STRATEGIC PLAN FOR THE DEVELOPMENT OF ADUS STANDARDS

FINAL

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1. INTRODUCTION

1.1 Purpose of the Strategic Plan

The Strategic Plan creates the framework for the development of standards related to the implementation of the Archived Data User Service (ADUS). Specifically, the Plan:

- Establishes the need for the development of ADUS standards and their potential benefits to transportation practice;
- Identifies the general types of standards that are required;
- Identifies other ongoing efforts that have an impact on the development of ADUS standards, and recommends how coordination may be achieved;
- Ascertains the policy implications of instituting ADUS standards, especially barriers to acceptance;
- Creates a schedule for the development of ADUS standards; and
- Identifies institutional mechanisms for developing and implementing ADUS standards.

1.2 ADUS History

The idea that real-time data from traffic and transit operations could be archived and used for purposes other than in ITS control strategies started to be expressed in the mid-1990s. The potential for ITS to provide such data was voiced in various contexts, for example, the Highway Performance Monitoring System (HPMS) Steering Committee on August 7, 1996. This was also one of the findings of a conference March 2-5, 1997, in Irvine, CA, on "Information Needs to Support State and Local Transportation Decision Making into the 21st Century."

These early discussions led FHWA to sponsor a meeting to discuss the use of ITS for archiving data for planning, research, performance monitoring, and policy purposes in January 1998. As a result of this meeting, it was decided that the best way to implement such a function was to revise the National ITS Architecture ("the Architecture") to include a new user service: the Archived Data User Service. The results of the Workshop are documented in the FHWA report *ITS As A Data Resource: Preliminary Requirements for a User Service* (April 1998). Through a series of subsequent meetings with stakeholders (Table 1), ADUS was specified and the Architecture (Version 3) was revised in September 1999 to accommodate it.

Now that the Architecture has been revised, attention has turned to activities to support ADUS deployments. Accordingly, FHWA has developed a 5-Year ADUS Program Plan that outlines the major Federal activities that should be undertaken to support ADUS deployment.[1] During the Architecture deliberations, standards development emerged as a major focus area, and the ADUS Program Plan carries this forward. One of the major categories of activities in the Program Plan focuses on standards, and the Strategic Plan for ADUS Standards was one on the specific activities identified. Further, many of the other activities in the ADUS Program Plan will feed the standards efforts as more is learned from research and case studies.

[1] *ITS Data Archiving: Five-Year Program Description*, prepared for FHWA by Mitretek Systems, March 2000.

To seek input from stakeholders on the direction for ADUS standards development, FHWA convened a two-day Workshop in March 2000. Workshop participants reviewed an early draft of this document and discussed many different topics related to ADUS standards and implementation. Many of the comments voiced at the Workshop have been incorporated into this document.

1.3 The Need for ADUS Standards

One of the features of ADUS that distinguishes it from other user services is the large number of stakeholder groups (14, as shown in Table 1). These stakeholders include public transportation agency personnel (e.g., planners, air quality analysts, researchers, transit operators, and safety administrators) as well as private sector groups. By using archived ITS data, data collection costs for stakeholder applications can be reduced. Further, the detailed nature of ITS-generated data allow for more accurate analyses and make possible many applications that could not have been undertaken except at substantial cost. Figure 1 [in back of this document] displays several examples of how a single subset of archived data – travel conditions data – support ADUS stakeholder functions. These stakeholders identified the lack of consistent standards as a major barrier to successful ADUS implementation. In addition to supporting the broad range of planning and operations functions of these stakeholders, standards for archived ITS data also have a positive impact on the ITS program in several ways:

- The National ITS Architecture defines an ADUS Standards Requirement Package for standardizing interfaces as a necessary step in fulfilling the Architecture's mission.
- Standards will provide guidance in system design and promote the integration of ITS with traditional information systems.
- Standards will ensure consistent deployments of archives within regions as well as throughout the nation.
- The customization of software products developed by private vendors will be minimized, reducing the costs to public agencies.
- Standards will encourage the use of data for multiple purposes, which will help to justify ITS deployments.
- Standards will facilitate the use of archived ITS data by the 14 stakeholder groups and will involve them directly in ITS affairs. In turn, this will promote the mainstreaming of ITS, especially among transportation planners who are responsible for identifying long-term transportation investment needs.

Standards will expedite national level analyses that rely on comparing conditions across the country in a consistent manner. Standards also allow historical comparisons and trend monitoring since data definitions will remain stable over time. They also will allow stakeholders to compare their operations with those of their peers.

Another feature of ADUS that distinguishes it from other ITS user services is that it relies on data collected and used by other ITS functions. As a result, the development of ADUS standards is closely tied to the standards used to support these other functions. This requires that close coordination be achieved with other ITS standard efforts. Since ADUS encompasses all forms of ITS data, the number of related standards efforts that must be embraced is

Table 1. Stakeholder Functions for the Archived Data User Service

1. Transportation Planning 2. Transportation System Monitoring 3. Air Quality Analysis 4. MPO / State Freight and Intermodal Planning 5. Land Use Regulation and Growth Management 6. Transportation Administration and Policy Analysis 7. Traffic Management 8. Transit Management 9. Construction and Maintenance 10. The Private Sector 11. Safety Planning and Administration. 12. Commercial Vehicle Operations 13. Emergency Management 14. Transportation Research

potentially quite large. An effort has been made to reduce the number to those that most highly relevant, as discussed in Chapter 2.

1.4 Program Goals and Objectives

The ADUS Program Plan defined goals and objectives for the ADUS program. These were built around the technical, institutional, deployment, standards, and integration issues that had been identified by stakeholders. The ADUS Program goals are:

1. Increase awareness of and professional capacity to implement ADUS;
2. Advance / expand application of state of the practice;
3. Understand impacts (benefits / costs);
4. Resolve technical ADUS issues;
5. Resolve institutional / organizational issues;
6. Advance / develop state of the art; and
7. Promote use of archived data in making better transportation decisions.

The development of ADUS standards addresses all of these goals in some way, but its greatest impact is on the seventh goal: promote use of archived data. Several specific objectives of the ADUS standards development process have been identified, as follows:

- Coordinate with other ITS data dictionary efforts, either planned or under development, that are relevant to ADUS.
- Help to reconcile differences between the data definitions in pre-existing ITS data dictionaries and those of ADUS stakeholders.
- Outline standards that will define and promote the interfaces necessary to implement ADUS in the field.
- Ensure consistent deployments of ADUS throughout the country.

- Facilitate the interchange of data between ITS and non-ITS information systems.
- Eliminate duplicative data collection and storage.
- Enhance the usefulness of archived ITS data to end users by providing consistent data definitions, documentation of data collection and processing activities, and efficient data management techniques.

2. BACKGROUND TO ADUS STANDARDS DEVELOPMENT

2.1 Categories of Standards

Standards can take several forms depending on the nature of the guidance that is intended. These include:

- Standard Test Method: a definitive procedure that produces a test result. Examples of test methods include identification, measurement, and evaluation of one or more qualities, characteristics, or properties. Precision and bias statements may be reported as part of a test method.
- Standard Specification: an explicit set of requirements to be satisfied by a material, product, system, or service. Examples of specifications include requirements for physical properties, and safety, quality, or performance criteria. A specification identifies the test methods for determining whether each of the requirements is satisfied.
- Standard Classification: a systematic arrangement or division of materials, products, systems, or services into groups based on similar characteristics such as origin, composition, properties, or use.
- Standard Practice: a definitive set of instructions for performing one or more specific operations that does not produce a test.
- Standard Guide: a compendium of information or series of options that does not recommend a specific course of action. A guide increases the awareness of information and approaches in a given subject area.
- Standard Terminology or Definitions: a document comprising definitions of terms; explanations of symbols, abbreviations, or acronyms.

All of the standards discussed in this document may be classified as one of these types.

It is important to point out that the existence of a standard simply means that it has been approved by a standards development organization. ***Adoption of the standard*** by implementing agencies is a matter of policy that follows its own process.

2.2 ADUS Interfaces

The starting point for ADUS standards development is to examine the interfaces between ADUS and other functions; these will determine the nature and extent of the standards that are

required. Figure 2 shows the interfaces between an Archived Data Management System (ADMS)[2] and:

1. ITS data sources. The implementation of ADUS through an ADMS relies on other ITS sources for data. This is an extremely important point to consider with regard to ADUS standards since it is clear that ADUS must "piggyback" on these other systems. As specified in the Architecture, data may also flow directly from roadside sources.
2. The ADMS manager. The management of access and data processing for the ADMS – particularly for multiple data sources – should rely on standards to ensure consistency.
3. Other archives. The ADMS will be a significant source of information for "traditional" data systems, such as the Highway Performance Monitoring System, Fatality Analysis Reporting System, and state roadway characteristics inventories. Likewise, other archives may possess data useful to the ADMS. Standards will facilitate the transfer of data between these systems.
4. Consumers of archived data. Consumers (users) of archived ITS data will benefit if the data they access in the ADMS is stored and transmitted in standard formats. Standard formats will also ensure that data from different archives are consistent, allowing users to combine data easily and avoid having to customize software products for each archive.

The systems with which ADMS must interface also have their own standards that must be considered in any ADUS-related standards that are developed. (Chapter 3 presents an overview of these other standards.) This is especially true for the interfaces with ITS sources and other archives. In fact, a large part of ADUS standards development will involve close coordination with these other efforts, and may also involve reconciliation of differences. In addition, ADUS has its own unique requirements for standards, as defined by the four interfaces in Figure 2.

It is anticipated that ADUS standards will take several forms: (1) data dictionaries, (2) metadata, (3) standard practices, and (4) message sets / data transfer protocols. These are discussed in the next section. Figure 3 summarizes the different types of standards by relating them to each step along the data "stream" from collection to end use.

2.3 Types of ADUS Standards Required

2.3.1 ADUS Data Dictionary (ADD)

An ADUS data dictionary is a logical standard to be implemented. A data dictionary provides a unique identification and description of the data elements used in the transmission and communication of messages between computer systems. For each data element there would be a description, size estimate, and listing and description of its critical attributes. Some dictionaries will include other features such as description of origin, timing requirements, and valid entries for the data element.

Despite the apparent straightforwardness of the above description, different data dictionaries have defined their data elements to different levels of detail. For example, the National ITS Architecture's data dictionary was developed to support the data flows in the Architecture.

[2] As a user service, ADUS is a concept or function. To implement ADUS, an Archived Data Management System is constructed. The two terms are used interchangeably in this report, but technically ADUS is a function while ADMS is an actual system.

Each entry may be a standalone element or a composite of multiple standalone elements. Further, the Architecture's data dictionary is conceptual rather than an actual dictionary – it is meant to guide the development of data dictionaries that implement the Architecture's concepts. In contrast, the entries in the Traffic Management Data Dictionary (TMDD) represent the *smallest variable data unit definable.* That is, a data element is one that cannot be further decomposed or subdivided.

The development of the ADD is fundamentally different from other ITS data dictionaries in that most of the data in the ADD will have first been defined by these other data dictionaries in some fashion. In fact, if the elements in these other data dictionaries are specified so as to satisfy the interface requirements, a separate ADD would not be needed. Two exceptions to this case are:

1. Transformations of data elements from their original form. Transformations may be either simple aggregations or more complex conversions involving other data or the application of analytic methods. An example of an aggregation is the development of 15-minute traffic counts from the lowest level specified in the Traffic Management Data Dictionary (for example). An example of a more complex conversion is the calculation of equivalent single axle loads (ESALs) from vehicle weight data or the calculation of capacity from network and traffic characteristics.

2. Documentation of how the data were collected and what was done to them at various points in the processing stream ("data collection and processing documentation"). A unique requirement of ADUS data consumers is that they understand what the data they receive actual represent, since they are not in control of data collection or much of the processing. Documentation of collection and processing activities is extremely similar in concept to that of metadata (discussed below): it describes the primary data in enough detail to allow informed use. However, collection and processing documentation involves the creation and maintenance of additional data elements that must be specified in a data dictionary. Table 2 displays some possible types of data collection and processing documentation.

Table 2. Potential Data Collection and Processing Documentation Data Elements

- **Data measurement status:** indicates how directly the data element relates to measured conditions. Possible categories include:
  - (1) *Measured data:* data measured directly by collection equipment
  - (2) *Aggregated data*: simple summaries of category {1} (e.g. annual average daily traffic)
  - (3) *Transformed/computed data:* data that have been combined with other data or subjected to a methodology (e.g., highway capacity, congestion indices, and equivalent single-axle loads)
- **Initial collection source:** the source of the data as collected by the initial ITS equipment, including make and model of equipment.
- **Equipment location:** details of the location of fixed equipment (such as roadway sensors).
- **Intermediate system recipient:** interim users / processors of the data between its source and the archive (e.g., traffic surveillance data sent to a Traffic Management Center (TMC), then to an Information Service Provider (ISP), then archive; the TMC and ISP are intermediate system recipients).

- **Collection conditions:** for field equipment, a description of the physical environment under which the data were collected (e.g., weather, special events).

Table 2. (Cont.)

- **Data collection equipment status:** the working status of the equipment used to collect the data as determined by personnel responsible for maintaining the data collection system.
- **Equipment self-diagnostics:** the results of tests made internally by the data collection equipment.
- **Equipment-assigned edit/quality check:** error flags assigned by data collection equipment.
- **Data quality control procedure:** the type of editing/quality control used to process the data.
- **Data quality control results:** the results of the data editing/quality control (e.g., error flags).
- **Data imputation/replacement:** any imputation used to fill in missing data (e.g., for aggregated data items) or the replacement of erroneous data (as determined by quality control procedures).
- **Equipment calibration**
  - **Calibration date**
  - **Calibration method**
  - **Calibration equipment**
  - **Calibration results**
- **Aggregated/Summarized data statistics**
  - **Method:** a textual description of the aggregation method.
  - **Number of observations used:** the actual number of observations used in the summary exclusive of imputed or altered data.
  - **Observation units:** the level from which the aggregation is made (e.g., hours for daily summaries; days for annual summaries).
  - **Distribution statistics:** standard deviation and selected percentiles (e.g., minimum, 5th, 25th, 50th, 75th, 95th, and maximum) from the data from which the aggregation is made.
  - **Precision:** where possible, a calculated precision for the aggregated data assuming only sampling bias.
  - **Precision method:** the methodology used to calculate the precision.
- **Transformed data statistics**
  - **Method:** a textual description of the computational method
  - **External data name**
  - **External data value**
  - **External data source**

2.3.2 Metadata

Commonly referred to as "data about data," metadata is typically thought of as dataset descriptions[3]. Metadata are analogous to a library card catalog that contains information about books: accession number, place of printing, author, etc. In this analogy, the books themselves are the "data". The descriptions typically found in a data dictionary (e.g., definition, size, source) are also metadata. Metadata has several purposes:[4]

- **Summary** - to summarize the meaning of the data.
- **Finding** - to allow users to search for the data.
- **Advisement** - to allow users to determine if the data is what they want.
- **Selection** - to help decide which instance of the data should be retrieved (if multiple formats are provided).
- **Retrieval** - to retrieve and use a copy of the data (i.e. ., where does one go to get the data).
- **Restriction** - to prevent some users from accessing data.
- **Interpretation** - to instruct on how to interpret the data (e.g., format, encoding, encryption).
- **Specifications** - to give information that affects the use of data (e.g., legal conditions on use, its size, or age); terms and conditions for use of an object (an access list of who can view the object, a conditions of use statement; a schedule of fees for use of the object; or a definition of permitted uses of an object).
- **History** - to describe the history or provenance of data, such its original source and any subsequent transformations (filtering, decimation, etc.).
- **Data administration** - to give specifications for the management of an object within a server or repository (date of last modification, date of creation, and the administrator's identity).
- **Data linkages or relationships** - to give specifications about the relationship between objects. (For example, linkages between a set of articles and a containing journal, between a translation and the work in the original language, between a subsequent edition and the original work, and between the components of a multimedia work.)
- **Data structure** - to list the logical components of complex or compound objects and how to access those components (table of contents; the list of components of a software suite).

Metadata have also been described in some circles as "self-describing data," that is, datasets come with "tags" that provide the metadata details. With the development of the Internet, "self-describing data" has become important so that applications can automatically access data in different formats. In terms of the Internet, there has been growing interest in promoting interoperability of formats using the Extensible Markup Language (XML) as a basis. XML is a

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[3] The distinction between metadata and what this report has termed "data collection and processing documentation" is not hardfast. Both categories will involve additional entries in the ADUS Data Dictionary. We have chosen to keep these separate under the interpretation that "data collection and processing documentation" are more like independent data elements than what is normally thought of as metadata. However, in another sense, both are "data about data".

[4] Hodgson, Katrina, *Metadata: Foundations, Potential and Applications,* School of Library and Information Studies, University of Alberta, March 1998. http://www.slis.ualberta.ca/538/khodgson/metadata.htm

slim subset of the SGML language which the Internet uses. XML addresses two sets of problems. First, SGML's powerful and broad nature has generated specific applications and varying compliance. This specificity in turn has created barriers to widespread use: the lack of widely supported style sheets, restricted development of complex software; and limited interchange of SGML data. Secondly, lack of SGML support in browsers has meant the conversion of SGML applications to HTML, whose simplified information content restricts information flexibility and poses a significant barrier to reuse, interchange, and automation. XML's construction enables SGML information to be delivered over the Web, thus overcoming the limitations of HTML. XML is itself a form of metadata that is rapidly attracting numerous applications, because of its potential to render broadly functional and valuable business applications on the Internet, intranets, and extranets.[5]

Some may argue that with the advancement of tools such as XML, there might be no need for standardized data dictionaries – every area would use their own formats and a "self-describing data" tool like XML would take care of the interfaces. However, if this were to be the case, there would still be a need to construct XML tags (or tags for other tools) that would be consistent. In other words, the attributes of the data imbedded in the tags should be in conformance. This approach also doesn't get to the core of the problem in transportation data inconsistency either, namely, the way data elements are defined. For example, a vexing problem in the safety area is that states may code crash data items with different codes (formats). Simply knowing what these codes are does not allow users to combine data from different states without development of a "crosswalk". In some cases, the codes are so different that one-to-one or one-to-many crosswalks are impossible to construct.

2.3.3 Standard Practices

Many standard transportation practices that have been developed by standards organizations deal with how data should be collected. Because the collection of ITS data is outside of the realm of ADUS (i.e., data are collected by other ITS entities), ***standard practices for ADUS will concentrate on data processing and management.*** One area where standard practices should be developed is ADUS data quality control (QC) procedures. Real-time applications have little opportunity for applying QC – data are constantly streaming and being used with very short turnaround times. Data discrepancies are usually noted by ITS personnel and data collection equipment will be fixed if broken, but there the process is not automated and there is no attempt to revise or replace the erroneous data. This is as it should be – ITS control strategies can operate without automated QC and operators can use their own judgement when data are clearly faulty.

However, error tolerances are probably lower for consumers of archived data than for ITS operators. For example, operators would like to know what the approximate speed on a roadway segment is so they can implement signal control or detect incidents. To do this, the resolution of the speed data doesn't have to be that great: general categories of traffic flow usually suffice ("are speeds 55 mph or 25 mph?"). On the other hand, smaller differences in speeds make a significant difference in many applications of ADUS stakeholders, such as emission modeling and performance monitoring. These requirements drive the need for QC procedures for archived data.

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[5] XML for Managers: Evaluating SGML vs. XML from a Manager's Perspective. Arbortext. http://www.arbortext.com/xmlwp.html

Three facets of QC procedures should be explored:

1. Identification of "bad" or "questionable" data. What methods and algorithms should be used to detect faulty data?
2. Editing procedures. Once faulty data are detected, what, if any, procedures should be used to revise the data.
3. Missing Values. A special case of editing, how should missing values be treated? Should imputation based on past history be made?

2.3.4 Message Sets and Data Transfer Protocols

Once data are stored in an ADMS, standardized communication formats should be developed to transfer data across the interfaces. The message sets might be combinations of data elements in a specified order in a particular data representation format. They may include "query sequences" for accessing archived data that include: (1) the initial request for data from the archive, (2) transmission of the actual data in a standard format, and (3) notification that the transmission has been completed successfully. The inclusion of metadata may also be specified.

3. RELATIONSHIPS WITH OTHER ITS DATA DICTIONARIES AND STANDARDS

3.1 Introduction

The development of ADUS standards must deal with a complex set of interfaces and relationships as part of the larger network of ITS data flows and standards development activities. This is particularly true because ADUS relies on other ITS entities as sources for data. In many cases, the standards set in these other areas will have a profound influence on ADUS. The more significant are discussed in this section. The ADUS standards development effort must be fully aware of and coordinate closely with these efforts.

3.2 National ITS Architecture

The National ITS Architecture is not a standards effort *per se*; rather, it sets out general guidelines and concepts that the ADUS standards effort can tap. Version 3.0 of the Architecture included specification of ADUS and represents a major revision in terms of data flows and associated standards requirements. The updated Architecture contains a 144-page document specifying standards requirements for archived data management interfaces, including those with:

- Commercial Vehicle Administration
- Emergency Management
- Emissions Management
- Information Service Provider

- Parking Management
- Toll Administration
- Traffic Management
- Transit Management
- Construction and Maintenance
- Intermodal Freight Depot
- Multimodal Transportation Service Provider
- Weather Service
- Roadside data sources.

These interfaces are a more detailed breakdown of the interfaces shown in Figure 1. To construct them, many existing data flows in the Architecture were directed to the new Archived Data Management Subsystem. In addition, new data flows were added to accommodate interaction between this subsystem and those listed above.

As a guidance document, the Architecture is meant to influence the development of other ITS standards, including data dictionaries. An important question to consider is: if an ITS data dictionary is developed that conforms to the Architecture's specifications for ADUS, does that data dictionary essentially function as a *de facto* ADUS data dictionary? Clearly, no individual ITS data dictionary can address the full range of data needed by ADUS stakeholders. However, if multiple data dictionaries comply with ADUS's expectations, does a separate archived data management system need to be constructed or can the separate systems be linked virtually?

3.3 NTCIP and TCIP

The primary objective of the **National Transportation Communications for ITS Protocol (NTCIP)** is to provide a communications standard that ensures the interoperability and interchangeability of traffic control ITS devices. The NTCIP is the first protocol for the transportation industry that provides a communications interface between disparate hardware and software products. The NTCIP development began with the traffic control equipment industry recognizing the need to extend existing standards to include more complex issues of systems interoperability and communications. This evolved into a national commitment to establish "open" protocol standards that would serve the transportation information network and be adaptable to different communications architectures. To achieve that objective, NTCIP has been developed in conformance with the ISO Open Systems Interconnection Reference Model which is a broadly accepted international set of standards for exchanging information between computer based systems.

The NTCIP Data Collection Monitoring (DCM) Working Group is developing standards that will facilitate the use of ITS devices for data collection. They are addressing three major elements: (a) configuration/setup of DCM equipment, (b) a methodology to put DCM equipment into monitoring mode, and (c) a file structure and methodology for file transfer.

The Transit Communications Interface Profiles (TCIP) is part of NTCIP. Its domain covers the data needs of the functions related to the support of Public Transportation operations, service and planning. This includes all input and output data needed for the following "business

areas" of transit: Fare Collection, Scheduling/Runcutting, Passenger Information, Incident Management, Vehicle On-board, Transit Control Center, and Traffic Management.

3.4 IEEE P1489: Standard for Data Dictionaries for Intelligent Transportation Systems

This standard addresses the concepts of ITS data dictionaries. It provides a framework to support the concepts as well as the set of data concepts and meta-attributes used to describe, standardize, and manage the contents of ITS data dictionaries. It specifies that specific types of entries and documentation be provided for each data element in the data dictionary. An ADUS data dictionary must conform to this standard.

3.5 Traffic Management Data Dictionary (TMDD)

The TMDD identifies and defines the specific data elements which make up the messages used within an Advanced Traffic Management System (ATMS) and exchanged with other ITS applications such as Advanced Public Transit Systems, Advanced Traveler Information Systems and Commercial Vehicle Operations. Because data related traffic management are very valuable to archived data consumers, the TMDD standard is extremely important to track.

3.6 IEEE P1512: Draft Standard for Common Incident Management Sets for Use by Emergency Management Centers

This standard describes sets of messages for use in the exchange of data among centers involved in incident or emergency management as described under the National ITS Architecture. This specification of message sets is independent of the types of centers and the network protocols used for communication between those centers. This is the base standard of a family of related standards addressing the communication among agencies involved in the processing of incidents. The term "incidents" in this standard includes any transportation-related event about which information is received by the emergency management system, including planned roadway closures and special events. This standard has been carefully tailored to allow a wide range of local implementation variation while still using the framework and the concepts of the National ITS Architecture, and the prior work of related standards which it references, and which forms a portion of the messages herein. The specification of messages is compliant with ASN.1.

Like the TMDD, IEEE P1512 is highly relevant to ADUS since incident-related data are an important component of many ADUS stakeholders' applications.

3.7 SAE J2353: Advanced Traveler Information Systems (ATIS) Data Dictionary and SAE J2354: ATIS Message Sets

The purpose of these standards is to develop a minimum set of medium-independent messages and data elements needed by potential information service providers (ISP's) to deploy ATIS services, and provide the basis for future interoperability of ATIS devices. The general objective is to create initial standards for data elements and messages that are essential to the provision of information to travelers in the next few years as this new market develops. The focus is intended to be pragmatic by dealing at first only with those data and messages where there is a

clear, current market and industry demand. At the same time, a comprehensive and systematic consideration is being made for: all stages of travel (pre-trip and en route), all types of travelers (drivers, passengers), all categories of information (advisory, route guidance, traveler services, etc.) all means of surface travel (auto, truck, transit, etc.), and all platforms for delivery of traveler information (in-vehicle, portable devices, kiosks in mobile, public, work, and home environments).

As with traffic and incident management, ADUS standards and ATIS standards are closely related. Standards (metadata and otherwise) are as important to the TMC-to-ATIS transfer as they are to ADUS stakeholders. ISPs would like to receive data that are already in a standard format and they want metadata to understand what the data represent. Archived traffic performance data are also needed by ATIS to develop information products: real-time predictive modeling and historical route planning guides rely on analysis of traffic history. Finally, archived data can be analyzed to determine level and type of ATIS deployments. The mix of recurring vs. nonrecurring congestion is seen as particularly valuable by ISPs.[6]

3.8 Non-ITS Standards

A wide variety of pre-existing data and reporting standards have been developed by ADUS stakeholders. These must be considered in the development of ADUS standards and should be incorporated wherever possible. Examples include:

- ANSI D16.1 – Manual on Classification of Motor Vehicle Traffic Accidents
- ANSI D20.1 – Data Element Dictionary for Traffic Records Systems
- Model Minimum Uniform Crash Criteria
- Existing Federal Data Systems (e.g., Highway Performance Monitoring System, Fatality Analysis Reporting System, National Transit Database, Motor Carrier Management Information System)
- FHWA's Traffic Monitoring Guide
- Emerging location referencing standards for transportation (e.g., LRMS, results from NCHRP 20-27)

3.9 ITS Data Registry

The ITS Data Registry (ITS DR) is a centralized data dictionary or repository for all ITS data elements and other data concepts that have been formally specified and established for use with the national ITS domain. The ITS DR is intended to serve as a common or shared data reference for the national ITS domain. The primary objective of the ITS Data Registry is to support the unambiguous interchange and reuse of data and data concepts among functional-areas of ITS (i.e., among associated ITS subsystems and their application systems) by recording unambiguous definitions of data concepts. As ITS data dictionaries are developed, they are entered in the ITS DR. If similar data elements or concepts from a submitting data dictionary already exist in the ITS DR, any differences need to be reconciled via a consensus process.

[6] Given these conditions, ATIS providers (e.g., ISPs) are a group of ADUS stakeholder that have not previously been identified.

Because ADUS gets data from different sources, data harmonization is very important. ADUS users will need to be involved in any harmonization process. Non-ITS data systems will need to be represented in any harmonization effort that would affect them.

4. POLICY CONSIDERATIONS

4.1 Standards Coordination

As pointed out previously, ADUS standards are intimately tied to the standards developed for the ITS entities that serve as data sources for ADUS. As a matter of policy, it is crucial that the USDOT and ITS standards development organizations (SDOs) promote ADUS and incorporate ADUS requirements into current and future standards efforts. This is especially relevant for the development of other ITS data dictionaries where specifications for data concepts and elements may be inconsistent with ADUS's needs.

One approach to the development of an ADD is to concentrate on data elements and concepts that are unique to ADUS (e.g., aggregations, transformations, and data collection/processing documentation). This relies on other ITS data dictionaries to develop most of the primary data elements. Another approach is to develop an ADD that is comprehensive and encompasses all of the data required by ADUS stakeholders. Such an approach could then serve as a guide to other data dictionaries, alerting them to the needs of ADUS stakeholders. The problem with the latter approach is timing: several key ITS data dictionaries are complete or nearing completion, and the window for influencing them is closing. However, standards in general are never permanent and undergo periodic revisions. This may particularly true of ITS where implementation experience is limited and technology is rapidly changing. Having an ADD that covers all ADUS requirements might be a beneficial in the long-term, although the results will not be obtained for several years.

Although the ITS Data Registry has been established for harmonizing differences in data concepts and definitions, it requires that a comprehensive ADD be registered – this will require substantial lead time if indeed a comprehensive ADD is developed. Also, at the point of ITS DR harmonization, substantial effort will have already gone into the development of other ITS standards and SDOs may be reluctant to make modifications at that point. Therefore, the expected influence of an ADD is earlier in the development process for other ITS standards where it can serve as the main vehicle for communicating the requirements of ADUS stakeholders. The ITS DR would be considered the "last resort" for influencing other ITS standards.

4.2 Building National Acceptance

National acceptance hinges on ADUS stakeholders taking an active role in standards development. In the past, many ADUS stakeholders have been removed from all facets of ITS, from conceptualization to deployments. With increased emphasis on "mainstreaming" ITS into everyday practice and on unifying transportation agency functions, however, ADUS stakeholders will become increasingly involved in the ITS decision process. Standards

development is a logical entry point for them into the process as it not only directly affects the nature of the data they could receive but provides an opportunity to interact with the other ITS players.

National acceptance of ADUS standards also depends largely on the cooperation received from ITS entities responsible for other ITS standards and deployments. Although archived data has not been a priority for these entities – they have correctly been concerned with real-time operations up to now – it is clear that they too can benefit from consistent applications of archived data. For example, operations personnel can use archived data to develop effective operations plans based on historical patterns in use. As previously mentioned, ATIS providers can profit from standardized archived data. This is especially important to the private sector firms seeking to enter multiple urban markets.

In spite of the large payoff potential of ADUS standards, development efforts will walk a fine line between alienation and inclusion. If ADUS standards are seen as being excessive, there is a risk that ITS entities will not embrace them. It is therefore crucial that the correct balance is struck between covering ADUS stakeholders' needs and the burden placed on other ITS SDOs.

5. DEVELOPMENT APPROACH

5.1 Organizational Structure and Roles

The organizational structure of the ADUS standards development process is shown in Figure 4. In this approach:

- The SDO leading the development of ADUS standards is the ***American Society for Testing and Materials (ASTM)***. An organizational meeting was held in December, 1999, and an ADUS committee was formed: E17.54.[7] As of this writing, the Committee is seeking members and will hold its first formal meeting in June 2000. The membership would ideally comprise all ADUS stakeholder interests as well as any other affected parties (equipment manufacturers, information system developers). This Strategic Plan will serve as a basis for the committee's activities. The Committee will interact with other SDOs developing ITS standards to resolve differences early.
- It is proposed that the ***USDOT*** support ASTM Committee E17.54 through the cooperative agreement with the ITS SDOs. The USDOT has developed an *ADUS Program Plan* in support of ADUS activities including research, deployments, and evaluations of standards. This input will be used by the ASTM Committee to develop ADUS standards. Likewise, the standards themselves may be included in future USDOT activities; this is in keeping with the expected evolutionary nature of ADUS standards development.
- A ***Program Manager*** will oversee all ADUS standards activities, except for those of USDOT and other ITS SDOs. The Program Manager will be responsible for coordinating the different activities, including the actions of the ASTM Committee and ADUS submittals to the ITS DR. The Program Manager will work with the ASTM Committee to determine

[7] This was formed as a subcommittee of Committee E17 (Vehicle-Pavement Systems). E17.54 is technically known as the Subcommittee on the Archived Data User Service.

which standards will be undertaken. (The final decision rests with the Committee, however.) In conjunction with the Committee, the Program Manager will strategically plan and guide the process by establishing the priority and sequence of work. The Program Manager may form a Steering Committee for advisement on overall direction. If this is done, the Steering Committee should take full advantage of the relevant professional organizations (see below). The Program Manager, in conjunction with the ASTM Committee, will also be responsible for outreach activities to promote the development of ADUS standards and will serve as the interface between the ASTM Committee and outside organizations. This includes soliciting support from relevant professional organizations.

- Support from ***Professional Organizations*** that represent stakeholder interests should be obtained. Examples of these organizations include, but are not limited to: Institute of Transportation Engineers (ITE); Transportation Research Board (TRB; particularly the data committees); Society of Automotive Engineers (SAE); Association of Metropolitan Planning Organizations (AMPO). Many of these organizations are represented on the National Associations Working Group (NAWG) for ITS. AASHTO committees that deal with data and information systems are another potentially valuable avenue of support for ADUS standards. Professional organizations would support the development of ADUS standards by encouraging participation in the ASTM Committee and incorporating standards into their operations.
- The ***ITS Data Registry*** will be used to reconcile differences in data concepts between and ADD, other ITS data dictionaries, and data dictionaries from transportation agencies.
- ***External influences*** on the standards development process include the National ITS Architecture and IEEE P1489.

5.2 Timeliness of Product and Prioritization

Because of USDOT's early efforts in this area – along with the visibility brought by the revision to the Architecture – transportation agencies have started to recognize the value of ADUS. As a result, ADUS implementation in the field has already begun. Further, because of the close ties with other ITS standards efforts that are completed or in progress, ADUS standards activities must begin quickly to have an impact on transportation practice. Therefore, one of the first activities that must take place is the creation of a development schedule in which standards efforts are prioritized. Clearly, if the development of all potential types of standards specified in this Strategic Plan is undertaken, several years will be required to complete all the tasks. If the release of standards is not staged, it will be too late in the development cycle of related ITS standards to exert any influence on them. The first iteration of the prioritization is presented below. However, these priorities may change depending on developments in other standards efforts or the discretion of the ASTM Committee.

5.3 Sequence of Standards Development

An aggressive schedule for ADUS standards development is thus foreseen, with the activities grouped into "waves" or "packages" of standards, similar to the way the 5-Year ADUS Program Plan is structured. Possibilities for these groupings can be based on the type of interface (as shown in Figure 1), by type of standard (data dictionary, metadata, standard practices, message sets) or some combination of the two. Because standards for archived ITS data are extremely varied, the "waves" of standards should be developed in clearly defined

"sections"; this mirrors the way in which the TMDD was developed. It also provides a logical sequence of steps to follow.

It is anticipated that the sections will be built around four categories of data and their associated "market package bundles" (as defined in the Architecture):

1. Traffic Data (Advanced Traveler Information Systems and Advanced Traffic Management Systems).
2. Transit Data (Advanced Public Transit Systems).
3. Incident Data (Emergency Management and Advanced Traffic Management Systems).
4. Freight Data (Commercial Vehicle Operations).

For each category of data, two types of standards will be considered: (1) guidelines for processing, storage, and retrieval and (2) data dictionaries. The guidelines will follow the general principles presented in Table 3; these were one of the useful products from the March 2000 Workshop. Both types of standards may not be pursued in each category; this will be determined by the ASTM committee and the ADUS Standards Program Manager.

Because ITS travel monitoring data are the most widely collected type of ITS data and they have the widest range of application, Section 1 will be built around them. The remaining three categories of data (i.e., transit, incident, and freight data) will comprise Sections 2, 3, and 4. The sequence in which these are addressed will also be determined by the ASTM committee and the ADUS Standards Program Manager.

Section 1: Standards for Archiving ITS-Generated Travel Monitoring Data

For each subsection, two forms of ITS travel monitoring data will be covered:

1. Traffic stream characteristics measured by roadway equipment (volume, speed, occupancy, and vehicle classification).
2. Travel time data measured by vehicle probes and personal devices (e.g., cell phones).

Section 1a: Guidelines for Processing, Storing, and Retrieving Archived ITS Travel Monitoring Data

Type of Standard: To be determined. Standards in this category could include guides, practice, specification, and test methods. Guides will probably be the preferred form to allow flexibility in implementation. A balance must be struck between "hard" and "soft" standards. For example, a hard standard would specify exactly what an aggregated data element would be, while a soft standard would allow users to create their own aggregations but require a complete documentation trail on how the aggregation was achieved.

Description: Several aspects may be explored including:

- Quality control methods / procedures
- Aggregation methods / procedures
- Message sets for transferring data across ADMS interfaces

Section 1b: Data Dictionary for Archiving ITS Travel Monitoring Data

Type of Standard: Specification

Description: The standard will cover both metadata and supporting data to describe adequately the collection, processing, and storage of "primary" data elements. (Primary data elements are those collected by the ITS sources supporting the archive.) Metadata will include not only the attributes of data elements specified in IEEE P1489 but additional metadata that may be necessary. Maintenance of metadata and supporting data will be covered.

Table 3. Guiding Principles for Archived Data Standards

- Care should be taken not to over-specify standards in order to encourage adoption by a wide variety of transportation agencies.
- Metadata standards and standard guidelines are the two types of standards that should be pursued first. These allow the greatest flexibility in user applications.
- Close coordination with other ITS standards efforts is crucial because most archived data originate at sources not under the direct control of ADUS stakeholders.
- Standards should accommodate widest variety of field sources, including new technologies (e.g., cell phones, probes).
- Data should be saved in their originally collected form for a period of time before they are deleted.
- Any changes, transformations, or creation of new data should be adequately documented.
- Privacy of individuals and firms must be maintained, except in cases where the data are explicitly collected for such purposes (e.g., enforcement).
- Indicators of data quality, collection conditions, and source should be documented.
- Standards should contribute to the reporting of Federally-required data.

5.4 Schedule

The Strategic Plan will form the basis for the development of individual Project Plans for individual ADUS standards. It is expected that the first Project Plan will cover Section 1, as discussed above. Preliminary target dates for specific events are presented below.

- June 2000 – get agreement on first Project Plan (Section 1) and organize one or more working groups of the ASTM committee.
- July 2000 – submit first Project Plan to the Joint Program Office within FHWA.
- August / September 2000 – receive approval of first Project Plan.
- October 2000 – working group(s) start to meet.
- June 2001 – first ballotable guideline (Section 1a).
- December 2001 – second ballotable guideline (Section 2a). Begin work on data dictionary standards (Sections 1b, 2b, 3b, and 4b).

- June 2002 – third ballotable guideline; first guideline approved.
- December 2002 – first ballotable data dictionary and fourth ballotable guideline; second guideline approved.
- June 2003 – second ballotable data dictionary; third guideline approved.
- December 2003 – third ballotable data dictionary; fourth guideline approved; first data dictionary approved.
- June 2004 – fourth ballotable data dictionary; second data dictionary approved.
- December 2004 – third data dictionary approved.
- June 2005 – fourth data dictionary approved.

Project Plans would be submitted as needed to support this aggressive schedule.

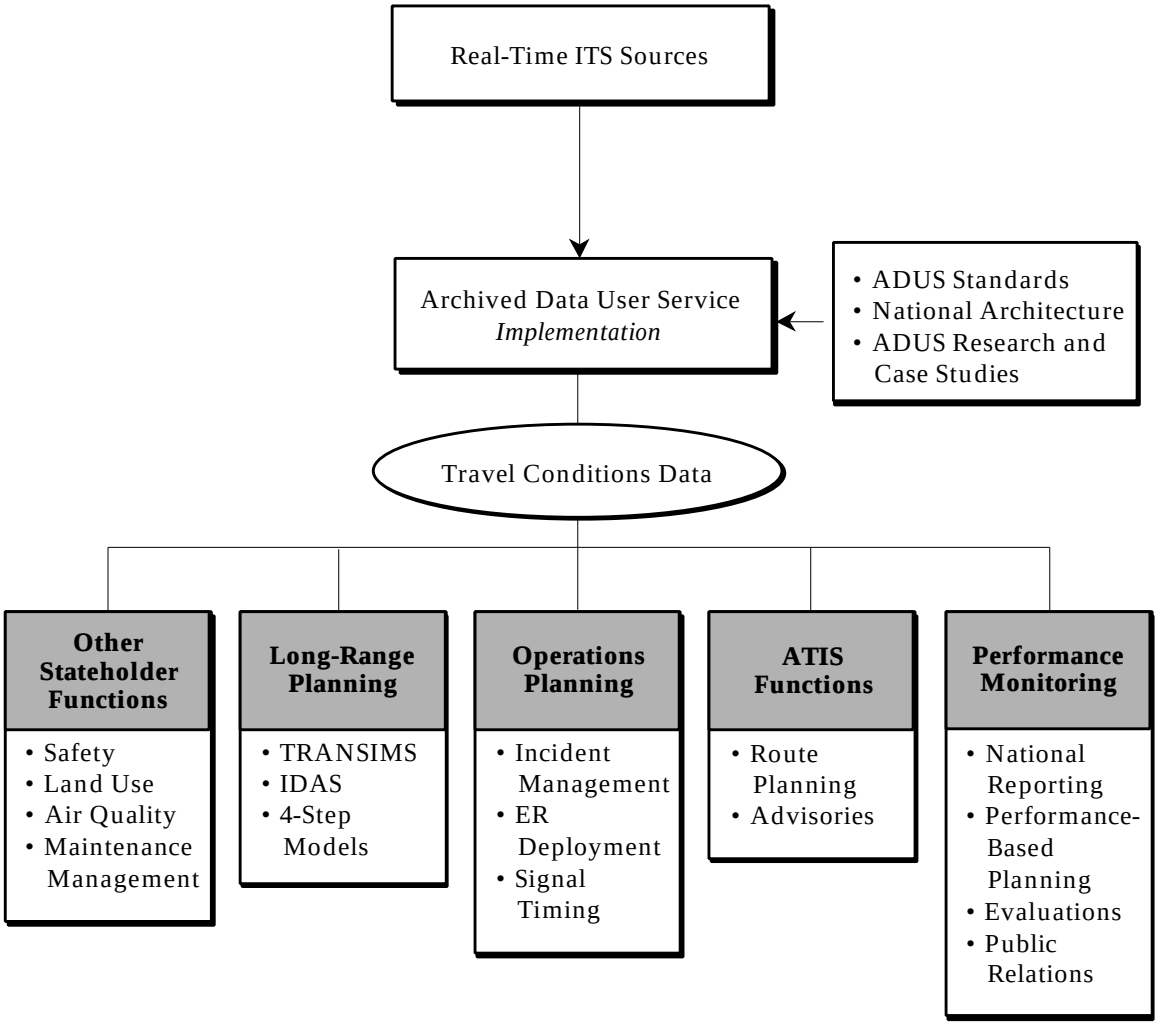

Figure 1. Use of Archived ITS Travel Conditions Data in Stakeholder Applications

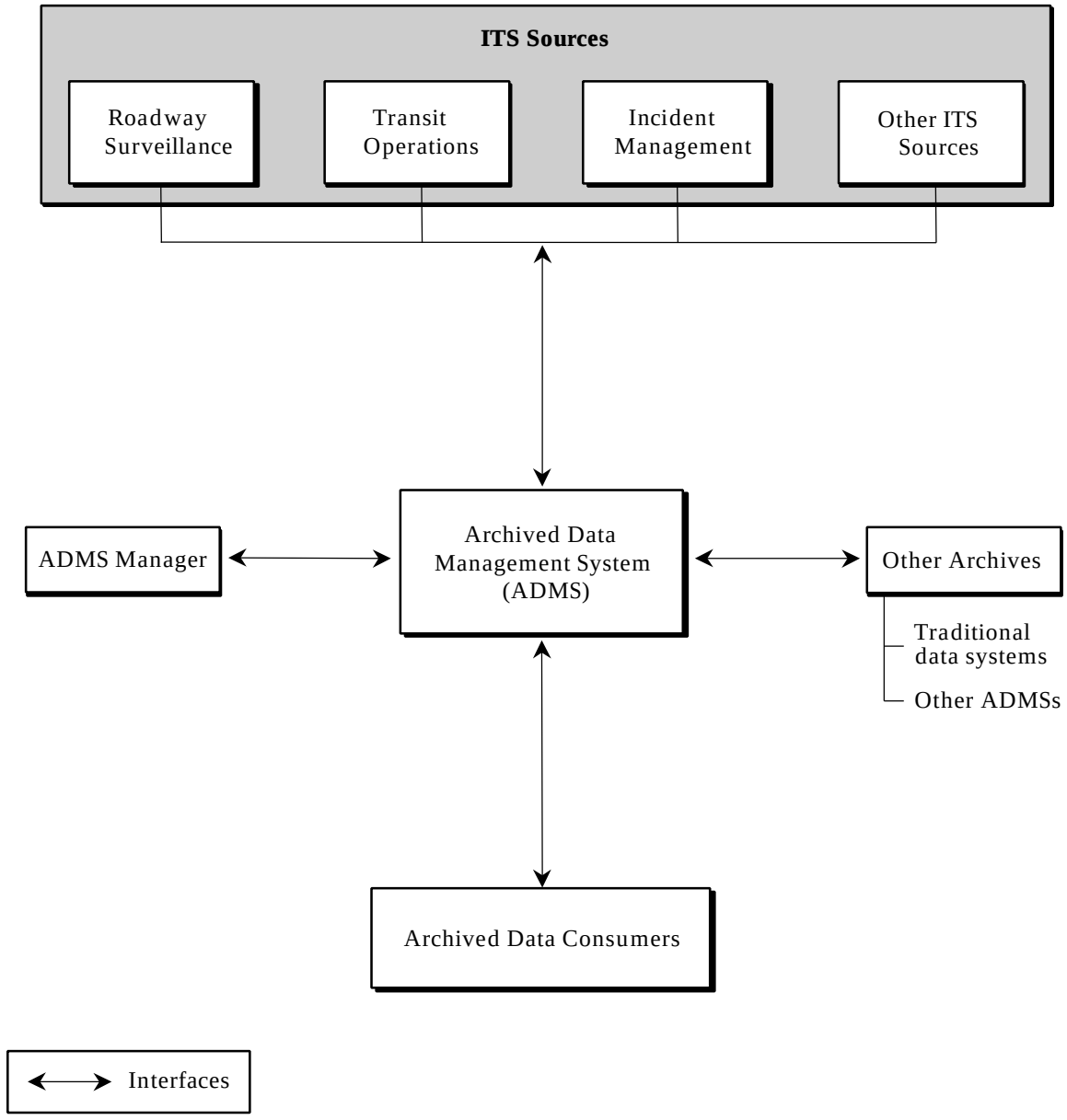

Figure 2. Standards Will Promote the Development of Interfaces for Archived Data Management Systems

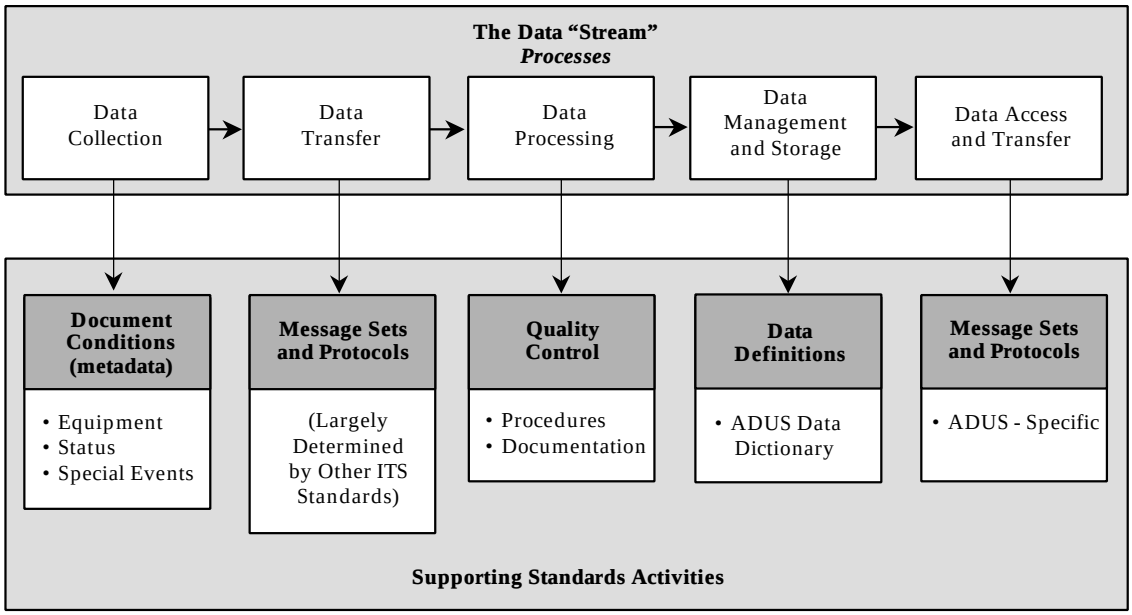

Figure 3. ADUS Standards Take Many Forms and Support the Various Process of the Data Stream

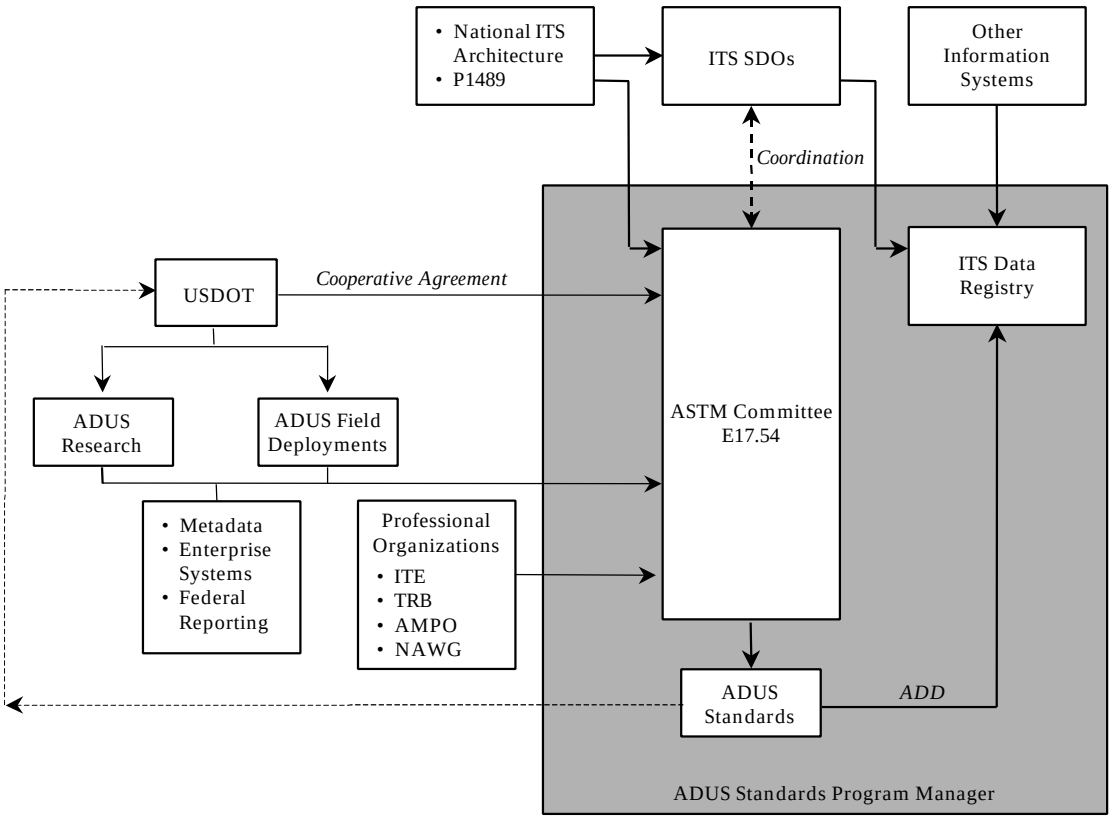

Figure 4. Organizational Structure for ADUS Standards Development