This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

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Standard Guide for Archiving and Retrieving Intelligent Transportation Systems-Generated Data[1]

This standard is issued under the fixed designation E2259; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

INTRODUCTION

This guide has been developed within the framework of developing standards of ASTM International and thus the format, structure, as well as the review, balloting, and approval processes conform to those specified by ASTM International. These processes may differ in their particulars from those used by other standards development organizations associated with developing ITS standards. However, their general intent is the same—that of having a representative group of interested and knowledgeable stakeholders develop standards that can be used by a wide variety of public and private organizations in developing Archived Data Management Systems (ADMS), which can be used to facilitate data sharing and interoperability among systems.

This guide has been prepared with various ITS data stakeholder groups in mind, that is, data users, ADMS policy makers, ADMS developers, and ADMS administrators. To data users and ADMS policy makers, it can provide a general understanding about technical approaches to archiving and retrieving ITS-generated data. For the ADMS developer group, which includes data application software developers, this guide can be a bench-marking reference against which existing ADMS could be further refined or improved with broader perspective. Further, it is also intended to bring greater awareness and consistency in the use and understanding of concepts and use of terminology by the ADMS developers. Finally, the ADMS administrators, whose main function includes collecting, archiving, managing, and distributing ITS data, can find practical guidance and approaches from this guide for effectively operating their ADMS.

It should be noted that there is a subtle distinction in the use of the acronym ADMS throughout this guide. When it is being used in the context of the National ITS Architecture, the *S* stands for a *subsystem* of the National ITS Architecture. When the acronym ADMS is being used in the context of an archived data management system in general, or a particular deployment of one, then the *S* stands for *system*. It is also noted that Appendix X1 to this guide presents relationships of the guide to several other activities and standards.

This guide follows the intent of all guides prepared within the ASTM International framework. In particular, it suggests approaches, offers an organized collection of information, or proposes series of options or instructions that give direction without recommending a specific course of action. Guides are also intended to increase awareness of potential users of the standards of the available techniques in the subject area, while at the same time providing information from which subsequent practices can be derived. This document, however, cannot replace a broad-based education or pertinent experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This guide is not intended to represent or replace the standard of care by which one judges the adequacy of a given professional service, nor should this document be applied without consideration of the many unique aspects of a project. The word *standard* in the title of this document means only that the document has been approved through the ASTM International consensus process.

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1. Scope

1.1 This guide covers desired approaches to be considered and followed in planning, developing, and operating specific ADMS for the archiving and retrieval of Intelligent Transportation Systems-generated data. The scope of this guide anticipates incremental or modular implementation of an ADMS, which over time and with a series of investment of resources will approach or exceed desired practice. However, it is recognized that programmatic constraints of time and budget resources do not always allow practitioners to follow a more desirable course of action, and that during interim periods the ability to implement a particular fully functioning system may be less than desired.

1.2 The desired approaches described in this guide are foundational and are not intended to be all-inclusive. Users of this guide are allowed, and indeed encouraged, to exceed the desired practices in one or more of several ways. An example of one way is that to address and satisfy the particular needs and requirements of some of the intended users and stakeholders for a particular implementation may necessitate exceeding the desired practice. Another example is that some implementations may want to foster innovations and research into new methods and procedures related to the overall implementation of a particular ITS activity. Part of that may be the recognition that specialized archiving or retrieval processes, or both, would facilitate such innovations or research, or both. A third example is that some organizations may simply have more resources to invest in activities such as archiving and retrieval systems and may choose to have more quantities or higher quality of data and information available to their planning or operations units to use in their day-to-day activities.

1.3 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E867 Terminology Relating to Vehicle-Pavement Systems

2.2 *IEEE Standard:*[3]

IEEE 1489 Standard for Data Dictionaries for Intelligent Transportation Systems

3. Terminology

3.1 *Definitions:*

3.1.1 The ASTM publication of the Committee on Definitions; Terminology E867 maintains a complete list of terminology some of which are applicable to this guide and by convention are not repeated here.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *aggregate, v*—to process or combine like items into a category; for example, adding together 30-s traffic volume counts, or averaging speeds from lane-by-lane detectors that are parts of traffic data counting station to be the total traffic volume or average speed at that traffic counting station for a 5-min time period.

3.2.2 *aggregation, n*—the resultant set of aggregated data associated with an aggregating process.

3.2.3 *archive, n*—the organized collection of data and information derived from selected ITS-generated data flows and other data sources.

3.2.4 *archived data administrator, n*—the person who is responsible for the day-to-day operations and long-term management of an ADMS.

3.2.5 *archived data management subsystem (ADMS), n*—a subsystem of the National ITS Architecture that provides a means for several organizations to collect, store, and subsequently, analyze and retrieve data from ITS data sources, usually by way of one or more ITS centers.

3.2.6 *archived data management system, (ADMS), n*—this is a system that is a specific implementation of an ADMS within the context of a local, regional, or statewide ITS architecture.

3.2.7 *archived data user service, (ADUS), n*—one of the ITS user services that defines the scope of the National ITS Architecture with regard to archiving and retrieving ITS-generated data.

3.2.8 *archive structure metadata, n*—descriptive data about the structure of the data archive itself and of the data and information in the archive that facilitate use of the archive.

3.2.9 *archiving, v*—collecting and actively managing original source and other data with the intent of saving the data as well as associated metadata.

3.2.10 *data, n*—a quantitative or qualitative representation that is observed, measured, collected, or gathered that characterizes some static or dynamic attribute of the physical world or the use of it by individuals or groups of people and that is suitable for communication, interpretation, or processing by humans or machines.

3.2.11 *database, n*—a collection of related data, typically organized in a computerized recordkeeping system that is part of a system whose purpose is to maintain the data and information derived from it so it can be made available for use.

3.2.11.1 *Discussion*—In addition, as noted by Smith (**1**),[4] it should (*1*) represent some aspect of the real world, organization, or enterprise; (*2*) that is logically related and has inherent meaning; and (*3*) be designed, built, and populated for a specific purpose.

[1] This guide is under the jurisdiction of ASTM Committee E17 and is the direct responsibility of Subcommittee E17.52 on Traffic Monitoring.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from Institute of Electrical and Electronic Engineers, Inc., 345 E. 7th St., New York, NY 10017.

[4] The boldface numbers in parenthesis refer to the list of references at the end of the standard.

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3.2.12 *database management system (DMBS), n*—a set of programs that manipulate and maintain a database while providing independence from an application.

3.2.13 *data collection system metadata, n*—data about the conditions and procedures under which original source data were observed, surveyed, measured, gathered, or collected, as well as about the equipment that was used.

3.2.14 *data dictionary, n*—an information construct that describes the particular data stored in a database, typically in terms of a common set of attributes that includes the meaning, concept, and use; see IEEE 1489.

3.2.15 *data element, n*—a data item that is a basic building block of a data dictionary that is a formal representation of some single unit of information of interest with a singular instance value at any point in time about some entity of interest.

3.2.16 *data logging, v*—to capture a stream of near-real-time data as it passes through a transportation management center.

3.2.17 *data mart, n*—a National ITS Architecture market package in which an archiving system collects and archives operational data from one organizational source; it is analogous to a library whose collection is acquired from a single publisher.

3.2.18 *data quality, n*—the fitness of data for all purposes that require it. Examples of data quality measures include accuracy, completeness, coverage, and timeliness.

3.2.19 *data sources, n*—the systems that provide data.

3.2.19.1 *Discussion*—Traffic count data can be retrieved from traffic management centers, or air temperature data can be retrieved from surface transportation weather service providers.

3.2.20 *data warehouse, n*—a National ITS Architecture market package in which physically distributed data sources (*1*) contribute to a central clearinghouse, where each data source is locally managed, and (*2*) exchange multiple transportation-related data; it is analogous to a library whose collection is acquired from multiple publishers.

3.2.21 *equipment package, n*—the building blocks of ITS subsystems that perform a specific function.

3.2.22 *erroneous data, n*—one or more pieces of data in a data set that has incorrect values due to a variety of reasons such as improper functioning of the data collection device, miscommunications, or shortcomings in subsequent processing programs.

3.2.23 *expired data, n*—the status assigned to a set of data, summary statistics, or information that is no longer current or valid and needs to be replaced.

3.2.24 *imputation, n*—the act of putting onto a data set estimated values for that data to fill in for missing values or to replace erroneous values.

3.2.25 *information, n*—the result of processing one or more pieces of data to produce a meaningful and useful statistic or indicator for users.

3.2.26 *integration, n*—the result of blending compatible data sources into a composite data set has a unity or wholeness for purposes of analysis, summarization, and retrieval of specific data or information.

3.2.27 *intelligent transportation systems (ITS), n*—systems that apply modern sensing, communication, computing, analysis, or display technologies, or a combination thereof, to one or more aspects of the operations, management, and use of transportation systems.

3.2.28 *log file, n*—a usually freeform set of text or data, or both, that sequentially lists or enumerates events, many of which may be independent, while some may be chained or interrelated

3.2.29 *market package, n*—a service-oriented perspective to the National ITS Architecture, including subsystems (with applicable equipment packages) and architecture flows.

3.2.29.1 *Discussion*—The market packages relevant to ADUS are ITS Data Mart, ITS Data Warehouse, and ITS Virtual Data Warehouse.

3.2.30 *metadata, n*—loosely has been defined as data about data but is more tightly defined as the detailed description of instance data, including the format and characteristics of instance data, where "instance data" is defined by Tannenbaum (**2**) as "that which is input into a receiving tool, application, database, or simple processing engine."

3.2.30.1 *Discussion*—Three categories of metadata are defined in this guide as: (*1*) archive structure metadata, (*2*) processing documentation metadata, and (*3*) data collection system metadata.

3.2.31 *missing data, n*—one or more fields in a data record that has no valid values due to a variety of reasons such as improper functioning of the data collection device, failed communications, or shortcomings in subsequent processing programs.

3.2.32 *national ITS architecture, n*—a document prepared through the sponsorship of the U.S. DOT that provides a common structure for the design of intelligent transportation systems, giving a framework around which multiple design approaches can be developed by defining: (*1*) the functions that must be performed to implement a given user service, (*2*) the physical entities or subsystems where these functions reside, (*3*) the interfaces/information flows between the physical subsystems, and (*4*) the communication requirements for the information flows.

3.2.33 *near-real-time data, n*—data that is collected, processed, aggregated very close in time, usually within seconds or just a few minutes, to the actual time period or instance when the phenomenon being measured or observed actually occurred.

3.2.34 *original source data, n*—data as received by a center that is a source for an archive.

3.2.35 *persistence history, n*—documentation of one or more modifications made to a set of data that can be used to trace back the specific procedures that were applied and when that was done and that becomes part of the processing documentation metadata.

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3.2.36 *processing documentation metadata, n*—information that describes the processes applied to data from original source data through to storage in an ADMS.

3.2.37 *quality control, n*—a system or process for obtaining, maintaining, and verifying a desired level of quality in a data set, process, or service by careful planning and design, the use of proper equipment, continued inspections, and taking corrective actions where and when required.

3.2.38 *resolution, n*—the level of spatial or temporal detail or administrative classification at which a particular data element is collected, archived retrieved, or both, from an ADMS; that is, lane-by-lane versus detector station or intersection approach; a 20-s versus a 15-min time period; or a particular named city versus the generic term of city.

3.2.39 *retrieving, v*—extracting from the ADMS one or more data values or information sets of interest to a user where the format of that may be one or more sets of text, tables, charts, graphs, schematic diagrams, or maps, using one or more varieties of media such as print, electronic files, electronic mail, or storage media such as CD ROMs or DVDs.

3.2.40 *stakeholder, n*—a person, party, or private or public agency or organization that is interested in one or more aspects of how ITS-generated data is collected, archived, analyzed, or retrieved from an existing or proposed ADMS.

3.2.41 *storage media, n*—the systems upon which the archive or data set, summaries, or displays extracted from it are kept for use by the ADMS or for distribution to various users or stakeholders.

3.2.42 *terminators, n*—functions that basically take place outside of the National ITS Architecture but which interfere with one or more subsystems of the National ITS Architecture by sharing data or information, or both, with them.

3.2.43 *transformed data, n*—values created by combining data with other data or subjected to a methodology or mathematical process such as logarithmic transformation, averaging; for example, annual average daily traffic, average speed by segment, congestion indices, or equivalent single-axle loads.

3.2.44 *truth-in-data, n*—provision of adequate and appropriate metadata that should be given to users of an ADMS that a particular information set they are using is not original source data or information but rather is transformed data; that is, some transportation management centers (TMC) estimate/calculate average traffic speed by detector for each time period based upon algorithms that use volume and lane occupancy as original source data, that could also apply to some of the data being imputed.

3.2.45 *user service, n*—the National ITS Architecture defines various user services that are groups of ITS-related functions that generally meet the need and requirements of a group of stakeholders for a particular type of service; the archived data user service was the thirty-first user service to be defined in the National ITS Architecture following a set process and period of interaction of the architecture team with the stakeholder community and the development and approval of a set of documentation of the need and characteristics of that user service.

3.2.46 *virtual data warehouse, n*—a National ITS Architecture market package in which physically distributed ITS archives exchange multiple transportation-related data even though the warehouse is not a center that directly collects its own ITS-related data, and it is analogous to a library whose collection is acquired from other libraries or from a central library system.

3.3 *Acronyms:*

AASHTO	=	American Associaton of State Highway and Transportation Officials
ADMS	=	Archived Data Management Subsystem or Archived Data Management System
ADUS	=	Archived Data User Service
DOT	=	Department of Transportation
FHWA	=	Federal Highway Administration
IEEE	=	Institute of Electrical and Electronics Engineers
ITE	=	Institute of Transportation Engineers
ITS	=	Intelligent Transportation Systems
JPO	=	Joint Program Office (for Intelligent Transportation Systems)
NCHRP	=	National Cooperative Highway Research Program
NEMA	=	National Electrical Manufactures Association
NMEA	=	National Marine Electronics Association
NTCIP	=	National Transportation Communication for ITS Protocol
SAE	=	Society of Automotive Engineers
TCIP	=	Transit Communication Interface Profile
TRB	=	Transportation Research Board
U.S. DOT	=	United States Department of Transportation

4. Summary of Guide

4.1 This guide intends to help a range of practitioners better understand and keep their practice current with this rapid pace of change by disseminating information and general direction about this evolving state of the art, which may be out ahead of the state of the practice. ADUS standards are to be developed for several sources of ITS-generated data, with traffic monitoring data being the first of these sources. This guide will help form the conceptual basis for developing these specific standards. This guide is to foster the timely development and use of many ADMSs that could benefit many stakeholders who are interested in using archived data and information from these expanded systems.

5. Significance and Use

5.1 This guide recognizes that activities associated with the archiving and retrieval of ITS-generated data must satisfy two classes of considerations: technical considerations and institutional considerations. Many aspects of such processes are analytic ones that need to address and satisfy various mathematical, statistical, database management, information technology, or other similar technical concerns. On the other hand, many aspects of such processes are ones that need to address and satisfy various intra-agency, intra and inter-organizational, management approaches, decision-making, public-private participation, public involvement, or other similar such institutional concerns. This technical-institutional duality usually must both be satisfied for operational archiving

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or retrieval process to be efficient and effective. That may also require a change in focus of the group responsible for the ADMS work to meeting the needs of their customers. Thus, in planning, designing, or operating the functions and interfaces of an ADMS, appropriate technical and institutional approaches must often be explored concurrently in order to have an overall efficient and effective archiving or retrieval of ITS-generated data, or both. However, even though this guide gives importance to the institutional considerations when planning, designing, or operating an ADMS, this guide gives more weight and attention to the technical considerations of the functions and interfaces associated with an ADMS. This approach of focusing on function will give more latitude to institutions to be freer to arrange institutional matters on their own.

5.2 This guide also deals in general with the questions of what data and information in particular should be considered for archiving, as well as what data and information in particular should be considered for being retrieved. While more in-depth consideration is to be given in the companion specifications, the following is a general characterization of what data and information should be considered for archiving. These include the following:

5.2.1 A structure of data storage based upon individual core data elements,

5.2.2 The data elements are stored in electronically readable media,

5.2.3 Documentation is included regarding the data structure and quality, and

5.2.4 Metadata is part of the archive relating to aspects such as the quality of the data and whether quality control adjustments have been made.

5.3 The particular original data sources and data elements that will be in an archive are expected to be unique to that archive. Which data sources and elements are used will depend upon a combination of the needs and requirements of potential users, as well as the availability of particular data sources from other systems. For example, a particular ADMS may have some emergency management data on incident management responses, some traffic station sensor data from a traffic management subsystem, and some pavement temperature data from a roadway weather information system.

5.4 With regard to *what is to be retrieved*, this guide recommends flexibility to provide for the needs of a diverse set of stakeholders. Some will want to retrieve short tabular summaries, while others will want longer and more complex ones; some will want graphs and charts, while others will want thematic maps of variations in the data. Accounting for different time periods and combinations of data and information quickly leads to an enormous range of possible data retrieval queries and approaches. While this guide does not recommend one retrieval approach being better than another because what is best will be very user specific, general guidance about the retrieval of data and information can be found in 10.16.8.

6. Concepts Related to Data Archiving, Retrieval, and Warehousing

6.1 *Distinctions Between Data Logging and Data Archiving*—Data logging is seen as a process where a transportation or TMC captures a stream of real-time data as it is passing through the TMC or as transmitted by the TMC. Various metaphors have been used to describe such logging processes such as turning on a spigot, or attaching a fire hose to the original source data. The data being captured through such a logging process typically gets saved in some data storage medium using some structured file or database system, and may actually subsequently go through a data archiving process. The term "data archiving" implies using some more comprehensive processes as well as longer-term storage than data logging. Extending the analogy to water flow, the archiving may do things such as the following: (*1*) put the data into various buckets or containers for later use, (*2*) filtering or distilling it in some way to remove impurities and improve its quality, or (*3*) redirecting, or aiming, the stream or containers of data at current or near-term applications that can use the data or derived information, or both to quench a need.

6.2 *The Terms "Data Archive" or "Data Warehouse"*—A data archive is a lot more than a collection or storage of original source data. Generally speaking, there is: (*1*) ongoing operational monitoring of some combination of the use, performance, characteristics, or events related to all or parts of a transportation system; (*2*) some sort of system for continually, or very frequently, capturing the data into the archiving process; (*3*) some quality control checks on the data; (*4*) information about the data that can be helpful to people trying to use the data; and (*5*) processes to get the data and information out of the archive and into the hands of users in ways that are meaningful to them. The use of the term "warehouse" to describe the archiving implies—drawing from a commerce analogy—a larger scale, more wholesale type of operation, rather than a more retail-oriented, limited-sized store. However, just as in the more contemporary styles of commerce, there can be mega-stores that do serve larger markets and often act as a blend between retail and wholesale. More discussion of a data warehouse is given in X2.4.4.

6.3 *The Growing Importance of Data and Information Retrieval*—This guide places a high degree of importance on the retrieval of data and information from the data archiving process. However, it is recognized that data and information retrieval has probably been the least developed aspect of the ADMSs that are in operation. As such, there are proportionately fewer terms and concepts referenced in this guide that directly deal with retrieval activities. Perhaps the experiences, lessons learned, and future practice will result in additions to the terminology that relate more to the analysis and retrieval of data and information than to the storage of the data. Concepts and terms related more to temporal analysis of the data, such as analyzing trends over time, comparative analysis, visualization of data, predictive applications, and very short-term forecasts, may be among those that will need to be added. Broader approaches to data warehousing and data mining should use

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applied in many other fields and disciplines beyond just that of transportation, may become a source of such future references and terminology.

7. Providing Systems to Archive and Retrieve ITS-Generated Data

7.1 *Reasons for Providing Systems*—There are many reasons why organizations should provide approaches and systems to archive and retrieve ITS-generalized data. Some of the ones given here are from a report prepared by Turner (**3**).

7.1.1 *Maximize Cost Effectiveness of Data Collection Infrastructure*—Data archiving permits transportation agencies to maximize their investments in data collection infrastructure by reusing the same data for numerous transportation-related functions such as planning, design, operations, and research. Two key goals related to this are: (*1*) collect data once and store it once, and (*2*) use the data for multiple purposes many times.

7.1.2 *Established Business Practice in Other Industries*—The retention and analysis of operational data is an established practice in most competitive industries that use data to manage their business activities. For example, the retail sales industry data warehouses full of customer transactions and inventories to better understand the basics of supply and demand in numerous markets around the world.

7.1.3 *Additional Information to Plan, Manage, Operate, and Evaluate the Transportation System*—Archived ITS data can be directly applied to a variety of transportation applications. These include:

7.1.3.1 *Operational Strategies*—The first step in proactive operations-oriented management is to know where problems are likely to occur before they actually do, then preventing or mitigating the impacts of those problems. Archived operations data can be used to: (*1*) predict when and where problems may occur again, (*2*) evaluate alternative strategies for preventing or mitigating problems, (*3*) provide feedback for existing operations strategies, including short-term performance measures and in-depth evaluation studies, and (*4*) develop sophisticated operations products such as real-time travel time predictions.

7.1.3.2 *Performance Measurement, Mobility Monitoring, Congestion Management Systems, and Research Studies*—There are a number of other transportation planning-related activities that can be better carried out when archived data is available as an information source, which include performance measurement, mobility monitoring, congestion management systems, and independent research studies. The need to incorporate ITS-archived data into such efforts may help foster the more timely development of an ADMS. Data archiving and retrieval can be significantly less expensive than having a planning or design workshop recollect even a small percentage of the data using conventional manual methods or special studies.

7.1.3.3 *Support Governmental Reporting Systems*—Those reasons are primarily locally focused on the value of developing an ADMS for a specific locality or region, functional agency, or business organization. In addition, archiving can help more inclusive organizations have better information, such as states having information from their metropolitan areas, or the U.S. DOT having better information from the states.

PLANNING, DEVELOPMENT, AND OPERATIONS OF ARCHIVED DATA MANAGEMENT SYSTEMS

8. Issues and Challenges in ADMS Development

8.1 Instituting an ADMS in practice raises several issues and challenges for developers of such systems. Specifically, developers should be aware of the following before embarking on ADMS development.

8.1.1 *Storage Requirements*—Real-time ITS-generated data, the source of primary data for an ADMS, is voluminous. Developers should make realistic assessments of storage requirements and balance these with the needs of archived data users. Delineating offline versus online storage for different types of data—and the procedures associated with using these—are parts of this assessment, and will aid in the optimum design of storage of data processing.

8.1.2 *Choice of Operating System Environment and Database Management System*—It is expected that in managing the archive, the archived data administrator will select an industry standard operating system and database management system that are generally available. That will facilitate the sharing of data and the gathering and retrieval of data and information. While the use of uniquely designed systems is discouraged, it is anticipated that each ADMS would tailor or configure a database management system to best meet their specific needs and requirements.

8.1.3 *Coordination With Existing ITS Data Systems and Sources*—ADMS development must account for the structure of existing systems, particularly those that are responsible for collecting and processing ITS-generated data (for example, TMC). Design cannot be done in isolation, but rather in conjunction, with those of these systems.

8.1.4 *Outside Contracting versus In-House Development*—Public agencies wishing to implement an ADMS need to determine whether system development can proceed with agency personnel, whether outside firms need to be contracted for the work, or perhaps whether an explicit blend of responsibilities for development can be established. There are many issues that will need to be addressed including those of: (*1*) system security, (*2*) ownership of source code, and (*3*) knowledge retention.

8.1.5 *System Development Process*—In general, the system development process should adhere to sound information design principles. Foremost among these is a detailed specification of system requirements prior to actual implementation (see 10.2), followed by a detailed design. If agencies have decided to use outside contractors for system development, then one approach of many for handling the requirements definition and design is a design/build type of contract. Under such a contract, requirements definition can be done either in-house or as part of the design process.

8.1.6 *Uniqueness of Many ITS Data Sources*—System developers need to recognize that several of the ITS data sources that form the basis of an ADMS are uniquely different from traditional transportation-related data sources. While the underlying nature of the data elements may be fundamentally the same as traditional transportation data (for example, traffic counts, passenger loadings, incident characteristics, etc.) the

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combined temporal and spatial relationship among the data elements that tends to be unique. Most traditional transportation-related data sources are either a sampling at a few locations very intensively over time, or are an extensive sampling of many locations during a smattering of different short intervals of time. It is this extensive concurrent spatial sampling at many locations for intensive short intervals of time that takes place over long periods of time that is unique to ITS-generated data. Structuring the ADMS to maintain that uniqueness can be very important to facilitate the effective retrieval of pertinent information from the ADMS that benefit a variety of different users.

9. Timing of ADMS Planning and Development

9.1 *Coincident Development*—In the ideal situation, an ADMS is identified and implemented as a system as part of a much broader ITS deployment in a city, region, or state. That is, it is designed and deployed simultaneously, or coincident to other ITS systems. This avoids the problem of retrofitting an ADMS to existing ITS deployments and is seen as more cost efficient. However, situations are not always ideal and it may be more important to independently proceed with developing an ADMS, roughly in parallel but perhaps off-set in time, than to necessarily wait for the needs and requirements for other systems to be sufficiently defined and ready to start their development cycle.

9.2 *Inclusion in the Transportation Planning and ITS Planning Processes*—To achieve coincident development, the ADMS should be fostered by its proponents into the ongoing planning and programming processes in place at transportation agencies. Several opportunities should be pursued, and the following are some of the typical planning and programming documents and processes that may be used to achieve the objective of developing an ADMS in a timely manner:

9.2.1 *Long-Range Transportation Plans*—ITS strategies and needs are being increasingly identified in regional long-range transportation plans. Where this is the case, identifying an ADMS in conjunction with other ITS deployments will bring the issue into future programming considerations. However, many of these processes are still just capital projects oriented and may not be set up to guide operations-oriented activities, such as development of an ADMS.

9.2.2 *Short-Range Transportation Programs*—Regional or statewide coordinated transportation programming processes provide for an explicit set of capital projects or operating programs, or both, within a given time period and a set of fiscal and human resources. Identification of the deployment of an ADMS as a specific project or program, or as an element of a more inclusive project or program, is often a prerequisite to being able to actually proceed with the development of an ADMS on a particular time schedule.

9.2.3 *Annual Capital or Operating Budgets*—Most agencies use annual capital or operating budgets, or both, and an ADMS may need to be explicitly included in order for development to proceed. In some circumstances, an agency may have sufficiently broad programming authority to enable an ADMS to be developed without the necessity to explicitly identify it in their budgets.

9.2.4 *ITS Strategic Plans and Other Pre-Deployment Documents*—In some cases, planning for ITS deployment occurs outside of the traditional transportation planning process. In that situation, many prospective users of an ADMS may not be initially included in such strategic planning or processes. It is suggested that the responsible parties make an effort to involve prospective users from the outset or the earliest appropriate time.

9.2.5 *Statewide and Regional ITS Architectures*—Proponents of an ADMS should be directly involved in the development of statewide and regional ITS architectures, as these are meant to be the specific set of systems that agencies and private sector organizations will provide for when deploying their individual ITS projects. Potential ADMS users should get involved early in the process, and the developers of these architectures should seek out the participation of such potential users.

10. Guiding Principles for ADMS Development

10.1 This section provides a detailed discussion of guiding principles that should be used in developing an ADMS. A total of eleven overarching principles are identified. The first nine of these eleven principles are organized around the functions found in the National ITS Architecture, although their titles and sequences have been modified slightly in some cases in order to meet the needs of this guide. The eleven guiding principles are the following:

10.1.1 Get archived data from other centers.

10.1.2 Integrate selected other transportation data, including roadside data collection.

10.1.3 Manage the archive to account for data quality.

10.1.4 Specify and maintain metadata to support the ADMS.

10.1.5 Manage the interfaces of the archive data administrator.

10.1.6 Interact with other archives and monitor other standards.

10.1.7 Process user requests for data.

10.1.8 Support analysis of the archived data.

10.1.9 Prepare data for government reporting systems.

10.1.10 Reliance on user needs and requirements processes.

10.1.11 Provide security for the ADMS.

10.1.12 Table 1 presents a grouping of ten of these principles that shows that they can be grouped primarily according to whether their focus is on: (*1*) acquiring data, (*2*) actually managing the ADMS, or (*3*) retrieving data and information. The activities associated with those ten principles take place within an overall context and backdrop of the first principle of reliance on user needs and requirements processes. This guide does not view these principles as being sequential with respect to one another. Rather, all of these are seen as being more organic in their interrelationships, with each interacting simultaneously with the others.

10.2 *Reliance on User Needs and Requirements Processes*—A general principle that should be followed in the establishment of an ADMS is to rely upon user needs and requirements processes that involve the range or sample of stakeholders that are anticipated as the providers and as the users of the archived data. This may involve determining

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