Cost Data Collection Guidelines for Intelligent Transportation Systems

July 1999

Executive Summary

This document provides guidance to local, State, and other agencies that are collecting cost data for ITS deployments. It outlines the steps and procedures that are recommended to effect the collection of ITS costing data. This information is specifically designed to assist those responding to the requirement in the U.S. DOT's ITS Evaluation Guidelines to produce cost accounting data. Those Guidelines apply to projects funded as part of the ITS Integration Program.

The collection, enumeration, and reporting of ITS deployment costs are important for a number of reasons. At the planning phase, costing data can be matched against the predicted benefits of a considered deployment to determine the overall feasibility of the solution and, in some cases, to assist in identifying a more cost effective approach. Quality cost data can also assist ITS planners to budget the funds that will be needed to support the future operations and maintenance costs of the proposed deployment. Finally, at the operations phase, a careful and concerted effort of updating previously predicted costs will assist in developing costing databases that should benefit all users of ITS in subsequent deployments.

For these reasons and others, it is important that accurate cost data be collected for actual ITS deployments. As stated above, this document outlines a number of steps that may assist in facilitating this collection process. First, recognizing that the cost data should reflect the expenses of the actual deployments, the costs of the deployments under consideration should be separated from the costs of the baseline, where the baseline involves those investments which were in place before a project was started. Second, an appropriate time frame that considers the accuracy of available data should be selected. Third, the data should be broken into a number of categories, including: recurring and non-recurring costs, shared and direct costs, and government, commercial, and personal costs.

It should be noted that in many cases, the cost collection process may not proceed in a linear fashion. For example, once an initial draft cost spreadsheet has been prepared, several iterations may be required, while consulting with the deployment program manager, as well as other managers and their staff. The spreadsheet may need to be modified based on what cost data are available, and on the format of cost data that are collected by local agencies. However, it is imperative that cost collectors remain flexible and open to any data sources that may become available.

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Section 1. Introduction

As one aspect of addressing the increasing traffic on the nation's urban and rural road network, the U. S. Department of Transportation (DOT) has established the Intelligent Transportation Systems (ITS) program. This program includes freeway management, advanced traffic signal control, and traveler information projects among other transportation-related applications of technology. ITS projects are expected to reduce travel times during peak travel periods, increase traveler safety and security, and reduce emissions, among other goals.

As part of the ITS program, the DOT is encouraging State and local agencies to collect and evaluate both benefits and cost information. This report provides guidelines for the collection of cost data for ITS deployments and operations.

1.1. Purposes of ITS Cost Data Collection

There are several reasons for collecting ITS cost data. One of these is to provide the annual cost accounting data that may be required by the U.S. DOT for agency self-evaluations. Cost data also provide the basis for estimating the life-cycle costs of ITS projects. In addition, the cost data may be utilized to carry out benefit / cost analyses for planning and trade-off studies, and the evaluation of the effectiveness of new ITS deployments.

The collected cost data should be saved in a costing database to make the data useful to a variety of ITS implementers and metropolitan planners. For example, agencies may need to compare a proposed ITS project with the "do nothing" case, with a traditional solution such as roadway expansion, or with another ITS project. The cost database could be augmented with projected costs to make comparisons of the life cycle costs of various comparable ITS projects.

In addition to assisting planners in selecting appropriate ITS solutions, the systematic collection of cost data will assist the same agencies in determining the appropriate operations and maintenance commitments necessary to keep selected deployments viable in the years to come. Currently, the relatively short history of ITS deployments has contributed to a substantial lack of knowledge of these types of expenses, and has made the need for this type of data collection even greater.

Beyond planning purposes, ITS cost data may be utilized to assist in program assessment. Throughout the history of ITS deployments, concerted efforts have been made to collect and report benefits data on such metrics as improvements in safety, travel time, etc. When matched against the associated costs necessary to achieve these benefits, an effective, systematic assessment in the form of a benefit / cost analysis may be performed. Such analyses serve to support a broad range of interests from the participating system implementers to colleagues across the nation considering similar solutions to their transportation challenges.

There is also a need for a substantial amount of cost-accounting data on ITS investments and operations to assist transportation budgetary decisions. This type of data includes acquisition costs, both initial and replacement, and operations and maintenance costs. Annual collection and reporting of these costs will allow the estimation of the start-up and sustaining resource requirements for ITS services.

A cost database can also be used by commercial companies, who may be considering introducing a traveler information service into the market place, and would like to examine the cost of obtaining, storing, and providing such information.

1.2. Some Previous Sources of ITS Cost Estimates

Several sources of ITS cost estimates are listed in the bibliography at the end of this report**.** The most detailed lists of costs are in the report, *ITS Architecture Cost Analysis*, by the Joint Architecture Team. Although this report is a good starting point for estimating unit costs, it, as well as all the other reports in the bibliography, should be used with some caution. The architecture cost estimates are generally from 1995, and, in many cases, based on extrapolations of costs from similar components and systems. The limitations of the available ITS cost estimates is one of the main reasons that further cost collection activities are necessary.

1.3 Structure of the Report

In section 2, this report describes some of the terminology of cost data, the types of costs to be collected, and important assumptions that have to be made before and during data collection. In section 3, it presents a procedure for collecting ITS project cost data. Some conclusions are presented in section 4. Two appendices are also included. Appendix A provides an example of a cost spreadsheet that has been prepared for a hypothetical ITS project. Appendix B provides a list of ITS cost elements that can be used as a starting point by cost data collectors.

Section 2. Cost Data Terminology

Collecting cost data is more complex than simply collecting price tags from various pieces of equipment, and tabulating them in a spreadsheet. The process can indeed be quite challenging. One of the challenges is the breaking down of simplified and aggregated cost records kept by the involved parties into more detailed records. Another is assigning aggregated maintenance and operations costs to specific projects or components. A further challenge can be in persuading all of the key owners of cost data of the value of coordinating the cost collection and definitions of terms.

Before a data collection procedure is outlined in section 3, several definitions of important cost-related terms are provided. Most of these definitions can be found in textbooks on engineering economics or cost-accounting. The terms include the following:

- Recurring and non-recurring costs
- Sectors bearing the ITS costs
- Sunk, or legacy system, costs
- Marginal ITS costs
- Shared costs
- Private partner costs
- Implicit transfer costs
- Free traveler information or services
- Cost baseline and base year
- ITS component lifetime vs. project life cycle
- Total component costs
- Annual costs

These terms will give the data collector an understanding of the different types of costs that should be collected, and how they are usually classified.

A hypothetical ITS deployment will be used to illustrate the application of most of the terms. This deployment distributes a number of electronic "tags" free of charge to individuals in an urban area. These tags are referred to as "automatic vehicle identification," or AVI, tags. Sensors placed along key roadways pick up speed or travel time data from the AVI tags, and a central computer uses information from the sensors to determine travel times along these roadways. The same, or other, individuals who purchase in-vehicle navigation (IVN) units from a commercial manufacturer, could then receive real-time traffic information and routing from the central computer.

2.1 Recurring and Non-Recurring Costs

It is important when collecting cost data to separate recurring costs from non-recurring costs. Non-recurring costs, sometimes referred to as "fixed" costs, are those costs that are accrued once at, or near, the beginning of a project and not required again. Capital costs, including the costs of hardware and its installation, are considered non-recurring costs.

Recurring costs, sometimes called "variable" costs, are costs that continue for a number of years after the project has been installed and become operational. These costs include, but are not always limited to, operations and maintenance costs.

An example of a recurring cost is the annual cost for a leased communication line associated with an ITS project. Other recurring costs are those incurred for renting cellular phone time, digital and analog phone lines, and Internet lines. A sample of communications services with recurring costs that is based on the *ITS Architecture Cost Analysis* report is presented in Table 2-1. (As pointed out in section 1.2, this, and the other previous ITS cost sources, should be used with some caution.)

In the case of the AVI/IVN project, the cost of the sensors, tags, master computer, IVN units, and software for the computer would be non-recurring start-up costs. The cost of maintaining the sensors, upgrading the software, and ensuring the system is operating smoothly would be recurring costs. Examples of operations and maintenance costs for various ITS deployments are contained in the *ITS Architecture Cost Analysis* report, and also in *TTI Operation and Maintenance Suggested Costs* and other local sources of data.

Table 2-1 Some Estimated Recurring Communications Costs

Lease Line (Ground)	Available Capacity	Monthly Price (low)	Monthly Price (high)
DS0	56 Kbps	$50	$100
DS1	1.54 Mbps	$400	$700
DS3	44.74 Mbps	$2000	$6000
Usage Level (Cellular)	Available Usage	Monthly Price (high)	Rate per Add. Kbytes
Low	125 Kbytes	$15	$0.12
Medium	1000 Kbytes	$50	$0.08
High	3000 Kbytes	$100	$0.05

2.2 Government, Commercial, and Consumer Costs

The US DOT has a stated objective for its ITS program that it will foster an environment where ITS can flourish in the public marketplace. In order to understand how successful cost sharing is occurring between public and private agencies, it is desirable to determine who is spending how much money on ITS deployment. It is therefore important to determine whether specific costs are being borne by government agencies, commercial companies, or consumers.

All three sectors of the economy may be represented in the hypothetical AVI/IVN project. For example, the government may have born the cost of the sensors and AVI tags, while the commercial operation may have born the cost of the master computer and software development. Consumers who purchased the IVN units would have born that particular Cost collectors should attempt to identify the cost that each group bears for each ITS component.

2.3 Sunk, or Legacy System, Costs

Many ITS deployments utilize "legacy" ITS infrastructure that is already in place. It is often desired to report only those costs associated with the new project, and omit the previous costs. This is the case when collecting the annual cost data for accounting or budgetary purposes. The cost of the legacy ITS infrastructure is referred to as a "sunk" cost when it is omitted. (There are also some types of evaluations, where it is desired to include the costs of the infrastructure already in place that makes the new deployment possible.)

One example of sunk costs would be the cost for sensors, which are necessary for some part of the ITS project, but where the implementation and operationalization were completed before the beginning of the project. A second example can be given using the AVI/IVN project. For example, if the AVI sensors relay information to the master computer through fiber-optic cable lines already installed as part of another, legacy ITS system; the cost of the cable lines is a sunk cost.

2.4 Marginal ITS Costs

Costs may be collected either for projects that are composed entirely of ITS-related components, or for those that contain some non-ITS components. For the latter type of project, costs may be separately reported for the ITS components. These costs can be called the marginal ITS costs.

2.5 Shared Costs

There are two categories of shared costs. The first category includes costs for components that are developed both for ITS, and for other purposes. An example of this might be a cellular communication service, which packages non-ITS voice telecommunications in a vehicle along with ITS data services. Under this scenario, the costs are shared between ITS and the other service(s) using the item. A second category of shared costs is where the cost is for ITS-related software, hardware, or labor that benefits two or more ITS projects.

In some cases, the costs are shared among different agencies, or different budget categories. However, even when there is not an actual out-of-pocket cost-sharing, many evaluations require that an estimated cost-sharing be performed among all of the benefiting projects. For example, if travel time information gathered by sensors is used for roadside traveler information, and is also sent to another computer that sends the information to a web page, the cost of the travel time data should be *shared*, are divided between, the two ITS project.

Shared costs are often difficult to treat, because there are no set accounting rules for allocating the costs. The relevant stakeholders should participate in the cost allocation.

2.6 Private Partner Costs

It may be difficult to obtain the disaggregated costs for the products and services contributed by private partners. It may not even be possible to check whether the aggregate valuations that the partners placed on their contributions are correct. This report suggests that no valuation be made for a private partner's contribution that is not concurred with by the partner.

2.7 Implicit Transfer Costs

In many cases of partnering, products and services can be traded between partners without money exchanging hands. The partners have implicitly valued the traded items as being equal to each other. We can call this value the *implicit transfer cost*. The monetary values in these trades may not ever be determined. The partners just agree when a deal is made. All cases where these transfers are made should be identified, and the cost valuations reported when possible.

2.8 Free Traveler Information Systems and Services

In some ITS projects, there may be test markets, where traveler information services are provided free of charge. Both private and public sector partners may participate in this way. These free services are provided to test either travelers' interest in an ITS service, or their ability to use new products. In these cases there are no market prices, and no user costs. It is recommended that any free services be identified, and the costs of the service be left blank. ("Shadow" prices not be inferred in these cases. A shadow price is one that is not paid in the market, but represents the inferred value of service.)

2.9 Cost Baseline and Base Year

ITS project costs should be estimated relative to a baseline. Normally, the baseline is defined as the base year – the year in which project costs begin. In this case, the costs that are collected are only those which occur after the base year, and the baseline includes all of the non-project costs. This is the approach that is used in a cost-accounting framework. It is also the approach that should be used when annual costs are collected to meet requirements in the ITS Evaluation Resource Guide. The baseline may be defined to include: (1) all of the ITS elements that have sunk costs; and (2) the non-ITS aspects of those products and services that have shared costs with ITS.

For some evaluations, a baseline should be defined in terms of what evolution of transportation construction and services would occur if the ITS project(s) were not implemented. This might be the case when planners are comparing potential future ITS and non-ITS investments.

The year of expenditure of all costs should be reported when collecting cost data. This applies to all recurring and non-recurring costs.

2.10 ITS Component Lifetime vs. Project Life Cycle

An important concept to understand in the collecting and analyzing of cost data is the difference between a project life cycle and the lifetime of individual components within the project. Component lifetime is the length of time that a particular ITS component lasts before needing to be replaced (thus incurring new costs). For example, if loop detectors have an average lifetime of five years, this implies that loop detectors will, on average, need to be replaced every five years. Clearly, the various components of a project may have quite different average lifetimes.

A project life cycle, on the other hand, is the number of years into the future for which the cost estimates for all of the components of a project must be made. During a given project life cycle, various non-recurrent, or capital assets, may be removed and replaced, as their particular average lifetimes are exceeded. All of these replacement costs must be included, as well as all of the relevant recurring costs for most evaluations. The replacement costs should be included when annual cost data are collected.

For a number of reasons, the project life cycle may be relatively short for ITS deployments. First, given the innovative technological nature of ITS, it is unlikely that any projections of operations, maintenance, or replacement costs beyond a few years will be better than guesses. For example, in ten to twenty years current loop detectors and cameras may be replaced by sensor and video technology that is not even available yet, and may have a significantly lower cost than today's devices. Second, few agencies are capable or willing to project their labor costs beyond a relatively short horizon. Again, this is partially due to rapid changes in technology that make projections beyond a few years very difficult.

This report leaves the decision up to the State and local agencies, and suggests they perform a trade-off analysis between the desirability to predict as far into the future as possible, and the decrease in the accuracy of estimates over time. Some documents have suggested using a twenty-year life cycle; others have suggested using as little as five or ten. Use of a common life cycle for all of the ITS projects being considered in an area will allow comparison of different projects on a level playing field.

To illustrate the concepts of average component lifetime and project life cycle, consider the hypothetical AVI/IVN project described previously. This project has several pieces of equipment, including sensors, tags, a master computer with communications equipment, and in-vehicle navigators (all of which have different average lifetimes). The first step is to identify the average lifetimes of each of the major components. Based on this information, and the project evaluation plans, a project life cycle is selected.

Suppose that the master computer has a predicted average lifetime of six years, and that a project life cycle of twenty years is selected. Then all costs associated with this project will be considered from the time costs are first incurred (base year) until twenty years from then. Combining this information with estimates of yearly maintenance and operations costs will allow the cost analyst to determine the total costs involved in keeping each component of the project operating for the entire span of the life cycle. For example, as figure 2-1 illustrates, the master computer will need to be replaced three times over the course of the project life-cycle. Thus capital costs are incurred for this component four times, specifically in years 0, 6, 12 and 18.

It should be noted that selecting the project life cycle, and predicting future costs, are not included in the tasks of cost collection. However, they are mentioned here, because the cost collection decisions are often interrelated with these analytical steps. The report by Das et al., listed in the bibliography, discusses the issues of estimating changes in future costs due to future technological and prices changes.

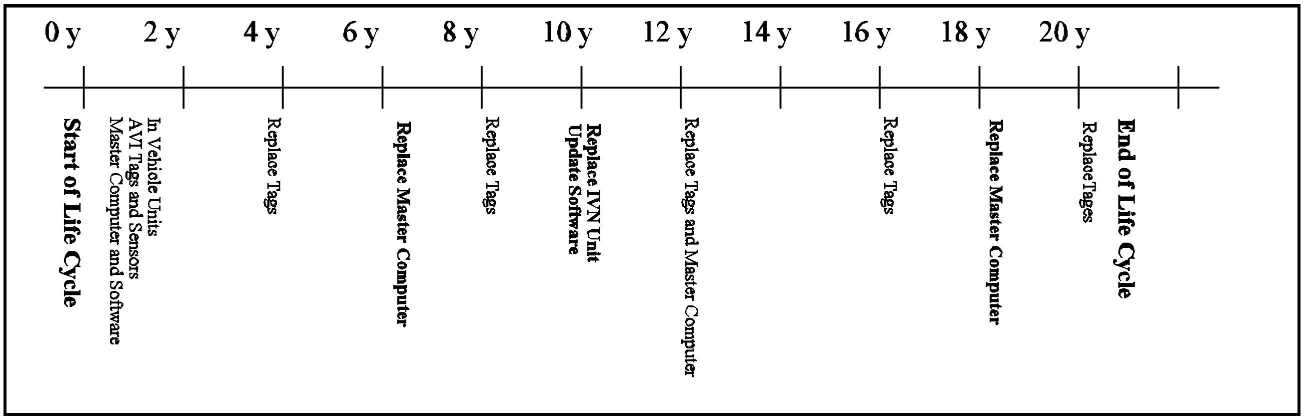

Figure 2-1: Project Life Cycle for AVI/IVN Project

2.11 Total Component Cost

The total cost of a component is the dollar value of the item bought from a seller, outfitted, and installed in the field. It includes development costs, planning costs, and costs of collateral equipment necessary for installation. These costs can also be called the *total capital costs*, or *total non-recurring costs*. If the recurring operations and maintenance costs over the component life are also included, then this total can be called the *total lifetime cost of the component*.

Using the example of the AVI/IVN project, the "total cost" of the AVI sensors includes the sensor and sensor housing, the communications hardware needed to connect it to a phone or Internet line, and the installation of the device in the field. The cost may also include the initial testing of the sensors. The cost of the master computer, similarly, will include the cost of the computer itself, its connection to the various incoming and outgoing communication devices, and its initial testing. The cost of the development of the software for the computer would be a separate "development" cost, however.

2.12 Annual Costs

An annual cost for a project can be defined as all of the recurring and non-recurring costs that are expended by all parties during a twelve month period for all of the components and services necessary for the project. Replacement costs should be included. Cost collectors should insure that there is no double counting – for example, the costs to manufacture a component by the private sector, and the cost to purchase it by consumers should not both be included.

Section 3. Steps in Collecting ITS Cost Data

Now that the cost terms have been defined, the suggested collection procedure can be presented. Figure 3-1 highlights each of the recommended steps. For a simple, standalone project, the entire process may take only days. For a more complicated ITS program, consisting of many integrated projects and legacy systems, with data being collected from field sites, the process may take as much as two months. The sections below describe each of the major steps in more detail. It should be noted that most of these steps must take place before cost data are actually collected. Many of the decisions that are discussed in these steps should involve the current participants in the ITS project, as well as potential local users of the cost data.

3.1 Identifying the ITS Baseline

The first step in collecting cost data is identifying the baseline for the ITS project. Defining the baseline allows the data collectors to identify what costs are shared or sunk. In the case of the AVI/IVN project, the baseline would include any communications equipment, computer servers, or AVI tags already installed or in use. For example, if an urban area already has a number of AVI tags distributed for electronic tolling purposes, the costs of those tags would be a sunk cost. If sensors are mounted on camera poles used for an already in-place freeway management system, the costs of the camera poles are also a sunk cost. It can often be assumed that existing wireline communications system used for ITS have sunk costs as part of the legacy system.

3.2 Choosing a Project Life Cycle

The choice of a project life cycle is very important, and one should be chosen that provides as much useful information as possible to evaluators, without relying on a large amount of guessing. For ITS deployments, a life cycle of ten to twenty years is suggested. For the hypothetical AVI/IVN project, a twenty-year life cycle is chosen.

3.3 Determining the Appropriate Level of Aggregation

Decisions must be made with regard to the level of aggregation of the collected data. The data collectors should consult with prospective local ITS analysts and evaluators to determine the level of detail that is desired by them for the cost data. Using this information, the data collectors must then make appropriate tradeoffs between data utility and collection feasibility.

At one extreme, one may wish to record only the total cost of the given deployment. For our AVI/IVN example, this may mean reporting a single number such as $20 million dollars for the proposed twenty-year project life cycle. While this may be sufficient for a simple high-level benefit/cost analysis, it is clearly insufficient for a detailed alternatives analysis or in providing much guidance to others considering similar deployments.

At the other extreme, one may record project costs as disaggregated as possible. For the hypothetical network, this may involve differentiating between the transport, storage, and handling costs for distributing the AVI tags to the various recipients. While this may provide very detailed data, it may be either unnecessary or infeasible.

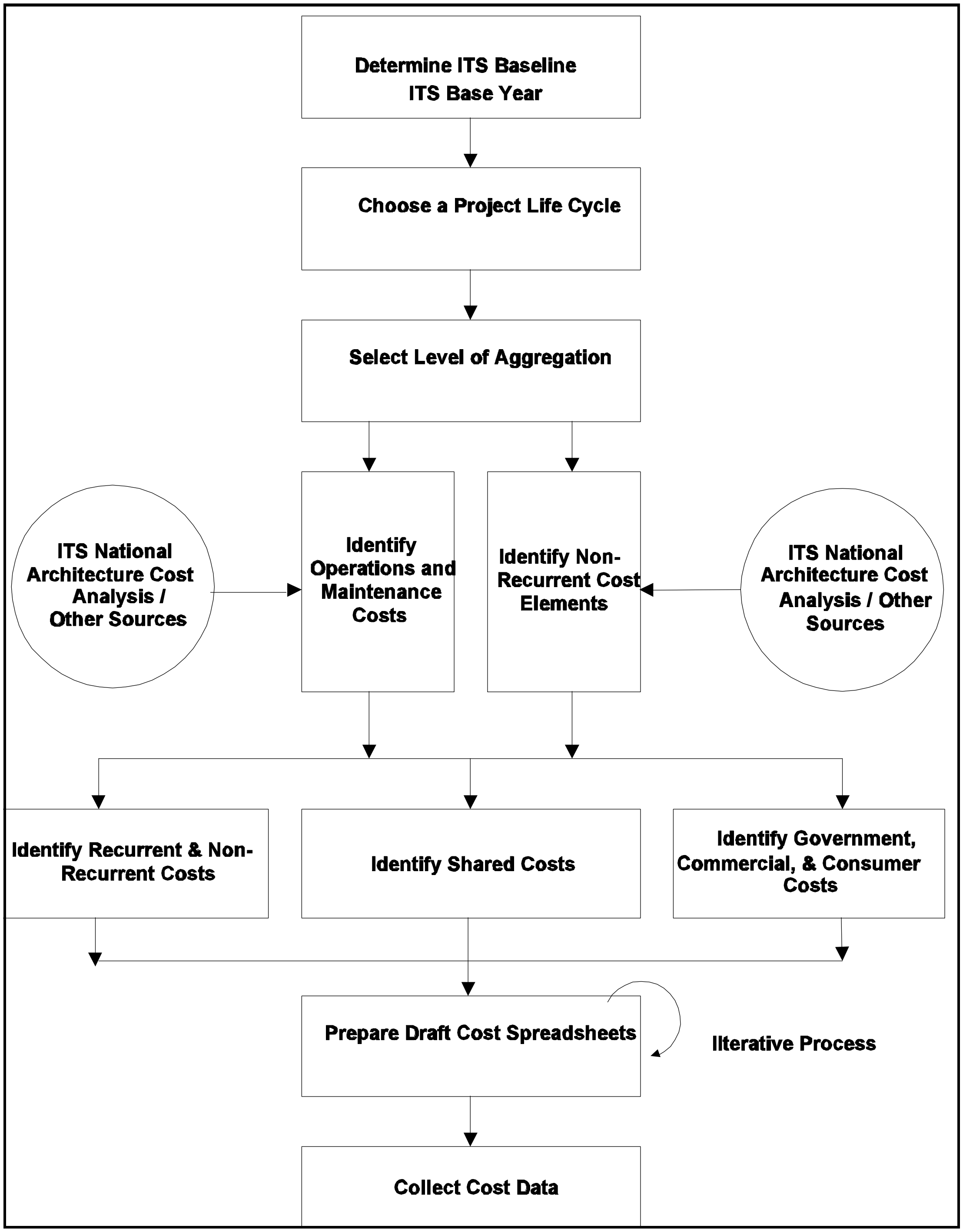

Figure 3-1: Cost Data Collection Procedure Flowchart

An appropriate level of aggregation should be selected somewhere between these two extremes. It is recommended that the ITS project be broken down by major component categories, which can reasonably be assigned unit costs. A reference list of ITS cost elements is presented in Appendix B. It is also recommended that the level of aggregation should separate elements with different average lifetimes.

For the hypothetical example, this would mean selecting the components identified earlier, namely; master computer (with communications hardware), AVI tags, sensors, and in-vehicle navigation units.

3.4 Enumerating Non-Recurring Cost Components

Consistent with the level of aggregation that is chosen, the next step is to compile an exhaustive list of the various ITS components in the project with non-recurring costs. The compilation of this list should be greatly aided by considering various documents provided by the deployment partners, including system design manuals and project descriptions, and by referring to the *ITS Architecture Cost Analysis* report.

The architecture report is particularly useful since it provides a fairly extensive list of nearly all ITS components at a level of aggregation that matches the recommendations given in this cost report. Furthermore, the document is organized in a fashion that allows the user to first identify more aggregate ITS components, such as probe surveillance, and then to select more disaggregated components as necessary for the expected evaluations.

Using this report, the following aggregate components were identified as being part of the AVI/IVN project:

In-Vehicle Navigator Packages

ISP1: Basic Information Provider

ISP4: Infrastructure Provided Route Selection

VS1: Basic Vehicle Communications Reception

VS16: Vehicle Route Guidance

AVI Tag / Sensor / Computer Packages

RS11: Roadway Probe Beacons

TMS13: Probe Information Collection

Using this list as a starting point, the project specific components were identified as in Table 3-1.

Table 3-1: List of Non-Recurring AVI/IVN Project Cost Items

Pkg.:	Item:
ISP1	Two Processors
	Five Workstations
	Integration
	Database Software
	Traffic Analysis Software
	Map Database Software
	Software Product Development Labor
ISP4	Route Selection Software
VS1	In-vehicle AM/FM Radio with subcarrier
	Dash Mounted LCD
VS16	GUI
	GIS Software
	Limited In-Vehicle Processor
	GPS/DGPS
	Wireless Data Transceiver
RS11	Radio Beacons (per location)
TMS13	Tags
	Probe Data Integration Software

3.5 Enumerating Recurring Cost Components

Once the non-recurring cost components have been identified, the next step is to identify the recurring cost components. Again, project specific documentation and the *ITS National Architecture Costing Repot* may be useful. Following a similar procedure as described for non-recurrent costs, the various recurring cost elements for our hypothetical project were enumerated as in Table 3-2. Note that the two main categories are communications costs and operations (including labor) and maintenance costs.

Table 3-2: List of Recurring AVI/IVN Project Cost Items

Pkg.:	Item:
ISP1	Maintenance for Processing Hardware Systems
	Maintenance for Traffic and Map Software Systems
	Wireline Communication DS1
	Wireline Communication DS0
	Staff
	FM Subcarrier Lease
ISP4	Maintenance for Route Selection Software Systems
VS1	Wireless Communication
VS16	Monthly ISP Service Fee
	Maintenance for GPS
	Maintenance for GUI
	Maintenance for In-Vehicle Processor
	Maintenance for FM Subcarrier Transceiver
RS11	Beacon Maintenance
	Leased Line Costs
TMS13	Maintenance for Probe Data Integration Software Systems

3.6 Determining Shared Costs

Once recurring and non-recurring cost elements have been determined, shared costs need to be identified. In the AVI example, the AVI tag sensor data are used both by IVN units and a separate, travel time web page project. Any items associated with the AVI tags, sensors, and the master computer, as well as associated labor, operations, and maintenance costs, should be shared between the two projects.

The difficult question is what portion of costs should be assigned to each project. One approach is to assign the costs equally to both projects. However, if one project uses the information more frequently than another, or is truly the primary user of the information, then costs may be distributed unequally. Whatever is decided, the way costs are shared should be made explicit in the reporting of cost data. In the case of the web page and IVN units, it was decided to share the cost equally between the two projects. See Appendix A, the finalized cost spreadsheet for this project, for which items have shared costs.

3.7 Determining Government, Commercial, and Consumer Costs

The last step before collecting cost data, is the identification of which items are government, which are commercial, and which are consumer costs. Appendix A shows the suggested breakdown between government, commercial, and personal costs for the hypothetical AVI project.

3.8 Collecting Cost Data

Once draft cost spreadsheets, such as the one presented in Appendix A, are developed, the actual cost data must be collected. It should start with consultation with the program manager and other managers connected with the deployment. They should be presented with the cost spreadsheets and asked for advice and help in filling in the cost data. It may be that the program managers will be able to complete the sheets as prepared. It is more likely that the managers will provide their budget data and some invoices, and the cost data collector will need to reconcile the spreadsheets and these new data. This will be the beginning of an iterative process that may result in a completely different spreadsheet. In any case, it is imperative that cost collectors remain flexible and open to any data source that may become available.

Section 4. Conclusions

Collecting a comprehensive set of ITS cost data is important to the collecting agencies for a number of reasons, including having the ability to estimate life-cycle costs, to evaluate ITS projects, and to estimate future ITS-related costs. Cost data are invaluable for performing alternative evaluation. It is also invaluable for determining the benefits of one type of ITS deployment relative to another.

These data can be useful to other urban and rural areas that may be considering deployment of ITS. The data can provide initial cost estimates for these areas, as well as provide insights into cost definition and collection problems.

For these reasons, it is important that accurate cost data be collected for all ITS deployments. These data should reflect the actual cost of the deployment, separating this deployment from the cost of the baseline. A project life cycle somewhere between five and twenty years, depending on the accuracy of available data, needs to be chosen. Cost data should also be broken into recurring and non-recurring costs, shared and direct costs, and government, commercial, and personal costs.

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Appendix A: AVI / IVN Project Cost Spreadsheet

AVI/IVN Project Spreadsheet

		Percent	Percent	Percent	Percent	TOTAL	1998		1999	
DIRECT PROJECT COSTS	**Equipment Description**	Direct	Gov't	Comm	Public	COST	# Units	Unit Cost	# Units	Unit Cost
Non-Recurring Costs										
Hardware and Software Installation										
ISP4	Route Selection Software			100%						
VS1	In-vehicle AM/FM Radio with subcarrier			50%	50%					
VS1	Dash Mounted LCD			50%	50%					
VS16	GUI			50%	50%					
VS16	GIS Software			50%	50%					
VS16	Limited In-Vehicle Processor			50%	50%					
VS16	GPS/DGPS			50%	50%					
VS16	Wireless Data Transceiver			100%						
Planning and Development										
	N/A									
TOTAL										
Recurring Costs										
Maintenance										
ISP4	Map Database Upgrade			100%						
ISP4	Maintenance for Route Selection Software Systems			100%						
VS16	Maintenance for GPS			100%						
VS16	Maintenance for GUI			100%						
VS16	Maintenance for In-Vehicle Processor				100%					
VS16	Maintenance for FM Subcarrier Transceiver				100%					
Operations										
ISP1	FM Subcarrier Lease			100%						
VS1	Wireless Communication			100%						
VS16	Monthly ISP Service Fee				100%					
TOTAL										
SHARED COSTS										
Non-Recurring Costs										
Hardware and Software Installation										
ISP1	Two Processors	50%	50%	50%						
ISP1	Two Workstations	50%	50%	50%						
ISP1	Integration	50%	50%	50%						
ISP1	Database Software	50%	50%	50%						
ISP1	Traffic Analysis Software	50%	50%	50%						
ISP1	Map Database Software	50%	50%	50%						
TMS13	Tags	50%	100%							
RS11	Radio Beacons (per location)	50%	100%							
TMS13	Probe Data Integration Software	50%	100%							
Planning and Development										
ISP1	Software Product Development Labor	50%	50%	50%						
TOTAL										
Recurring Costs										
Maintenance										
ISP1	Maintenance for Processing Hardware Systems	50%	100%							
ISP1	Maintenance for Traffic and Map Software Systems	50%		100%						
RS11	Beacon Maintenance	50%	100%							
TMS13	Maintenance for Probe Data Integration Software Systems	50%	100%							
Operations										
ISP1	Staff	50%	70%	30%						
ISP1	Wireline Communication DS1	50%	70%	30%						
ISP1	Wireline Communication DS0	50%	70%	30%						
RS11	Leased Line Costs	50%	70%	30%						
TOTAL										
GRAND TOTAL										

Appendix B. Exemplary List of ITS Cost Elements

Tele-Communications (TC)

- Twisted-pair Cable
- Fiber-optic Cable
- Fiber-optic Hub
- DS0 Communication Line (56Kbps capacity)
- DS1 Communication Line (1.544Mbps capacity)
- DS3 Communication Line (44.736 Mbps capacity)
- Wireless Communications, Low Usage (1)
- Wireless Communications, Medium Usage (2)
- Wireless Communications, High Usage (3)
- ISP Service Fee

Roadside Surveillance, Information, and Control (RS)

- Loop Detector (double set) (4)
- Video Camera
- Video Camera Tower
- Linked Signal System LAN, including Computers and Controllers
- Signal Controller Upgrade for Signal Control
- Signal Preemption Receiver
- Signal Controller Upgrade for Signal Preemption
- Ramp Meter System
- Fixed Lane Signal
- Roadside Message Sign
- Wireline to Roadside Message Sign
- Software for Lane Control (HOV, etc.)
- Lane Control Monitoring Equipment
- Lane Control Gates
- Variable Message Sign
- Variable Message Sign Tower
- Highway Advisory Radio & Controller
- Intersection Collision Avoidance System
- Roadside Probe Beacon
- Rail Crossing 4-Quad Gate, Signals
- Rail Crossing Train Detector
- Rail Crossing Controller
- Rail Crossing Pedestrian Warning Signal, Gates
- Rail Crossing Trapped Vehicle Detector

Toll Plaza (TP)

- Manual AVI (per lane)
- Automatic AVI (per lane)
- Manual Automatic AVI (per lane)
- AVI Dedicated (per lane)
- Express AVI (per lane)
- Electronic Toll Reader

High-Speed Camera
Electronic Toll Collection Software
Electronic Toll Collection Structure

Remote Location (RM)

CCTV Camera
Integration of Camera with Existing Systems
Informational Kiosk
Integration of Kiosk with Existing Systems
Kiosk Upgrade for Interactive Usage
Kiosk Software Upgrade for Interactive Usage
Smart Card Vending Machine
Software, Integration for Smart Card Vending

Emergency Management Center (EM)

Basic Facilities and Communications
Emergency Response Hardware
Emergency Response Software
Emergency Response O&M Staff
Emergency Management Communications Software
Hardware, Software Upgrade for E-911 and Mayday

Emergency Vehicle On-Board (EV)

Communications Equipment
Communications Interface

Information Service Provider (IS)

Basic Facilities and Communications
Information Service Provider Hardware
Systems Integration
Information Service Provider Software
Map Database Software
Information Service Provider O&M Staff
FM Subcarrier Lease
Hardware Upgrade for Interactive Information
Software Upgrade for Interactive Information
Added Labor for Interactive Information
Software Upgrade for Route Guidance
Map Database Upgrade for Route Guidance
Hardware Upgrade for Emergency Route Planning
Software Upgrade for Emergency Route Planning
Hardware Upgrade for Dynamic Ridesharing
Software Upgrade for Dynamic Ridesharing
Added Labor for Dynamic Ridesharing
Liability Insurance for Dynamic Ridesharing
Software Upgrade for Probe Information Collection

Traffic Management Center (TM)

Basic Facilities and Communications
Hardware for Signal Control

Software, Integration for Signal Control
Labor for Signal Control
Hardware, Software for Traffic Surveillance
Integration for Traffic Surveillance
Hardware for Freeway Control
Software, Integration for Freeway Control
Labor for Freeway Control
Hardware for Lane Control
Software, Integration for Lane Control
Labor for Lane Control
Software, Integration for Regional Control
Labor for Regional Control
Video Monitors, Wall for Incident Detection
Hardware for Incident Detection
Integration for Incident Detection
Software for Incident Detection
Labor for Incident Detection
Video Monitor for Incident Response
Hardware for Incident Response
Integration for Incident Response
Software for Incident Response
Labor for Incident Response
Hardware for Traffic Information Dissemination
Software for Traffic Information Dissemination
Integration for Traffic Information Dissemination
Labor for Traffic Information Dissemination
Software for Dynamic Electronic Tolls
Integration for Dynamic Electronic Tolls
Hardware for Probe Information Collection
Software for Probe Information Collection
Integration for Probe Information Collection
Labor for Probe Information Collection
Software for Rail Crossing Monitor
Integration for Rail Crossing Monitor
Labor for Rail Crossing Monitor

Transit Center (TR)

Basic Facilities and Communications
Transit Center Hardware
Transit Center Software, Integration
Transit Center Additional Building Space
Transit Center O&M Staff
Hardware, Software Upgrade for Automatic Scheduling, Run Cutting, or Fare Payment
Integration for Automatic Scheduling, Run Cutting, or Fare Payment
Software Upgrade for Electronic Fare Payment
Vehicle Location Interface

- Video Monitors for Security System
- Hardware for Security System
- Integration of Security System with Existing Systems
- Labor for Security System

Transit Vehicle On-Board (TV)

- Driver Interface and Schedule Processor
- Cellular Based Communication Equipment (Radio, Display, etc.)
- GPS/DGPS
- AVI Transponder
- Signal Preemption Processor
- AVL equipment
- Trip Computer and Processor
- Security Package (CCTV, Hot Button)
- Electronic Farebox

Transit Ticketing Site

- Electronic Fare Payment Vending Machines
- Smart Card

Toll Administration (TA)

- Toll Administration Hardware
- Toll Administration Software

Commercial Vehicle Administration (CA)

- Commercial Vehicle Admin Hardware
- Commercial Vehicle Admin Software, Integration
- Commercial Vehicle Admin Labor
- Software Upgrade for Electronic Credential Purchasing, Mgt
- Software Upgrade for Inter-Agency Info Exchange
- Added Labor for Inter-Agency Info Exchange
- Software Upgrade for Safety Administration

Commercial Vehicle Check Station (CC)

- Check Station Structure
- Signal Board
- Signal Indicator
- Roadside Beacon (used for electronic screening)
- Wireline to Roadside Beacon
- Check Station Software, Integration
- Check Station Hardware
- Detection System
- Software Upgrade for Safety Inspection
- Handheld Safety Devices
- Software Upgrade for Citation and Accident Recording
- Weigh-In-Motion Facility
- Wireline to Weigh-In-Motion Facility

Commercial Vehicle On-Board (CV)

- Electronic ID Tag
- Communication Equipment

Central Processor and Storage
GPS/DGPS
Driver and Vehicle Safety Sensors, Software
Cargo Monitoring Sensors and Gauges

Fleet Management Center (FM)

Fleet Center Hardware
Fleet Center Software, Integration
Fleet Center O&M Staff
Software for Electronic Credentialing, Clearance
Software for Tracking and Scheduling
Vehicle Location Interface
Software Upgrade for Fleet Maintenance
Integration for Fleet Maintenance
Software Upgrade for HAZMAT Management
Hardware Upgrade for HAZMAT Management

Vehicle On-Board (VS)

Communication Equipment
In-Vehicle Display
In-Vehicle Signing System
GPS/DGPS
GIS Software
Route Guidance Processor
Upgrade to Guidance Processor for Interactive Information
Electronic Toll Equipment
Mayday Sensor and Processor
Lateral, Longitudinal, Lane Sensors
Advanced Steering Control
Advanced Cruise Control
Intersection Collision Avoidance Processor, Software
Vision Enhancement System
Driver and Vehicle Safety Monitoring System
Pre-Crash Safety System
Software, Processor for Probe Vehicle

Personal Devices (PD)

Basic PDA
Advanced PDA for Route Guidance, Interactive Information
Modem Interface, Antenna for PDA
Software Upgrade for Interactive Information
GPS/DGPS
GIS Software

System Design and Integration

TMC, TIC, EMC, Transit MC
Electronic Fare Payment System

(1) 125 Kbytes/month available usage
(2) 1,000 Kbytes/month available usage
(3) 3,000 Kbytes/month available usage
(4) One double set = 2 detectors