue of seeking national versus international standards.

The scope of the National ITS Architecture program is, obviously, national. It would be unfortunate, however, to miss an opportunity to develop internationally accepted standards. Predicting how markets will develop and systems will deploy is difficult; early decisions to seek standardization at less than international levels can limit the size of the market that a product producer or integrator can address.

In some cases it is possible that the US ITS efforts can be "internationalized" with relatively little effort beyond what would be required for a domestic-only standard. This would most likely be the case in situations where there are no competing entrenched technologies. In these situations it may be worthwhile to initiate the standards process through an international standards body from the start, rather than trying to later promote a US standard into an international one. A non-ITS example of this type of situation is the development of the Asynchronous Transfer Mode (ATM) standards.

For areas where there are established competing ideas, standardization can be trickier. One problem is that standardization will almost inevitably establish winners and losers between different options. While this clarification of preferred technology can stimulate a market, the process of making the selection and creating the standard can be arduous. In these situations, expanding the scope of the standard from national to international may be impossible from the start. A non-ITS example of this type standard is the emerging US digital television standard.

The current National ITS Architecture interoperability ratings do not explicitly consider "international" interoperability needs. There are, however, subsets of the interfaces rated as requiring "national" or "product" interoperability that would benefit from an internationally recognized standard. We will briefly consider these here.

The interfaces rated as requiring “national” interoperability could be rated as “international” in situations where there would be benefit from full North American interoperability. These fall in two categories:

1. Dedicated short range communications
   - tolling
   - border clearance
   - in-vehicle signage
2. Advanced Vehicle Safety / Automated Highway Systems
   - vehicle-roadside communications (probably DSRC)
   - vehicle-to-vehicle coordination

The key idea here is that vehicles will move across the North American borders relatively freely. So there can be significant benefit from having the interfaces to the vehicle be internationally compatible.

In the “product” interoperability category, there are two issues that affect the market. The first is the buyer’s desire for multiple suppliers that all support a standard. This provides price competition and investment security. The second issue is the seller’s desire to have access to as large a potential market as possible. Both of these suggest that an international product standard is desirable in all cases.

A major issue for product standards for interfaces is that the owners and operators of the subsystems on each side of the interface may vary for different countries. While in the US a parking lot and an information service provider might both be separate private companies, in Britain they might both be owned by a government transport agency. Because of these different institutional arrangements the nature of the interface may change dramatically. This could make a single international standard very difficult to achieve.

In general, the “product” interoperability rated interfaces that pertain to travelers, such as interfaces to personal information access devices and kiosks, are the most likely candidates for international standardization. Other interfaces, like the one between emergency management and traffic management, will vary so widely between countries that attempting to achieve an international standard might simply delay the availability of a standard without achieving any net benefit.

3.6 Summary

In the analyses above, we have explained the perspectives available for grouping data flows into standards requirements packages. We have explained ratings systems for interoperability needs and technology readiness. And we have discussed our early efforts to embed stakeholder standards priorities and existing standards activities information into the Architecture. The result is a set of attributes for each Physical Architecture data flow that gives a rich set of information about the drivers for standardization and the implications of a standard. This data can also be coupled with other analyses such as cost and data loading to contribute additional information, or used in meta-level analyses such as “market package”-based recommendations for deployment timing.

4. The National ITS Architecture Reference Model

4.1 Introduction

To make decisions about where standardization is required, it is necessary to analyze the Physical Architecture from a number of perspectives. The primary analytical perspective is to determine where interfaces exist. These interfaces then are focused upon as likely aspects for standardization. The results of the interface-level analyses that are relevant to standardization are captured in this section as the National ITS Architecture Reference Model (ARM).

4.1.1 Purpose of the Architecture Reference Model

The Standards Requirements Document is intended to provide the raw material for the initiation of standards drafting work, or for the enhancement of ongoing standardization efforts. Essentially the "standards requirements" offered in this document are reorganizations of material from other documents, collected together to be more accessible for those who will use them. The accompanying danger in excerpting material is that some of the context will be lost. This may lead to narrow interpretations or the failure to explore secondary relationships that may gain significance in the future.

The ARM is intended to offer some of that "contextual background" that is lost in the requirements extraction process. A committee interested in drafting a standard, using one of this document's standards requirements packages as a starting point, could examine the ARM to understand how their subset of requirements, data flows, etceteras, fit into the overall Architecture. If necessary, questions raised in this process can be resolved by consulting the more detailed Theory of Operations, Logical, and/or Physical Architecture documents.

4.1.2 Components of the Architecture Reference Model

The architecture provides a framework through which stakeholders can efficiently implement ITS services which are interoperable. This framework is based on a collection of diagrams which represent different aspects of the architecture. The Architecture Reference Model is a set of four types of these diagrams and associated analyses that examine the Physical Architecture at the interconnect level. The four types of diagrams are:

1. The Physical Architecture *Top Level Diagrams*

   The top level diagrams are a hierarchy of highly abstracted representations of the physical architecture. They show the broad "classes" of entities that are in the Architecture. While they provide relatively little specific information about how the Architecture functions, the top level diagrams clearly show the small number of fundamental types of classes of subsystems and interactions. A very simple example follows:

Figure 4-1. Simplified Top Level Diagram Example

2. The Physical Architecture level 0 *Architecture Interconnect Diagram* (AID 0)

   This captures the physical architecture subsystems and terminators, and the aggregated interfaces that connecting them. The interconnects are actually composed of sets of data flows; the additional level of data flow detail is captured for specific portions of the Architecture in the standards requirements packages. The AID is an abstract representation in that it also provides basic information about the underlying communications layer required to support the architecture. A very simple example follows:

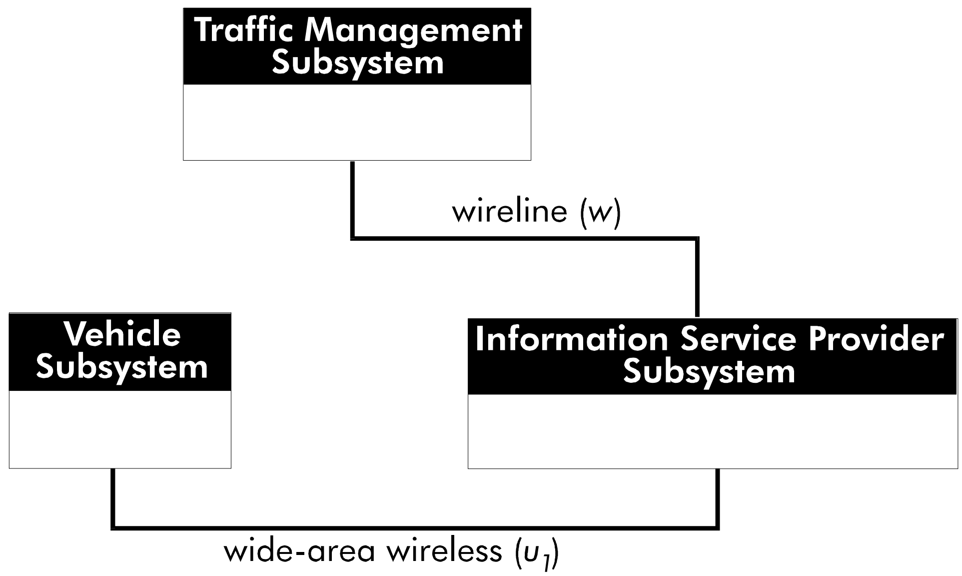

Figure 4-2. Example of an Architecture Interconnect Diagram (Level 0)

3. The *Communication Network Reference Model* (CRM)

   This set of diagrams indicates the appropriate communications technologies and standards needed to support the communications for implementation of the Physical Architecture. This captures the standards needs at the ISO reference model transport layer level and below. This reference model explains the communications options for the various interconnect types used in the AID 0. A very simple example follows:

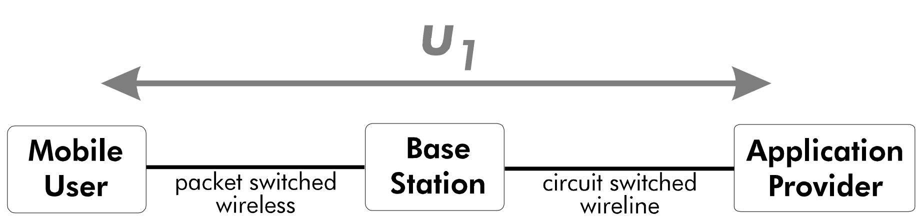

Figure 4-3. Simplified Communications Network Reference Model for Wide-Area Wireless Interconnects

4. The *Interoperability Requirements Diagram* (IRD)

   This is the AID 0 diagram, annotated to capture the expected interoperability requirements for the interconnects, based on an analysis of the requirements, the theory of operations, and the deployment strategy. A very simple example follows:

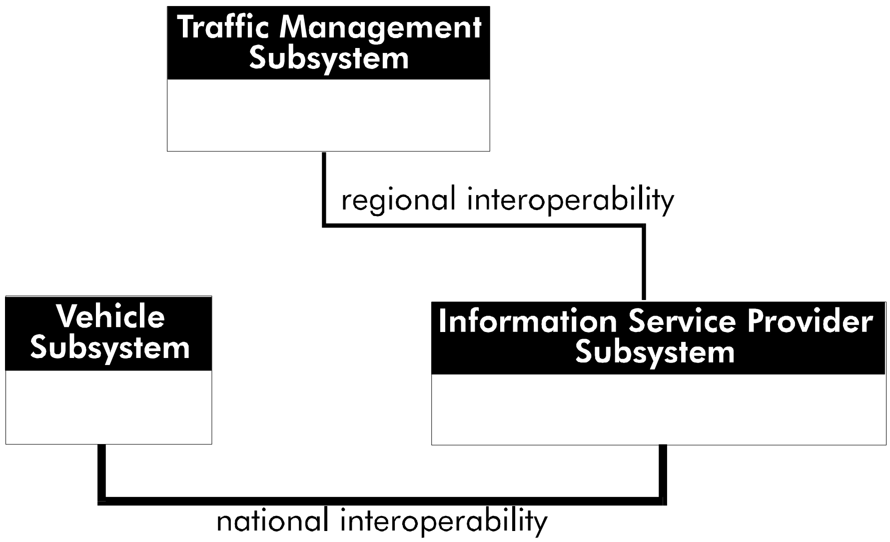

Figure 4-4. Interoperability Reference Diagram Example

These four items together form the National ITS Architecture Reference Model. They are required to interpret a full picture of the Architecture. For example, the Interoperability Requirements Diagram may imply the need for a standard for a particular interface. The AID 0 shows what type of interconnect is suitable for that interface. And then the Communications Network Reference Model shows the communications technologies that can be used to support that interface. All this information is then augmented with more specifics in the standards requirements packages, such as the data flow content, candidate technologies, and existing applicable standards for the interface of interest.

The following sections present the actual Architecture Reference Model.

4.2 Architecture Top Level Diagrams (TLD)

4.2.1 Very Top Level Simplified Architecture

The first set of ARM diagrams show the architecture at only the "top level". By top level we mean abstracted to a general set of categories or classes. This information portrays the fundamental nature of the entities both within and external to the National ITS Architecture.

A very simple view of the architecture is presented in Figure 4-5. The box in the center represents the architecture subsystems while the outside boxes represent collections of terminators with which the subsystems interact. The lines between boxes represent at a high level the interfaces to the ITS system. Five classes of physical entities are defined:

- *Subsystems* - These perform transportation functions (e.g., collect data from the roadside, perform route planning, etc.). All of the functions are define in the logical architecture as process specifications. Processes that are likely to be collected together under one physical agency, jurisdiction, physical unit are grouped together into a subsystem. This grouping is done to optimize the overall expected performance of the resulting ITS deployments taking into consideration anticipated communication technologies, performance, risk, deployment, etc. Significant detail is included for each of these subsystems and its interfaces.

- *Users* - These are people who interact with the architecture implementation. The people could either be travelers who use ITS to achieve travel goals, or operators of ITS who use features to streamline their operations, improve service, or make money. Each interface to a user involves human interaction with the system.

- *Other Systems outside ITS* - These are organizations or agencies that will likely interact with ITS through computer interfaces. These interfaces are similar to internal architecture interfaces

- *Environment* - This is the physical world of pavement, air, obstacles and so-on.

- *Other Subsystems within the Architecture* - There may be a multiplicity of instances of each of the Architecture subsystems. To adequately model the interaction between these multiple implementations, one representative of each subsystem is explicitly included in the diagrams while those which it communicates with are represented as Other Subsystems.

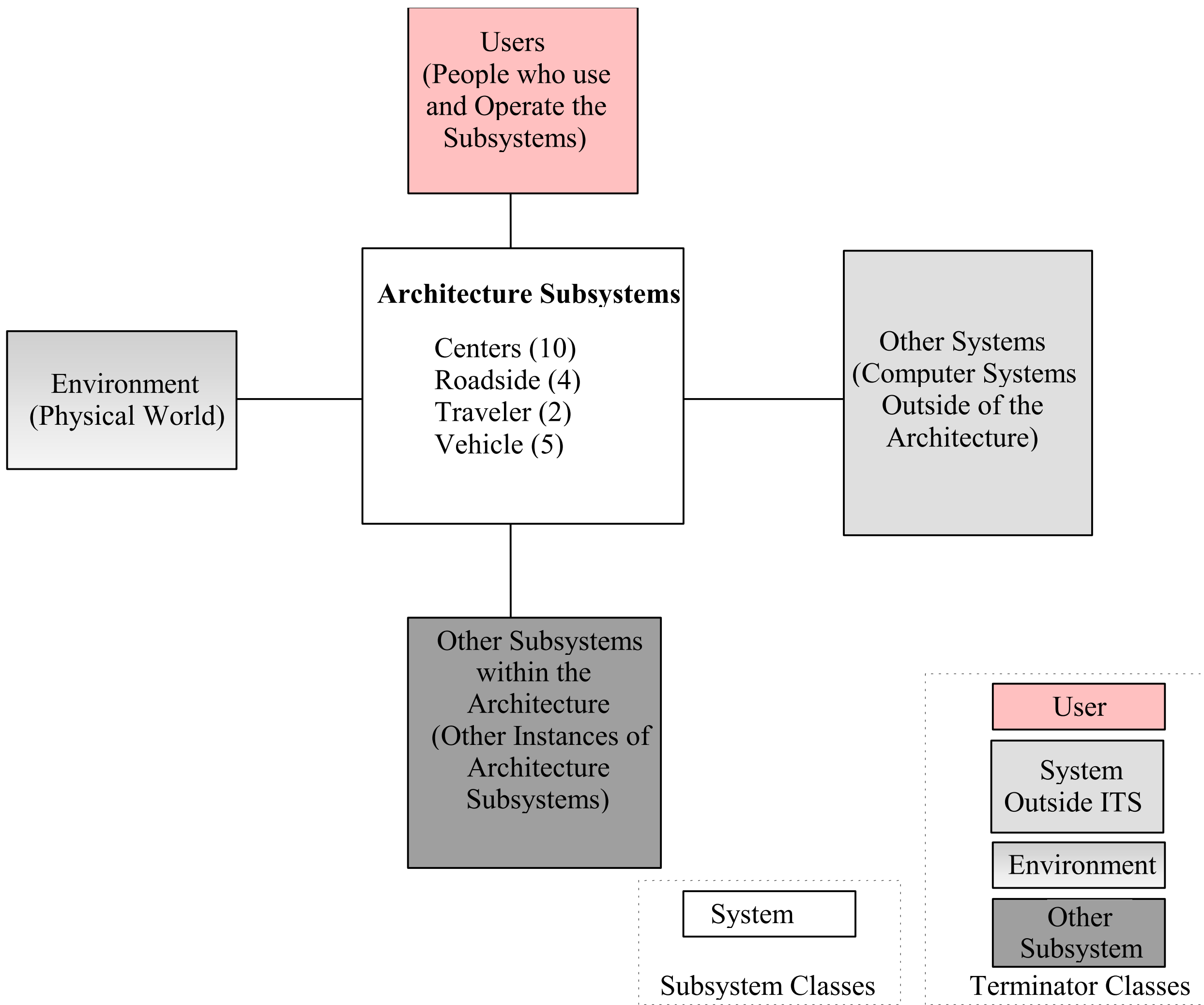

Figure 4-5. Simple View of ITS Architecture Structure

In ITS, there are four subclasses of subsystems, terminators, and users:

- Centers which collect and store information within the infrastructure
- Roadside which is deployed along the side of the road at many locations
- Vehicles
- Travelers representing ITS users with transportation needs

For example, other center systems may be a weather service or a law enforcement agency. Other subsystems within the Architecture could be peer Emergency Management subsystems or TMC's that reside in an adjacent jurisdiction.

Figure 4-6 presents a very top level simplified Architecture Flow Diagram. The diagram represents the four classes of subsystems, the terminators associated with each of the classes and the type of information that is exchanged between the classes. A definition of each of the entity classes in the figure is provided in Table 4-1.

The information types indicated in Figure 4-6 are exchanged between entity classes using different types of communication media. A very simplified view of this communications interface is provided in the Very Top

Level simplified Architecture Interconnect Diagram in Figure 4-7. The details of each of the interconnections are further explained in the communications layer of the architecture.

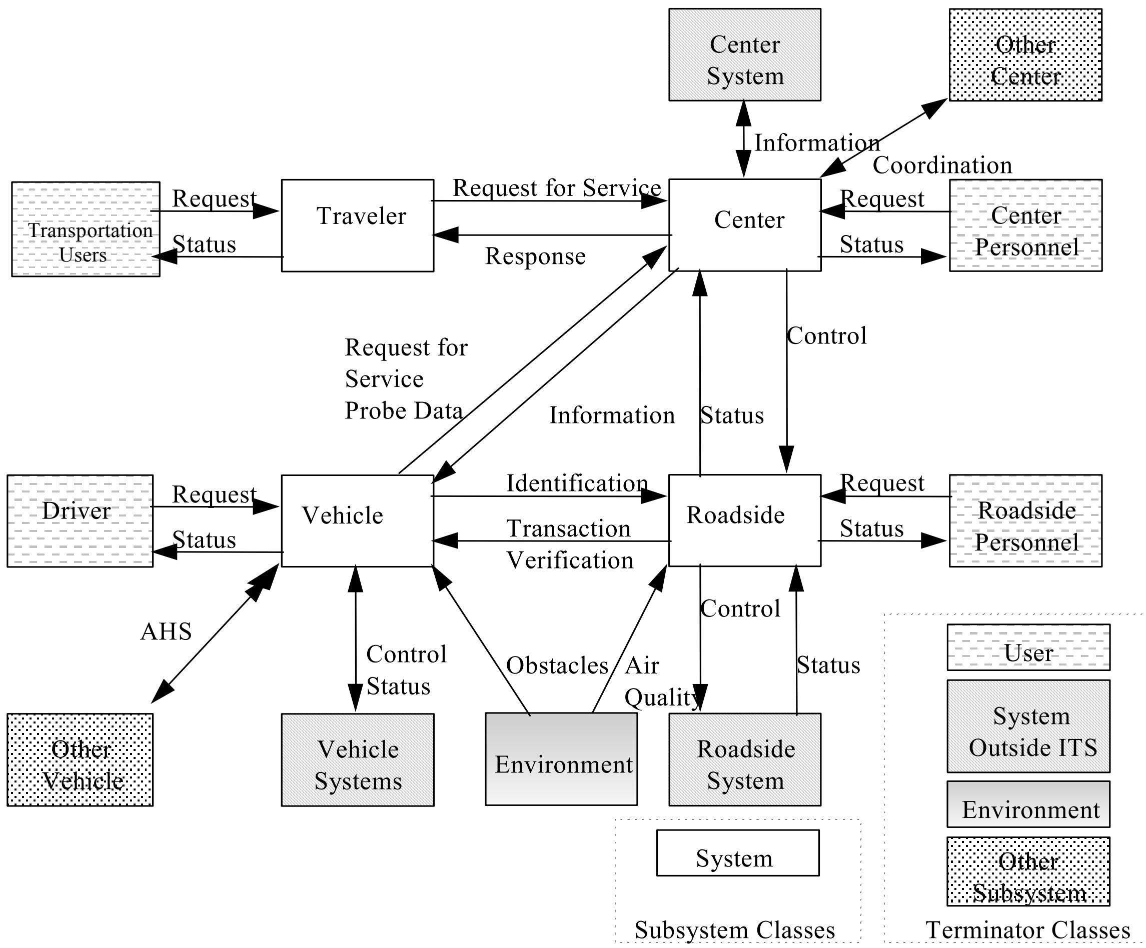

Figure 4-6. Very Top Level Architecture Flow Diagram

Table 4-1. Contents of Entity Classes

Entity	Entity Name	Entity Kind	Entity Class
ADMS	Archived Data Management Subsystem	Subsystem	Center
CVAS	Commercial Vehicle Administration	Subsystem	Center
CVCS	Commercial Vehicle Check	Subsystem	Roadside
CVS	Commercial Vehicle Subsystem	Subsystem	Vehicle
EM	Emergency Management	Subsystem	Center
EMMS	Emissions Management	Subsystem	Center
EVS	Emergency Vehicle Subsystem	Subsystem	Vehicle
FMS	Fleet and Freight Management	Subsystem	Center
ISP	Information Service Provider	Subsystem	Center
MCMS	Maintenance and Construction Management	Subsystem	Center
MCVS	Maintenance and Construction Vehicle	Subsystem	Vehicle
PIAS	Personal Information Access	Subsystem	Traveler
PMS	Parking Management	Subsystem	Roadside
RS	Roadway Subsystem	Subsystem	Roadside

Entity	Entity Name	Entity Kind	Entity Class
RTS	Remote Traveler Support	Subsystem	Traveler
TAS	Toll Administration	Subsystem	Center
TCS	Toll Collection	Subsystem	Roadside
TMS	Traffic Management	Subsystem	Center
TRMS	Transit Management	Subsystem	Center
TRVS	Transit Vehicle Subsystem	Subsystem	Vehicle
VS	Vehicle	Subsystem	Vehicle
X01	Intermodal Freight Shipper	Terminator	Center
X02	Multimodal Transportation Service Provider	Terminator	Center
X03	Basic Vehicle	Terminator	Vehicle
X06	Commercial Vehicle Driver	Terminator	Vehicle
X07	Commercial Vehicle Manager	Terminator	Center
X08	Basic Commercial Vehicle	Terminator	Vehicle
X09	Construction and Maintenance	Terminator	Center
X10	CVO Inspector	Terminator	Roadside
X12	Driver	Terminator	Vehicle
X13	Emergency Telecommunications System	Terminator	Center
X14	Emergency System Operator	Terminator	Center
X15	Emergency Personnel	Terminator	Vehicle
X18	Environment	Terminator	Roadside
X19	Event Promoters	Terminator	Center
X21	Financial Institution	Terminator	Center
X23	Map Update Provider	Terminator	Center
X24	Yellow Pages Service Providers	Terminator	Center
X26	Location Data Source	Terminator	Vehicle
X27	Media	Terminator	Center
X29	Multimodal Crossings	Terminator	Roadside
X30	Other EM	Terminator	Center
X31	Other ISP	Terminator	Center
X33	Other TRM	Terminator	Center
X34	Other Vehicle	Terminator	Vehicle
X35	Other TM	Terminator	Center
X36	Parking Operator	Terminator	Roadside
X38	Pedestrians	Terminator	Traveler
X39	Potential Obstacles	Terminator	Roadside
X41	Roadway Environment	Terminator	Roadside
X42	Secure Area Environment	Terminator	Roadside
X43	Toll Operator	Terminator	Roadside
X44	Toll Administrator	Terminator	Center
X45	Traffic	Terminator	Roadside
X46	Traffic Operations Personnel	Terminator	Center
X47	Transit Fleet Manager	Terminator	Center
X49	Transit System Operators	Terminator	Center
X50	Transit User	Terminator	Traveler
X51	Basic Transit Vehicle	Terminator	Vehicle
X52	Transit Driver	Terminator	Vehicle
X53	Transit Maintenance Personnel	Terminator	Center
X56	Traveler	Terminator	Traveler
X57	Vehicle Characteristics	Terminator	Roadside
X58	Weather Service	Terminator	Center
X59	Other CVAS	Terminator	Center
X60	Intermodal Freight Depot	Terminator	Center

Entity	Entity Name	Entity Kind	Entity Class
X61	Traveler Card	Terminator	Traveler
X62	Enforcement Agency	Terminator	Center
X63	ISP Operator	Terminator	Center
X64	DMV	Terminator	Center
X65	CVO Information Requestor	Terminator	Center
X66	Wayside Equipment	Terminator	Roadside
X67	Rail Operations	Terminator	Center
X68	Other Archives	Terminator	Center
X69	Archived Data User Systems	Terminator	Center
X70	Archived Data Administrator	Terminator	Center
X71	Other Data Sources	Terminator	Center
X72	Government Reporting Systems	Terminator	Center
X73	Other Parking	Terminator	Roadside
X74	Other Roadway	Terminator	Roadside
X75	Maintenance and Construction Center Personnel	Terminator	Center
X76	Maintenance and Construction Field Personnel	Terminator	Vehicle
X77	Surface Transportation Weather Service	Terminator	Center
X78	Other MCM	Terminator	Center
X79	Asset Management	Terminator	Center
X87	Basic Maintenance and Construction Vehicle	Terminator	Vehicle
X88	Maintenance and Construction Administrative Systems	Terminator	Center
X89	Equipment Repair Facility	Terminator	Center
X90	Other MCV	Terminator	Vehicle
X91	Storage Facility	Terminator	Center
X92	Trade Regulatory Agencies	Terminator	Center
X93	Care Facility	Terminator	Center
X94	Other Toll Administration	Terminator	Center

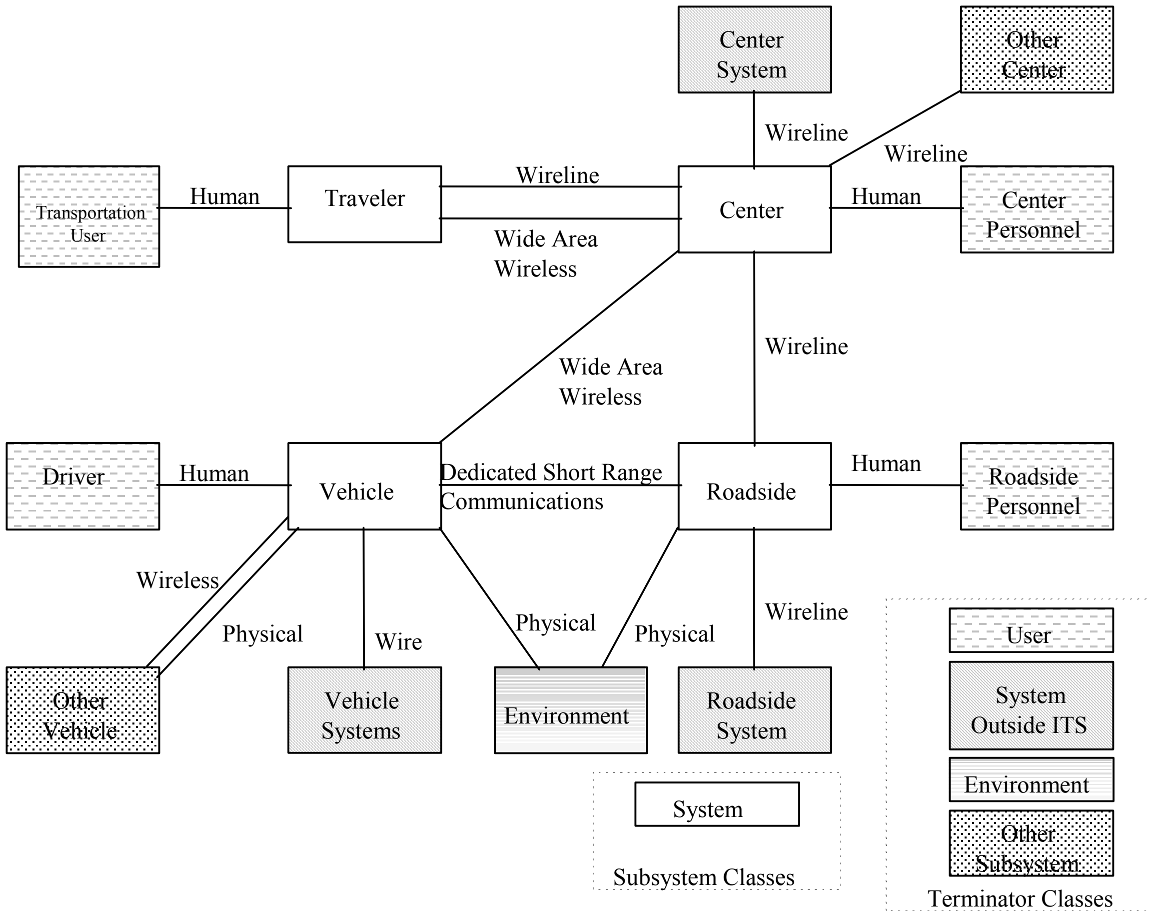

Figure 4-7. Very Top Level Architecture Interconnect Diagram

One of the end products of the architecture will be guidance regarding the areas where standards should be developed. To achieve nationwide interoperability, standards at interfaces between specific subsystems will be critical. A Very Top Level simplified Standards Reference Diagram that indicates the general area where standards will be required is presented in Figure 4-8. Significantly more detail indicating which specific subsystems are involved in each standard requirement and what data must be supported is provided later in this document.

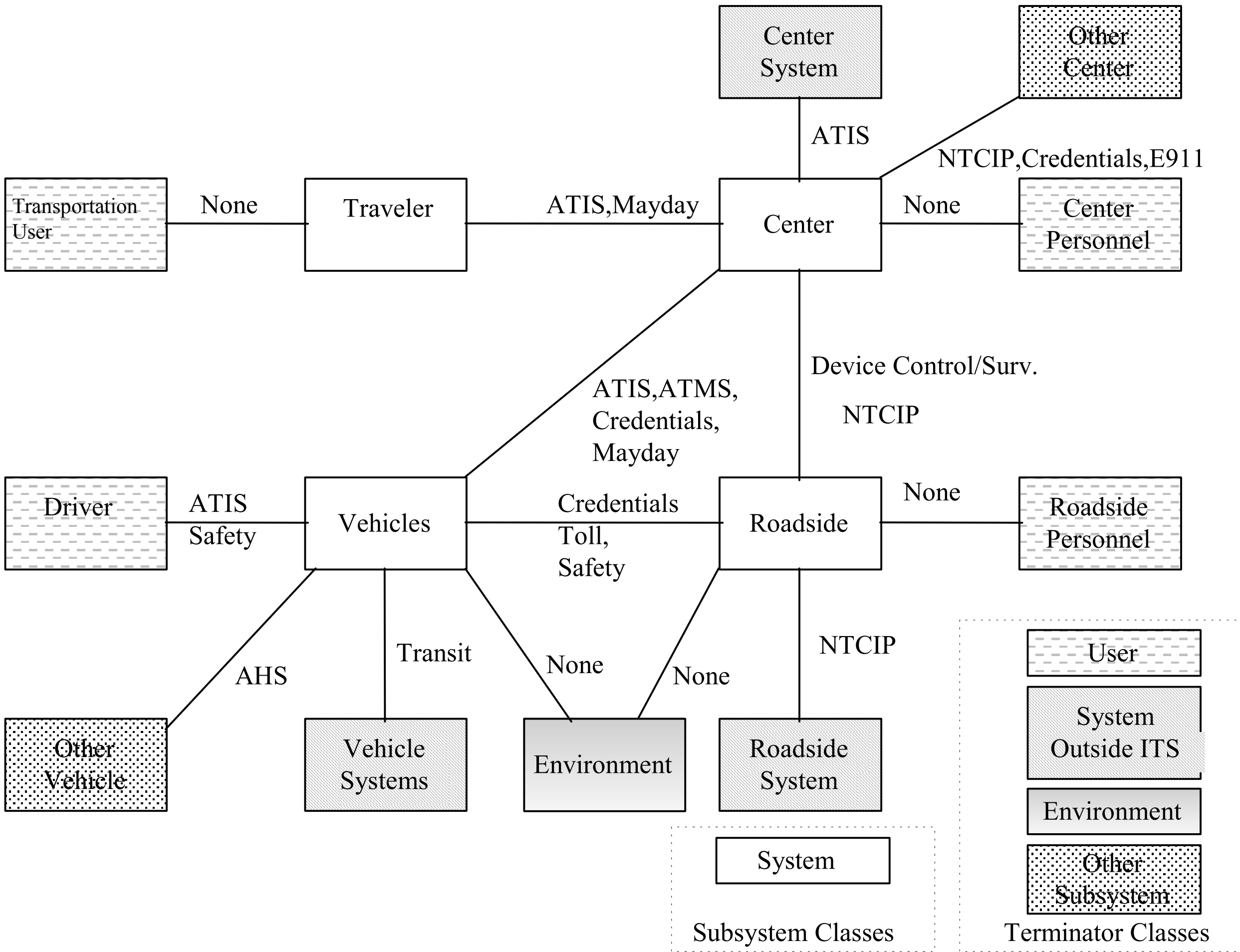

Figure 4-8. Very Top Level Standards Reference Diagram

Expanding each of the entity classes represented in Table 4-1 results in a detailed level 0 Architecture Flow Diagram. These diagrams are presented in the Physical Architecture document and in the standards requirements packages for the specific data flows covered in each package.

In general, the top level diagrams are useful as a starting point for understanding at a high level what is inside and what is outside of the National ITS Architecture. The top level diagrams are also useful as a framework for discussing system-level requirements for performance, reliability, etceteras. These types of requirements can often be developed at the entity class level, and then inherited by all the subsystems in that class. An example would be safety requirements for the vehicle entity class; the requirements would likely apply to all four vehicle subsystems.

The next section will present the Architecture Interconnect Diagram (AID), which is the next level of detail beyond the top level diagrams. The next level of detail beyond the AID are the Architecture Flow Diagrams (AFD). The AFDs do not form part of the Architecture Reference Model, but are presented for specific "viewpoints" in both the Physical Architecture document and in the standards requirements packages in this document.

4.3 Architecture Interconnect Diagram (AID)

The full set of subsystems and terminators, and their interconnectivity, are depicted in Figure 4-9. Also shown is the appropriate class of communications technology for the interconnect; the four available options (wireline, wide area wireless, short range dedicated wireless, and human interface) will be discussed further in the Communications Reference Model section.

4.3.1 Terminator Entity Descriptions

Entities which are outside of the Architecture are called *terminators*. The terminators are entities that Architecture subsystems must interface to, but to which the Architecture process cannot allocate any requirements or functionality. These subsystem-terminator interfaces are none-the-less critical, and many may require some form of standardization. Refer to the Physical Architecture documentation for definitions of the terminators.

4.3.2 Internal Entity Definitions

As previously shown in the top-level diagrams, the ITS architecture subsystems may be grouped into four distinct subsystem classes that share basic functional, deployment, and institutional characteristics. These classes are used to frame top level descriptions for each of the subsystems in this section. Definitions of the subsystems can be found in the Physical Architecture documentation.

4.3.2.1 Center Subsystems

The center subsystems (Table 4-2) provide management, administration, and support functions for the transportation system. The center subsystems each communicate with other centers to enable coordination between modes and across jurisdictions within a region. The center subsystems also communicate with roadside and vehicle subsystems to gather information and provide information and control that is coordinated by the center subsystems.

Table 4-2. Center Subsystems

Entity Name
Archived Data Management Subsystem
Commercial Vehicle Administration
Emergency Management
Emissions Management
Fleet and Freight Management
Information Service Provider
Maintenance and Construction Management
Toll Administration
Traffic Management
Transit Management

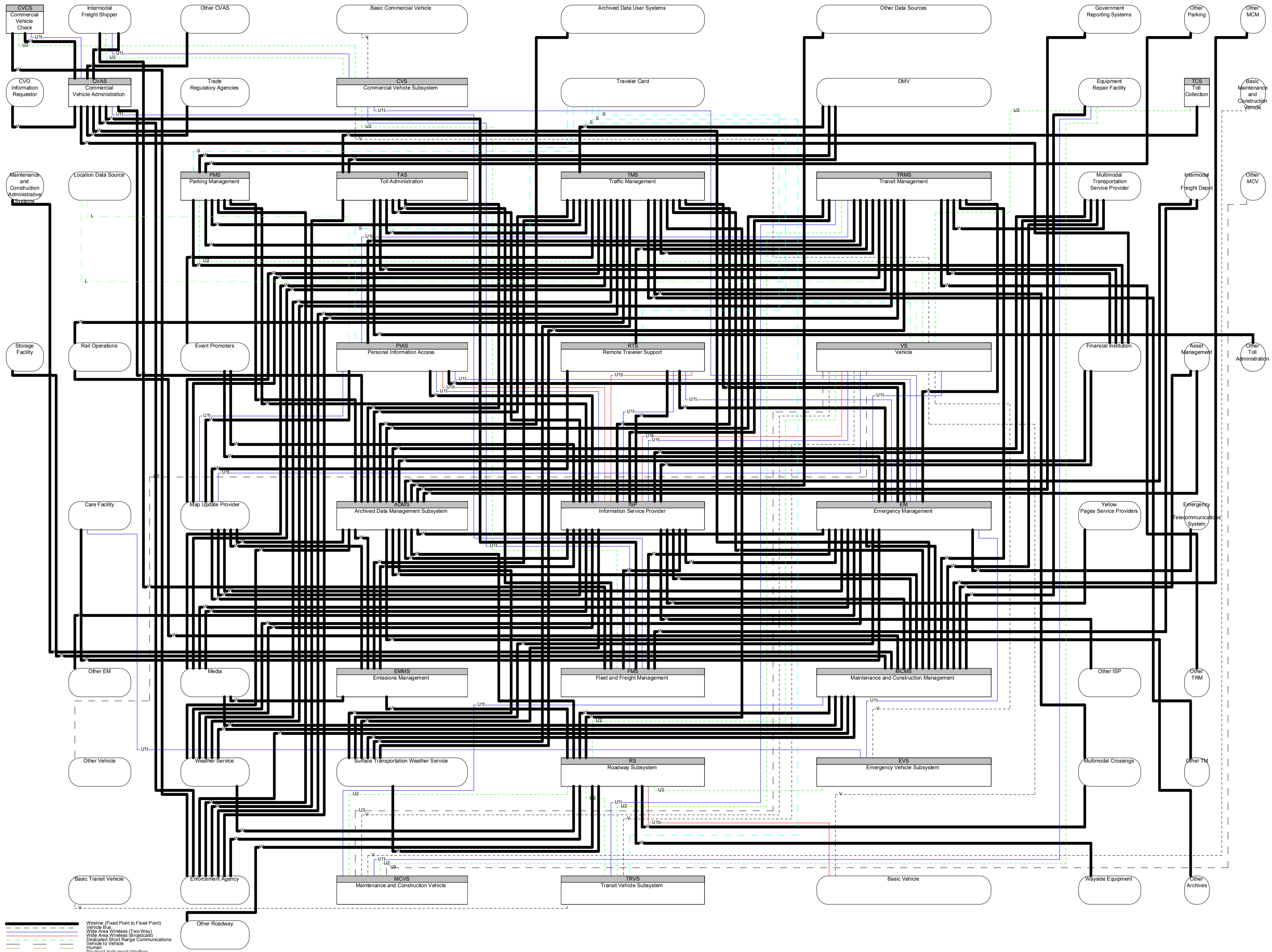

Figure 4-9. The Architecture Interconnect Diagram for Subsystems and Terminators

4.3.2.2 Roadside Subsystems

These infrastructure subsystems (Table 4-3) provide the direct interface to the roadway network, vehicles traveling on the roadway network, and travelers in transit. Each of the roadside subsystems includes functions that require distribution to the roadside to support direct surveillance, information provision, and control plan execution. All roadside subsystems interface to one or more of the center subsystems that govern overall operation of the roadside subsystems. The roadside subsystems also generally include direct user interfaces to drivers and transit users and short range interfaces to the Vehicle Subsystems to support operations.

Table 4-3. Roadside Subsystems

Entity Name
Commercial Vehicle Check
Parking Management
Roadway Subsystem
Toll Collection

4.3.2.3 Vehicle Subsystems

These subsystems (Table 4-4) are all vehicle-based and share many general driver information, vehicle navigation, and advanced safety systems functions. The vehicle subsystems communicate with the roadside subsystems and center subsystems for provision of information to the driver. The Vehicle Subsystem includes general traveler information and vehicle safety functions that are also applicable to the four fleet vehicle subsystems (Commercial Vehicle Subsystem, Emergency Vehicle Subsystem, Maintenance and Construction Vehicle Subsystem, and Transit Vehicle Subsystem). The fleet vehicle subsystems all include vehicle location and two-way communications functions that support efficient fleet operations. Each of the fleet vehicle subsystems also include functions that support their specific service area.

Table 4-4. Vehicle Subsystems

Entity Name
Commercial Vehicle Subsystem
Emergency Vehicle Subsystem
Maintenance and Construction Vehicle
Transit Vehicle Subsystem
Vehicle

4.3.2.4 Traveler Subsystems

The traveler subsystems (Table 4-5) include the equipment that is typically owned and operated by the traveler. Though this equipment is often general purpose in nature and used for a variety of tasks, this equipment is specifically used for gaining access to traveler information within the scope of the ITS architecture. These subsystems interface to the information provider (one of the center subsystems, most commonly the Information Service Provider Subsystem) to access the traveler information. A range of service options and levels of equipment sophistication are considered and supported. Specific equipment included in this subsystem class include personal computers, telephones, personal digital assistants (PDAs), televisions, and any other communications-capable consumer products that can be used to supply information to the traveler.

Table 4-5. Traveler Subsystems

Entity Name
Personal Information Access
Remote Traveler Support

4.3.3 Physical Architecture Flows

Entities are connected in the physical architecture flow diagram with architecture flows. The set of architecture flows between two entities comprises the *total* interface between those two entities. For the purposes of the Standards Requirements Document, the reference model is detailed only at the interconnect/interface level or above. The actual architecture flows and the logical architecture data flows are discussed in each standards requirements package as appropriate. For additional information on architecture flows and data flows, it is necessary to consult, respectively, the Physical Architecture and Logical Architecture documents.

4.4 Communication Network Reference Model (CRM)

The Communication Network Reference Model (CRM) defines the communications layer entities required to support the transportation layer physical data flows. That is, the nature of a given data flow will dictate the possible options for the communications systems that can support it. This section discusses the components of a generic CRM that can support the major wireless and wireline communications modes found in the National ITS Architecture. The interested reader is directed to the National ITS Architecture Communications Document for a more complete discussion of communications options and the architecture development process.

This section is an abstraction of material from the Physical Architecture and Communications documents. Readers who find this treatment insufficient for their needs are encouraged to consult these additional sources for more depth. For the purposes of the Architecture Reference Model, we present the high level analysis on the communications options for the National ITS Architecture.

4.4.1 Communication Architecture

The Communication Architecture is a generic communication model which illustrates the basic relationship between the ITS Physical Architecture's Transportation and Communication Layers. This generic communication model is based on the Open Systems Interconnection (OSI) model. The OSI model consists of seven layers: application, presentation, session, transport, network, data link, and physical layer. In general, the application, presentation, and session layers are supported by the Transportation Layer while the transport, network, data link and physical layers are supported by the Communications Layer. The Communication Architecture Section also provides definitions of the various components that make up the communication layer. Some of these components include: communication services, communication logical functions, communication functional entities, and communication network reference model. The communication network reference model is the primary ITS communication model.

The generic communication hierarchical model presented in Figure 4-10 shows the relationship between the Transportation and Communication Layers. Each data user can be one entity in the Transportation Layer (e.g., the Information Service Provider Subsystem or Vehicle Subsystem in an information exchange). The user does not care about and should not be concerned with the specifics of this information transfer layer. In fact, the Communication Layer can be viewed as plumbing that carries information from one user to another.

The complex makeup of the network is usually defined by system architectures developed to meet specific requirements, performance objectives, and socio-economic drivers. In the absence of crisp specifications and because of the jurisdictional-independence of this particular architecture, the end framework precludes the design of low level implementation details. However, to properly evaluate the communication architecture candidates, select technologies and detailed designs are recommended in an evaluatory design (see the National ITS Communication Document.)

The generic hierarchical communication model shown in Figure 4-10 follows the OSI model which organizes the communication network in a highly structured format to reduce its overall design complexity. This model is structured as a series of layers each with the function of providing certain services to the layer above and capable of conversing with the corresponding layer at the other end of the link. Thus the high level layers (e.g. ITS application) are shielded from the actual implementation details of the communication services. Different networks can use layers different from the OSI model, such as the IBM SNA (Systems Network Architecture).

When different protocols are used in different networks, an interworking function must provide the conversion between the protocols at the various levels.

The lowest layer in the OSI model is the physical layer (layer 1), which provides the transmission of bits over wires or radio links . Layer 2 is the data link layer, and is concerned with making the link appear to the receiver as bit error-free as possible by implementing error detection and correction (EDAC) coding schemes in the transceiver; one example is the use of a cyclic redundancy code (CRC) to a block or frame of the data and when the data passes the CRC check at the receiver, the returned acknowledgment indicates whether re-transmission is needed. Layer 3 is the network layer, which controls the operation of the network, where the key issue is routing packets, which is also used to generate billing information for the communications service provider; billing is tied to IP addresses. Layer 4 is the transport layer, which mediates between the session layer and the network layer, providing end-to-end accounting for all the data at the receiving end, and isolates the system from the changing physical technologies. Layer 5 is the session layer, which allows users on different machines to establish communications, or sessions, between them, involving ordinary data transport but with enhanced services such as remote log-in or file transfer. Layer 6, the presentation layer, performs syntax and semantic operations on the information transmitted between the users, such as encoding data in a standard way, or compressing or encrypting that data. Layer 7 is the application layer, which provides commonly used protocols for such tasks as terminal emulation, file transfer, electronic mail and remote job entry. (Note that for many ITS applications, layers 5 and 6 are absorbed into the application layer, layer 7.)

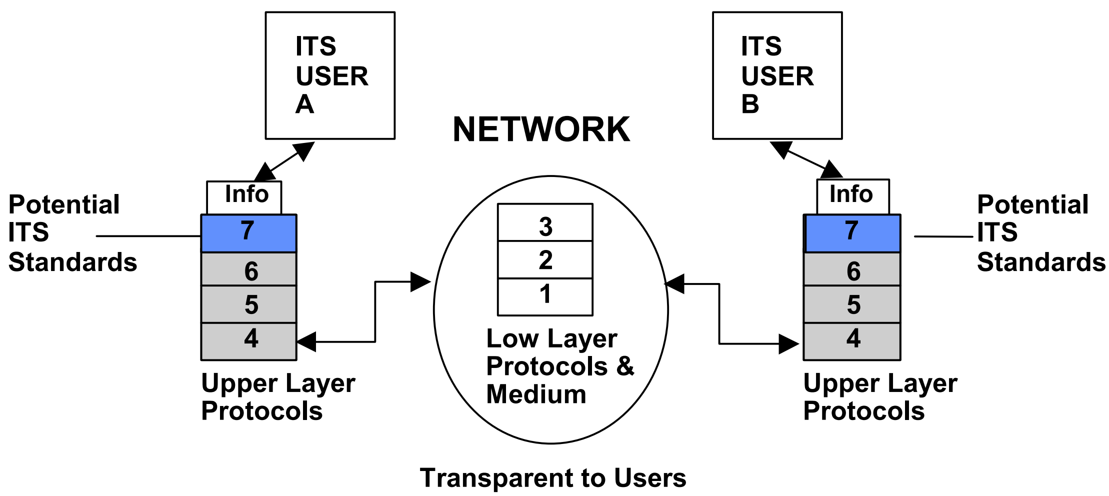

Figure 4-10. Generic Hierarchical Communication Model

From the Communication Layer perspective, the term "services" is defined according to communications governing bodies (*e.g.*, ITU, TIA, etc.), and should be used with care. That is, when describing a communications architecture, one should not refer to Route Guidance or Pre-trip Planning as services. Rather, they are applications in need of a communication service. Elaborating more along these lines, ITS appears to the Communication Layer as a collection of applications with markedly different communication requirements. Thus the service provided by the communication model is characterized more by 1) the application's directionality requirements (*e.g.*, one-way or two-way) for information transport, 2) whether it is between mobile elements, mobile and stationary elements or stationary elements, 3) the amounts of data to be transported, and 4) the urgency rather than the precise description as Route Guidance or Pre-trip Planning.

The next section identifies various communication services to which the Transportation Layer data flows can be matched. This matching process will assign broad generic communication services to the data flows without specifying a particular technology.

4.4.2 Communication Services

The communication services define the exchange of information between two points and are independent of media and application (i.e., ITS user service). In essence, they are a specified set of user-information transfer capabilities provided by the communication layer to a user in the transportation layer. Figure 4-11 illustrates the hierarchy of communication services, the detailed of these is given in Appendix A-1 of the National ITS Communications Document. In what follows a brief description of the services is presented.

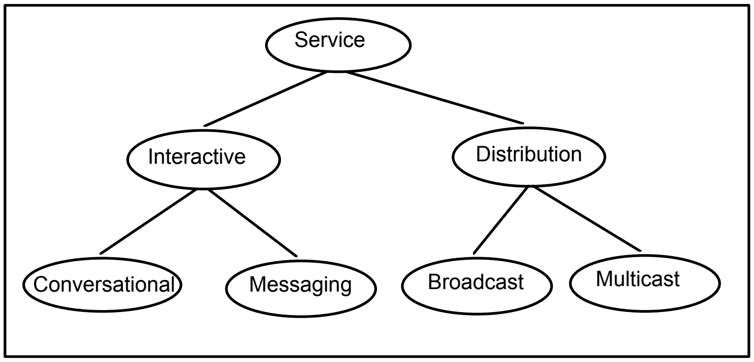

Figure 4-11. Communication Services Hierarchy

Communication services consist of two broad categories, interactive and distribution. Interactive services allow the user to exchange data with other users or providers in real or near real time, asking for service or information and receiving it in the time it takes to communicate or look up the information. Distribution services allow the user to send the same message to multiple other users.

Interactive services may be either conversational or messaging. Conversational implies the use of a two-way connection established before information exchange begins and terminated when the exchange is completed. Messaging, on the other hand, works more like electronic mail being exchanged between users. The messages are exchanged without establishing a dedicated path between the two sites. Each message is addressed and placed on the network for transmission, intermixed with messages from other users. The communications community labels this mode of communication a “datagram” service.

Distribution services may be either broadcast or multicast and may be used over wireline and/or wireless communication links. Broadcast messages are those sent to all users while multicast messages are sent only to a subset of users. Multicast differs from broadcast in its use of a designated address for all users and user groups. Examples of broadcast information might include current weather or road conditions, whereas multicast information might be information sent to all drivers working for a specific company. A changing group membership could be the set of users traveling between two locations or with a certain destination, for which unique information must be transmitted. The services that can be supported using circuit or packet connection mode include voice, video, image and data. (see Appendix A-1 of the Communication document for a complete description.)

Not shown in Figure 4-11 are location services. These fall in two categories: (1) the services that do not use the communication network (i.e., GPS, and stand alone terrestrial systems); (2) location services that use the network for providing the service (e.g., cellular based systems). In the latter case, the location services fall under the interactive services. The service will be rendered by a service provider in response to a request for information or help.

4.4.3 Logical Communication Functions

Based on the objectives of the communication architecture, a list of logical functions to support the ITS system communication requirements was identified. The primary logical communication functions can be confined to the following:

- Wireless Access: permits a user to access the network/communication resource from a tetherless device (typically in, or needing communication with, a mobile element).
- Wireline Access: permits a user to access the network/communication resource through a fixed device.
- Switching: interconnects functional units, transmission channels, or telecommunications circuits for as long as required to convey a signal.
- Routing: provides for the transparent transfer of data between two transport entities, even if they are dissimilar.
- Registration: describes a set of procedures for identifying a user to the network resource as being active.
- Authentication: ensures that the current user is legitimate, friendly, and acceptable to the network.
- Interworking: supports interaction between dissimilar operation modes and networks, specifically handling the conversion of physical and electrical states and the mapping of protocols.
- Validation/Billing: associates a user's profile with a valid accounting record to ensure payment for network usage and/or to compile usage statistics.
- Operations Support: provides management and administration functions for the various Communication Layer entities.

4.4.4 Functional Entities

The functional entities that make up the communication layer were derived from existing and emerging infrastructure specifications and standards (*e.g.*, TIA, ITU, Bellcore, ANSI). These basic building blocks form the foundation of a generic communication system. As with the transportation layer, each functional entity consists of one or more logical functions. The description of each functional entity shows the mapping of that entity to the logical entities it supports.

User Device	Access to a network or communication link through wireless or wireline media. The device includes a terminal connected to a transceiver and supports voice, data, and/or video information types.
User Profile Module	User-specific information used for registration, authentication, information delivery, mobility management, and billing. This module holds user-specific characteristics such as personal schedule data, credit card data, encryption keys, preferred service mode, etc. (*e.g.*, smart card).
Switch	Switching functions for information delivery as well as routing. Two types of switches are considered — circuit-switch and packet-switch[1]. The circuit switch accommodates circuit-mode operation for voice and data information types and connects to wireline networks such as the PSTN and ISDN. One circuit-switch can hand-off a live connection to another circuit-switch. The packet switch accommodates packet mode operation for data information types and connects to wireline networks such as the PDN, ISDN, and Internet. One packet-switch can hand-off a live connection to another packet-switch. For interworking between two different switch types, refer to the Interworking Function.

[1]Although Asynchronous Transfer Mode (ATM) utilizes cell-switching, it is no more than a fast-packet-switch algorithm, and therefore classified as packet-switching.

Wireless Controller	The Wireless Controller (WC) provides an interface between multiple wireless devices and the switches. The WC allocates wireless facilities and coordinates network facilities. To meet the objective of uninterrupted coverage in the cell-based system, the controller performs hand-off between wireless base stations served by the same controller. The Wireless Controller can also be viewed as the back-end for a suite of short-range beacons.
Wireless Base Station	The Wireless Base Station provides access for information delivery to and from tetherless users. The Wireless Base Station handles radio frequency exchanges and converts the information coming over the radio link into baseband for the subsequent system components. The air interface may be realized in many combinations of physical interfaces, link layers, and multiple access techniques.
Interworking Function	The Interworking function provides transmission, including routing, between dissimilar networks, especially for inter-mode communication (*e.g.*, circuit-to-packet, packet-to-circuit). This function can be viewed as an adjunct "black-box" capable of performing functions beyond the domain of the switch or interconnected network. It is loosely defined, and can be configured according to the specifications of the network service provider.
Profile DBase	Registration, mobility management, authentication, validation are supported in the signaling plane rather than by the transport network (see Figure 4-12). The defined entities include Personal Registers and Terminal Registers, with the former archiving information related to an individual and the latter storing information associated with a device. This subtle and important distinction satisfies the objective of seamless operation and provides the user with tremendous flexibility. Records are maintained for all information types (*i.e.*, voice, data, video). Note that not all data flows need to have their user profiles tracked, especially for free or highly localized applications. Detailed elaboration of the public databases is beyond the scope of this study. Example Profile Databases include: • Personal Home Location Register (HLR_p): stores user identity and contains user information (*e.g.*, current user location, current device, service profile). • Terminal Home Location Register (HLR_t): stores device identity and contains device information (*e.g.*, current station location, device capabilities, device identity for authentication). • Personal Visitor Location Register (VLR_p): stores information regarding a user that is now associated with a device being served by a "visiting" network. Information associated with this user is retrieved from the HLR_p. • Terminal Visitor Location Register (VLR_t): stores information regarding a device that is being served by a "visiting" network. Information associated with this user is retrieved from the HLR_t. • Authentication Center (AC): manages encryption keys associated with an individual user or user device and verifies the legitimacy of the user.

Wireline Network	The wireline network provides access for information delivery as well as inter-entity (except wireless) connectivity. Wireline network resources handle information transfer between the switch and the fixed user device or among user devices. Although the wireline network is a cloud or collection of multiple nodes, each cloud will be viewed as one virtual node. Example Wireline Networks include: • Public-Switched Telephone Network (PSTN): is the ubiquitous telephone network, operating in circuit-mode. A variety of switching technologies, physical interfaces media, and link layer services contribute to a wide range of implementation choices. Basically, there is something for everyone. • Integrated Services Digital Network (ISDN): offers interactive voice and data services, operating in both circuit and packet mode. The choice of ISDN interface (BRI or PRI) determines the available data rate. • Internet: provides users with a connection-less datagram carriage protocol accommodating interactive as well as distribution services. It has witnessed explosive growth during the past year. Access is becoming near-ubiquitous. To accommodate growth, OSI is introducing a new routing protocol, CLNP (Connection-less Network Protocol), which supports a 256-bit address field versus the 32-bit address field used in IP. • Packet Data Network (PDN): provides users with traditional interactive packet services, typically virtual circuit carriage (*e.g.*, X.25 networks, Frame Relay networks). • Local Networks (LAN, MAN, WAN): provide both switched and non-switched interactive and distribution services among data communicating devices within a local, metropolitan, and wide area. Typically, switching becomes necessary for the WAN case (*i.e.*, interconnecting two or more MANs).

4.4.5 Communication Network Reference Model for the National ITS Architecture

The previous sections presented the communications architecture, communications logical functions and the communication physical entities. We can now present the basic Communication Network Reference Model. This model provides an architecture or structure that shows how various communication technologies can implement the Architecture Interconnect Diagrams developed in the next section.

The network reference model depicted in Figure 4-12 is a generic abstraction representative of several reference models developed for standard commercial systems including Personal Communications Services (PCS) architectures, Groupe Speciale Mobile (GSM) or DCS-1800, TIA-IS-41, Cellular Digital Packet Data (CDPD), Intelligent Network (IN) architectures, etc. Boxes represent the various physical equipment (with descriptive uppercase letters) that perform the communication functions. Identified by lowercase letters (s, v, u_1, u_2, u_3), the interfaces important to ITS are described in the following paragraphs.

Since the wireline segment encompasses standard wireline configurations, the ITS-critical elements from a standards perspective are those comprising the wireless portion on the left side of Figure 4-12. The wireless portion consists of the User Profile Module (UPM), the User Terminal (UT), the Wireless Transceiver (WT) and the Wireless Base Station (WBS). The connections through the Dedicated Terminal and various User Terminals are shown in the column of boxes on the right. The equipment in the center is the existing public telecommunications services, so the details are transparent to ITS, which is a major benefit to the ITS community. *All management, operations, expansion, and improvement costs are shared with the wider set of all telecommunications users.*

This is a very important point to jurisdictions and agencies who prefer to procure and trench their own network along the right-of-way. Whereas a financial sensitivity analysis may point to a private solution, it frequently does not consider the enormous Operation, Administration, Management, and Provisioning (OAM&P) fees that the agency will have to pay the telecommunications vendor during the system's life cycle.

The most important reference point is the wireless interface (*u*) connecting the WBS and the wireless transceiver. To meet most of the communication element's objectives, as well as those of the overall architecture, it is imperative that the air interface become standard. The wireless portion of the architecture is manifested in 3 different ways, all of which demand a nationally-acceptable air link. Therefore, the *u* interface is realized in three ways: u_1, u_2, u_3, with each interface corresponding to one of the wireless manifestations, as defined:

- u_1 defines the wide area wireless airlink with one of a set of base stations providing connections to mobile or mobile or untethered users. It is typified by the current cellular telephone and data networks or the larger cells of Specialized Mobile Radio for two way communication, as well as paging and broadcast systems.
- u_2 defines the short-range airlink used for close-proximity (less than 50–100 feet) transmissions between a mobile user and a base station, typified by transfers of vehicle identification numbers at toll booths; and
- u_3 addresses the vehicle-vehicle (AHS-type) airlink, for high data rate, burst, usually line-of-sight transmission with high reliability between vehicles, where standards are in their infancy.

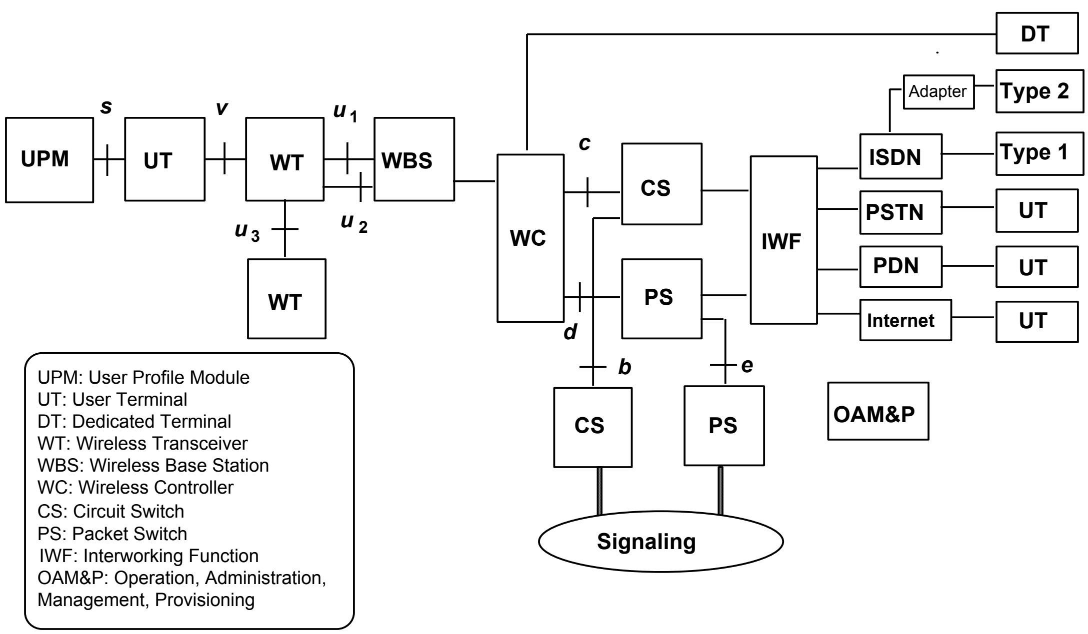

Figure 4-12. Network Reference Model for the Communications Layer

On the wireline side, user devices attach through the PSTN, ISDN, Internet, or PDN, operating in circuit or packet mode. The dedicated terminal accesses non-switched, dedicated infrastructures (e.g., a direct connect to a base station's wireless controller). An Interworking Function (IWF) mediates between two different operational modes. As will become evident in later sections, the IWF assumes more than one composition. In some implementations, there may be no IWF between the switched and the wireless networks. OAM&P (Operations, Administration, Management, and Provisioning) systems interface to virtually all functional entities except user devices.

The switches appearing in this model are the functional communication entities mediating wireless traffic. It is likely that the circuit switch handles both voice and data information types whereas the packet switch handles data exclusively. The *b* and *e* interfaces are points of connectivity between switches of the same kind, and noted as reference points because neighboring switches must be able to communicate with each other to hand-off live connections, regardless of information type. Although both *b* and *e* interfaces should be considered for standardization, they are beyond the purview of the ITS community.

The interfaces between the switches and the wireless controller (WC) can be considered for standardization, if only to maintain a network open to all vendors (*i.e.*, a network operator does not have to purchase a switch, WC, and WBS from the same vendor). The *c* and *d* interfaces may be standardized by the telecom community.

The wireless transceiver is actually the RF front-end to a user terminal. The terminal contains the protocol control logic to establish and tear-down connections and to process packets. Given the objective of integrating maximum functionality into a single device, the user terminal may have the capability to handle both voice and data information types (slow-scan video or compressed video, such as MPEG files, are considered as data types rather than video types). Identity information (either personal or terminal) is described by the User Profile Module, which may be hardwired into the terminal or portable (*e.g.*, a smartcard). The team favors the portable approach to the UPM, but does not preclude terminals with hardwired UPMs. The UPM-terminal interface, noted as the *s* interface, should be standardized to maintain an open and flexible system. A traveler renting a vehicle in a foreign city should be able to use a UPM to activate a terminal in the vehicle. For the short-range information transfer scenario, the terminal may be a dock for a UPM that stores payment information.

Appendix A-4 of the communication document presents a detailed description of the wireline side of the above network reference model, in addition to a more thorough treatment for the required interfaces, such as switches, controllers, and terminals. This appendix also presents the network entities, interfaces, and signaling plane, and includes a discussion on circuit connection and data packet transmission.

Given the generic Communications Network Reference Model, we can recast this in what is referred to as a “rendition 0” version. This is the highest level representation of the CRM where we actually depict some of the implementation technology options. Figure 4-13 depicts a composite view of the options for the various communications modalities in the National ITS Architecture.

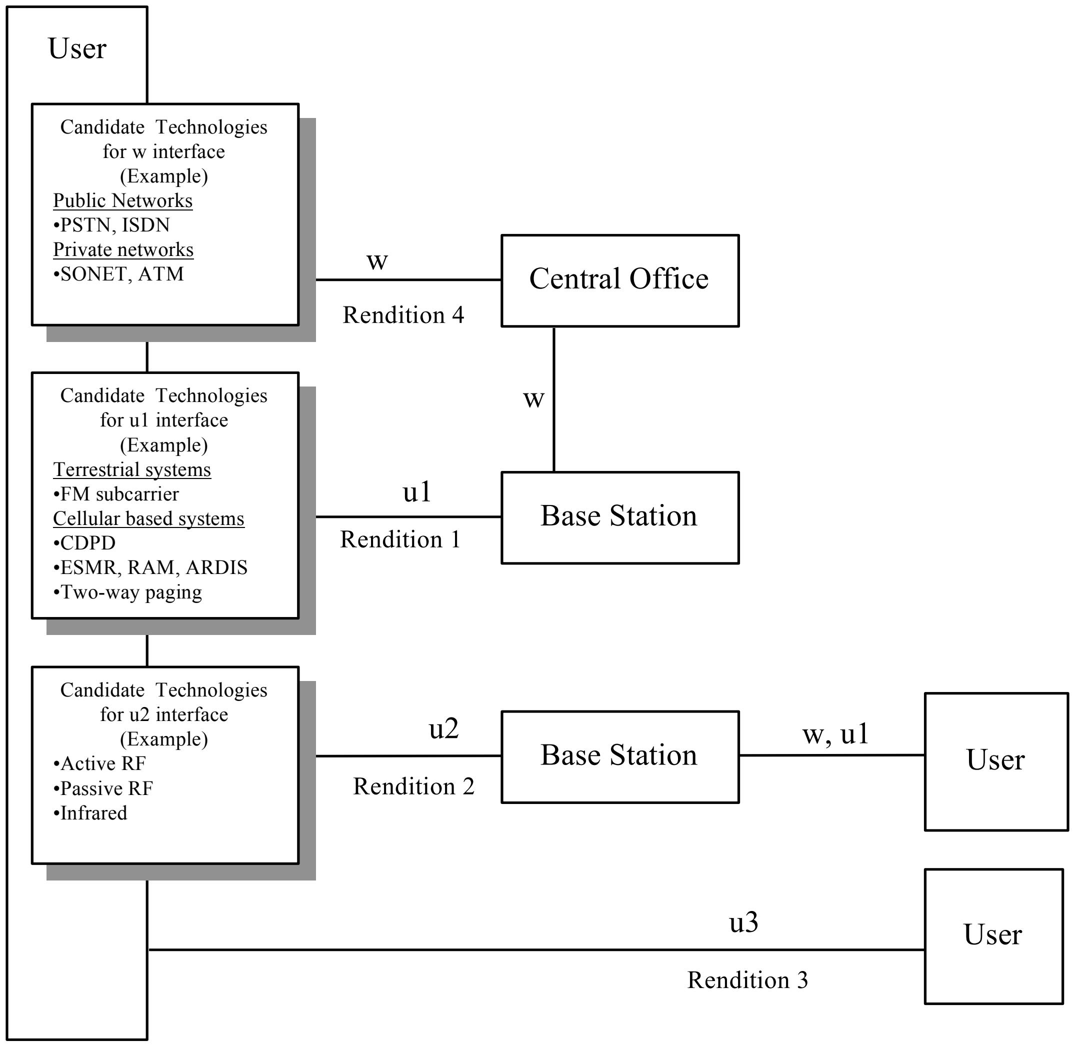

Figure 4-13. Level 0 Rendition

This concludes the Communications Network Reference Model portion of the Architecture Reference Model.

4.5 Architecture Interoperability Requirements Diagram (IRD)

The interoperability requirements have been assessed on a four level scale. The levels are, in order of decreasing stringency:

1. *National Interoperability*
2. *Regional Interoperability*
3. *Product Interoperability*
4. *None*

Section 3 defines these levels in detail. The analysis was carried out at the architecture flow level; that is, the interoperability of each Physical Architecture data flow was assessed individually based on the type of information it was carrying and subsystems it connected. It was then verified that all data flows that composed a given interconnect had the same rating (which was the expectation). The interconnect was then given the same rating as its data flows; this information is shown in the IRD in Figure 4-14 below.

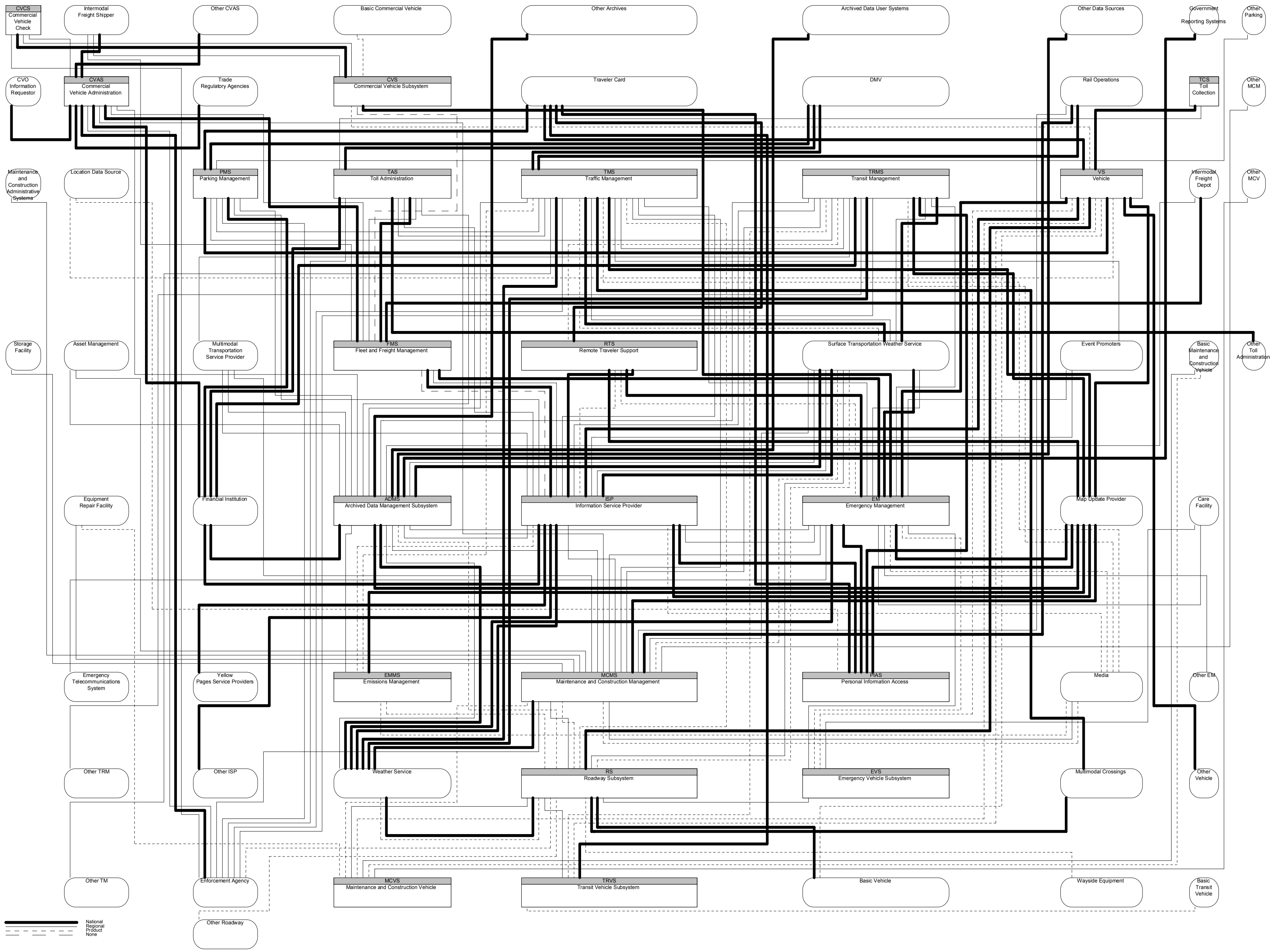

Figure 4-14. The Interoperability Requirements for the National ITS Architecture Interconnects

4.6 Architecture Reference Model Summary

This section has presented a series of items intended as high level supporting material for the standards requirements packages. Taken as a set, the different views have been labeled the "Architecture Reference Model". They form a reference model in the sense that they abstract the Physical Architecture (and to some extent the Logical Architecture) to the most basic levels of descriptions and implementation options. Choices like roadside versus a building for subsystem location or wireless versus wireline for a communication path.

The items in the National ITS Architecture Reference Model are:

- *The Top Level Diagrams ("TLD")*
- *The Level 0 Architecture Interconnect Diagram ("AID")*
- *The Communications Network Reference Model ("CRM")*
- *The Interoperability Requirements Diagram ("IRD")*

In sum these different interpretations of the Architecture provide a foundation for interpreting a standards requirements package in the context of the larger ITS Architecture, without the necessity of immediately going to other architecture documentation. Figure 4-15 shows how these four components fit together.

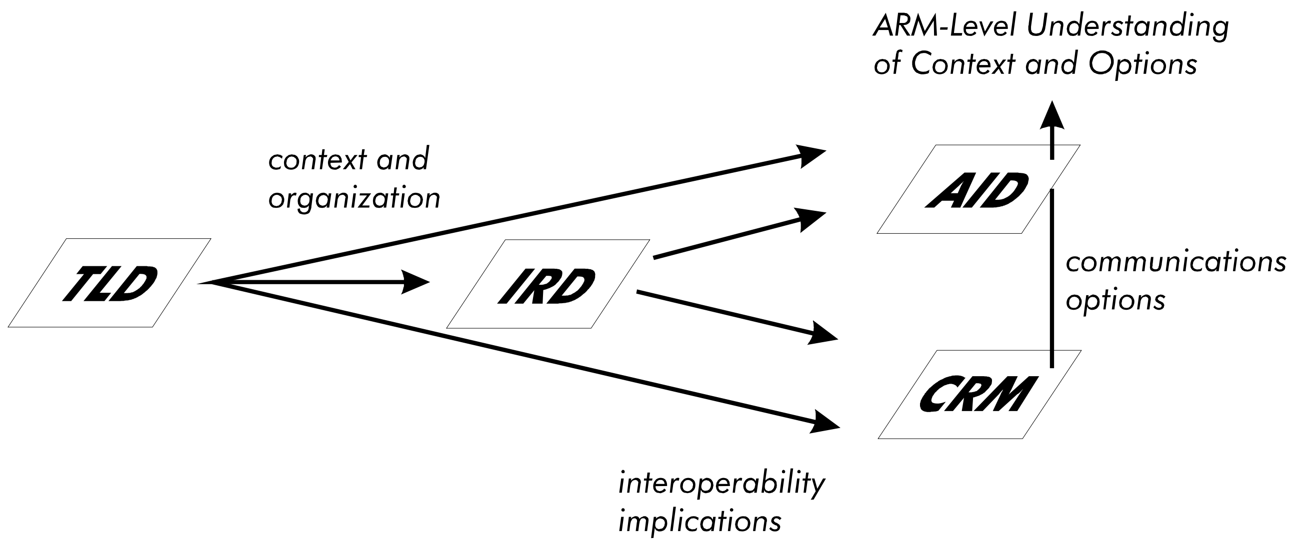

Figure 4-15. Interrelationship of the Different ARM Components.

Figure 4-15 depicts the top level diagram offering a context and organizational framework for the more complex AID 0 and the IRD. The IRD provides the interoperability information for the interconnect diagram. These interoperability needs have been called out as the main driver for the Architecture-based standardization requirements. The AID provides the catalog of the appropriate communications modalities between the different architecture entities. The CRM then provides a context for the communications options that support that type of architecture interconnect.

It should be repeated that the ARM is not a substitute for the other architecture documentation; it is a distillation of selected pieces of it. The hope is that this will facilitate an SDO's initial efforts at defining a program of work related to Architecture standardization, helping the committee members familiarize themselves with the Architecture products.

5. Descriptions of the Standards Requirements Packages

5.1 Introduction

This document is composed of two main portions. The first is the introductory material that provides the context for the development of standards from the National ITS Architecture. The second part is a set of standards requirements packages that group together information from the Architecture to support specific standardization goals. This section contains these packages. Each package is intended as a standalone entity; taken with the introductory material, a package should provide a good starting point for beginning the development of a draft standard.

The following descriptions cover the planned content of the Standards Requirements Document. There are 14 "packages" defined below. Following this section, we will cover which categories of architecture interfaces are not planned for coverage in the SRD. This front portion material then concludes with a summary of coordination issues for SDOs to be aware of when pursuing standardization of the contents of a package.

5.2 Summary of Standards Requirements Packages

The following are brief synopses of the standards requirements packages that are in this document. Based on the prioritization analyses and stakeholder interest assessments, the following thirteen packages were selected to cover the broadest set of needs and interests possible, while still maintaining a logical grouping of information that is likely to be of interest to an SDO as a package.

5.2.1 Dedicated Short Range Communications (DSRC)

This is the set of wireless interfaces between roadside devices and the vehicle subsystems. These interfaces are dedicated short range links that most commonly utilize radio frequency or infrared communications technology. The DSRC links support electronic tolling and commercial vehicle electronic clearance in current deployments, and the architecture envisions that parking management, AHS and in-vehicle signing could also utilize DSRC in the future.

The critical need for standardization for DSRC is to create the possibility of the various applications using the same hardware. This will require the coordination of message set and protocol development. And, of course, common hardware and lower level protocols.

The only DSRC-type links that are omitted from this package are those that support emergency vehicle and transit vehicle signal prioritization. These links will be addressed in their own package.

5.2.2 Digital Map Data Exchange and Location Referencing Formats

Many of the Center subsystems, Vehicle subsystems, and Remote Access subsystems require digital maps for navigation and other functions. In addition, the mobile or portable subsystems require the ability to determine their positions. Currently there is a rapid proliferation of both digital map suppliers and devices that provide location (primarily GPS based). While these providers may gain market advantage through proprietary technologies within their products, creating open interfaces and exchange formats will benefit all, by creating larger markets and increasing consumer confidence.

Location referencing is grouped with the map data since it must typically be interpreted with respect to a road network. The transmittal of locations between different devices or users must have a common semantic and syntactic standard, to insure the information will be usable. For example, a request for roadside assistance would be most useful if it unambiguously located the roadside position of the requester.

This package will need to be coordinated with the Mayday package. Clearly Mayday messages will require a location reference component; the standards developed to meet the requirements in this package should also meet the location referencing needs for Mayday.

5.2.3 Information Service Provider Wireless Interfaces

In the spirit of creating a seamless nationwide transportation information service, the wireless link between the ISP and its mobile customers is critical for the creation of wide spread usage and acceptance of these services. Achieving standards that allow an ATIS user to move across jurisdictions while continuing to receive services will aid the development of the larger markets necessary to attract investment in developing services.

The ISP wireless link is primarily the wide area wireless link to the vehicle, both for point-to-point and broadcast communications. Also covered are wireless links to PDA-type devices and to remote kiosk-like devices. We have also chosen to include the Transit Management Center information that is supplied via wireless means in this package, since it is fundamentally similar to how the ISP would supply the same information.

This package will need to be coordinated with the Personal Mayday in the Mayday package, if a common set of devices will support both ATIS and Mayday.

5.2.4 Inter-Center Data Exchange for Commercial Vehicle Operations

This package is primarily concerned with the interfaces that support government-to-government and carrier-to-government interaction for processing commercial vehicle, driver, and cargo information. This is distinct from the wireless vehicle to roadside interface, which is covered in the DSRC package. This package deals with the center-to-center data exchange required for electronic forms and data processing.

This package is critical for standardization of the government regulatory interface to the commercial carriers. Achieving accepted nationwide standards could lead to a consistent method for purchasing credentials and providing records. This would, in turn, lead to tremendous reductions in paper work and processing time for vehicles. Based on the size and importance of commercial trucking in the US, any increase in efficiency can yield a tremendous cost-benefit payoff.

Services that require this package include one-stop shopping for credentials, electronic fuel and registration fees filing, and a host of others. Standardization of this package will need to be coordinated with the CVO aspects of the DSRC work, to ensure that both this package and DSRC in concert provide the entire set of required interactions.

5.2.5 Personal, Transit, and HAZMAT Maydays

One way ITS may provide increased safety for transportation users is through the development of a nationwide system that can support Mayday requests from mobile systems. The architecture identifies several distinct types of Mayday alerts that can exist. Because of the difficulty of defining both a nationwide technology choice and operational concept acceptable to emergency services personnel, it is logical that the full set of Mayday users needs be coordinated. Hopefully this will allow a common standard that meets all the needs, without creating any redundant infrastructure.

Issues associated with Mayday include coverage for uninterrupted service and an acceptable form for the electronic alert that will be considered as valid as the current standard voice-contact requirement.

5.2.6 Traffic Management Subsystem to Other Centers (except EMS)

Many of the key services and efficiencies associated with ITS accrue through the actions of the TMC. Part of this comes from coordination of the TMC with other TMCs and other centers. This package is intended to capture the interfaces and interactions necessary to achieve the level of coordination and integration envisioned by the national architecture.

These are anticipated to typically be wireline interfaces (probably WAN or MAN-based). Excluded from this package is the TMC to Roadside interface, which has its own package, and the TMC to Emergency Management, which is covered in the Emergency Management to Other Centers package. Coordination with standardization of these packages is clearly necessary.

5.2.7 Traffic Management Center to Roadside Devices and Emissions Monitoring

This package addresses the interface between the TMC, the Emissions Management subsystem, and the Roadside devices. The TMC provides control to these devices and reads data from the associated sensors. The current standards effort supporting NTCIP is looking at this area; this package will supply a direct extraction of the relevant requirements from the national architecture.

Ultimately the TMC may implement control and pricing decisions based on congestion and emissions levels. This type of sophistication will require coordination between jurisdictions, to ensure that the net control strategies do not operate at cross purposes. This means that ultimately the standardization in this package will also imply the need for the preceding package for inter-center coordination and data exchange.

5.2.8 Signal Priority for Emergency and Transit Vehicles

This is the third and final package that principally concerns the TMC. This package captures the requirements for providing traffic signal priority or preemption for emergency and transit vehicles. For the future high functioning TMC, this could be handled via communication with the TMC, which would then handle the signal control. As opposed to the more traditional local DSRC based cycle modification. The advantage to the TMC controlled approach is that better strategies can be pursued that limit risks to other drivers and general disruption to traffic flow.

Part of the definition of this package includes some of the data flows in the TMC-EM and TMC-TRMS interfaces, specifically those associated with requesting and granting signal priority. Since the next package addresses the general TMC-EM interface (among others), standardization of this package should be coordinated with the standardization of the EMC to Other Centers package.

5.2.9 Emergency Management Subsystem to Other Centers

Emergency response and emergency management are recognized as key factors in both traveler safety and in congestion reduction. As MPOs design strategies for integrated incident management, an important component is invariably interagency coordination and data exchange. The national architecture envisions a high degree of cooperation between traffic management, transit, media/information providers, and emergency management. Through coordinated responses to emergencies, safety and service can be enhanced. This package collects the requirements from the architecture to support the data exchange necessary for this type of coordination.

A related package is the Signal Priority package, which supports the preemption of signals for emergency vehicles. Neither package requires the other, but if both are standardized and deployed then the full level of coordinated emergency response envisioned in the national architecture would be realized.

5.2.10 Information Service Provider Subsystem to Other Centers (except EMS and TMS)

The ISP is either a private or public sector entity providing travel information and other services. In order to create useful information products, it is necessary for the ISP to have connections to the various information sources. This would include transit, traffic management, emergency management and others. As ISPs gain subscribers for their services, they may also build their own information repositories, which could be usefully provided to other centers. An example would be vehicle probe data on traffic conditions or user reports of incidents.

The ISP Wireless package defines the ISP to vehicle interface. This package focuses on the wireline interfaces that allow the ISP to coordinate with other center. Absent from this package are the ISP to emergency management interface and the ISP to traffic management, both of which are addressed in other packages.

Standardization of this package should consider and coordinate with these other efforts.

5.2.11 Transit Management Subsystem Interfaces

This is the wireless interface that supports data exchange between the transit management center and transit vehicles such as buses and paratransit vehicles. This package also contains the typically wireline interface from the transit management center to the remote traveler support subsystem at transit stops (these devices are more commonly called “kiosks”). Information like routing assignments, vehicle position, status of vehicle systems, and other information are transferred across these interfaces. By formalizing these interfaces and developing operating procedures based on their existence, it will be possible to institute measures to improve transit schedule performance and also create more flexible routing options.

The support for signal priority for transit vehicles is covered in another package. Standardizing and deploying both this and the Signal Priority package, plus the TRMS interfaces to the TMS and ISP also covered in other packages, would yield a tight integration of transit with other transportation services. This would result in ease of access to information about transit schedules, selection of modes, seat reservations and paratransit requests, signal priority, and a host of other integration benefits.

If the TRMS to TRVS interface uses a DSRC-type link, then this package will overlap with the DSRC package and will need to be coordinated. The architecture supports both wide area wireless and DSRC links for this interface and each may be cost effective in particular situations.

5.2.12 Highway-Rail Intersections (HRI)

A highway-rail intersection (HRI) is an at-grade crossing between a roadway and a rail system. These occur widely in the US for passenger, freight, and mixed-use tracks. It is taken as a given that the trains have right-of-way at these intersections for all normal operating scenarios. The issue is then how to manage roadway vehicle traffic so as to maximize safety while minimizing delays. This involves the coordination of rail signals with traffic signals, as well as the dissemination of crossing status information to aid in route planning.

This package is primarily concerned with the new interface between the roadside subsystem and the wayside equipment terminator, and with the new interface between the rail operations terminator and the traffic management subsystem.. These are the basis of signal coordination capability. There is also consideration of the enrichment of other existing interfaces to carry more detail about the rail crossing status and schedules.

5.2.13 Archived Data Management Interfaces

This standards requirements package captures the requirements for providing interfaces to an Archived Data Management Subsystem (ADMS). The interfaces to the ADMS include the sources for the data, other archives, consumers of the data contained in the archive, and the manager of the archive. The sources of data for the ADMS include all of the center subsystems in the National ITS Architecture plus many of the terminators that represent center type systems.

5.2.14 Maintenance and Construction Management Interfaces

This standards requirements package captures the requirements for providing interfaces to the Maintenance and Construction Management Subsystem (MCMS) and the Maintenance and Construction Vehicle Subsystem (MCVS). The MCMS monitors and manages roadway infrastructure construction and maintenance activities. Representing both public agencies and private contractors that provide these functions, this subsystem manages fleets of maintenance, construction, or special service vehicles (e.g., snow and ice control equipment). The MCVS resides in maintenance, construction, or other specialized service vehicles or equipment and provides the sensory, processing, storage, and communications functions necessary to support highway maintenance and construction. All types of maintenance and construction vehicles are covered, including heavy equipment and supervisory vehicles. The subsystem provides two-way communications between drivers/operators and dispatchers and maintains and communicates current location and status information. Interfaces in this package include those to and from the MCVS, between the MCMS and the terminators, between the MCMS and the other center-type subsystems, as well as interfaces to and from the Roadway Subsystem (RS) that relate to Maintenance and Construction Management.

5.3 Categories of Data Flows and Interfaces Not Packaged

The following are types of connections not covered in the SRD. Explanations are included as to why the material is not appropriate for the SRD.

5.3.1 Physical Interfaces

These interfaces are included in the architecture for completeness, primarily to show how the architecture interfaces to the physical world. Examples are cameras viewing vehicles or emissions in the atmosphere being sampled by a sensing system. While the devices may adhere to standards, the actual interface is not under human control: it is the environment that ITS operates in.

This category encompasses about 17 interfaces and a like number of PA flows.

5.3.2 Human Interfaces

The human operators of the national architecture are considered to be external to the system, and are captured as terminators. The issue for standardization of the interfaces to the humans that interact with ITS is primarily for safety, when dealing with mobile systems, and training when dealing with complex data processing and control systems. Both of these are human factors issues; any standards contemplated for human users would concern nomenclature and appearance issues. The architecture does not specify requirements in the human factors area, other than citing when there is a safety or training issue, and consequently would provide limited contributions to standards in this area.

There are approximately 32 interfaces to humans in the national architecture containing a total of approximately 69 PA flows.

5.3.3 Inherently Proprietary Interfaces

There are some interfaces where the stakeholders are not receptive to standards because they view a closed solution as a competitive advantage. The architecture only identifies one interface in this area currently: CVS to FMS. This contains about 4 PA flows.

5.3.4 Automated Highway System Data Flows

Because to the relative depth of the national architecture definition of AHS versus the primary study in this area, this is not viewed as a fruitful area for standards requirements definition. The architecture teams have already determined that the requirements that the consortium is developing will subsume any that might come out of the architecture effort. This encompasses the interface between the VS and the Other VS terminator and 2 PA flows currently.

5.3.5 Data Flows Internal to the Vehicle Subsystems

In general the national architecture has not made explicit interfaces that are internal to subsystems; these are instead left to the implementers to define. It is assumed that as long as subsystem to subsystem open interface objectives are met, the interoperability goals of the national architecture will be realized without this additional level of detail.

However, as an artifact of the multiple vehicle types in the vehicle class of the architecture, a number of interfaces have been created that are actually internal to a given vehicle. For example, Basic Vehicle to Vehicle subsystem is the connection that supplies the operating parameters of the vehicle platform to the ITS components, to help support automated control functions. By creating these as separate subsystems or terminators, we can eliminate some redundancy between subsystems by simply linking all vehicles that require Basic Vehicle functionality to that terminator.

These interfaces are not covered in the standards requirements. They are a level of detail below all the other requirements, and are clearly in the domain of the vehicle manufacturers. There are 9 interfaces and 14 PA flows that fall into this category.

5.3.6 Data Flows and Interfaces Already Sufficiently Covered by Standards

Some data flows or interfaces, while critical to ITS, already have received or are currently receiving sufficient standardization attention. There is no purpose in triggering redundant efforts within the ITS community. An example of this is the wireline interface for financial transactions. Current credit card and internet activities will yield usable standards in this area before the ITS requirements will even be finalized. This particular example covers 5 interfaces and 13 PA flows.

5.3.7 Other Categories

There are some other categories of flows not included in a standards requirements package for various reasons.

- **Emergency Vehicle Data Flows**
  Currently, no standards efforts are underway that include the data flows interface between the Emergency Management (EM) subystem and the Emergency Vehicle Subsystem (EVS). There are 11 PA flows in this category including 2 flows between EVS and the Care Facility terminator.
- **Traveler Card Flows**
  Payment requests and payment information pass between an instrument held by a traveler. Such flows are likely to be standardized by the financial community. Other flows in this category include personal profile information that could also be stored on such an instrument. There are 14 PA flows in this category.
- **DMV Interfaces**
  License request and registration information passes between Departments of Motor Vehicles and the transportation related subystems. There are 6 PA flows in this category.
- **Multimodal Crossing (Drawbridge) Intefaces**
  Status information can be shared between the RS or TMS and a crossing like a drawbridge. There are 3 PA flows in this category.
- **Toll/Parking Internal Interfaces**
  Included in this category are flows between parking management facilities (PMS <-> Other Parking) as well as between Toll administration facilities. Also included are the interfaces to the Enforcement Agency terminator. These interfaces could be standardized for public sector agencies wishing to implement mechanisms to share pricing, availability and other information. There are 4 interfaces and 8 PA flows in this category.

5.4 Coordination Issues between Standards Requirements Packages

Section 5.2 has addressed some of the potential redundancies and conflicts between the different packages. The problem is that it was not possible to come up with a set of standards requirements packages that both covered all items of interest and had no overlap. In developing the actual content of the packages, we have resolved the overlaps in favor of one package or another. This section will summarize these actions and the rationale behind them. We will also present a few general coordination concerns. It is important that any SDO undertaking a program of work based on one of the standards requirements packages be aware of these decisions. The SDO does not necessarily have to abide by the decisions, if they have a better plan, but there needs to be coordination to avoid redundancy and confusion.

The table below, Table 5-1, shows where there are conflicts or coordination issues between packages. The issues are numbered and are discussed one at a time following the table. The left hand column lists abbreviated titles for the thirteen SRD packages. The top row has just the number references for the same packages.

Table 5-1. SRD Package Coordination and Conflict Issues

	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.	13.	14
1. DSRC				1				2			3			
2. Digital Map & LR			4		5						6			
3. ISP Wireless														
4. EDI for CVO														
5. Maydays									7					
6. TMS to Other Centers							8	9	10	11				
7. TMS to RS & EMMS								12						
8. Signal Priority									13					
9. EMS to Other Centers										14	15			
10. ISP to Other Centers														
11. TRMS Interfaces														
12. HRI						16	17							
13. Archived Data Management														
14. Maint. And Construction	18					19	20		21	22	23		24	

The numbered issues are as follows:

1. To provide the full set of CVO user services, it is necessary to coordinate the DSRC standardization with respect to CVO and the *inter-center data exchange for CVO* standardization. The issue is to ensure no overlap and no missing services from the standards coming out of package 1 and 4.
2. One option for implementing "signal priority" is via a DSRC system. The issue here is to ensure that those pursuing standardization of package 1 are fully aware of the requirements for DSRC implied in package 8. The goal is coordination of package 1 and 8 requirements.
3. The wireless link between the transit management center and the transit vehicle is currently assumed to use a wide area wireless link. However, this could also very plausibly be implemented via DSRC in some urban settings. The TRMS to TRVS wireless requirements currently only appear in package 11. If an SDO working on standards related to package 11 felt it was appropriate, they might want to coordinate with the package 1 DSRC standardization efforts to keep this option open for transit.
4. The specifics of the map data and location referencing requirements are discussed only in package 2. However these items are intrinsic parts of other services. For package 3, *ISP wireless interfaces*, the ISP will expect location updates from travelers and will be providing navigation information. It would be very desirable to develop the standards associated with package 2 so that they accommodate the needs of the ISP wireless interface. Coordination is recommended, to ensure that

there were no omissions in the creation of package 3.

5. Providing a location description that can be interpreted relative to a navigable map is clearly a critical part of an automated Mayday. While package 5, *Mayday*, calls out location identity as part of its message requirements, the details of location identity are presented in package 2. It is recommended that these two areas maintain coordination with each other, to ensure a single location reference and digital map standard (or set of standards) that is appropriate for both.

6. Much the same comments as in (3) and (4) above. Transit management will be increasingly interested in tracking bus location and in route planning. This will accommodate both more advanced operations and ADA mandated flexible routing requirements. The standards selected for package 2 should also satisfy the needs of package 11 for transit. This is a coordination issue.

7. This is a redundancy between the *user service-based* Mayday package and the *total subsystem interface-based* EMS to other centers package in the specific area of TRMS-EMS flows to support transit Maydays. The data flows cannot be left out of either package without sacrificing some of the necessary coverage, so those considering these packages will need to coordinate their efforts.

8. This is a coordination issue. In general there will be an interest in sharing information gathered from roadway devices and emissions monitoring facilities with other centers. This sharing would be simplified if the roadway devices' interfaces and the inter-center interfaces had some similar data content and formats. A second issue is a conflict; EMMS, which is classified as a "center subsystem", is placed in package 7 rather than 6. This was because the environmental sensing nature of the data exchange seemed more like the roadway device queries found in package 7.

9. This is an intentional redundancy that needs to be coordinated. One method of providing signal priority to emergency vehicles and to transit vehicles requires EMS-TMS and TRMS-TMS communications. These particular data flows are all in package 6 and are also in the *signal priority package*, package 8, as part of the overall emergency vehicle signal priority function. This redundancy is a natural result of our packaging rationale; these data flows are required for both the *user service-based* signal priority package and the *total subsystem interface-based* EMS to other centers package. The data flows cannot be left out of either package.

10. To resolve an overlap conflict, all TMS-EMS interface requirements are placed in package 9, the *EMS to other centers* standards requirements. Those working on package 6 should be aware of this and coordinate with those working on package 9.

11. To resolve another overlap conflict, all the ISP-TMS interface standards requirements are presented only in package 6 and not in package 10, *ISP to other centers*. Those working on package 6 should be aware of this and coordinate with those working on package 10, to ensure an end results that meets both ISP and TMS interests.

12. A subset of the flows in the TMS to RS package, package 7, is needed in package 8 to support signal priority. The required flows are present in both packages; these two efforts should be coordinated in this area

13. This is an unresolved redundancy. The EMS-TMS data flows associated with signal priority are repeated in both packages 8 and 9, signal priority and EMS to other centers, respectively. Standardization efforts will need to coordinate this aspect of these two packages. For various reasons it was deemed inappropriate to place these requirements in only one of the two packages.

14. The potential conflict of which package to assign the ISP-EMS interface to was decided in favor of package 9, *EMS to other centers*. In general, for the center-to-center interfaces, the EMS package was given priority, followed by the TMS package, and then the ISP package. This ordering was not intended to reflect importance as much as an expectation of which constituent groups were likely to be the final arbiters on any coordination conflicts.

15. Coordination issue. The traveler safety user services lead to Mayday functionality on transit vehicles and at transit stops. These Maydays are handled, at least initially, by transit management. However TRMS may also request assistance from EMS. This aspect of the possible hand-off of a Mayday situation needs to be coordinated between package 12 and package 9.
16. The addition of HRI information to the TMS data repository implies expanded definitions of some of the data flows between the TMS and EMS and/or ISPS. The package 6 work will need to be defined with sufficient flexibility to support the additional data options that are required by package 12.
17. The HRI capabilities will enrich the interface between the traffic management subsystem and the roadside subsystem. It is likely that those working on package 7, TMS to RS & EMMS, will probably define the fundamental nature of this interfaces protocol. The development of the components of the package 12, HRI, that affect this interface will need to coordinate with this other effort.
18. A DSRC link may be used to carry information between the MCVS and the RS.
19. There are a number of similarities between the new MCMS interfaces and the TMS interfaces that should be coordinated.
20. The new interfaces with RS that are described in SRP 14 need to be coordinated with existing interfaces described in SRP 7.
21. Incident information, described in SRP 9, should be coordinated with the interfaces described in SRP 14 that also carry incident information. Also, emergency management facilities can receive conditions about the roadway network from their vehicles that can be shared with other centers.
22. There are a number of flows described in the new SRP 14 that affect the ISP related interfaces, such as weather and road conditions information.
23. The collection of road condition data by transit vehicles is described in SRP 14, but efforts to standardize the interface should be coordinated with efforts to standardize the interfaces described in SRP 11.
24. Efforts to standardize weather and road condition information that is to be archived should be coordinated with the efforts to standardize the other archived data interfaces described in SRP 13.

This concludes the introductory portion of the Standards Requirements Document. In the previous sections we have explained the definition of a standard requirement, presented the results of analyses to determine the priority areas for standardization and to determine the logical groupings of requirements into packages. We have provided an Architecture Reference Model that is a quick-reference to the National ITS Architecture. This reference model is intended to provide a broader context for the specific material in the standards requirements packages. This final section of the introductory material has covered the specifics of what items are covered and not covered in the standards requirements packages.

The remainder of this document is composed of the standards requirements packages.

6. The Standards Requirements Packages

Contained in separate document files are the standards requirements packages. Each package is a special grouping of standards requirements and contextual information intended to be used in a nearly standalone fashion by an SDO. Thus, packages have been selected that cover the key ITS priorities, maintain the integrity and vision of the National ITS Architecture, and also are perceived as having an interested stakeholder constituency that will help drive standardization. This is a difficult balancing act, but the following 14 packages were identified as covering the high priority standardization needs for the architecture program:

1. Dedicated Short Range Communications (DSRC)
2. Digital Map Data Exchange and Location Referencing Formats
3. Information Service Provider Wireless Interfaces
4. Inter-Center Data Exchange for Commercial Vehicle Operations (Modified for Version 4.0)
5. Personal, Transit, and HAZMAT Maydays
6. Traffic Management Subsystem to Other Centers (except EMS)
7. Traffic Management Subsystem to Roadside Devices and Emissions Monitoring
8. Signal Priority for Transit and Emergency Vehicles
9. Emergency Management Subsystem to Other Centers
10. Information Service Provider Subsystem to Other Centers (except EMS and TMS)
11. Transit Management Subsystem Interfaces
12. Highway-Rail Intersections (HRI)
13. Archived Data Management Interfaces (Modified for Version 4.0)
14. Maintenance and Construction Management Interfaces (New for Version 4.0)

These 14 areas cover much of the National ITS Architecture and represent the distillation of stakeholder interests and architecture interoperability requirements. If standardization can be achieved in the near term for all or most of these packages, then ITS will be a long ways towards achieving the original vision captured in the user service requirements.

For this version of the Standards Requirements Packages, some of the changes from Version 3.0 to Version 4.0 of the National ITS Architecture are reflected in the addenda found on the Version 4.0 CD-ROM and website. Addenda were compiled to reflect the smaller changes to affected Standards Requirements Packages that did not necessitate a wholesale rewrite. Addenda have been created for Standards Requirements Packages 1, 2, 3, 5, 6, 7, 9, 10 and 11.