ITS Data Archiving

Five-Year Program Description

March 2000

EXECUTIVE SUMMARY

The purpose of this document is to explain the need for and elements of a Federal program addressing the archiving and multi-agency use of data generated from Intelligent Transportation Systems (ITS) applications. The development of this program builds from previous work done under the U.S. DOT ITS program, such as the development of a user service to support this concept (the Archived Data User Service or ADUS) and the addition of that service to the National ITS Architecture, and represents the next phase in fostering its deployment. This document describes the development of the Federal ADUS Five-Year Program (2000-2004) to support the implementation of ADUS.

A key feature of Intelligent Transportation Systems (ITS) is the use of information about transportation system conditions to improve overall system performance. ITS can generate massive amounts of data that are used primarily in managing system operations and providing information on system conditions and choices to the public. Increasing deployment of ITS throughout the nation has brought an awareness that ITS-generated data offer great promise for uses beyond the execution of ITS control strategies. Often, ITS-generated data provide similar information to data traditionally used in transportation planning, operations, administration, and research. In many instances, ITS-generated data have no current counterparts in these disciplines but offer the potential for new and extended applications. Therefore, archiving ITS-generated data after they have been used in ITS operations can provide a valuable resource for a variety of uses.

A vision statement was crafted for the Federal ADUS Five-Year Program based on input received from the stakeholder community that represents the needs and desires of the various stakeholder groups. The ADUS vision statement describes the ultimate archive data and retrieval system for transportation related information. The common vision for ADUS is to:

Improve transportation decisions through the archiving and sharing of ITS generated data.

Building upon this vision, a program plan was developed that includes goals and objectives to achieve the vision and the individual projects that are needed to meet these goals and objectives. The projects are focused within several categories of activities including researching and resolving technical issues, understanding and overcoming institutional / organizational issues, deployment of ADUS systems, standards and architecture coordination, and awareness / outreach activities. These activities are scheduled to be rolled out in one of three waves over the course of the five year program plan.

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1 INTRODUCTION

The purpose of this document is to explain the need for and elements of a Federal program addressing the archiving and multi-agency use of data generated from Intelligent Transportation Systems (ITS) applications. The development of this program builds from previous work done under the U.S. DOT ITS program, such as the development of a user service to support this concept (the Archived Data User Service or ADUS) and the addition of that service to the National ITS Architecture, and represents the next phase in fostering its deployment.

After this section, a background section is included to lay the context for the ITS Data Archiving program. This includes an overview of the ITS data archiving concept, a description of previous and ongoing work, discussion of the current state of practice and implementation examples, and a presentation of issues that have been identified as potentially delaying or impeding the implementation of ITS data archiving systems across the country. The following section (Section 3) describes the long term vision for archiving and sharing of ITS data and the accompanying program goals to help achieve the vision. Consistent with these high-level goals, a series of objectives are then identified to provide focus and measurable outcomes for the program over the next 5 years (2000-2004). This is followed by an overview of the set of program activities and milestones needed during that time frame to help meet those objectives. A set of important references is provided in Section 4. An appendix is also included which provides a graphical view of the program and a description of each program element.

2 BACKGROUND

2.1 Archived ITS Data Overview

Basic Concepts

A key feature of Intelligent Transportation Systems (ITS) is the use of information about transportation system conditions to improve overall system performance. ITS can generate massive amounts of data that are used primarily in managing system operations and providing information on system conditions and choices to the public. Examples include the adjustment of ramp meter timing based on freeway flow conditions and the use of variable message signs (VMSs) to communicate traffic conditions to travelers. Increasing deployment of ITS throughout the nation has brought an awareness that ITS-generated data offer great promise for uses beyond the execution of ITS control strategies. Often, ITS-generated data provide similar information to data traditionally used in transportation planning, operations, administration, and research. In other instances, ITS-generated data have no current counterparts in these disciplines but offer the potential for new and extended applications. Therefore, archiving ITS-generated data after they have been used in ITS operations can provide a valuable resource for a variety of uses. Illustrative types of data available from ITS can be found in *ITS As A Data Resource: Preliminary Requirements For A User Service* (Margiotta, 1998).

Previous Efforts and Ongoing Work

The idea that real-time data from traffic and transit operations could be archived and used for planning and other secondary purposes has been expressed many times, but institutional and technical barriers have worked against it. As ITS has grown, the potential for ITS to provide such data has been voiced in various forums including:

- The Highway Performance Monitoring System (HPMS) Steering Committee on August 7, 1996.
- A conference March 2-5, 1997, in Irvine, CA, on "Information Needs to Support State and Local Transportation Decision Making into the 21st Century."
- Technical reports sponsored by FHWA and the National Cooperative Highway Research Program.

Recognizing the potential of ITS-generated data for uses other than supporting real time operations, US DOT mounted an effort to promote the archiving of ITS data. The first step in the process was to revise the National ITS Architecture to include the functions necessary to archive ITS-generated data. New capabilities enter the National ITS Architecture through requiring existing User Service requirements or generating requirements for new User Services. Therefore, development of the Archived Data User Service (ADUS) was initiated.

To lay the groundwork for ADUS, a preliminary workshop was held in January, 1998: the *ITS As A Data Resource Workshop*, a joint effort between ITS America and USDOT. This meeting brought many of the stakeholders together to discuss how data generated by ITS could be used to address many of their data needs. As a result of the Workshop, several activities ensued:

- A preliminary requirements document was developed;
- An addendum to the ITS Program Plan was prepared;
- User Service Requirements were specified; and
- Subsequent workshops with stakeholders were held at key junctures to review the above documents.

Upon completion of the User Service Requirements, USDOT embarked on revising the National ITS Architecture to include ADUS. Additional stakeholder meetings were held at various points in the process. In September, 1999, the final ADUS-related revisions to the Architecture were made.

With the addition of ADUS to the National ITS Architecture, USDOT is now focusing on moving the principles of archiving ITS data into implementation. One of these efforts is the preparation of the Five-Year Program Plan for ITS Data Archiving, as described in this document. Other US DOT-sponsored efforts currently underway include the reconciliation of data standards and definitions between ITS and existing data systems; case studies of how data are being used in four cities; Web collection and storage of urban travel time data from traffic information web sites; and demonstration of how ITS data may be used for traffic monitoring.

Stakeholders for Archived ITS Data

Fourteen stakeholder groups have been identified as having an interest in the use of data generated by ITS. Table 2.1 introduces these stakeholder groups along with their primary functions. It is noteworthy that significant beneficiaries of archived data are Traffic Management and Transit Operators, whose systems collect the data in the first place. In addition to aiding current operations by establishing pre-determined operation plans (e.g., ramp metering rates), use of archived data will allow Traffic Management operators to move to the next level of control strategies: proactive plans that intervene prior to conditions worsening. This next level of control is sometimes referred to as modeling support for traveler information and traffic management, and it is expected to take on greater significance to the transportation profession in the near future. Likewise, Transit Operators who have implemented electronic fare payment systems or automatic passenger counters to improve efficiency are also able to make use of data for short-range planning activities such as route and schedule delineation.

Uses and Benefits of Archived ITS Data

Table 2.2 displays some possible ways in which archived ITS data can be used in stakeholders' applications. Archived ITS data can not only replace or supplement "traditional" data sources but, because of their high level of temporal and spatial detail, also allow new forms of analysis to develop. Because traditional data collection activities are expensive to undertake, they are typically based on taking samples; examples include: short-term (48-hour) traffic counts; household travel activity surveys; transit ridership counts; and commodity flow surveys. ITS-generated data are continuously collected, or nearly so, thus greatly reducing sampling bias. Also because of their continuous nature, variability in system performance and response can be studied. Finally, much ITS-generated data are available for very small time intervals, allowing for greater resolution in analyses and models.

2.2 The Current State of the Practice in ITS Data Archiving

That archived ITS-generated data is of great value is apparent in the number of transportation agencies that have already developed archival systems independent of US DOT guidance. Some agencies have been archiving ITS data for many years while others are just getting started. A thorough coverage of existing applications for traffic information can be found in Turner's report (Turner, 1999); key findings of that study are summarized below.

Locations Now Archiving ITS Traffic Data or Developing Archival Systems

- Phoenix, Arizona – loop detector data[1] from freeways and arterials are archived; plans underway to archive all "relevant" data used by the Traffic Operations Center.
- Los Angeles, California – developing an archival system for freeway loop detector data.
- Orange County, California – developing an archival system for arterial loop detector data.
- Chicago, Illinois – loop detector data from selected freeways are archived.
- Montgomery County, Maryland – loop detector data from selected arterials are archived.
- Detroit, Michigan – loop detector data from freeways are archived.
- Minneapolis-St.Paul, Minnesota -- loop detector data from freeways are archived.
- TRANSCOM, New York / New Jersey / Connecticut – travel times derived from AVI-equipped vehicles are archived.
- Houston, TX -- travel times derived from AVI-equipped vehicles are archived.
- San Antonio, TX – loop detector data from freeways, travel times derived from AVI-equipped vehicles, and incident management data are archived.
- Seattle, WA – loop detector data from freeways are archived
- State of Virginia – currently developing an archival system for ITS-generated data.

Existing Applications Using Archived ITS Traffic Data

- *Freeway Performance Evaluation in Puget Sound Region, Washington*. Loop detector data have been used to monitor congestion patterns, including variability in speeds and travel times.
- *Evaluation of HOV Lanes in Houston, Texas.* Probe vehicle data were used to compare travel times for HOV and non-HOV lanes.
- *Traffic Statistics in Chicago, Illinois.* Loop detector data has been used to produce an "atlas" of traffic statistics.

[1] Loop detector data include volume counts and loop occupancy time (percent of time a loop is "occupied" with detecting a vehicle). Density (vehicles per lane-mile) is computed from loop occupancy assuming an average vehicle length. Some loop detectors are capable of measuring speeds directly. Where this is not possible, speed is often estimated by applying the traditional traffic engineering relationship: speed = volume / density.

- *Traffic Statistics and Congestion Monitoring, Montgomery County, Maryland.* Arterial loop detector used to develop traffic statistics.
- *Ramp Metering Evaluation, Minneapolis-St. Paul, Minnesota.* Freeway and ramp loop detector data used to evaluate cycle lengths on ramps.
- *Development of Travel Time Prediction Models, Texas.* Data from probe vehicles being used to develop short-term travel time prediction models for traffic operations.

Common Themes and Recurring Issues in Current Archiving Activities

- Traffic surveillance data are the primary type of data being archived. Since the study focused on traffic management centers this result is not surprising. However, many transit systems that have instituted electronic fare payment and automatic vehicle location systems also routinely archive these data (including ridership counts by route segment and time of day, and station origin-destination patterns).
- Many existing traffic management centers are either currently archiving or plan to archive traffic surveillance data. However, archiving is often done on an informal basis with no storage guidelines and limited access capabilities. In some of these areas, where data are stored but are relatively inaccessible, data users have developed the tools required to access the data.
- Researchers and Planners have been the primary users of archived ITS traffic data to date. Transit planners, for instance, can use Automatic Passenger Counters (APC) to track where and when passengers come onto and exit the transit system. APC linked with Automatic Vehicle Location Systems can reduce the amount of person hours required to collect and properly display this information. There may be many other potential users of the data that have yet to be active users of archived ITS data such as safety analyzers.
- Data quality and location referencing are the two most common problems encountered by archived ITS data users. There is no clear consensus on to what level the data should be aggregated.

2.3 Issues Surrounding the Implementation of Archived Data Systems

Development of the ITS Data Archiving Program Plan is driven by the identifying the issues and developing strategies to address them. Several issues have been identified that must be addressed to achieve sucessful implementation of archived data systems in practice.

Technical Issues

1. Guidance on System Design. The National ITS Architecture presents several conceptual alternatives for archived data system design. Which designs are the most appropriate for different situations and user needs? What is the best way to implement the design concepts in practice?
2. Regional ITS Architectures. How can ADUS design principles be incorporated into the development of regional architectures?

3. Retrofitting Existing ITS Deployments. Much ITS has already been deployed with wither no or highly informal archiving functions. Can these systems be retrofitted to include formal archiving?
4. System Procurement and Implementation Process. What is the best way of influencing the purchasing and designing of archived data systems? How can ADUS features be incorporated into ITS RFP requirements and design documents?
5. Data Quality. What procedures and standards could be used to perform quality control? How are erroneous data detected? How should missing and erroneous data be handled (interpolated, based on historical patterns, not changed)? If nonoperations stakeholders identify data problems related to equipment, who is responsible for field equipment maintenance and calibration?
6. Data Standards. How can ITS data definitions be reconciled with "traditional" data counterparts? What metadata are required and who is responsible for collecting or assigning metadata? (Metadata is defined as information about data being collected.) How can conflicting geo-referencing systems be resolved?
7. Data Management. What ITS-generated data should be archived? Should data be sampled or aggregated before permanent storage or should all data be retained (data reduction cycles)? Should descriptive statistics be developed whenever data are aggregated to capture variability (e.g., standard deviation, percentiles of distribution)? What are alternative structures for online and offline data storage (archiving-on-demand, data "broadcasts")?
8. Data Analysis. What analysis techniques are best suited to analyzing archived ITS data? What new types of analyses will ITS-generated data allow stakeholders to conduct?
9. Integration of ITS Equipment with Non-ITS Data Collection Systems. How can nonoperations stakeholders take advantage of existing ITS equipment to achieve additional data coverage (e.g., probe readers for toll-tagged vehicles, video image processing of CCTV, O/D data from in-vehicle or personal devices)
10. Integration with Existing Transportation Information Systems. To what degree should an ITS data archive be directly or indirectly integrated into other transportation information systems? Will local archives be stand-alone systems or will they be linked? What methods are available to provide linkages with "traditional" state and local systems?
11. Data Reporting. How can the reporting of Federally-required data be automated? What will Federal agencies accept in terms of automatically-reported data (amount, structure, quality)?

Institutional and Organizational Issues

1. Stakeholder Involvement in the ITS Planning and Deployment Process. How can stakeholders/secondary users be involved in the early stages of project development (e.g., development of system requirements)?

2. Degree of Private Sector Involvement. Is it feasible to expect the emergence of ISPs for archived data (i.e., is there enough of a market to make entry profitable)? Can the archival function be part of an overall agreement with an ISP whose primary market is real-time data? Can ISP-collected data be incorporated into a public use archive? Are public agencies willing to buy data from ISPs?
3. System Access and Ownership. Should different stakeholders have different access restrictions? Who owns the information? Who maintains and cleans it? What rights transfer with data use / purchase?
4. Privacy of Individuals and Firms. What is the best way of preserving privacy while maintaining the ability for certain stakeholders to identify individuals or firms in the data?
5. Liability. Is there a possibility that archived ITS data may be used against transportation agencies in either litigation or other adversarial efforts? If so, how can liability be managed?
6. Cost-Sharing Among Agencies. What share of funding are non-operation stakeholders likely to provide? Are there ways to offset costs (e.g., selling data or products, in-kind services)?

Outreach/Awareness and Evaluation Issues

1. Basic Awareness of Stakeholders Regarding Intelligent Transportation Systems and Their Data. How do ITS-generated data track to traditional forms of data? How are the data collected? What standards exist for their communication and storage (e.g., ITS data dictionaries)?
2. Demonstration of Benefits to Stakeholders. How do archived ITS data improve existing forms of analyses? Are archived ITS data more applicable to short-range activities (TIP development, transit / highway performance monitoring) than to long-range activities (20 year travel forecasts)? Can an ITS data archive reduce data collection costs and / or supplement existing data collection programs? Can archived ITS data improve the efficiency of mandatory data reporting (e.g., HPMS, NTD) and increase the accuracy of data that reside in these systems? Can archived ITS data be the basis for new forms of analyses (e.g., system reliability, performance measures) and how can they support the next generation of models (e.g., TRANSIMS, modal emissions models)?
3. Demonstration of Benefits to ITS Implementers. What incentives are there to develop systems that primarily benefit other (nonoperation) interests? What are the benefits for operations planning?
4. Demonstration of benefits to Senior Transportation Agency Management. Is it worth the extra effort, in terms of increased customer satisfaction, to encourage ITS data archival systems? Can requiring cooperation among various units and agencies on archiving ITS data foster communications in general (i.e., are there spin-off benefits in addition to providing data for general use)?

5. System Development, Operation, and Maintenance Costs. Identification and documentation of initial capital outlay and recurring costs is an activity that remains to be done as there are so few actual precedents. How much will data archiving systems cost?

6. Funding Opportunities. Will USDOT allow flexible funding opportunities for building and operating an archive and will a targeted funding program be developed in the early stages of the ADUS life-cycle? Will future Federally-sponsored ITS deployments be required to implement ADUS features?

2.4 Summary

A review of the state of the practice demonstrated the limited use of archiving of ITS information and exchange of data between agencies. This section also identified a list of issues that must be addressed to further the development and widespread adoption of ITS data archiving practices. Section 3 describes the program vision and 5-year activities to address these issues and further the ADUS concept.

Table 2-1 Stakeholders for Archived ITS Data

Stakeholder Group	Primary Transportation-Related Functions	Example Applications
MPO and state transportation planners	Identifying multimodal passenger transportation improvements (long- and short-range); congestion management; air quality planning; develop and maintain forecasting and simulation models	• congestion monitoring • link speeds and truck percents for TDF and air quality models • macroscopic traffic simulation • parking utilization and facility planning • HOV, paratransit, and multimodal demand estimation • congestion pricing policy
Traffic management operators	Day-to-day operations of deployed ITS (e.g., Traffic Management Centers, Incident Management Programs)	• pre-planned control strategies (ramp metering and signal timing) • highway capacity analysis • saturation flow rate determination • microscopic traffic simulation - historical - short-term prediction of traffic conditions • dynamic traffic assignment • incident management • congestion pricing operations
Transit operators	Day-to-day transit operations and short-range planning: scheduling, route delineation, fare pricing, vehicle maintenance; transit management systems; evaluation and planning	• capital planning and budgeting • corridor analysis planning • financial planning • maintenance planning • market research • operations / service planning (routes and fares) • performance analysis planning • strategic / business planning
Air quality analysts	Regional air quality monitoring; transportation plan conformity with air quality standards and goals	• emission rate modeling • urban airshed modeling
MPO / state freight and intermodal planners	Planning for intermodal freight transfer and port facilities	• truck flow patterns (demand by origins and destinations) • HazMat and other commodity flow patterns
Safety planners and administrators	Identifying countermeasures for general safety problems or hotspots	• safety reviews of proposed projects • high crash location analysis • generalized safety relationships for vehicle and highway design • countermeasure effectiveness (specific geometric and vehicle strategies) • safety policy effectiveness
Construction and maintenance personnel	Planning for the rehabilitation and replacement of pavements, bridges, and roadside appurtenances; scheduling of maintenance activities	• pavement design (loadings based on ESALs) • bridge design (loadings from the "bridge formula") • pavement and bridge performance models
Commercial vehicle enforcement personnel	Accident investigations; enforcement of commercial vehicle regulations	• HazMat response and enforcement • congestion management • intermodal access • truck route designation and maintenance • truck safety mitigation • economic development

Stakeholder Group	Primary Transportation-Related Functions	Example Applications
Emergency management services personnel (local police, fire, and emergency medical)	Response to transportation incidents; accident investigations	• labor and patrol planning • route planning for emergency response • emergency response time planning • crash data collection
Transportation system monitoring personnel	Data collection related to system conditions and performance	Provide data for other stakeholders: • Traffic counts and travel times for planners (AADT, K- and D-factor estimation; temporal distributions) • Truck weights for maintenance personnel • Performance metrics for administrators
Land use regulation and growth management planners	Development and monitoring of ordinances related to land development	• Zoning regulations • Comprehensive plan development • Impact fees • Taxation policies
Transportation researchers	Development of forecasting and simulation models and other analytic methods; improvements in data collection practices	• car-following and traffic flow theory development • urban travel activity analysis
Private sector users	Provision of traffic condition data and route guidance (Information Service Providers); commercial trip planning to avoid congestion (carriers)	
Federal government	Maintain National databases related to traffic operations, safety, transit, freight / CVO, etc.	▪ HPMS ▪ FARS ▪ NTB

Table 2-2 Example Stakeholder Applications Supported by Archived ITS Data

Stakeholder Group	Application	Method or Function	Collection and Use of:	
			Current Data	ITS-Generated Data
MPO and State Transportation Planners	Congestion Management Systems	Congestion Monitoring	Travel times collected by "floating cars": usually only a few runs (small samples) on selected routes. Speeds and travel times synthesized with analytic methods (e.g., *HCM*, simulation) using limited traffic data (short counts). Effect of incidents missed completely with synthetic methods and minimally covered by floating cars.	Roadway surveillance data (e.g., loop detectors) provide continuous volume counts and speeds. Variability can be directly assessed. Probe vehicles provide same travel times as "floating cars" but greatly increase sample size and areawide coverage. The effect of incidents is imbedded in surveillance data and Incident Management Systems provide details on incident conditions.
	Long-Range Plan Development	Travel Demand Forecasting Models	Short-duration traffic counts used for model validation. O/D patterns from infrequent travel surveys used to calibrate trip distribution. Link speeds based on speed limits or functional class. Link capacities usually based on functional class.	Roadway surveillance data provide continuous volume counts, truck percents, and speeds. Probe vehicles can be used to estimate O/D patterns without the need for a survey. The emerging TDF models (e.g., TRANSIMS) will require detailed data on network (e.g., signal timing) that can be collected automatically via ITS. Other TDF formulations that account for variability in travel conditions can be calibrated against the continuous volume and speed data.
	Corridor Analysis	Traffic Simulation Models	Short-duration traffic counts and turning movements used as model inputs. Other input data to run the models collected through special efforts (signal timing). Very little performance data available for model calibration (e.g., incidents, speeds, delay).	Most input data can be collected automatically and models can be directly calibrated to actual conditions.
Traffic Management Operators	ITS Technology	Program and Technology Evaluations	Extremely limited; special data collection efforts required.	Data from ITS provide the ability to evaluate the effectiveness of both ITS and non-ITS programs. For example, data from an Incident Management System can be used to determine changes in verification, response, and clearance times due to new technologies or institutional arrangements. Freeway surveillance data can be used to evaluate the effectiveness of ramp meters or HOV restrictions.
		Pre-Determined Control Strategies	Short-duration traffic counts and "floating car" travel time runs. A limited set of pre-determined control plans is usually developed mostly due to the lack of data.	Continuous roadway surveillance data makes it possible to develop any number of pre-determined control strategies.

Stakeholder Group	Application	Method or Function	Collection and Use of:	
			Current Data	**ITS-Generated Data**
Traffic Management Operators (cont.)	ITS Technology (cont.)	Predictive Traffic Flow Algorithms	Extremely limited.	Analysis of historical data form the basis of predictive algorithms: "What will traffic conditions be in the next 15 minutes?" (Bayesian approach).
Transit Operators	Operations Planning	Routing and Scheduling	Manual travel demand and ridership surveys; special studies.	Electronic Fare Payment System and Automatic Passenger Counters allow continuous boardings to be collected. Computer-aided dispatch systems allow O/D patterns to be tracked. AVI on buses allows monitoring of schedule adherence and permits the accurate setting of schedules without field review.
Air Quality Analysts	Conformity Deter-minations	Analysis with the MOBILE Model	Areawide speed data taken from TDFs. VMT and vehicle classifications derived from short counts.	Roadway surveillance provides actual speeds, volumes, and truck mix by time of day. Modal emission models will require these data in even greater detail and ITS is the only practical source.
MPO/State Freight and Intermodal Planners	Port and Intermodal Facilities Planning	Freight Demand Models	Data collected through rare special surveys or implied from national data (e.g., Commodity Flow Survey).	Electronic credentialing and AVI allows tracking of truck travel patterns, sometimes including cargo. Improved tracking of congestion through the use of roadway surveillance data leads to improved assessments of intermodal access.
Safety Planners and Administrators	Safety Management Systems	Areawide Safety Monitoring; Studies of Highway and Vehicle Safety Relationships	Exposure (typically VMT) derived from short-duration traffic and vehicle classification counts; traffic conditions under which crashes occurred must be inferred. Police investigations, the basis for most crash data sets, performed manually.	Roadway surveillance data provide continuous volume counts, truck percents, and speeds, leading to improved exposure estimation and measurement of the actual traffic conditions for crash studies. Incident management can identify unreported crashes. ITS technologies also offer the possibility of automating field collection of crash data by police officers (e.g., GPS for location).
Maintenance Personnel	Pavement and Bridge Management	Historical and Forecasted Loadings	Volumes, vehicle classifications, and vehicle weights derived from short-duration counts (limited number of continuously operating sites).	Roadway surveillance data provide continuous volume counts, vehicle classifications, and vehicle weights, making more accurate loading data and growth forecasts available.
Commercial vehicle enforcement personnel	Enforcement of Commercial Vehicle Regulations	Hazardous Material Inspections and Emergency Response	Extremely limited.	Electronic credentialing and AVI allows tracking of hazardous material flows, allowing better deployment of inspection and response personnel.

Stakeholder Group	Application	Method or Function	Collection and Use of: Current Data	Collection and Use of: ITS-Generated Data
Emergency Management Services (local police, fire, and emergency medical)	Incident Management	Emergency Response	Extremely limited.	Electronic credentialing and AVI allows tracking of truck flows and high incident locations, allowing better deployment of response personnel.
Transportation Researchers	Model Development	Travel Behavior Models	Mostly rely on infrequent and costly surveys: stated preference and some travel diary efforts (revealed preference).	Traveler response to system conditions can be measured through system detectors, probe vehicles, or monitoring in-vehicle and personal device use. Travel diaries can be imbedded in these technologies as well.
		Traffic Flow Models	Detailed traffic data for model development must be collected through special efforts.	Roadway surveillance data provide continuous volume counts, densities, truck percents, and speeds at very small time increments. GPS-instrumented vehicles can provide second-by second performance characteristics for microscopic model development and validation.
Private Sector Users	Truck Routing and Dispatching	Congestion Monitoring	Current information on real-time or near real-time congestion is extremely limited.	Roadway surveillance data and probe vehicles can identify existing congestion and can be used to show historical patterns of congestion by time-of-day. Incident location and status can be directly relayed.
	Information Service Providers	Trip Planning	Information on historical congestion patterns is extremely limited. This information could be used in developing pre-trip route and mode choices, either alone or in combination with real-time data.	
Federal Government	National Transit Database	Historical ridership	Information is typically collected using staff to collect number of riders and origin / destination data.	Automatic Passenger Counting equipment along with AVL equipment buses can be used to collect these data more efficiently.

3 ADUS Vision and Program Description

As stated, the Archived Data User Service was formally incorporated into the National ITS Architecture in September 1999. ADUS, in the Architecture, identifies the sources of ITS data, logical data flows from the sources to the archives, functions required for archiving, different market packages and ways to implement ADUS, potential users and issues. Thus, while it marks the end of a major work effort it also marks the beginning of implementing ADUS throughout the country. This section describes the development of the Federal ADUS Five-Year Program (2000-2004) to support the implementation of ADUS.

3.1 Program Development Approach

The development of the ADUS Five-Year Program began in August, 1999. It is being carried out in two phases: Phase I focused on the conceptual elements of the program and included: gathering input from stakeholders and other programs; refinement of the issues; development of the ADUS vision which is based on the needs and desires of all stakeholders; and definition of the Federal Program Goals, Objectives, and Focus Areas to further the vision. An ADUS Stakeholder Workshop was held in October 1999 to allow for feedback from the stakeholder community on Phase I activities and suggestions for the next phase. Phase II of the program development effort defines the specific Federal program activities around the concepts and program framework developed in Phase I. Phase II is expected be completed in early 2000; however, further development and refinement of the program is an on-going activity .

Two outputs of the development process will be provided. The first is the Program Description (this document) which provides the background, justification, and specifics of the overall program. The second is the ADUS Five-Year Program Roadmap which provides a graphical representation of the program. The roadmap is particularly useful in showing how the program elements are connected and how the program develops over time.

To determine the direction that ADUS will take over the long term, it was necessary to understand the concerns and needs of the providers and users of archived ITS generated data. A review of early stakeholder meeting findings was conducted along with a brief review of the state of the practice. In addition, interviews were conducted within USDOT and with non-Federal stakeholders to discuss the following items:

- interviewees' vision of ADUS
- long term goals for ADUS
- near term objectives
- suggested motivation to increase ADUS use
- suggested methods to achieve program goals
- on-going projects in interviewee's area involving archiving of ITS data

It should be noted that the USDOT is a stakeholder in the successful implementation of ADUS. Many databases are maintained by USDOT that provide information as to how the roadway system in this country is operating. The archiving of ITS generated data may help to improve

the turn around time for data submission, reduce the cost of data collection and allow USDOT to react more quickly and efficiently to problems detected in the roadway system.

Using the information gathered in the review and interview process, a draft vision for ADUS and a draft set of goals were developed. The draft ADUS Five-Year Program Description was provided to the stakeholder group which participated in the October 21 stakeholder meeting. During the stakeholder meeting, breakout sessions were held in which the participants were asked to review the draft ADUS vision and goals and provide suggestions to ensure that the needs of the stakeholder community was represented. In addition, the participants were asked to develop a comprehensive list of issues and potential strategies that could be used to overcome these issues related to implementing ITS data archiving systems nationwide. The suggestions and ideas gathered at the stakeholder workshop were used to refine the draft ADUS vision and goals and also used to generate a series of five-year program objectives.

3.2 ADUS Vision

A common ADUS vision statement is needed to represent the needs and desires of the various stakeholder groups including federal, state, local, private, etc. The ADUS vision statement is intended to describe the ultimate archive data and retrieval system for transportation related information that is believed to be achievable in the next 20-25 years. Based on the findings of the interview process and the review of materials generated from stakeholder meetings, the following vision statement has been crafted for ADUS:

Improve transportation decisions through the archiving and sharing of ITS generated data.

In order to achieve this vision, these principles are to be applied:

- Archiving of data is considered and encouraged for all ITS deployments
- Data are archived to maximize integration of information with other data sources / systems
- Data are archived to ease retrieval for those with access
- Information provided is integral to the transportation practice

The vision statement characterizes the ultimate archived data management system. This system will allow for archiving of all data generated by ITS sources. In addition, data will be archived, in such a manner, as to allow for easy integration with other ITS and non-ITS data sources. The program plan will foster this vision by addressing issues associated with

- Single source / single user of data
- Single source / multiple users of data
- Multiple source / single user of data
- Multiple source / multiple users of data

By addressing the issues associated with the simplest system through the most complex throughout the development stage of ADUS, program activities will be consistent with the vision of ADUS.

3.3 Program Description

While the vision statement for ADUS is a common vision among all stakeholder groups, the Program Plan for ADUS is a set of activities to be undertaken by USDOT to propel the use of archived data in the transportation industry. This section presents the ADUS Program goals, objectives, activities, and outcomes that have been developed.

3.3.1 ADUS Federal Goals

Building on the vision of ADUS, a series of program goals have been developed that focus on the steps necessary to achieve the vision of ADUS. These goals are to:

- Increase awareness of and professional capacity to implement ADUS
- Advance and expand the application of the state of the practice of ADUS
- Understand impacts (benefits / costs) of ADUS
- Resolve technical ADUS issues
- Resolve institutional / organizational ADUS issues
- Advance and develop the state of the art of ADUS
- Promote use of archived data in making better transportation decisions
- Promote use of archived data in streamlining federal reporting systems and performance monitoring

These goals address the technical and institutional / organizational issues associated with implementing a successful archived data management system. In addition, the issues associated with expanding the use of archived data management systems in transportation are captured in these draft goals. Achieving the vision of a fully integrated archived data management system is captured in the ideas of propelling the state of the art and maximizing the use of archived information. Finally, understanding the achievable benefits and associated costs of an archived data management system is a goal of the ADUS program.

The goals identified can be related to the issues presented in Section 2 of this document. Along with these issues, possible strategies for solving these issues have been identified, as shown in Table 3.1.

Due to the diverse stakeholders, needs, and applications the use of “focus areas” with the ADUS program may be helpful in ensuring that unique perspectives, needs and issues are addressed. Many of the goals, issues, and strategies of Table 3.1 will be common to all ADUS applications. However, there are also instances where the ADUS implementation, stakeholders, and / or issues will be so different that they are not addressed under the general analysis. For example, research and recommendations carried out for large technology rich urban areas may not be applicable for small cities where there is only one traffic engineer, the MPO may have only one employee, or the resources are limited in many other ways. Possible dimensions along which focus area can be defined include:

- Environment and ADUS/Implementation (Large Urban, Small Urban, Rural/Statewide…)
- Stakeholder Users (Safety Community, CVO, Transit, Transportation Planning and Programming…)
- ITS Sources (Traffic Management Centers, Transit Management Centers, Incident Management…).

Table 3-1 Examples of Potential Strategies for Addressing ADUS Issues and Goals

Goal	Example Issues	Example Strategies to Resolve Issues
Increase awareness of and professional capacity to implement ADUS	What data are available? What are the uses of archived data? What are the advantages of archiving ITS generated data?	Publish lessons learned from early case studies. Attend and present findings at state and national conferences.
Advance/expand application of state of the practice	How to accommodate archiving in existing ITS?	Research: develop mechanisms for retro-fitting existing ITS to allow for archiving
Understand impacts (benefits/costs)	Can data archived through ITS be used for required data collection program? What are typical initial capital and recurring costs associated with archiving data?	Conduct survey of pioneers of ITS archiving. Sponsor evaluation efforts. Publish results from early implementation evaluations. Identify ITS data sources for safety analysis.
Resolve technical ADUS issues	Data quality, missing data. When to store data? How long to store data? When to aggregate data? Lack of design guidance.	Synthesize data archiving lessons learned from other disciplines. Investigate the needs of aggregated vs. raw data. Provide guidance on using the National ITS Architecture to implement ADUS.
Resolve institutional /organizational issues	Data ownership. Privacy concerns. Integration of data collected by various agencies.	Examine public/private working relationships. Conduct research and case studies/testing of integration of ITS archived data.
Advance/develop state of the art	Are there new/unique uses for archived data? How can an integrated system be used to improve the performance of the transportation system?	Research: investigate the development of new models which utilize ITS archived data
Promote use of archived data in making better transportation decisions	What information can be gathered from ITS sources that can be used to make better informed decisions?	Publish case studies demonstrating the use of ITS archived data to help better manage the transportation system.

Any area where the stakeholders, concerns and implementation issues are sufficiently different as to warrant attention may be a candidate focus area. A focus area may also become the lead for an issue that is common to all applications but of particular importance to its stakeholders and/or central to its implementation. For example, privacy issues may be addressed specifically in the CVO area and the recommendations/findings transferred to other areas. As the program advances and the ADUS implementations are connected/integrated, it is anticipated that some of the short-term focus areas may also be merged.

The participants of the stakeholder workshop in October 1999 did not identify any particular focus areas along which the ADUS program should be developed; however, many stakeholders did stress that it may be too early in the program development to fully understand special needs of various user communities. Therefore, it has been determined that initially the ADUS program will be developed without focus areas but with the ability to accommodate focus areas if a need is identified at a later date. In order to determine the necessity of focus areas, six specialty areas have been chosen and included in the state of the practice review. The state of the practice review will be used to determine if the development of parallel research tracks is warranted in the future.

3.3.2 5-Year Program Objectives

Five-year program objectives have been developed based on comments received at the stakeholder workshop in October 1999 and also from USDOT representatives. These five-year program objectives capture the essence of the Federal program goals while focusing on achievable activities within the first five years of the program. These objectives are:

- Plan and implement one or more integrated systems that combine information from multiple ITS data sources
- Provide case studies to illustrate implementation issues, costs, quantitative benefits and uses for better decision making
- Quantify costs of various market packages and components necessary to build, operate, and maintain archive data systems (i.e., data marts, data warehouses, virtual warehouse)
- Develop and provide multi-faceted ADUS awareness program
- Conduct research and issue guidance on:
    - Single stream data management (illustrate how to address technical issues)
    - Data integration across different ITS sources and organizations (illustrate how technical and institutional issues can be overcome)

These five-year program objectives reflect the major activities to be accomplished within the first five years of the ADUS program in addressing program goals. To be able to measure the progression of the federal ADUS program, a number of program outcomes have been identified and are described in the following section.

3.3.3 5-Year Program Outcomes

To monitor the overall development growth of the ADUS federal program, a number of indicators of success have been identified. These indicators of success are intended to be achievable in the first five years of the program. If the program progresses as planned, these milestones should be achieved and the proliferation of ADUS programs across the nation should be witnessed. The indicators of a successful program are:

- Sharing of ITS generated data between and within agencies will be common
- Federal reporting system procedures allow for ITS generated data where appropriate
- Regional architectures include data archiving functions and concept of operations (100% of 78 Major Metro Areas)
- ITS projects consider and include data archiving
    - All ITS projects that receive Federal funding consider archiving data
    - 50% of ITS-funded projects involve archiving
    - 25 of 78 Major Metro areas actively archive

If the activities and projects identified in the federal program are successfully completed, within five years, data collected using ITS technologies should be provided by some instrumented regions to federal reporting systems. The inclusion of archiving functions and concepts of operations into regional architectures should be nearly automatic at the end of five years. Finally, due to the acceptance of ITS generated data into federal reporting systems and the inclusion of archiving functions into regional architectures, there will be an increase in the number of federally funded projects that include archiving of ITS generated data.

3.3.4 Program Activities

A series of program activities have been developed that will lead to the achievement of the five-year program objectives. The individual activities have been classified into one of three waves of activities. The waves range in time required for completion but it should be noted that the activities in the early waves, in many cases, feed activities in later waves. In general, the first wave of the program is intended to assess the state of the practice regarding the technical issues related to implementing ADUS. The second wave builds on the first wave of activities and focuses on resolving technical and institutional issues. The final wave focuses on integration of data sources, evaluating the costs associated with building an ADUS system and publishing deployment results. In addition, the program contains activities that will monitor the deployment of ITS projects nationwide in order to streamline evaluation efforts. A complete list of program activities, along with a brief description and estimated time to completion, are included in Appendix A for the reader's use. In addition, a visual interpretation of the program activities and their interaction, the ADUS Program Roadmap, is included in Appendix A.

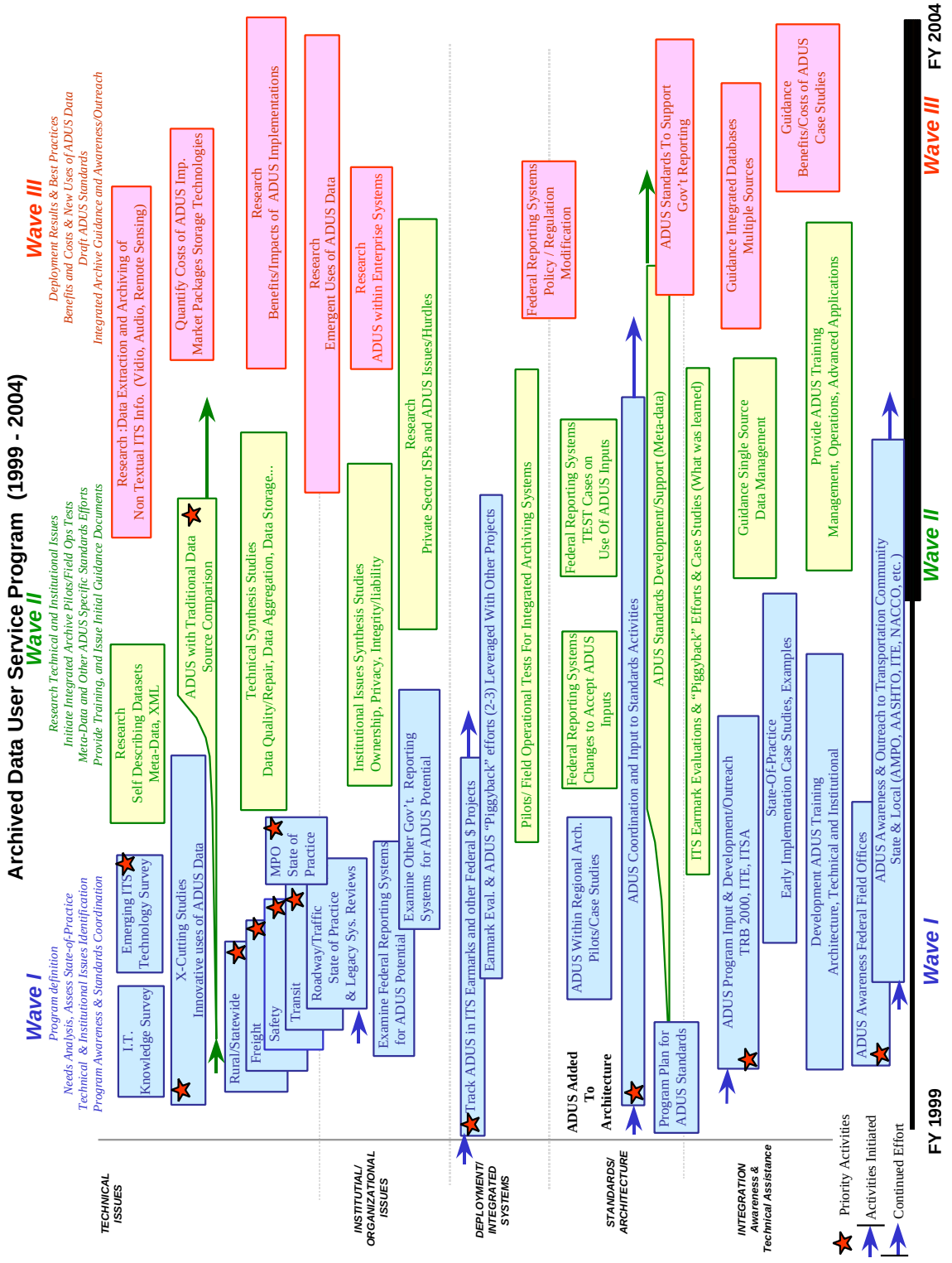
4 References

Margiotta, Richard, *ITS as a Data Resource: Preliminary Requirements for a User Service*. Report FHWA-PL-98-031. Federal Highway Administration, Washington, DC, April 1998.

Turner, S.M., Eisele, W.L., Gajewski, B.J., Albert, L.P., and Benz, R.J., *ITS Data Archiving: Case Study Analyses of San Antonio TransGuide® Data*. Report No. FHWA-PL-99-024. Federal Highway Administration, Texas Transportation Institute, College Station, Texas, August 1999.

Appendix A

ADUS Roadmap and Program Element Descriptions



ADUS Program Elements (1999 – 2004)

Wave 1 Elements

1. Information Technology Knowledge Survey ***0.5 Year Project***

This project will provide a serious review of emerging Information Technology (IT) methods, software, and hardware with regards to its ADUS applicability. These include: methods for data warehousing, data mining, and data fusion and visualization; new approaches such as On-line Analytical Processing (OLAP) and multi-dimensional data stores, and data storage technologies such as the use of banks of recordable CD-Roms, Re-Writable CD-Roms, RAIDS, or "flying disk" systems. The goal will be to sort through the confusing array of IT terms and technologies, determine promising items for use in ADUS systems, and the provide a lay person's primer for transportation professionals, on their potential and use. The project should help professionals determine what types of systems and technologies are appropriate given the attributes of the ADUS system that they may be implementing. This project will also address project management trends in the IT field. This will provide background for the Wave II technical studies and training and guidance efforts.

2. Survey: Emerging ITS Technologies and Data Collection ★ ***1 Year Project***

Wireless personal electronic devices and telephonics, changing cell phone standards (grid size), toll tags, universal smart cards, DSRC, and local area wireless ("Blue Tooth") all are emerging technologies used in ITS that offer new opportunities for data collection and performance monitoring. The potential for these technologies to help provide information previously collected by traditional means (flows, travel times) and/or new information never before available (travel patterns in time and space, system variability) and the issues associated with their use in data collection has not been explored. This project would provide a survey and forecast of emerging ITS technologies (within 5 years), their state of development, and the data collection opportunities that they may provide. New issues associated with the archiving and use of their data (e.g. privacy) would also be noted. The project's results will be used to help define the technical and institutional issues research, and the Wave II and Wave III ADUS program details. It will also be a key component of the ADUS outreach and awareness efforts, especially as these technologies move from development into widespread deployment.

3. Cross Cutting Studies of Innovative uses of ADUS ★ ***2 Year Project***

Many ADUS applications are now ongoing, or in the process of being implemented. Some of these systems for traffic and highway monitoring have been recently reported in "ITS Data Archiving: Case Study Analyses of San Antonio TransGuide Data" by the Texas Transportation Institute (FHWA, 1999). However, the pioneering efforts for archiving and use of ITS data in other areas such as transit and safety have not been systematically examined. This project would seek out existing ADUS efforts in each area focusing on documenting both creative/innovative implementations and subsequent uses of the data. It will both provide input to, and receive information from each of the State-of-Practice and Legacy System Reviews. Its aim is to provide real world examples of existing practices where ADUS can provide benefits today (low hanging fruit) for use in the training and outreach efforts.

4. State of the Practice Review: Roadway/Traffic ★ ***0.5 Year Project***

A state of the practice review will be conducted to determine the use of ITS technologies in the roadway/traffic area with a focus on the uses of archived data generated with these technologies. Various systems will be identified that are in use to collect roadway/traffic data including vehicle sensors, image detection systems and the extent to which these data are being archived and used off-line. This project's findings will be coordinated with the Wave I Cross Cutting Studies and will be used for inputs into the Technical and Institutional Synthesis Studies included in Wave II. Note, that work on the state of the practice for roadway/traffic is already underway or completed. This effort would summarize the research by the Texas Transportation Institute, Oak Ridge National Labs and others: build upon it and establish priorities. **Note, the five State of the Practice Review projects will need to be coordinated and may be combined to improve the output of the studies.

5. State of the Practice Review: Transit ★ ***0.5 Year Project***

A state of the practice review will be conducted to determine the use of ITS technologies in transit with a focus on the uses of archived data generated with these technologies. Various systems will be identified that are in use to collect transit related data including passenger measurement equipment, vehicle location devices, vehicle performance monitoring equipment and the extent to which these data are being archived and used off-line. This project's findings will be coordinated with the Wave I Cross Cutting Studies and will be used for inputs into the Technical and Institutional Synthesis Studies included in Wave II.

6. State of the Practice Review: Safety ★ ***0.5 Year Project***

A state of the practice review will be conducted to determine the ITS technologies that may be generating and archiving data which is useful for safety purposes. The various ITS systems such as incident logs, in-vehicle monitoring systems, and traffic condition survellance systems, and their related types and uses of data and analyses, relevant for safety purposes will be identified. The coordination and uses of the ITS systems and data with other safety-related systems and data will also be determined. This project's findings will be used for inputs into the Technical and Institutional Synthesis Studies included in Wave II.

7. State of the Practice Review: Freight/CVO ★ ***0.5 Year Project***

A state of the practice review will be conducted to determine the use of ITS technologies in commercial vehicle operations with a focus on the uses of archived data generated with these technologies. Various systems will be identified that are in use to collect CVO related data including weight in motion equipment, vehicle location devices, vehicle performance monitoring and the extent to which these data are being archived and used off-line. This project's findings will be coordinated with the Wave I Cross Cutting Studies and will be used for inputs into the Technical and Institutional Synthesis Studies included in Wave II.

8. State of the Practice Review: Rural/Statewide ★ ***0.5 Year Project***

A state of the practice review will be conducted to determine the use of ITS technologies in rural and statewide areas with a focus on the uses of archived data generated with these technologies. Various systems will be identified that are in use to collect rural/statewide related data including roadway weather information systems, traveler information systems and the extent to which these data are being archived and used off-line. This project's findings will be coordinated with Wave I Cross Cutting Studies and will be used for inputs into the Technical and Institutional Synthesis Studies included in Wave II.

9. State of the Practice Review: Metropolitan Planning Process ★ ***0.5 Year Project***

A state of the practice review will be conducted to determine the use of data generated from ITS sources in the metropolitan planning process. Data used by planners are generated in several areas including traffic, transit and safety. The format and requirements of these data, to be used in the planning process, differ than the format and requirements of the original generators of the data. The necessary adjustments to these data needs to be explored along with emerging uses for new data in the planning process. This projects findings will be coordinated with the Wave I Cross Cutting Studies and will be used for inputs into the Technical and Institutional Synthesis Studies included in Wave II.

10. Examine Federal Reporting Systems for ADUS Potential ★ ***0.5 Year Project***

This project will investigate the possible uses of data collected using ITS systems in the Federal Reporting System. A thorough review of the various Federal Reporting Systems such as the Federal Accident Reporting System (FARS) and the Highway Performance Monitoring System (HPMS), will be conducted to determine where data generated from ITS technologies can be used in place of traditionally collected data. The use of ITS generated data may also reduce the time lag between submission of data and publishing of findings. This project's findings will be used for inputs into Wave II activities that are focused on making changes to Federal Reporting Systems to accept ADUS inputs.

11. Examine Other Reporting Systems for ADUS Potential ***0.5 Year Project***

This project will investigate the possible uses of data collected using ITS systems in other reporting systems such as state and local databases. Many states require local agencies to submit various data about their roadway system such as average annual daily traffic (AADT) and percent trucks using the system. These data

may be collected using ITS technologies quicker and more efficiently than traditional methods. This project's findings will be used for inputs into Wave II activities that are focused on making changes to reporting systems to accept ADUS inputs.

12. Track ADUS in ITS Earmarks & Other Federally Funded Projects ★ ***4 Year Project***

This project will be an on-going task to track the use of ADUS in ITS projects that receive funding through congressional earmarks or federal funds in general. By tracking where ADUS is being implemented, opportunities for evaluating the impact of archiving data for off-line uses will be identified. Initial assessment of the FY 1999 ITS Earmarks has already been carried out, and the projects that include ADUS components identified. The findings from this effort will feed directly into efforts to begin to evaluate the success of implementing ADUS around the country (proposed Wave I project). It is also anticipated that findings from this task will be used to target areas where pilots or field operational tests for integrated systems should logically be performed (proposed Wave II project).

13. Earmark Evaluations and ADUS Piggyback Efforts Leveraged with Other Projects ***4 Year Project***

This project will be an on-going task to track the evaluation of ADUS in ITS projects that receive funding through congressional earmarks or federal funds in general. Using the National Evaluation program to track the challenges and opportunities provided by ADUS is a logical use of funds. This project will essentially promote the evaluation of ITS projects that include an archiving facet to gain additional information as to technical or institutional areas where additional challenges exist. This project will also feed into the awareness and technical assistance area of the program by providing case study examples as to how to best implement ADUS.

14. ADUS Within Regional Architecture Pilots/Case Studies ***2 Year Project***

This project will focus on identifying those regions in which a regional architecture is being developed and work with agencies to determine the challenges and opportunities provided by incorporating ADUS into a regional architecture. It is proposed that several regions representing rural, suburban and urban areas be identified and studied to give the user community a better understanding of why archiving of ITS generated data is essential.

15. Development of Program Plan for ADUS Standards ***0.5 Year Project***

In order for ADUS standards activities to be funded through the ITS Standards Program, an ADUS Standards Program Plan must be developed which further refines the ADUS standards efforts found in this overall program description. The ADUS Standards Program Plan will discuss the general needs for ADUS standards, identify potential areas where standards are warranted, and describe the activities leading ultimately to specific ADUS standards (refinement to specific items/requirements, coordination efforts, development efforts once the refined list is justified). The program plan will also incorporate additional inputs from stakeholders on their needs and priorities, the benefits and costs of specific standards, and lay out the overall standards development budget. The outcome of this project will define the subsequent standards activities shown here (Projects 16, 30, and 40).

16. ADUS Coordination and Input to Standards Activities ★ ***(Continuous) Project***

There are a number of ongoing standards activities that impact the definitions and collection of ITS data including: NTCIP, TCIP, The ITS Data Registry, Location Reference Measurement Specifications, various data dictionaries (e.g. Traffic Management Data Dictionary), etc. Because these efforts are specifying data structures and definitions they are highly relevant to ADUS, and it would be advantageous if the potential needs of ADUS users were incorporated into their development. This project would provide the support and resources required to ensure that the ADUS concerns were met in various standards activities. Initially this will be a coordination effort primarily providing inputs to other activities. While large-scale development of ADUS standards is premature (see Phase II) this project would also provide support of the initial organizing activities for ADUS standards. Initial activities coordinating with other standards efforts and initiating the ASTM standards subcommittee on ADUS have already begun.

17. ADUS Program Input and Development/Outreach ★ ***1 Year Project***

Much effort has already taken place to gather inputs on the development of the ADUS program including presentations at TRB, workshops, and posting of information on the ITS America and FHWA websits. To continue to gain input from the user community, efforts will be made to reach out to stakeholders at several annual conferences including TRB, ITE and ITSA in 2000. At these conferences, presentations will be made

describing the federal program and how ADUS can be beneficial to all users. In return, it is anticipated that input will be received that can be used to better define the program to reflect the needs of the user community.

18. State of the Practice Early Implementation Case Study Examples ***1.5 Year Project***

This project will provide information regarding early implementations of ADUS and the challenges and opportunities presented to the developers. These early descriptions of how to implement ADUS will be useful to the stakeholder community, in that, these case studies will document some of the pioneering efforts made by their peers. Case study descriptions and findings will be published in a number of formats including electronic documents that can be accessed through the Internet to assist new developers in their work. The work will build from the Wave I State of the Practice Reviews.

19. Development of ADUS Training For Architecture (Technical, and Institutional Issues) ***2 Year Project***

The Archived Data Service has been added to the National ITS Architecture release 2.3 in September 1999. This project will develop a number training and guidance materials for the implementation of ADUS including: Workshops on the use of the Architecture for defining the ADUS implementation for a local area; Resolution of technical issues regarding ADUS; and Resolution of institutional issues regarding ADUS. The early efforts will focus on architecture issues, and lessons learned from the state-of-practice analyses, cross-cutting studies, and pilot/case study efforts. A hierarchy of material will be developed aimed at both the high level decision and policy makers of a region (awareness) and technical/institutional details (technical staff). Materials from this project may also be used in the Awareness and Outreach presentations and efforts to the federal field staff and the state/local transportation community.

20. ADUS Awareness to Federal Field Offices ★ ***0.5 Year Project***

To better prepare federal employees in the field as to the effects of the new ADUS program, training sessions will be held in which field personnel (in particular ITS Specialists) will be brought together to learn about the benefits of archiving ITS generated data. In addition, the various projects which compose the ADUS program will be described to the group along with the intended schedule to complete each. Given that many of the projects proposed in this program require cooperation with field personnel (i.e., tracking of ITS earmarks), it is necessary that they understand the intention of the program before they are expected to work with it.

21. ADUS Awareness and Outreach to Transportation Community:State and Local (AMPO, AASHTO, ITE, NACCO, etc.) ***2 Year Project***

This project reflects the continuing efforts made to keep members of the transportation community abreast of the ADUS program and the impact that this new program might have on the individual areas of transportation and the overall operation of the transportation system. The initial ADUS implementation program's vision, goals, and objectives were described to users at a September 1999 workshop, and at the 2000 Transportation Research Board Annual Meeting. To reach affected members, representatives from USDOT will attend various conferences and meetings throughout the first two years of the program. At these conferences and meetings, when possible, presentations will be made regarding the purpose of the ADUS program and the progress of the program to date. It is the intention of this project to use these opportunities to interact with the user community to make sure their needs are being met by the program.

Wave 2 Elements

22. Research: Self Describing Datasets, Meta-Data, XML Use ***1 Year Project***

A key ingredient to developing successful ADUS implementations is providing consistent Meta-Data about the information archived within. The archives themselves need to be able to retain information about data definitions, note when they change, and what has been carried out on the information. This information also needs to be transmitted to the user when a request has been made. Meta-Data standards, self-describing data sets, the XML markup language are all concepts that may play an important role in ADUS systems as they are implemented. This project would research and make recommendations on what information is required when describing archived data elements in the Meta-data, and then examine options for storing and providing the Meta-data in different forms. The new internet retrieval options provided by the XML markup language will be

explored. This project will build upon the Information Technology (IT) review, and also be used as a source of information for the ADUS standards efforts, particularly in regards to the Meta-Data standards.

23. ADUS with Traditional Data Source Comparison ★ ***3 Year Project***

Before archived ITS data can be used as an input to continuous statistical series and annual databases such as the HPMS data and the National Transit Database the differences/biases introduced by changing data collection methods (from traditional methods to ITS) must be well understood and documented. Where possible procedures should also be developed to adjust for any differences and biases found. This project will compare statistics derived from both sources (traditional and ITS) and determine if the use of archived ITS data does introduce differences, and explore corrective procedures for any biases. More important, it will examine how collection and processing procedures must be modified to ensure consistency in results. The project's focus will depend upon the gaps and issues found in the State-of-Practice and Legacy System reviews, and the data series found important in the Federal and Other Government Reporting System analyses for ADUS potential. This project's results will be key inputs in developing the changes to the Federal Reporting System procedures to allow the acceptance of ADUS. Some initial. comparisons for traffic data have already been carried out by the Texas Transportation Institute and Oak Ridge National Laboratory. This project will build upon these initial investigations and attempt to generalize their findings.

24. Technical Synthesis Studies (Data Quality/Repair, Data Aggregation, Data Storage…) ***2 Year Project***

The "ITS Data Archiving Five-Year Program Description", the "ITS As a Data Resource: Preliminary Requirements for a User Service", and the "Archived Data User Service (ADUS): An Addendum to the ITS Program Plan" identify technical issues that must be addressed in the implementation of ADUS. These include issues regarding: data quality (error checking and validation, imputation of missing information), data management and storage (what to store, aggregation, reduction cycles, new technologies such as warehousing and OLAP, and costs), data analysis (data mining, data fusion, summary statistics), and data communication and reporting (Meta-data standards, data visualization techniques). The Wave I state-of-the-art studies will help determine where each focus area is on addressing these issues and set priorities. This effort will provide synthesis studies based upon the Wave I efforts to fully explore the identified issues/concerns and how they are being addressed. Where possible cross-cutting syntheses will be carried out; however, focused efforts on specific areas and their unique issues may also be warranted. These studies will be used in developing guidance and as inputs to the continuous outreach and awareness efforts.

25. Institutional Issues Synthesis Studies (Ownership, Privacy, Integrity/liability…) ***2 Year Project***

Similar to the technical issues, The "ITS Data Archiving Five-Year Program Description", the "ITS As a Data Resource: Preliminary Requirements for a User Service", and the "Archived Data User Service (ADUS): An Addendum to the ITS Program Plan" identify institutional issues that will arise in the implementation of ADUS, especially for integrated systems. Institutional issues include: data access, ownership, and privacy concerns; defining concepts of operations on who cleans, stores, maintains and pays for the data; degree of private sector involvement; and security issues. The Wave I state-of-the-art studies will help determine where each focus area is on addressing these issues and set priorities. This effort will provide synthesis studies based upon the Wave I efforts to fully explore the identified issues/concerns and how they are being addressed. Where possible cross-cutting syntheses will be carried out, however, focus are specific efforts may also be warranted. These studies will be used in developing guidance and as inputs to the continuous outreach and awareness efforts.

26. Research: Private Sector ISPs and ADUS Issues/Hurdles ***2 Year Project***

Private Sector independent service providers (ISPs) and ADUS create a number of issues/hurdles that need to be investigated as ADUS is implemented across the country. Can/should private sector ISPs re-package and market the archived data? Who owns the information? How should access and data integrity issues be resolved? How can we obtain, share, use data collected by the private sector ISPs as part of the ADUS systems? How will advertising within the ISPs be addressed? This project will investigate these issues, both from the perspective of how to encourage private sector ISP involvement, and what type of involvement is desirable from the public's perspective. The project will produce recommendations and examples to be used in developing guidance and the outreach/awareness efforts of the program.

27. Pilots/Field Operational Tests for Integrated Archiving Systems ***3 Year Project***

As we move towards the ADUS vision to "Improve transportation decisions through the archiving and sharing of ITS generated data" integration across ITS data sources becomes key. New issues arise once integration is desired including how to define key fields, consistency in data definitions, and data update cycles. Institutional issues concerning who is responsible for what processes, how the data is shared, liability, etc. also become critical. This project would focus on funding integrated archive case studies which combine the information from two are more ITS data sources (or centers) as they are defined in the National ITS Architecture. An example is the integration of information from both transit and traffic management centers. The case studies will be used to support the development of the Integrated Archived Databases from Multiple Sources guidance in Wave III.

28. Federal Reporting Systems Changes to Accept ADUS Inputs ***1 Year Project***

This project builds on a project in Wave I that will review Federal Reporting Systems to determine the potential to accept data collected using ITS technologies in place of traditionally collected data. This project involves the meticulous identification of data elements that can be supplemented with data retrieved from an archived data system. In addition, this project will involve changing the regulations associated with the various Federal Reporting Systems that will in the future accept ITS generated data for these systems. Upon completion of this project, test cases will be conducted to identify any further changes that are required to make the new reporting systems flawless. The performance of the test cases will be conducted through another program element also included in Wave II.

29. Federal Reporting Systems Test Cases on Use of ADUS Inputs ***1 Year Project***

This project builds on a project also included in Wave II that focuses on identifying Federal Reporting Systems and the individual elements within each that may be supplemented with data collected using ITS technologies. This project involves conducting test cases to ensure the seamless acceptance of ITS generated data into traditional data elements included in various Federal Reporting Systems. These case studies will be made available to the transportation community through a variety of media to ensure the awareness of this new form of reporting that agencies can use to report their statistics at the National level.

30. ADUS Standards Development/Support (Meta-data) ***(Continuous) Project***

The ASTM has recently initiated a "Archived Data User Service" subcommittee of the Vehicle-Pavements Systems Group V on ITS to consider: ITS meta-data standards; standard ITS data validation procedures; and Data interchange standards for archived ITS data. This project will support the ADUS standards activities associated with the ASTM and other ADUS specific efforts. While large scale development of ADUS standards for specific data items is premature effort can, and should, be initiated on how to store and describe the archived data (meta-data), and ADUS processes (data error analysis, imputation, etc.). This project will build upon the work carried out in the Technical Synthesis Studies, and research on self describing data sets, meta-data, and XML. It will also be closely coordinated with the Wave III standards development to support government reporting.

31. ITS Earmark Evaluations & Piggyback Efforts Case Studies (What was learned) ***1 Year Project***

This project builds on efforts made in two Wave I projects that will track the use of ADUS in ITS Earmarks and other Federally funded projects. In addition, information gained through the evaluation of these ITS Earmarks and other Federally funded projects will be used to increase the user community as to the benefits and challenges experienced by some of the initial investments into archive data systems. Case studies will be published in a variety of methods including as electronic documents that can be accessed through the internet.

32. Guidance: Single Source Data Management ***1 Year Project***

This project will develop guidance for those implementing the archiving of ITS data from a single ITS Data source such as a traffic management center, or transit management center. It's purpose is to develop guidance on both technical and institutional issues regarding implementing a data archive within a single source or operations center. It will build upon the technical and institutional synthesis studies, state-of-the practice reviews and case studies. It will provide inputs to both the integrated ADUS system guidance, and the training/outreach efforts.

33. Provide ADUS Training: (Management, Operations, and Advanced Applications)
(Continuous) Project

This project will provide training on the management, operations, and advanced applications in implementing ADUS systems. It is envisioned to cover a variety of training and outreach approached including formal training courses developed in Wave I, and peer-to-peer support. The project will evolve as time progresses and the results of the Wave I, Wave II, and Wave III projects become available. .

Wave 3 Elements

34. Research: ADUS within Enterprise Systems ***1 Year Project***

Just as integration is a key goal for the implementation of ADUS systems within transportation, the information technology and management information systems are moving more and more towards "Enterprise Systems". Enterprise Systems are designed to integrate all of a companies data and information systems towards meeting the "mission" of the enterprise. When data are archived for internal purposes and uses only, it is clear that the agency/enterprise system becomes a part of the enterprise effort. Issues arise when data are being archived and shared for/with users outside the enterprise itself, and especially when ADUS integration across agencies and/or systems is desired. This project would investigate the relationships between ADUS and enterprise data systems and how they can/should be mutually supportive in their design and development. It will provide information to the Wave II activity addressing guidance for single source and integrated ADUS systems.

35. Research: Data Extraction and Archiving of Non-Textual ITS Information (Video, Audio, Remote Sensing)
2 Year Project

Video surveillance and the extraction of data from video images is advancing rapidly in transportation. Remote cameras are now almost standard in monitoring freeway conditions at key locations in urban areas. From the use of Autoscope for measuring traffic volumes and speed, to using video for license plate identification and origin destination studies, to security surveillance in transit applications video surveillance provides new opportunities for the analysis of the transportation system. Remote Sensing and Satellite Imaging also provide additional sources of information. A number of issues still remain, however, regarding the archiving of video images, and/or the extraction of information from them for archiving. These include storage requirements and information reduction techniques, liability concerns regarding video images, privacy issues, validation methods, and new ways to extract additional information. This effort would examine video surveillance and data archiving to determine the state-of-the-art, identify issues and concerns, and make recommendations to transportation professionals on how these new technologies can be used and the issues overcome.

36. Quantify Costs of ADUS Implementations: Market Packages, and Storage Technologies ***1 Year Project***

This project will build on the knowledge gained in Wave II studies including the Technical Synthesis Study and the comparison of archived data to traditional data sources. This project will be performed to determine the costs associated with various market packages and storage technologies available when designing an archived data system. This project will be performed in Wave III to allow the most promising and compatible systems to emerge from the field of many possible systems. The information gathered, through surveys most likely, will be made available to the user community through a variety of media including electronic documents available from the internet. The findings from this study will be useful to the user community for determining cost benefit ratios and in making better purchasing decisions.

37. Research: Benefits/Impacts of ADUS Implementations ***1 Year Project***

This project will synthesize findings from a variety of projects including those identified in Wave II of the program that evaluate the usefulness of archived systems in the ITS Earmarks. The product of this project will be a synthesis of successful and beneficial applications of archiving systems to transportation agencies. The project team will attempt to quantify the benefit associated with implementing archiving systems in areas where ITS technologies are implemented or exist. In addition, the lessons learned in the test cases of using ITS archived data in place of traditional data sources in Federal Reporting Systems will be included in this synthesis to emphasize the multiple uses of archived data. The information gained in this project will be widely distributed to the user community to assist them in their management decisions.

38. Research: Emergent Uses of ADUS Data ***1 Year Project***

This project will build upon the knowledge gained in Wave II projects regarding technical and institutional issues and will promote non-traditional uses of archived data in areas such as planning and traffic management. This project will provide funding to cutting edge researchers who think outside traditional boundaries associated with utilizing archived data for planning and operational applications to develop unique uses for archived data.

39. Federal Reporting Systems Policy/Regulation Modification ***1 Year Project***

This project builds upon efforts made in Wave I and Wave II regarding the use of data collected from ITS sources in traditional Federal Reporting Systems. The final phase of this effort will involve changes to policy and regulations to allow for the use of data collected using ITS technologies in place of traditionally collected information.

40. ADUS Standards to Support Government Reporting ***2 Year Project***

This project builds upon the Wave I and II efforts regarding government reporting (both at the Federal level and to state and local agencies), and the ADUS standards activities. The requirements for specific data elements and procedures needed to enable the use of archived ITS data for input to the mandated government reporting systems should be understood by the time this project is initiated. It may be important to develop standards around specific data items for consistency and comparability across the nation when/if the archived data feeds these systems. Concerns that are important to address include data definitions, coverage, aggregation levels and data transformations, statistical reliability, and validation procedures. This effort will explore what data items may need specific standards, what type of standards are needed, and then support their development.

41. Guidance: Benefits/Costs of ADUS, Case Studies ***1 Year Project***

As experience mounts and case studies are completed a growing base of knowledge will develop regarding both the costs of different ADUS implementations and their associated benefits. The benefits/impacts fall into two categories: tangible benefits leading to direct savings to either the providers or users of ADUS; and/or intangible benefits that may be difficult to monetarize such as new types of information for planning, and the ability to analyze new relationships (system variation) previously not possible. This project will gather the information from the state-of-practice reviews, case studies, syntheses, and benefits and impacts analysis and provide guidance to the user on both the different costs expected to implement different types of ADUS, and the likely benefits that will accrue. It will be aimed at providing assistance in selecting and designing ADUS features and making tradeoffs associated with their implementation. The guidance will support the ongoing training, outreach, and awareness efforts.

42. Guidance: Integrated ADUS Databases, Multiple Sources ***1 Year Project***

The ultimate vision for archived data user systems is the integration and sharing of ITS data from different sources and types of collection. In Wave II, case studies focusing on the integration of ITS from different data sources will be developed. This project will bring information from these case studies and the other technical and institutional synthesis efforts to provide guidance and best practice examples on how to develop integrated ADUS systems and overcome hurdles to their implementation. It will provide guidance on both technical and institutional issues concerning integration. The guidance when complete will become part of the awareness and outreach activities and course materials.