ITS Cost Analysis

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COST ANALYSIS DOCUMENT
June 1996

EXECUTIVE SUMMARY

The goal of the cost analysis of the ITS National Architecture program is twofold. First, the evaluation is to produce a high-level estimate of the expenditures associated with implementing the physical elements and the functional capabilities of ITS Services as these services are likely to be deployed utilizing the ITS National Architecture. The second goal of the cost evaluation is to provide a costing tool for ITS implementors.

The Cost Analysis document presents the estimate of expenditures for an Evaluatory Design implemented over three scenarios. One scenario includes a major urban area described as Urbansville. Additional scenarios are an inter-urban area, Thruville, and a rural area, Mountainville. The cost evaluations are based upon a detailed physical element categorization within each subsystem and an aggregation of total expenditures into initial investment (non-recurring) expenditures, as well as operation and maintenance (recurring) expenditures. Each scenario analysis covers a twenty-year deployment period.

The bases for cost analysis were the Subsystems and Equipment Packages defined by the Physical Architecture. The relationship between Market Packages (i.e. User Services) and Equipment Packages (i.e. physical deployment of ITS services) is detailed in Table 4.5.2-1. Using the quantities for Equipment Package Deployment (high and low by time frame and scenario) developed in the Evaluatory Design the expenditures for the three typical area-wide deployments, Urbansville, Thruville, and Mountainville were calculated. Some of the summary results of this effort are presented below. However, the expenditures for typical area-wide deployments have limited value to implementors outside of the order of magnitude estimate for fully deployed ITS services. A major emphasis for the Phase II evaluation, therefore, is to provide a costing methodology and ranges of unit prices for the various ITS services, rather than emphasizing a bottom line expenditure for the three scenarios. The Cost Analysis Document provides a detailed cost estimate for each Equipment Package in the architecture, and presents a methodology for the development of non-recurring and recurring costs on any configuration an implementor would define. As such, the actual document serves as a resource guide for costing activities.

Unit price ranges for Equipment Packages are based on available information for recently deployed ITS projects, as well as the justified unit prices developed during the architecture program by not only the Phase II teams, but by the other teams which participated in Phase I of the architecture program. In addition to providing a range of unit prices for equipment, a range of market penetration is incorporated into the analysis. The basis for the market penetration range is provided in the Evaluatory Design Document. The application of the high and low market penetrations are demonstrated through spreadsheet applications.

Any effort to create summary cost numbers is highly influenced by the assumptions made in the analysis. The Evaluatory Design contains many, but not all of the assumptions used in the analysis. It contains the definition of populations (of users) and the definition of the elements (and the number of each) that are contained in each Equipment Package. For

example, the Network Surveillance Equipment Package (which is in the Roadway Subsystem) has a number of detector loops which is tied to the number of intersections and the penetration estimate (what percentage of intersections are instrumented).

In addition to the Evaluatory Design quantities, there are other assumptions which have a critical impact on the summary results. For example, are communication lines between the Roadway and the Traffic Management Subsystem owned by the public agency (and hence subject to initial capital installation costs), are they leased from a private communications provider, or are they paid for on a per use basis (again from a communications provider)? On this key decision the Cost Analysis has chosen to use leased lines for all of the wireline communications (i.e. fixed communications between centers). This has the impact of lowering significantly the non-recurring costs for the public infrastructure, and increasing the recurring costs. The architecture teams recognize that each locality will make its own decision on whether to install communications or purchase the needed lines.

Another assumption which impacts the cost summaries is which elements to include as part of each ITS functionality and which to not include. The architecture teams have tried to include all new hardware, software, building space, and personnel required to provide the functionality of the Equipment Packages. That is, neither existing vehicles (e.g. for incident management) nor existing functionality (e.g. call boxes) are included.

Scenario expenditures for Urbansville, Thruville, and Mountainville are classified into likely stakeholder responsibility for funding. The resulting allocations for each scenario are presented below.

Urbansville High Market Penetration
Twenty Year Non-Recurring Expenditure Totals

Stakeholder	Percent of Total Funding Requirements
Government	12%
Commercial	7%
Individual	81%

Thruville High Market Penetration
Twenty Year Non-Recurring Expenditure Totals

Stakeholder	Percent of Total Funding Requirements
Government	13%
Commercial	5%
Individual	82%

Mountainville High Market Penetration
Twenty Year Non-Recurring Expenditure Totals

Stakeholder	Percent of Total Funding Requirements
Government	36%
Commercial	18%
Individual	46%

The non-recurring expenditures for the government stakeholder group are tabulated below for the deployment year milestones. Note that the five year summation consists of the expenditures for the year stated plus the expenditures for the four previous years.

GOVERNMENT NON-RECURRING EXPENDITURES
URBANSVILLE HIGH MARKET PENETRATION
Non Discounted, Five Year Summations

		Non-Recurring Expenditures		
		Yrs	Yrs	Yrs
Subsystem	Subsystem Name	1-5	6-10	11-20
CVAS	Commercial Vehicle Administration Subsystem	$379	$1	$16
CVCS	Commercial Vehicle Check Subsystem	$326	$0	$80
EMS	Emergency Management Subsystem	$406	$309	$792
EMMS	Environmental And Emissions Management Subsystem	$1	$0	$0
EVS	Emergency Vehicle Subsystem	$1,867	$4,855	$12,560
PMS	Parking Management Subsystem	$645	$920	$3,625
PS	Planning Subsystem	$0	$35	$35
RS	Roadside Subsystem	$66,969	$95,737	$224,677
RTS	Remote Traveler Subsystem	$1,600	$3,125	$12,100
TAS	Toll Administration Subsystem	$56	$10	$60
TCS	Toll Collection Subsystem	$315	$0	$168
TMS	Traffic Management Subsystem	$4,738	$5,662	$15,721
TRMS	Transit Management Subsystem	$3,089	$3,168	$270
TRVS	Transit Vehicle Subsystem	$10,220	$13,236	$29,788

Expenditures are in constant 1995 dollars in (1,000's)

GOVERNMENT NON-RECURRING EXPENDITURES
THRUVILLE HIGH MARKET PENETRATION
Non Discounted, Five Year Summations

		Non-Recurring Expenditures		
		Yrs	Yrs	Yrs
Subsystem	Subsystem Name	1-5	6-10	11-20
CVAS	Commercial Vehicle Administration Subsystem	$676	$1	$32
CVCS	Commercial Vehicle Check Subsystem	$809	$6	$202
EMS	Emergency Management Subsystem	$203	$203	$393
EMMS	Environmental And Emissions Management Subsystem	$0	$1	$0
EVS	Emergency Vehicle Subsystem	$895	$2,321	$5,380
PMS	Parking Management Subsystem	$172	$231	$905
PS	Planning Subsystem	$0	$35	$35
RS	Roadside Subsystem	$6,648	$92,638	$89,690
RTS	Remote Traveler Subsystem	$520	$1,261	$5,750
TAS	Toll Administration Subsystem	$56	$10	$60
TCS	Toll Collection Subsystem	$450	$0	$240
TMS	Traffic Management Subsystem	$2,273	$1,313	$6,110
TRMS	Transit Management Subsystem	$1,624	$3,548	$918
TRVS	Transit Vehicle Subsystem	$3,649	$4,327	$9,193

Expenditures are in constant 1995 dollars in (1,000's)

GOVERNMENT NON-RECURRING EXPENDITURES
MOUNTAINVILLE HIGH MARKET PENETRATION
Non Discounted, Five Year Summations

		Non-Recurring Expenditures		
		Yrs	Yrs	Yrs
Subsystem	Subsystem Name	1-5	6-10	11-20
CVAS	Commercial Vehicle Administration Subsystem	$338	$1	$16
CVCS	Commercial Vehicle Check Subsystem	$405	$3	$101
EMS	Emergency Management Subsystem	$203	$0	$196
EMMS	Environmental And Emissions Management Subsystem	$0	$1	$0
EVS	Emergency Vehicle Subsystem	$2	$8	$17
PMS	Parking Management Subsystem	$0	$0	$0
PS	Planning Subsystem	$0	$0	$0
RS	Roadside Subsystem	$0	$1,094	$1,572
RTS	Remote Traveler Subsystem	$0	$0	$30
TAS	Toll Administration Subsystem	$0	$0	$0
TCS	Toll Collection Subsystem	$0	$0	$0
TMS	Traffic Management Subsystem	$0	$679	$911
TRMS	Transit Management Subsystem	$0	$1,968	$85
TRVS	Transit Vehicle Subsystem	$0	$133	$137

Expenditures are in constant 1995 dollars in (1,000's)

As expected the major government expenditure item in each of the deployments is the RS, with transit systems the next largest cost items. Using the methodology, and unit prices described in this document, a public sector implementor can make their own set of assumptions and compute both recurring and non-recurring expenditures.

Tabulated below are the non-recurring and recurring expenditures for an individual user for three levels of service. Basic service provides the capability for drivers to interface with the ISP Subsystem's Basic Information Broadcast Equipment Package, receive formatted traffic advisories including accurate traveling information concerning available travel options, their availability, and congestion information in their vehicle. Basic Service also provides Vehicle MAYDAY service. Mid-range Service provides the Basic services plus In-Vehicle hardware, and software for Vehicle Route Guidance and Interactive Vehicle Reception. The comprehensive Service provides the Basic and Mid-range Services plus equipment for In-Vehicle Signing, Probe Vehicle Software, Smart Probe, and Vehicle Route Guidance.

INDIVIDUAL NON-RECURRING EXPENDITURES

Basic Service	$450
Mid-range Service	$1,350
Comprehensive Service	$2,500

If all vehicle Equipment Packages including safety systems and AHS are combined, the total per vehicle non-recurring expenditure is $8,310.

INDIVIDUAL MONTHLY RECURRING EXPENDITURES

	Operation	Maintenance
Basic Service	$10	$1
Mid-range Service	$35	<$5
Comprehensive Service	$35	<$8

The total monthly cost for in-vehicle ATIS services are in the range of $0 to $43 per month for individual users (based on average usage) and are comparable to current service cost experiences for cellular telephone service.

1. INTRODUCTION

The goal of the cost analysis for Phase 2 of the National ITS Architecture project is twofold. First, the evaluation is to produce a high-level estimate of the expenditures associated with implementing the physical elements and the functional capabilities of ITS Services as these services are likely to be deployed under the confines of the National ITS Architecture. The second goal of the cost evaluation is to provide a costing tool for ITS implementors. The range of unit prices and quantities provided throughout the evaluation may be used by public and private stakeholders in determining appropriate deployment plans and strategies.

For the first goal, the analysis addresses expenditures for equipment deployment, as well as operations and maintenance for the subsystems identified in the physical architecture. The cost evaluation is based on the Phase 2, physical architecture configuration which includes the subsystem listed below.

1. Commercial Vehicle Administration Subsystem (CVAS)
2. Commercial Vehicle Check Subsystem (CVCS)
3. Commercial Vehicle Subsystem (CVS)
4. Emergency Management Subsystem (EM)
5. Emissions Management Subsystem (EMMS)
6. Emergency Vehicle Subsystem (EVS)
7. Fleet Management Subsystem (FMS)
8. Information Service Provider Subsystem (ISP)
9. Personal Information Access Subsystem (PIAS)
10. Parking Management Subsystem (PMS)
11. Planning Subsystem (PS)
12. Roadway Subsystem (RS)
13. Remote Traveler Support Subsystem (RTS)
14. Toll Administration Subsystem (TAS)
15. Toll Collection Subsystem (TCS)
16. Traffic Management Subsystem (TMS)
17. Transit Management Subsystem (TRMS)
18. Transit Vehicle Subsystem (TRVS)
19. Personal Vehicle Subsystem (VS)

The relationships of the architecture subsystems in terms of their interconnections are illustrated in the Architecture Interconnect Diagram, located in the Physical Architecture Document. The cost evaluations are based upon a detailed physical element categorization within each subsystem and an aggregation of total expenditures into initial investment (non-recurring) expenditures, as well as operation and maintenance (recurring) expenditures. The products of the analyses include the following:

(1) an expenditure profile for the ITS life cycle. The analysis also addresses the allocation of expenditures among three stakeholder groups, government, commercial

and private consumers. The allocation of expenditures is correlated to the benefits analysis, provided under a separate deliverable,

(2) some examples of existing technology and price ranges for implementing Equipment Packages,

(3) En estimating tool for implementors of ITS systems.

In accordance with FHWA costing guidelines, the phase two analyses include the cost evaluation of three distinct deployment scenarios. These scenarios are described in detail in the Evaluatory Design Document. Each scenario represents a typical geographical area for implementing the architecture into deployment services. Not all services are deployed in each scenario. However, among the three scenarios, each ITS service is deployed in at least one area. The analyses assume a twenty-year deployment period in which time the operations and maintenance activities are included.

The second goal of the cost evaluation provides the range of unit prices and quantities throughout the evaluation to be used by public and private stakeholders in determining appropriate deployment plans and strategies. The major emphasis for the phase two evaluation is to provide a costing methodology and ranges of unit prices for the various ITS services. The expenditures for the scenarios serve as an example in implementing the costing methodology.

The accuracy of any cost evaluation is a function of evaluating the state-of-the-practice, the state-of-the-art, or the yet to be defined technology. The delivery of ITS services to the end user encompasses all three of these situations. Where the state-of-the-practice technology is being deployed in the delivery of ITS services, the accuracy of the cost evaluation is significantly better than cost estimates for developing technology and those technologies which are still in the research stages. This being the case, the unit prices for near term deployed and currently deployed ITS systems rely on existing price catalogs, state's department of transportation construction pay item ranges, as well as other public records including construction bid unit prices. Where feasible, a range of estimates is provided for specific technology equipment. This range should be balanced with local construction pricing indices, such as the Means Cost Estimating Indices.

1.1 Organization of Report

This cost evaluation report is separated into seven main chapters, with chapters five, six, and seven containing the expenditure analyses for the three identified scenario deployments. Chapters one is the Introduction. Chapter two outlines the objectives of the National ITS Architecture Cost Evaluation. Chapter three provides a basic definition of the terms utilized in the costing exercise. The relationships of ITS User Services to the deployable physical devices which provide the required functionality of the services is provided in the following chapter. Chapter four, the heart of the document, details the method for determining expenditures for each ITS service through the deployment of Equipment Packages. This chapter provides the cost analysis for determining the expenditures for each Equipment Package based on any specified scenario. Chapters five, six, and seven, are examples of

expenditure calculations for the specified scenarios, Urbansville, Thruville, and Mountainville, respectively. These chapters execute the methodology outlined in chapters three, and four, as well as demonstrate the assumptions necessary in determining the costing parameters.

1.2 Relationship to Other Documents

This report is written as part of a series of reports for the National ITS Architecture Program. While much of this report may be used without outside reference, there is specific reliance of the Cost Evaluation on several of the other documents. A list of deliverable documents upon which this analysis relies follows:

Physical Architecture
Logical Architecture
Theory of Operations
Implementation Strategy
Evaluatory Design
Communications

The Physical and Logical Architecture Documents represent the core descriptions of the national architecture structure. Their relationship to the cost document is significant in that the bases for the cost evaluation are deployment scenarios as functions of the national architecture. These documents provide details on the standards, protocols, and interconnections for the various subsystems in the architecture.

The Theory of Operations Document provides a description of how the architecture provides for user services. The concepts of this document have been incorporated into the Cost Evaluation document through the establishment of sample deployment scenarios.

The Implementation Strategy describes the various issues and concerns in deploying ITS services. Stakeholder relationships, required interactions, and potential partnerships are detailed as they relate to implementing various services. The Cost Evaluation document utilizes these concepts in formulating expenditures by stakeholder group.

The Evaluatory Design Document (EDD) is the greatest source of information for the Cost Evaluation Document. The EDD identifies the parameters utilized to evaluate the architecture. For the second phase, sample deployment scenarios are described for a typical urban area (Urbansville), a typical interurban corridor (Thruville), and a typical rural area (Mountainville.) Basic parameters for each of these sample deployments are detailed in the EDD. Some specific parameters which are only used for the sample cost evaluation are described below, in the Sample Expenditure Calculation sections for each scenario.

The Communications Document is correlated to the Evaluatory Design Document so that the data loading analysis parameters coincide for the various evaluation activities. The cost evaluation utilizes the parameters from the EDD directly.

1.3 Relationship to National ITS Architecture

The National ITS Architecture represents the framework for the conceptual description of subsystems, standards, protocols, performance objectives, and interactions which form the basis for user services for ATIS, ATMS, CVO, APTS and AVVS, and for their system interconnectivity, allowing the integration of a national system which promotes compatibility, flexibility, expandability, and openness. This Cost Evaluation Document contains an evaluation of expenditures for sample deployments of ITS services. By its nature, a cost for the architecture itself cannot be quantified. What is quantified is the expenditure of sample implementations of the architecture, or system designs of ITS service deployments. As sample deployments, these evaluated implementations do not fully encompass the deployment variations possible under the architecture framework.

Cost issues which are associated with the architecture but are not included in the cost evaluation include the negative costs (or cost savings) from having a national architecture program. For example, one of the driving forces in establishing a national architecture was the desire to efficiently utilize the country's resources and avoid the wasteful expense of multiple and duplicative efforts in technology development for advancing the ITS services. These types of expenditures cannot be easily estimated. Projected research and development expenditures are very subjective and highly volatile.

Other costs associated with the architecture which are not included in the cost evaluation include the costs for monitoring compliance to the architecture. It is anticipated that the benefits of complying with a national compatibility framework are sufficient incentives for federal, state, local, private developer and commercial compliance. The risks associated with noncompliance, and its effect on the ITS deployments are described in the Feasibility/Risk Document.

1.4 Relationship to Typical Deployments

As part of the National ITS Architecture Program, Cost Analysis, typical deployment scenarios have been developed. The three scenarios described in the Evaluatory Design Document detail ITS Services deployed in three types of regions: a highly congested urban area, a moderately congested interurban area, and a rural area. These scenarios are selected and crafted to test multiple aspects of the architecture program. In order to provide a coherent set of evaluations of the architecture, each evaluation activity, of which the cost evaluation is only one, utilizes the same evaluatory design scenario.

In an effort to make the architecture documents more usable for the implementors of ITS services, the Cost Evaluation Document is changed in structure from the phase one format. The Cost Evaluation Document is formatted to provide preliminary cost information for an implementor to begin planning. Under chapter five of this document the methodology for developing cost expenditure estimates for each ITS service is detailed. By selecting those services which are of interest to the implementor, a specific deployment scenario may be

developed that better suits the implementors' interests. A set of expenditures for those services may then be calculated.

2. OBJECTIVES

During the second phase, there were no officially issued revised guidelines. However, a series of evaluation meetings were held during the second phase, wherein the focus of the document was altered.

During the first phase of the project, the focus for the cost evaluation was to provide a mechanism for evaluating the disparate architectures developed by the four architecture teams. The focus for the second phase is to provide a useable report for a target audience of ITS implementors, i.e., those people which will be planning, formulating and implementing the deployment of ITS services in their local area. These implementors generally fall into two categories; category one: public agencies, or category two; private entrepreneurs, and commercial businesses.

The objectives of the phase two cost evaluation of the National ITS Architecture can be summarized as follows:

1. To produce a high-level cost estimate of the implementation of the functional capabilities supported by the architecture.
2. To allocate expenditures to the stakeholder group bearing the expenditure ("who pays, who benefits").
3. To allocate expenditures into recurring, and non-recurring (including life cycle expenditures) categories.
4. To support analysis of design tradeoffs and provide expenditure data for analyzing the implementation alternatives.
5. To support the benefits and performance analyses by addressing the allocation of expenditures to stakeholder groups.
6. To develop quantity, prices and expenditure estimates of the ITS architecture implementation to aid in FHWA's overall evaluation of alternative implementation strategies.
7. To develop estimates of the level and time line of the estimated government investment necessary for the ITS architecture deployment.
8. To develop and identify the level of government investment and private entrepreneur potential for deployment of Core Infrastructure components.
9. To identify those elements of the architecture that represent dominant cost features, the projected time-lines for incurring these costs and the entities projected to absorb these costs.
10. To provide elemental costs for implementors, which allow the Equipment Package Unit Price Worksheets to be utilized in costing ITS implementations for any designated deployment.

3. EQUIPMENT PACKAGE DEFINITION

The expenditures and unit prices utilized in this ITS National Architecture Evaluation represent the final **price** of the installed equipment, not the manufacturer's **cost** of production. This is an important point in differentiating between **price** and **cost**. A manufacturer's **cost** of production is only one factor in determining the final price for a product which the market will bear and for which a reasonable profit may be made. Research and development costs, production costs, transportation costs, intermediary shippers' and handlers' costs, marketing costs, and retail markups are all a part of the determination of the final retail price of a product. These items are very difficult to estimate in developing manufacturing industries. Therefore, the expenditures presented in this analysis represent estimates of retail prices for equipment and staff based on comparable technology retail pricing, or estimates of market prices based on historical pricing strategies for specific industries.

Formulating Unit Prices for certain devices, specifically the in-vehicle electronics products, involves cost recovery concepts and the following considerations:

- The total cumulative volume of that product which will be sold to all possible customers, over a period of years.
- The cost of software per product that is generally spread across all customer volumes, but includes considerations that a portion of that software was used previously, and / or if it can be shared by another product under development.
- Considerable tooling expense, and test equipment capital expense in the manufacturing of electronics.
- The cost of product recall if it is related to the safety or emissions;
- Target pricing policies. In the present day automobile manufacturing environment, it is common practice to operate with a policy of target pricing, wherein the component product supplier is given a specified selling price. This policy invariably leads to a negotiating process involving component product specifications, and quality control issues.

In view of these considerations, the approach adopted in the development of Unit Prices is to compare Equipment Packages to similarly available commercial products. In addition, these comparisons are tempered by the likely total volumes of the product by a given supplier. This is evident within the vehicle subsystem where low unit prices are correlated to a high unit production quantities, and the high unit prices are correlated to low production quantities.

3.1 Basis for Definition

The basis for cost analysis is the subsystems and Equipment Packages of the Physical Architecture.

Subsystems perform transportation functions (e.g., collect data from the roadside, perform route planning, etc.) All of the functions are defined in the logical architecture as process specifications. Processes that are likely to be collected together under one physical agency, jurisdiction, or physical unit are grouped together into a subsystem. This grouping is done to optimize the overall expected performance of the resulting ITS deployments taking into consideration anticipated communication technologies, performance, risk, deployment, etc.

For a complete description of the subsystems of the National ITS Architecture refer to the Physical Architecture Document. The Equipment Packages represent subsets of functionality within a single Subsystem. Each Equipment Package is described in the following sections 5.6.1 through 5.6.19.

4. METHODOLOGY

As stated earlier in this document, one of the goals of the Phase II national architecture cost evaluation process is to produce a usable document for a target audience of ITS Service Implementors. These implementors include federal, state, and local government planners, and politicians, as well as the commercial industry, and the individual entrepreneurs seeking to conceptually estimate the costs for system deployments. This section of the report responds to this goal by outlining the steps necessary in determining a specific ITS deployment scenario's expenditures that are independent from the prescribed Urbansville, Thruville, and Mountainville scenarios provided by FHWA.

For reference, sample calculations for deployed services are provided in the following chapters for the prescribed typical areas, the urban area, interurban area, and rural area. The cost evaluation in these later chapters evaluates five, ten and twenty year deployment milestones as specified in the Phase II Deliverable Guidelines. The analyses also assumes operations and maintenance schedules for this period, during which all devices remain operable and expenditures required to facilitate the Market Packages are incurred through life cycle costing.

4.1 Summary of Approach

The cost evaluation is conducted based on 1995 constant dollars for the unit prices in determining Equipment Package expenditure. The evaluation approach discussed below is that which was applied by the Architecture Team in evaluating the ITS National Architecture. This approach may be used by other implementors of ITS services in determining conceptual pricing and expenditures for various services. The essential steps in cost evaluations are outlined below:

1. Definition of the ITS baseline. This baseline represents a reference point for the development and cost analysis of a future deployment.

2. Identification of ITS User Services and possible combinations of architecture functionality to be bundled into Market Packages that provide various levels of service to the users at various costs. The selection of Equipment Packages for similar User Services will span across Subsystems, as Market Packages require the functionality from multiple architectural Subsystems.

3 Examination of the lists of equipment as itemized in the Equipment Package Worksheets for such user services.

4 Examination of unit prices for end user services and/or packages of such equipment.

5 Identification and evaluation of equipment, markets/quantities and timing for a local deployment.

6 Calculation of the parametric quantities.

7 Calculation of the expenditure matrices for Equipment Packages.

8 Summation of Equipment Package expenditures to determine Market Packages expenditures.

The outputs of this analysis are the following:

- Equipment Package identification and existing technology components listing.
- Matrix tying Equipment Packages to architectural elements.
- Matrices of Quantities - one for each stakeholder group for each scenario (identified in the Evaluatory Design Document.)
- Matrices of unit prices for each Equipment Package.
- Matrices of expenditures for each Equipment Package, for each stakeholder group, for the specific scenario, for the analysis period.
- Discounted present values for the expenditure matrices.

4.2 The Goal of Cost Evaluation, End User Expenditures

End user expenditures, for any deployment, are the results of multiplying the quantities of items purchased for that deployment with the unit prices for each quantity item to be deployed in the scenario. The end user expenditures may be segregated by purchasing sectors and by year. The Equipment Packages, the basis for pricing strategies of an ITS deployment, are segregated by the architectural Subsystems. Each Equipment Package will have a time period of deployment, defined by the planned evolutionary deployment. Depending on the particular deployment scenario, or the implementor's interests, end user expenditures may be segregated into differing stakeholder groups, or purchasing sectors.

The three broad classifications of stakeholder groups are the Individual/Private Consumer, the Commercial Sector, and the Public/Government Sector. For every Equipment Package, there are two financial flows: (1) non-recurring expenditures, the initial funding or financing of service delivery and (2) recurring expenditures, the expenditures for continual operation and maintenance of the Equipment Packages.

Non-recurring expenditures are those which would be mostly attributable to a one-time capital investment sufficient for the useful life of the equipment necessary for the applicable service. Recurring expenditures are those expenditures which are attributable to the operation and maintenance of the ITS service. These expenditure items include consumables

for the equipment as well as for service fees and access expenditures. Replacement devices with useful lives of one year or less are included in the recurring expenditure tabulations.

4.3 Life Cycle Costing

Life cycle expenditures for the non-recurring items are accounted for by full replacement at the end of the scheduled useful life. These life cycle replacements may be included in the non-recurring expenditures throughout the entire deployment period and operation period for the evaluation. For the sample calculation scenarios in the following chapters the deployment period encompasses twenty years, beginning in 1993.

Specific technology selection for each deployment is specified in this cost evaluation document for the purposes of cost estimating. This technology, whether state-of-the-practice, state-of-the-art, or in its development phase is not specifically endorsed by the national architecture. The national architecture is not a deployment design. However, in order to evaluate the architecture some initial deployment design is needed. The design information is provided as a baseline from which future technological improvements may be judged. For example, the unit prices for the Roadway Subsystem include installations of loop detectors. These loop detectors have an estimated capital cost, an estimated operation and maintenance cost, and an estimated useful life. Other technology which has been classified as state-of-the-art that is currently being used includes video technology. The video monitoring industry is well aware of the current state-of-the-practice use of loop detectors and the subsequent life cycle costs are the main competition. Many factors are weighed in deciding a specific technology design, including full life cycle cost evaluation, safety, reliability, etc.

The life cycle expenditures for alternative technology used in Equipment Packages may be evaluated and compared using the baseline deployment technology listed in the Worksheets.

4.4 Analytical Tools

Included with this document are spreadsheets for calculating end user expenditures for specific deployments, and other variations on the three FHWA provided scenarios. These spreadsheets include an analysis time frame for the three scenarios. These parameters may be altered for different scenario analyses.

In these spreadsheets the annual expenditures are tabulated in the matrix for a total of twenty years. As certain Market Packages are deployed and become operational, the recurring operation and maintenance expenditures become activated, and the life cycle for the system components begins.

The Equipment Package Unit Price Worksheets contain the itemized listings of equipment, such as sensors, communication apparatus, processing requirements, interfaces (workstations), as well as additional staffing requirements, equipment maintenance requirements, and operations required communications.

Other analytical tools include, the previously mentioned Table 4.5.2-1, which details the relationship of Equipment Packages and Architecture Subsystems to Market Packages, as well as the Evaluatory Design Document, which describes the sample deployments for prescribed areas. These assumptions and deployment designs for the three typical design scenarios provide some insight into selecting parameters for each Equipment Package.

4.5 Analytical Procedure

The cost evaluation procedure objective is the expenditure profile for a particular stakeholder, or several stakeholders, for any ITS User Service or Market Package. The expenditure profile includes a time frame for analysis in order to evaluate life cycle costs, as well as to obtain a feeling for the relative dimensions of non-recurring costs (initial capital expenditures) and recurring costs (annual operation and maintenance expenditures.)

4.5.1 Definition of ITS Baseline

For the purposes of the National ITS Architecture development project, the ITS baseline is a definition of a no ITS baseline. That is, the baseline for analysis assumes that there is no current ITS technology deployed. For each implementor's scenario, an inventory of existing systems is necessary. This inventory includes such items as signal controller technology, existing closed loop signal controls, existing traffic control/management facility capabilities and limitations, existing transit facility technology, existing emergency facilities, existing communication network along the roadway infrastructure, etc.

A starting point for the development of this inventory is contained in the Evaluatory Design Document. Specifically, the lists of parameters, and the list of bases of estimates for each of the analysis scenarios are included.

4.5.2 Market Package Selection

The next step is to determine which Market Packages are to be implemented. To some degree, the selection of Market Packages (i.e. User Services) to be deployed is a function of the estimated expenditures. Once the proposed User Services are selected for expenditure analysis, then the selection of the specific Market Packages that encompass the User Services is required. For the prescribed scenario analyses, the selection of the User Services and Market Packages is contained in the scenario descriptions. For purposes of evaluation activities, all User Services and all Market Packages are evaluated through the three scenarios, at least once. The deployment timing for Equipment Packages is detailed in the Evaluatory Design Document.

Following the selection of Market Packages, the Matrix in Table 4.5.2-1, may be employed to determine which Architecture Subsystems are involved, and which pieces of those Subsystems, the Equipment Packages, are required.

Table 4.5.2-1 Market Package to Equipment Package Relationship			
Market Package	Market Package Name	Sub-system	Equipment Package Name
APTS1	Transit Vehicle Tracking	TRMS	Transit Center Tracking and Dispatch
APTS1	Transit Vehicle Tracking	TRVS	On-board Trip Monitoring
APTS2	Transit Fixed-Route Operations	TRMS	Transit Center Fixed-Route Operations
APTS2	Transit Fixed-Route Operations	TRVS	Vehicle Dispatch Support
APTS3	Demand Response Transit Operations	ISP	Interactive Infrastructure Information
APTS3	Demand Response Transit Operations	PIAS	Personal Interactive Information Reception
APTS3	Demand Response Transit Operations	TRMS	Transit Center Paratransit Operations
APTS3	Demand Response Transit Operations	TRVS	On-board Transit Driver I/F
APTS3	Demand Response Transit Operations	RTS	Remote Interactive Information Reception
APTS4	Transit Passenger and Fare Management	RTS	Remote Transit Fare Management
APTS4	Transit Passenger and Fare Management	TRMS	Transit Center Fare and Load Management
APTS4	Transit Passenger and Fare Management	TRVS	On-board Transit Fare and Load Management
APTS5	Transit Security	TRVS	On-board Transit Security
APTS5	Transit Security	RTS	Remote Transit Security I/F
APTS5	Transit Security	TRMS	Transit Center Security
APTS5	Transit Security	EM	Emergency Response Management
APTS6	Transit Maintenance	TRMS	Fleet Maintenance Management
APTS6	Transit Maintenance	TRVS	On-board Maintenance
APTS7	Multi-modal Coordination	RS	Roadside Signal Priority
APTS7	Multi-modal Coordination	TRMS	Transit Center Multi-Modal Coordination
APTS7	Multi-modal Coordination	TMS	TMC Multi-Modal Coordination
APTS7	Multi-modal Coordination	TRVS	On-board Vehicle Signal Coordination
ATIS1	Broadcast Traveler Information	RTS	Remote Basic Information Reception
ATIS1	Broadcast Traveler Information	PIAS	Personal Basic Information Reception
ATIS1	Broadcast Traveler Information	ISP	Basic Information Broadcast
ATIS1	Broadcast Traveler Information	RTS	Remote Basic Information Reception
ATIS1	Broadcast Traveler Information	VS	Basic Vehicle Reception
ATIS2	Interactive Traveler Information	PIAS	Personal Interactive Information Reception
ATIS2	Interactive Traveler Information	RTS	Remote Interactive Information Reception
ATIS2	Interactive Traveler Information	VS	Interactive Vehicle Reception
ATIS2	Interactive Traveler Information	RTS	Remote Interactive Information Reception
ATIS2	Interactive Traveler Information	ISP	Interactive Infrastructure Information
ATIS3	Autonomous Route Guidance	VS	Vehicle Route Guidance
ATIS3	Autonomous Route Guidance	PIAS	Personal Route Guidance
ATIS4	Dynamic Route Guidance	VS	Basic Vehicle Reception
ATIS4	Dynamic Route Guidance	VS	Vehicle Route Guidance
ATIS4	Dynamic Route Guidance	ISP	Basic Information Broadcast
ATIS4	Dynamic Route Guidance	VS	In-Vehicle Signing System
ATIS4	Dynamic Route Guidance	PIAS	Personal Route Guidance
ATIS4	Dynamic Route Guidance	PIAS	Personal Basic Information Reception
ATIS5	ISP Based Route Guidance	VS	Vehicle Route Guidance
ATIS5	ISP Based Route Guidance	VS	Interactive Vehicle Reception
ATIS5	ISP Based Route Guidance	ISP	Interactive Infrastructure Information
ATIS5	ISP Based Route Guidance	PIAS	Personal Route Guidance
ATIS5	ISP Based Route Guidance	ISP	Infrastructure Provided Route Selection
ATIS5	ISP Based Route Guidance	PIAS	Personal Interactive Information Reception

Table 4.5.2-1 Market Package to Equipment Package Relationship			
Market Package	Market Package Name	Sub-system	Equipment Package Name
ATIS6	Integrated Transportation Management/Route Guidance	TMS	TMC Advanced Signal Control
ATIS6	Integrated Transportation Management/Route Guidance	ISP	ISP Advanced Integrated Control Support
ATIS6	Integrated Transportation Management/Route Guidance	VS	Vehicle Route Guidance
ATIS6	Integrated Transportation Management/Route Guidance	VS	Interactive Vehicle Reception
ATIS6	Integrated Transportation Management/Route Guidance	ISP	Interactive Infrastructure Information
ATIS7	Yellow Pages and Reservation	VS	Interactive Vehicle Reception
ATIS7	Yellow Pages and Reservation	ISP	Interactive Infrastructure Information
ATIS7	Yellow Pages and Reservation	RTS	Remote Interactive Information Reception
ATIS7	Yellow Pages and Reservation	ISP	Infrastructure Provided Yellow Pages & Reservation
ATIS7	Yellow Pages and Reservation	PIAS	Personal Interactive Information Reception
ATIS8	Dynamic Ridesharing	RTS	Remote Interactive Information Reception
ATIS8	Dynamic Ridesharing	ISP	Infrastructure Provided Dynamic Ridesharing
ATIS8	Dynamic Ridesharing	PIAS	Personal Interactive Information Reception
ATIS8	Dynamic Ridesharing	ISP	Interactive Infrastructure Information
ATIS8	Dynamic Ridesharing	VS	Interactive Vehicle Reception
ATIS9	In Vehicle Signing	TMS	TMC Input to In-Vehicle Signing
ATIS9	In Vehicle Signing	VS	In-Vehicle Signing System
ATIS9	In Vehicle Signing	RS	Roadway In-Vehicle Signing
ATMS01	Network Surveillance	TMS	Collect Traffic Surveillance
ATMS01	Network Surveillance	RS	Roadway Basic Surveillance
ATMS02	Probe Surveillance	RS	Roadway Probe Beacons
ATMS02	Probe Surveillance	VS	Probe Vehicle Software
ATMS02	Probe Surveillance	TMS	TMC Probe Information Collection
ATMS02	Probe Surveillance	ISP	Interactive infrastructure information
ATMS02	Probe Surveillance	VS	Vehicle Toll/Parking interface
ATMS02	Probe Surveillance	VS	Interactive Vehicle Reception
ATMS02	Probe Surveillance	ISP	ISP Probe Information Collection
ATMS03	Surface Street Control	TMS	Traffic Maintenance
ATMS03	Surface Street Control	RS	Roadway Signal Controls
ATMS03	Surface Street Control	TMS	TMC Basic Signal Control
ATMS04	Freeway Control	TMS	Traffic Maintenance
ATMS04	Freeway Control	TMS	TMC based freeway control
ATMS04	Freeway Control	RS	Roadway Freeway Control
ATMS04	Freeway Control	TMS	TMC Incident Detection
ATMS04	Freeway Control	RS	Roadway Incident Detection
ATMS05	HOV and Reversible Lane Management	RS	Roadway HOV Usage
ATMS05	HOV and Reversible Lane Management	TMS	TMC HOV/Reversible Lane Management
ATMS05	HOV and Reversible Lane Management	RS	Roadway Reversible Lanes
ATMS06	Traffic Information Dissemination	TMS	TMC Traffic Information Dissemination
ATMS06	Traffic Information Dissemination	RS	Roadway Traffic Information Dissemination
ATMS07	Regional Traffic Control	TMS	TMC Regional Traffic Control
ATMS08	Incident Management System	EM	Emergency Response Management
ATMS08	Incident Management System	TMS	TMC Incident Dispatch Coordination/Communication
ATMS09	Traffic Network Performance Evaluation	TMS	TMC Traffic Network Performance Evaluation

Table 4.5.2-1 Market Package to Equipment Package Relationship			
Market Package	Market Package Name	Sub-system	Equipment Package Name
ATMS10	Dynamic Toll/Parking Fee Management	TMS	TMC Toll/Parking Coordination
ATMS10	Dynamic Toll/Parking Fee Management	PMS	Parking Management
ATMS10	Dynamic Toll/Parking Fee Management	TAS	Toll Administration
ATMS10	Dynamic Toll/Parking Fee Management	TCS	Toll Plaza Toll Collection
ATMS10	Dynamic Toll/Parking Fee Management	VS	Vehicle Toll/Parking Interface
ATMS11	Emissions and Environmental Hazards Sensing	EMMS	Emissions and Environmental Data Management
ATMS11	Emissions and Environmental Hazards Sensing	RS	Roadway Pollution and Environmental Hazards Indicators
ATMS12	Virtual TMC and Smart Probe Data	TMS	Distributed Road Management
ATMS12	Virtual TMC and Smart Probe Data	RS	Roadway Probe Beacons
ATMS12	Virtual TMC and Smart Probe Data	VS	In-vehicle Signing System
ATMS12	Virtual TMC and Smart Probe Data	VS	Smart Probe
ATMS12	Virtual TMC and Smart Probe Data	RS	Automated road signing
AVSS01	Vehicle Safety Monitoring	VS	Vehicle Safety Monitoring System
AVSS02	Driver Safety Monitoring	VS	Driver Safety Monitoring System
AVSS03	Longitudinal Safety Warning	VS	Vehicle Longitudinal Warning System
AVSS04	Lateral Safety Warning	VS	Vehicle Lateral Warning System
AVSS05	Intersection Safety Warning	VS	Vehicle Intersection Collision Warning
AVSS05	Intersection Safety Warning	RS	Roadway Intersection Collision System
AVSS05	Intersection Safety Warning	TMS	TMC Multi-Modal Coordination
AVSS06	Pre-Crash Restraint Deployment	VS	Vehicle Pre-Crash Safety Systems
AVSS07	Driver Visibility Improvement	VS	Driver Visibility Improvement System
AVSS08	Advanced Vehicle Longitudinal Control	VS	Vehicle Longitudinal Control
AVSS09	Advanced Vehicle Lateral Control	VS	Vehicle Lateral Control
AVSS10	Intersection Collision Avoidance	RS	Roadway Intersection Collision System
AVSS10	Intersection Collision Avoidance	VS	Vehicle Intersection Control
AVSS11	Automated Highway System	RS	Roadway Systems for AHS
AVSS11	Automated Highway System	TMS	TMC for AHS
AVSS11	Automated Highway System	VS	Vehicle Systems for AHS
CVO01	Fleet Administration	ISP	Infrastructure Provided Route Selection
CVO01	Fleet Administration	FMS	Fleet Maintenance Management
CVO01	Fleet Administration	CVS	On-board Trip Monitoring
CVO01	Fleet Administration	FMS	Fleet Administration
CVO02	Freight Administration	CVS	On-board Cargo Monitoring
CVO02	Freight Administration	FMS	Freight Administration and Management
CVO03	Electronic Clearance	CVS	On-board CV Electronic Data
CVO03	Electronic Clearance	CVCS	Roadside Electronic Screening
CVO03	Electronic Clearance	CVAS	CV Information Exchange
CVO04	CV Administrative Processes	CVAS	Credentials and Taxes Adminstration
CVO04	CV Administrative Processes	FMS	Fleet Credentials and Taxes Management and Reporting
CVO05	International Border Electronic Clearance	CVCS	International Border Crossing
CVO05	International Border Electronic Clearance	CVAS	CV Information Exchange
CVO05	International Border Electronic Clearance	FMS	Fleet Credentials and Taxes Management and Reporting
CVO05	International Border Electronic Clearance	CVS	On-board CV Electronic Data
CVO05	International Border Electronic Clearance	CVAS	International CV Administration
CVO06	Weigh-In-Motion	CVS	On-board CV Electronic Data
CVO06	Weigh-In-Motion	CVCS	Roadside WIM
CVO07	Roadside CVO Safety	CVCS	Citation and Accident Electronic Recording

Table 4.5.2-1 Market Package to Equipment Package Relationship			
Market Package	Market Package Name	Sub-system	Equipment Package Name
CVO07	Roadside CVO Safety	CVAS	CV Information Exchange
CVO07	Roadside CVO Safety	CVAS	CV Safety Adminstration
CVO07	Roadside CVO Safety	CVCS	Roadside Safety Inspection
CVO07	Roadside CVO Safety	CVS	On-board CV Electronic Data
CVO08	On-board CVO Safety	CVAS	CV Information Exchange
CVO08	On-board CVO Safety	CVS	On-board CV Safety
CVO08	On-board CVO Safety	CVAS	CV Safety Administration
CVO08	On-board CVO Safety	CVS	On-Board Trip Monitoring
CVO08	On-board CVO Safety	CVCS	Citation and Accident Electronic Recording
CVO09	CVO Fleet Maintenance	FMS	Fleet Maintenance Management
CVO09	CVO Fleet Maintenance	CVS	On-board Trip Monitoring
CVO10	HAZMAT Management	EM	Emergency Mayday and E-911 I/F
CVO10	HAZMAT Management	EM	Emergency Response Management
CVO10	HAZMAT Management	EM	Emergency and Incident Management Communication
CVO10	HAZMAT Management	CVS	Vehicle Mayday I/F
CVO10	HAZMAT Management	TMS	TMC Incident Dispatch Coordination/Communication
CVO10	HAZMAT Management	CVS	On-Board Cargo Monitoring
CVO10	HAZMAT Management	FMS	Fleet HAZMAT Management
EM1	Emergency Response	EM	Emergency and Incident Management Communication
EM1	Emergency Response	EVS	On-board EV Incident Management Communication
EM1	Emergency Response	EM	Emergency Response Management
EM2	Emergency Routing	EM	Emergency Vehicle Routing and communications
EM2	Emergency Routing	ISP	EM Route Plan Information Dissemination
EM2	Emergency Routing	TMS	TMC Multi-Modal Coordination
EM2	Emergency Routing	EVS	On-board Vehicle Signal Coordination
EM3	Mayday Support	PIAS	Personal Mayday I/F
EM3	Mayday Support	EM	Emergency Mayday and E-911 I/F
EM3	Mayday Support	VS	Vehicle Mayday I/F
EM3	Mayday Support	RTS	Remote Mayday I/F
ITS1	ITS Planning	PS	Data Collection and ITS Planning

4.5.3 Identification of Architectural Subsystems

This step identifies the required subsystems for the implementation of Market Packages. Reference to Table 4.2, yields an immediate indication of the relationships. The table identifies the Equipment Packages (in alphabetical order). Going across the table, the architecture subsystem is identified and then the required Market Package(s). The Market Package is repeated each line for every additional Equipment Package required for the ITS service. For example, four Equipment Packages and the following three Subsystems provide the Transit Vehicle Tracking:

Equipment Package	Subsystem
Basic Information Broadcast	Information Service Provider
Transit Center Tracking and Dispatch	Transit Management Center
Interactive Vehicle Reception	Transit Vehicle Subsystem
On-Board Tracking System	Transit Vehicle Subsystem

4.5.4 Examination of Equipment Package Worksheets

Equipment Package Worksheets are included in the following sections. Each worksheet lists equipment and price ranges for that equipment, including hardware and software, as well as operation (additional staffing) and maintenance requirements. A review of the equipment listed and a comparison to the preferred local technology may yield different expenditure estimates. The price ranges represent state-of-the-practice equipment using installed construction bid prices for some packages, state-of-the-art equipment using comparable technology and developing technology, also using comparable technology.

The low range of the unit prices in the equipment worksheets were used for the evaluation of the prescribed scenarios. The anticipation is that the early deployment plans and developments for the 75 largest urban areas will provide the beginnings of a standardization of equipment, software, hardware, communications, and operations and maintenance. Local implementors may incorporate the price ranges provided, or per their discretion, adjust the price ranges. Some adjustments to the price ranges are recommended based on the following section.

4.5.5 Identification and Evaluation of Quantities and Market Size

For the Equipment Package parameters the quantity of items purchased influences the unit price for the equipment. Obviously, price breaks come into effect when larger quantities are purchased. One consideration to take into account, when developing the parametric quantities is the existing product development curve. For existing technology, many equipment prices are at a steady state price (exhibited in the far right columns of the Equipment Worksheets.) The prices are generally not subject to wide fluctuations based on quantities. Newer technology or services which are on the front end of a market/product development curve are subject to wide price ranges. Early deployments are obviously higher priced. The implementor may make a judgement as to the particular product development based on the existence of other similar systems in operation.

4.5.6 Calculation of Expenditure Matrices for Equipment Packages

Expenditure Matrices are calculated automatically through the linked spreadsheet programs. These files are submitted with the electronic version of this report, in government requested format. Included in the calculation are non-recurring expenditures (one-time capital costs) and recurring expenditures (annual operation and maintenance costs). The non-recurring expenditures are incurred during the year of deployment as indicated in the Evaluatory

Design Document deployment quantities for the five, ten and twenty deployment years. The recurring expenditures are incurred in the deployment year and every year thereafter.

Non-recurring expenditures also include the asset replacement at the end of its useful life. These expenditures are automatically incorporated into the spreadsheet utilizing the "Years to Replacement" column in the Equipment Package Worksheets. This evaluation is important when considering comparative technologies and life cycle costs (see previous section on life cycle costing.)

4.5.7 Summary of Equipment Package Expenditures

This step in the cost evaluation process tabulates the Equipment Package expenditures for the stakeholder groups. Specifically, the government stakeholder expenditures are tallied for those Equipment Package which are attributable to government investment. These Equipment Packages are identified in the Evaluatory Design Document.

4.6 Equipment Package Worksheets

The Equipment Package Worksheets are grouped according to Subsystem. Within each Subsystem section, there is a discussion of equipment and assumptions utilized in developing the unit prices.

Common Equipment Throughout Subsystems

Some common equipment across all subsystems are listed below. Primarily, this section describes the correlation to wireline and wireless unit prices which are derived from the Data Loading Analysis, as part of the evaluation activities for the program.

Wireline Communication levels stem from the communication layer of the architecture and the resulting usage rates for data, voice, and image transfer from Equipment Packages across subsystems and from Equipment Package to Equipment Package within each subsystem. The wireline unit prices are based on leased digital circuits, and on current pricing structure for telephone company provided circuits. These are based which appear to be the most feasible option notwithstanding the preferences of the local implementors.

A full life cycle cost analysis for the tradeoff of leased verses owned lines for implementors is a local study which must take into account many factors that are external to a strictly accounting function of life cycle costing. The information provided in this cost analysis may be used by local implementors as a comparison for these local studies.

The types of the leased lines for these circuits are grouped into three categories. These include the DS0 circuits which have a capacity of 56 Kbps, the DS1 circuits (comparable to a T1 rate) have a capacity of 1.544 Mbps, and the DS3 circuits which have a capacity of 44.736 Mpbs. Individual circuits may be multiplexed to provide a desired data rate that falls somewhere in the middle of these ranges.

The prices for these line types are based upon national averages for GTE services. National studies have found that some charges may vary as much as 100% between telephone companies and regions. The unit prices utilized represent both high and low ranges for typical leased lines. The typical distance from terminus to terminus for these prices is eight to fifteen miles, but most of the cost is not distance sensitive. The part of the communication link from the telephone central office to the equipment using the line is not a major component of the total line cost. The length of line between central telephone offices is the chief component of the unit prices. Many telephone companies have upgraded their central offices to digital transmission facilities thus providing the cost of analog leased lines, with a maximum guaranteed data rate of 9600 baud, to be approximately the same cost as the DS0 digital lines. The unit prices for these lines are described below. The prices given may be discounted further (up to 50%) for multiple line users and long term (five year) commitments or contracts. This discounting is advantageous, but not relied upon for this cost analysis as the decisions for these discounts usually falls under the institutional layer of the architecture. These prices represent a snapshot in time given the uncertainty of the telecommunication industry.

Line	**Available**	**Monthly Price**	
Type	**Capacity**	**Low**	**High**
DS0	56Kbps	$50	$100
DS1	1.544Mbps	$400	$700
DS3	44.736Mbps	$2000	$6000

The wireless communication levels stem from the communication layer of the architecture and the resulting usage rates for data, voice, and image wireless transfer from Equipment Packages across subsystems and from Equipment Package to Equipment Package within each subsystem. CDPD prices are utilized as a comparative technology which will serve the functional requirements of the architecture. Other systems may be available which will meet the functional needs of the architecture and remain compliant with the standards and protocols. The selection of CDPD for this evaluation of the national architecture does not preclude these other systems. Rather, it provides a baseline for cost and functionality comparison.

The wireless unit prices utilized for this analysis, are based upon a recent announcement from GTE regarding CDPD prices. The prices for wireless communication are divided into three major categories, based on monthly usage from the data loading analysis. The unit prices are detailed below.

Usage	**Available**	**Monthly**	**Rate per**
Level	**Usage**	**Price**	**Additional Kbytes**
Low	125Kbytes	$15	$0.12
Medium	1,000Kbytes	$50	$0.08
High	3,000Kbytes	$100	$0.05

To derive a range of high and low unit prices, and to account for some individual variation in the monthly usage, the cost analyses utilizes the base monthly price as the low unit price, and increases the data loading analysis wireless communication requirements by 10% to calculate the high unit price, based on the usage level for each Equipment Package. For example, a wireless communication data loading analysis requirement result of 125Kbytes per month for an Equipment Package would have a low unit price of $15 per month, and a high unit price of $16.50 (10% extra, or 12.5Kbytes at $0.12 = $1.50 additional to the base monthly unit price of $15.) The usage for each Equipment Package is derived from the data loading analysis, except for three transit vehicle Equipment Packages, TRV2, TRV3, and TRV7, which are described in section 4.6.18.

4.6.1. Commercial Vehicle Administration Subsystem (CVAS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	**Descriptor**
Credentials and Taxes Administration	(CVA1)
CV Information Exchange	(CVA2)
CV Safety Administration	(CVA3)
International CV Administration	(CVA4)

Each Equipment Package is described below.

4.6.1.1 Credentials and Taxes Administration, (CVA1)

This Equipment Package provides administrative capabilities for commercial vehicle operations including database management and administrator-to-roadside and administrator-to-administrator interfaces. For example, this Equipment Package would manage the electronic credentials database for a state, perform reconciliation of mileage and fuel taxes (possibly post trip), and interface with roadsides performing credential checks. This Equipment Package communicates with similar packages in other CVAS locations to exchange credentials database information. Example locations would be state agency or regional offices that are involved with commercial vehicle operations.

4.6.1.2 CV Information Exchange, (CVA2)

This Equipment Package supports the exchange of safety and credentials data among jurisdictions The package also supports the exchange of safety and credentials data between agencies (for example, an administrative center and the roadside check facilities) within a single jurisdiction. Data are collected from multiple authoritative sources and packaged into snapshots (top-level summary and critical status information) and profiles (detailed and historical data).

A software clearinghouse is used to maintain a database of carrier, id and driver numbers and status. The database also supports update and interrogation of these numbers. The software

may be set up as a collection of mirror sites each containing an up-to-date copy of specific information residing within some authorizing agency. Additional software is used to collect screening events to support tax filing reports for post trip reconciliation.

Additional staff is used to support maintaining the databases, updating database values based on inputs from the roadside and inputs from other CV centers.

Either leased line or privately installed line is used to other centers. Some centers may require higher performance than other centers. Some centers may get by with dialup capability.

4.6.1.3 CV Safety Administration, (CVA3)

This Equipment Package augments the Credentials and Taxes Administration Equipment Package with safety data. This package ensures that safety criteria are available for automated roadside safety checks. It supports the collection and review of carrier safety data and determines the carrier safety rating based on criteria supplied by Government Administration

This Equipment Package builds upon CVA2 equipment. An additional database is used as well as additional software upgrades. Additional software and processor capability are required to maintain databases and support updates to database from check stations.

4.6.1.4 International CV Administration, (CVA4)

This Equipment Package is used by government agencies such as customs and immigration, carriers, and service providers (e.g., brokers) to generate and process the entry documentation necessary to obtain release of vehicle, cargo, and driver across and international border, report the results of the crossing event, and handle duty fee processing.

This Equipment Package builds upon CVA2 equipment. An additional database is used as well as additional software upgrades. Additional database software is used to access international information and exchange international credentials with other agencies. Additional staff with expertise in international credential requirements. Staff is required to maintain databases and support updates to database from check stations.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Credentials and Taxes Administration (CVA1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Wireless Communication I/F	5	0.5	1			Exist. Technology		0.5	
	Electronic Credentials Purchase Software	20	20	40			Per Loral, Rockwell exper. in		20	
	Database and Management for Post-Trip Processing &						Similar Integration Projects			
	Electronic Credentials	20	40	100					40	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	Processor and Integration	20	200	220					200	
	Workstations (3)	10	15	30			Existing Technology Work-		15	
							stations for Operator Interface			
	Communication Lines DS0 to CVCS & Financial Institution	20	0.5	1					0.5	
	Communication Lines DS1 to FMS	20	0.5	1					0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	CVCS & Financial Institution Wireline Communication DS0 from						Current Price Structure			
	Data Loading (see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	FMS Wireline Communication DS1 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		4.8	8.4			from GTE		4.8	
	Additional Staff : 4 @ $75,000									
	Note : Salary Costs are fully loaded prices (Base Salary,		270	330					270	
	Overtime, Overhead, Benefits, etc.)									
	Maintenance for Processor @ 2% of Capital Cost		4	4.4					4	
	Maintenance for Workstations @ 2% of Capital Cost		0.3	0.6					0.3	
	Maintenance for Database & Software @ 2% of Capital Cost		1.2	2.8					1.2	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.1-1 CREDENTIALS AND TAXES ADMINISTRATION, (CVA1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

CV Information Exchange (CVA2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Communication Line DS0 to Enforcement Agency & DMV	20	0.5	1			Existing Technology		0.5	
	Communication Line DS1 to Gov't. Admin.	20	0.5	1			Existing Technology		0.5	
	Processor and Integration Add-on	20	20	40			Per Loral, Rockwell		20	
	Note : Software is off-the-shelf technology and unit price does						Exper. in similar			
	not reflect product development.						Integration Projects			
	Communication Line DS1 to Planning Subsystem	20	0.5	1			Existing Technology		0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Additional Staff (1 at $75,000 average)		67	82					67	
	Note: Salary cost are fully loaded prices (Base salary,									
	overtime, benefits, etc.)									
	Maintenance for Processor @ 2% capital cost									
	DMV Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	Gov't. Admin. Wireline Communication DS1 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		4.8	8.4			from GTE		4.8	
	Planning Subsystem Wireline Communication DS1 from						Current Price Structure			
	Data Loading (see Common Equipment in Section 5.6)		4.8	8.4			from GTE		4.8	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.1-2 CV INFORMATION EXCHANGE, (CVA2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

CV Safety Administration (CVA3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Database Add-on	20	20	40			Per Loral, Rockwell		20	
	Software and Integration	20	20	40			Exper. in similar		20	
	Communication Line Included in CVA1						Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for addon processor @ 2% capital cost		0.1	0.2					0.1	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.1-3 CV SAFETY ADMINISTRATION, (CVA3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

International CV Administration (CVA4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	International Database Management Add-on	20	20	40			Per Loral, Rockwell Exper. in		20	
	Additional Processing and Integration	20	20	40			similar Interation Projects		20	
	Additional Communication Wireline (International) DS0	20	0.5	1			Existing Technology		0.5	
	Note : Software is off-the-shelf technology and unit price does not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Additional Staff (2 at $75,000 average)		135	165					135	
	Note : Salary Costs are fully loaded prices (Base Salary, Overtime, Overhead, Benefits, etc.)									
	Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.1-4 INTERNATIONAL CV ADMINISTRATION, (CVA4)

4.6.2. Commercial Vehicle Check Subsystem (CVCS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Citation and Accident Electronic Recording	(CVC1)
International Border Crossing	(CVC2)
Roadside Electronic Screening	(CVC3)
Roadside Safety Inspection	(CVC4)
Roadside WIM	(CVC5)

Each Equipment Package is described below.

4.6.2.1 Citation and Accident Electronic Recording, (CVC1)

The Equipment Package documents violations and forwards the information to the Commercial vehicle if available and to the CVAS for processing as part of the normal credentials processing package

This package utilizes additional roadside beacons for wireless transmission to the vehicles for recording of information onto the vehicle itself. This beacon is not included in the roadside subsystem as it is specifically dedicated to this package, subsystem, and stakeholder. Additionally, there is the need for a direct wireline connection to the roadside beacon from the CVC facility. This package has as a prerequisite Equipment Package the base equipment in CVC3.

4.6.2.2 International Border Crossing, (CVC2)

This Equipment Package is used by government agencies such as customs and immigration to check compliance with import/export and immigration regulations to allow release of cargo, vehicle, and driver across an international border.

This Equipment Package provides the Commercial Vehicle Inspection Subsystem the capabilities for two-way communication with approaching properly equipped commercial vehicles at mainline speeds, reading tags for automated vehicle identification and credential checking.

Due to the potential for independent operation of international facilities from domestic CVC's, this package is similar in equipment to the CVC3 package.

4.6.2.3 Roadside Electronic Screening, (CVC3)

This Equipment Package provides the Commercial Vehicle Check Subsystem the capabilities for two-way communication with approaching properly equipped commercial vehicles at

mainline speeds, reading tags for automated vehicle identification and credential checking. There is a capability to appropriately screen all vehicles, not just those that are equipped. This Equipment Package is able to process the data from the commercial vehicles along with accessed database information to determine whether a pull-in message is needed or to generate random pull-in messages with provisions for facility operators and enforcement officials to have manual override capabilities. Support is provided to both interstate and intrastate carriers.

Roadside beacons are used for roadside electronic screening application. This requires a two way beacon system with an interface to the roadside computer station. A vehicle detection system is required upstation. This system may be either installed on a tower or through portable devices.

An additional leased line or privately installed line is required to communicate to other centers. Some centers may require higher performance than other centers. Some centers may get by with dialup capability.

4.6.2.4 Roadside Safety Inspection, (CVC4)

This Equipment Package provides the Commercial Vehicle Check Subsystem the capabilities for operators to automate the roadside safety inspection process including the support of use of hand held devices to rapidly inspect the vehicle and driver. In addition this Equipment Package provides the Roadside Check Subsystem the capabilities for operators to automate the roadside safety inspection process including the support of automated mainline speed reading of on-board safety data to rapidly screen the vehicle and driver. This Equipment Package also provides the capabilities to collect, store, maintain, and provide safety data and access historical safety data after receiving identification from vehicles at mainline speeds or while stopped at the roadside. Results of screening and summary safety inspection can be written back onto the tag. The capabilities to process safety data and issue pull-in messages or provide warnings to the driver, carrier, and enforcement agencies are provided. These capabilities have a prerequisite of the Roadside Electronic Screening Equipment Package (CVC3) and are provided primarily through the utilization of an additional safety database.

Since a vehicle may cross jurisdiction boundaries during a trip, this Equipment Package supports the concept of a last clearance event record (a.k.a. trip ticket) carried on the vehicle's tag. The last clearance event record reflects the results of the roadside verification action. For example, if the vehicle is pulled over in State A and undergoes credential, weight, and safety checks, the results of the clearance process are written to the vehicle's tag. If the vehicle continues the trip and passes a roadside station in State B, the State B station has access to the results of the previous pull-in because it can read the last clearance event record written by the State A roadside station.

Handhold Safety Devices are utilized to inspect Commercial Vehicles. The devices either measure data themselves or read data from the vehicle. Safety Database Vehicle I/F is located in Roadside Facility. Wireline and wireless communications are required.

4.6.2.5 Roadside WIM, (CVC5)

This Equipment Package allows for roadside high speed weigh in motion. This package can be fixed to a location or mobile. It can include an interface to the credential check package and augment electronic credentials check with electronic weight check or it can be a stand alone package with display.

Specific equipment includes an interface to the roadside facility, and a WIM Fixed Load Cell.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Citation and Accident Electronic Recording (CVC1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software Add-ons	20	20	40			Per Loral, Rockwell exper. in		20	
							similar Integration Projects			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Processor @ 5% of Capital Cost		1	2					1	
	CVAS Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.2-1 CITATION AND ACCIDENT ELECTRONIC RECORDING, (CVC1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

International Border Crossing (CVC2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Commercial Vehicle Detection System	10	50	75			Ref. Help Cresent and Advan.		50	
	Roadside Signal Board	10	10	15			I-75 Installation Costs		10	
	Roadside Structure - Mainline w/ Lane Indicator Signals	20	50	75					50	
	Signal Indicator System	20	5	10					5	
	Software and Processor and Integration	20	180	215					180	
	Workstations (3)	10	15	30			Typical Operator Interface		15	
							Workstation			
	Communication Line DS0 to International CVA Signals	20	0.5	1			Existing Technology		0.5	
	Roadside Beacon (not included in Roadside Subsystem)	10	5	8			Ref. Seimens		5	
							Beacon Technology			
	Dedicated Wireline Communication from Beacon to Roadside						Ref. Seimens			
	(1 mile upstation)	20	10	20			Beacon Technology		10	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	International CVAS Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	Maintenance for Detection System @ 5% of Capital Cost		2.5	3.8					2.5	
	Maintenance for Signal System @ 5% of Capital Cost		0.3	0.5					0.3	
	Maintenance for Processor @ 2% of Capital Cost		3.6	4.3					3.6	
	Maintenance for Signal Board @ 10% of Capital Cost		1	1.5					1	
	Beacon Repair/Replacement Maintenance @ 10% of Capital Cost		0.5	0.8					0.5	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.2-2 INTERNATIONAL BORDER CROSSING, (CVC2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadside Electronic Screening (CVC3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Commercial Vehicle Detection System	10	50	75			Ref. Help Cresent and Advan.		50	
	Roadside Signal Board	10	10	15			I-75 Installation Costs		10	
	Roadside Structure - Mainline w/ Lane Indicator Signals	20	50	75					50	
	Signal Indicator System	20	5	10					5	
	Software and Processor and Integration	20	180	215					180	
	Workstations (3)	10	15	30			Typical Operator Interface		15	
							Workstation			
	Communication Line DS0 to CVA Signals	20	0.5	1			Existing Technology		0.5	
	Roadside Beacon (not included in Roadside Subsystem)	10	5	8			Ref. Seimens		5	
							Beacon Technology			
	Dedicated Wireline Communication from Beacon to Roadside						Ref. Seimens			
	(1 mile upstation)	20	10	20			Beacon Technology		10	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	CVAS Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	Maintenance for Detection System @ 5% of Capital Cost		2.5	3.8					2.5	
	Maintenance for Signal System @ 5% of Capital Cost		0.3	0.5					0.3	
	Maintenance for Processor @ 2% of Capital Cost		3.6	4.3					3.6	
	Maintenance for Signal Board @ 10% of Capital Cost		1	1.5					1	
	Beacon Repair/Replacement Maintenance @ 10% of Capital Cost		0.5	0.8					0.5	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.2-3 ROADSIDE ELECTRONIC SCREENING, (CVC3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadside Safety Inspection (CVC4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Handheld Safety Devices (3 per location)	5	3	5			Estimate		3	
	Vehicle I/F (located in Roadside Facility)	20	0.5	1			Existing Technology		0.5	
	Wireless Communication to/from Facility to Handheld Device	20	0.5	1					0.5	
	Safety Database Add-on	20	20	40			Per Loral, Rockwell Exper. in		20	
							similar Interation Projects			
	Result Writing to Vehicle Tag Processor Add-on	20	20	40			Per Loral, Rockwell Exper.		20	
							In similar Interation			
							Projects			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	No Additional Staff									
	Wireless Communication High from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		1.2	1.8			from GTE		1.2	
	Maintenance for Hand-held Devices @ 10% of Capital Cost		0.3	0.5					0.3	
	Maintenance for Processor @ 2% of Capital Cost		0.8	1.6					0.8	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.2-4 ROADSIDE SAFETY INSPECTION, (CVC4)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadside WIM (CVC5)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	WIM - Load Cell - Fixed (Software Included)	10	10	15			Current Vendor Prices		10	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	Interface to Roadside facility	10	4	6			Current Vendor Prices		4	
	Wireline Communication (Local Line)	10	1	2			Current Vendor Prices		1	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance and Testing WIM Load Cell (10%)		1	1.5					1	
	Maintenance for Processor / IF @ 2% of Capital Cost		0.1	0.1					0.1	
	Maintenance for Comm. Line @ 10% of Capital Cost		0.1	0.2					0.1	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.2-5 ROADSIDE WIM, (CVC5)

4.6.3 Commercial Vehicle Subsystem (CVS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
On-board Cargo Monitoring	(CVS1)
On-board CV Electronic Data	(CVS2)
On-board CV Safety	(CVS3)
On-board Trip Monitoring	(CVS4)

Each Equipment Package is described below.

4.6.3.1 On-board Cargo Monitoring, (CVS1)

This Equipment Package provides the Commercial Vehicle Subsystem the capability to monitor both interstate and intrastate cargo safety such that enforcement and HAZMAT response teams can be provided with timely and accurate information. This includes only the equipment on board the cargo container such as a communication device, possibly the addition of a cell-based radio, and equipment for the processing and storage of cargo material. This can also include optional sensors for temperature, pressure, load leveling, or acceleration depending upon the items monitored. It is already expected that the location devices such as GPS equipment and an integration processor already exist on the vehicle. These items are presented as part of the On-board Trip Monitoring Equipment Package (CVS4).

Cell based phones with digital capability are utilized for wide area wireless communications. In-vehicle processor and storage device are used for basic monitoring and other add-ons. In-vehicle sensors are utilized for various monitoring activities, including - temperature, load level gages, pressure gages, etc.

4.6.3.2 On-board CV Electronic Data, (CVS2)

This Equipment Package provides the Commercial Vehicle Subsystem the capability for two-way data exchange between the vehicle and the roadside facility with the transmission of information such as status of driver, vehicle, and carrier IDs and cargo information. The driver, vehicle and carrier are identified via the tag so that actual weight from roadside mainline weigh-in-motion may be checked. This includes only the equipment on the commercial vehicle including a processor/tag for identification, especially a HAZMAT identification. The actual reading and processing required for the credential checking and weigh-in-motion is performed by the roadside.

This Equipment Package may exist separately from CVS1 and CVS4 or be provided as an upgrade or add-on. The unit prices utilized here are reflective of separate systems. Marginal cost savings may be obtained by combining processors and software with add-on capability.

In-Vehicle software is required to provide entry of clearance numbers and interface to roadside. This could be as simple as a fixed ROM, numeric key pad, or on-board computer. A vehicle identification tag is also included, along with wireless communication devices similar to those of CVS1

4.6.3.3 On-board CV Safety, (CVS3)

This Equipment Package provides the Commercial Vehicle Subsystem the capability to collect and process on board vehicle and driver safety information to monitor the safety status and supply this information to the roadside facilities both at mainline speeds and while stopped for inspections. The capability to alert the commercial vehicle driver whenever there is a critical safety problem or potential emergency is also provided. These capabilities include only the equipment on the commercial vehicle including the sensors and processors to monitor the vehicle and driver with the information stored on the vehicle. When the information is transmitted to the roadside facility or after the trip, it utilizes the communication devices already in place. The package also supports onboard driver safety log maintenance and checking.

This Equipment Package builds upon the existence of either CVS1 or CVS4 or both. The equipment used for wireless communication and the software and processor for these previous Equipment Packages may be utilized with slight modifications or add-ons. The software for this Equipment Package is to assimilate all safety sensor inputs and flag warnings for unsafe conditions. Also, the software contains an interface to an active tag for transmitting the safety information to the roadside beacon(s).

4.6.3.4 On-board Trip Monitoring, (CVS4)

This Equipment Package provides the Vehicle Subsystem the capabilities to support fleet management with automatic vehicle location and automated mileage and fuel reporting and auditing. This package may also record other special events resulting from communication with roadside equipment. This includes only the equipment on board the vehicle to support this function including the vehicle location devices such as GPS equipment, communication interfaces, a processor to record trip length, and the sensors/actuators/interfaces necessary to record mileage and fuel usage.

The equipment used for wireless communication and the software and processor for the CVS1 Equipment Package may be utilized with slight modifications or add-ons. The software for this Equipment Package is to assimilate all vehicle location sensors, relying on GPS or DGPS. Additional assimilation is for trip computer mileage sensors and fuel reporting sensors.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board Cargo Monitoring (CVS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	On-Board Processor & Storage	10	0.3	0.5			Existing Technology		0.3	
	Note : Software is off-the-shelf technology and unit price does not reflect product development.									
	On-Board Sensors - Temperature	10	0.02	0.05			Existing Technology		0.02	
	Pressure Gauges	10	0.05	0.1			Existing Technology		0.05	
	Load Level Gauges	10	0.1	0.2			Existing Technology		0.1	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication High from Data Loading (see Common Equipment in Section 5.6)		1.2	1.8			Current Price Structure from GTE		1.2	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Gauges @ 10% of Capital Cost		0.02	0.04					0.02	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.3-1 ON-BOARD CARGO MONITORING, (CVS1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board CV Electronic Data (CVS2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	ID tag	10	0.05	0.1			Estimate		0.05	
	Additional Software and Processing	10	0.3	0.5			Per Loral, Rockwell Exper. in		0.3	
	Database Storage	10	0.3	0.5			similar Interation Projects		0.3	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication Low from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.18	0.2			from GTE		0.18	
	Maintenance for Processor and Database @ 2% of Capital Cost		0.01	0.02					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.3-2 ON-BOARD CV ELECTRONIC DATA, (CVS2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board CV Safety (CVS3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Additional Software and Processor for Warning Indicator and	10	0.5	1			Per Loral, Rockwell Exper. in		0.5	
	Audio System Interface						similar Interation Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
							Per Loral, Rockwell Exper. in			
	Data Storage	10	0.3	0.5			similar Interation Projects		0.3	
	On-board Sensors - Engine / Vehicle	10	0.2	0.4			Estimate		0.2	
	On-board Sensors - Driver	10	0.4	0.8			Estimate		0.4	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.02					0.01	
	Maintenance for Data Storage @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Sensors @ 5% of Capital Cost		0.02	0.04					0.02	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.3-3 ON-BOARD CV SAFETY, (CVS3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board Trip Monitoring (CVS4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Commercial Vehicle Communications Interface	10	1	2					1	
	Mileage and Fuel Reporting Sensors	10	0.25	0.5					0.25	
	GPS	10	0.3	0.5			Current Price Structure		0.3	
							(Ref. GPS World)			
	Trip Computer and Processor	10	0.1	0.15			Existing Technology		0.1	
	Note : Software is off-the-shelf technology and unit price does						Comparable to 286 CPU			
	not reflect product development.									
	Communication Device - Cell Based Radio	10	0.15	0.25			Existing Technology		0.15	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Trip Computer @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Sensors @ 5% of Capital Cost		0.02	0.03					0.02	
	Maintenance for GPS @ 2% of Capital Cost		0.006	0.01					0.006	
	Maintenance for Cell Radio @ 5% of Capital Cost		0.01	0.01					0.01	
	Wireless Communication Low from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.18	0.2			from GTE		0.18	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.3-4 ON-BOARD TRIP MONITORING, (CVS4)

4.6.4. Emergency Management Subsystem (EM)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Emergency and Incident Management Communications	(EM1)
Emergency Mayday and E-911 Interface	(EM2)
Emergency Response Management	(EM3)
Emergency Vehicle Routing and Communications	(EM4)

Equipment Package is described below.

4.6.4.1 Emergency and Incident Management Communications, (EM1)

This Equipment Package provides a direct interface between emergency and incident management officials through shared databases and direct communications linkages. An example is the Computer Aided Dispatch (CAD) system used in California.

This Equipment Package relies on the initial deployment of the Emergency Response Management (EM3).

4.6.4.2 Emergency Mayday and E-911 Interface, (EM2)

This Equipment Package receives the MAYDAY data request from an in-vehicle unit and based on some criteria forwards the emergency message to the appropriate agency. The nature of the emergency is determined based on the information in the MAYDAY message as well as other inputs. This package is primarily an interface between automated MAYDAY calls and the E911 or Emergency Telephone Dispatch in the appropriate area.

This Equipment Package relies on the initial deployment of the Emergency Response Management (EM3). Additional equipment includes E-911 interface software and hardware as well as additional workstations.

4.6.4.3 Emergency Response Management, (EM3)

This Equipment Package provides the management of emergency response. It interfaces with emergency vehicles and other agencies/offices during an emergency and develops and stores emergency response plans. This Equipment Package provides emergency and MAYDAY management the capability to coordinate with multiple and other agencies before and during emergencies, to implement emergency response plans and track progress through the incident. Additionally, emergency management software is utilized with a workstation type processor. This Equipment Package also provides the capability to maintain the availability of emergency vehicle fleets and determine the best suited emergency vehicle to a particular emergency response.

The Emergency Response Management Equipment Package communicates with other ITS subsystems in order to receive information about emergencies and to convey recommended actions to appropriate entities in the system. Each emergency management center is connected to the TMC through communication lines for which the flow of information is two ways. Each Emergency Management Center receives information from the TMC for emergency situations, and the TMC in turn receives information from each Emergency Management Center for traffic management, route guidance, and signal control.

Existing centers are fully staffed with trained personnel, and fully equipped with power supply, backup generators, software, processors, displays, keyboards, system operator interfaces, and wire and wireless communications systems. Dedicated wire communication systems are in-place for information transfer from the existing Transportation Management Center. The existing operations include standard emergency response center functions. It is assumed that the physical structure that houses the operations staff, maintenance personnel, and equipment is in-place. It is also assumed that the maintenance staff, emergency response vehicle operators, dispatchers and other operations staff are already in-place. Only the incremental expense of incorporating ITS functions and communications is included in the expense for the this subsystem.

Additional equipment includes two way radios for special emergency frequency access when commercial wide area wireless does not provide sufficient support during critical situations, and wide area cell based wireless phone with digital capability. Existing communication lines are assumed to be fully utilized for existing services. Additional wirelines are required, either leased line or privately installed lines, to connect other centers. Some centers may require higher performance than other centers. Some centers may get by with dialup capability, and a shared database with software (per site). Additional staff is necessary to input new and revised emergency response plans into software.

4.6.4.4 Emergency Vehicle Routing and Communications, (EM4)

This Equipment Package provides the ability to track emergency vehicles responding to an incident. It interfaces with emergency vehicles and other agencies/offices during an emergency. This Equipment Package provides emergency and MAYDAY management the capability to coordinate with multiple and other agencies before and during emergencies, to track and manage vehicles automatically using real-time traffic conditions and signal timing for best routes, and preplan and generate automated responses to emergencies and MAYDAY. These capabilities are provided by the support of communications such as 2-way radio, mobile satellite telephone, or private fiber optic cable using modems and telephones. Additionally, vehicle tracking software is utilized with a workstation type processor.

This Equipment Package is an add-on to the previous subsystem Equipment Packages. Additional communication include an existing short wave transceiver.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Emergency and Incident Management Communication (EM1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Database Connections (per site)	10	0.5	1			Estimate	1-2	0.5	
	Direct Communication Links (per site)	20	0.5	1			Estimate	1-2	0.5	
	Shared Database Software (per site)	20	5	10			Network Hosts	10-20	5	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Shared Database Software Maintenance Contract		2.5	5					2.5	
	(est'd. $10k/region split by 4 sites)									
	EM & TRMS Wireline Communication DS1 from Data									
	Loading (see Common Equipment in Section 5.6)		4.8	8.4			Current Price Structure		4.8	
							from GTE			
	Maintenance for Comm. Links @ 5% of Capital Cost		0.05	0.1					0.05	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.4-1 EMERGENCY AND INCIDENT MANAGEMENT COMMUNICATIONS, (EM1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Emergency Mayday and E-911 I/F (EM2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Data Communication Translation Software	10	20	50			Data/Modem		20	
	E-911 Interface Software & Processor	10	70	100			transf. Protoc.		70	
	Note : Software is off-the-shelf technology and unit price does						to ASCII			
	not reflect product development.						character set			
	Workstation (3 total)	10	15	30			Existing		15	
							Workstations			
							for Operator			
							Interfaces			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	No Additional Staff									
	Maintenance for Interface @ 2% of Capital Cost		1.4	2					1.4	
	Maintenance for Workstation @ 2% of Capital Cost		0.3	0.5					0.3	
	E-911 & RTS Wireline Commmunications DS0 from Data		0.6	1.2			Current Price Structure		0.6	
	Loading (see Common Equipment in Section 5.6)						from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.4-2 EMERGENCY MAYDAY AND E-911 INTERFACE, (EM2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Emergency Response Management (EM3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Communication To / From TMC	20	0.5	1			Per Loral, Rockwell		0.5	
	I/F with Vehicles and Other Agencies	20	0.5	1			Experience		0.5	
	Emergency Response Plans Database	10	25	50			in Similar		25	
	Vehicle Tracking Software	10	40	80			Integration Projects		40	
	Real Time Traffic Coord.	10	10	20					10	
	Workstations (3 total)	10	15	30			Existing Workstation		15	
							for Operator			
							Interface			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireline Communication DS0 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	Database Management Contract (per site) 5%		0.5	2.5					0.5	
	Workstation & Computer Maintenance (per site) 2%		0.3	0.6					0.3	
	Additional Staff (2 @ $75,000 each)		135	165					135	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.4-3 EMERGENCY RESPONSE MANAGEMENT, (EM3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Emergency Vehicle Routing and communications (EM4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Communication from Center to TMC & Coordinating Agencies	20	0.5	1			Estimate	1-2	0.5	
	Cell Based Radio (per radio)	5	0.2	1			Voice Radios	0.08-1	0.2	
	2-way Radio (per radio)	5	0.2	1			Radios	0.08-1	0.2	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Communication from Center to TMC									
	Wireline Communication DS0 from Data									
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			Current Price Structure		0.6	
	Communication from Center to ISP & FMS						from GTE			
	Wireline Communication DS0 from Data									
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			Current Price Structure		0.6	
							from GTE			
	Note: No additional staff									
	Maintenance for Radios @ 5% of Capital Cost		0.02	0.1					0.02	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.4-4 EMERGENCY VEHICLE ROUTING AND COMMUNICATIONS, (EM4)

4.6.5 Emissions Management Subsystem (EMMS)

This subsystem contains only one Equipment Package, Emissions and Environmental Data Management (EMM1). This Equipment Package assimilates and stores the roadside collected environmental data, including emissions and environmental hazards such as icy road conditions and fog. Emissions data are stored and analyzed for evaluation and planning purposes. Environmental hazardous conditions are disseminated through CMS/HAR, etc.

Typical equipment for the Equipment Package is described below. Additional equipment to service these functions are included in the Roadside Subsystem. The Equipment Package is separated into two distinct functions, one for emissions management for localized detection and one for environmental hazards indicators.

The emissions management portion of the Equipment Package monitors and detects localized emissions levels for various contaminants per the EPA regulations. The identified devices for monitoring are included for all four measured contaminants. Non-attainment designated areas may wish to deploy only those sensors which may be required to monitor and detect the specific area(s) of non-attainment. The sensor information is stored in a local database for future analysis. Wireline communication capabilities are included for direct feed of emissions data to the Traffic Management Center for travel demand and other mitigating measures including congestion pricing and rideshare and HOV coordination.

The environmental hazards portion of the Equipment Package concentrate on the current weather conditions which contribute to environmental hazards, such as fog, and icing. Environmental hazard stations are anticipated to be located upstation from those areas which have histories of hazardous conditions. The number of locations is determined in the Evaluatory Design Document.

Specific equipment is outlined in the worksheet. Rather than include staff and equipment inventory specific for these limited devices, it is anticipated that annual contracts are a more economical method for these operation and maintenance requirements.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Emissions and Environmental Data Management (EMM1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Equipment Costs are identified in Roadside Subsystem									
	Communication Line DS0 to PS,RS,TMS	20	0.5	1					0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Emissions Sampling & Analysis Contract		3	5			Existing Site Installations		3	
	Emissions Maintenance Contract		5	5			prices from New England		5	
	Emissions Data Management		7	10			projects per LBA		7	
	Emissions Quality Assurance		15	18					15	
	Environmental Sampling & Analysis Contract		10	15					10	
	Environmental Maintenance Contract		3	5					3	
	Environmental Data Management		5	8					5	
	Environmental Quality Assurance		5	10					5	
	Wireline Communication DS0 from Data Loading									
	(see Common Equipment in Section 5.6)		0.6	1.2			Current Price Strucure		0.6	
							from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.5-1 EMISSIONS AND ENVIRONMENTAL DATA MANAGEMENT, (EMM1)

4.6.6. Emergency Vehicle Subsystem (EVS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
On-board EV Incident Management Communication	(EVS1)
On-board Vehicle Signal Coordination	(EVS2)

Each Equipment Package is described below.

4.6.6.1 On-board EV Incident Management Communication, EVS1)

This Equipment Package provides a direct interface between the emergency vehicle and incident management personnel. This communication is through existing emergency vehicle communication devices. The additional ITS related component of this communication is located at the incident management facility.

The communication occurs at the time of dispatch and throughout the incident occurrence. Information transmitted includes incident description, coordination activities among response vehicles and progress/completion of incident. This Equipment Package may be independent of EVS2.

4.6.6.2 On-board Vehicle Signal Coordination, (EVS2)

This Equipment Package provides the capability for vehicles to request signal priority or preemption, through communication either to the roadside or to the traffic management center. This Equipment Package is independent of EVS1. Typical equipment includes AVL capacity, data transceiver, and a separate transceiver to roadside signal systems.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board EV Incident Management Communication (EVS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	EV Communication Interface	10	1	2					1	
	Cell Based Radio	10	0.15	0.26			Current		0.15	
							Voice Radios			
							0.1-1.0			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Communication Low Use Bracket		0.18	0.2			Current Pricing Structure		0.18	
	(See Common Communication costs, Section 5.6)						from (GTE)			
	Allocating 10% extra for higher unit price									
	Cell Based Radio Maintenance (5% Capital Cost)		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.6-1 ON-BOARD EV INCIDENT MANAGEMENT COMMUNICATION, (EVS1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board Vehicle Signal Coordination (EVS2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	On Board Processor System	10	0.3	0.3					0.3	
	Cell Based Radio (Data Transceiver Capability)	10	0.15	0.25			Current Voice		0.15	
							Radios (0.1-1.0)			
	GPS/DGPS	10	0.5	0.8			Current Price		0.5	
							Structures			
	Note: Software is off-the-shelf technology and unit price does not						(ref. GPS			
	reflect product development						World)			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Comm.-Wireless Low Use (see Common Equipment in Section 5.6)		0.18	0.2			Current Price Structure		0.18	
	assumes 10% excess of plan for high unit price						from GTE			
	Maintenance for Processor @ 2% Capital Cost		0.01	0.01					0.01	
	Maintenance for Cell Based Radio @ 5% Capital Cost		0.01	0.01					0.01	
	Maintenance for GPS/DGPS @ 2% Capital Cost		0.01	0.02					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.6-2 ON-BOARD VEHICLE SIGNAL COORDINATION, (EVS2)

4.6.7. Fleet Management Subsystem (FMS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Fleet Administration	(FMS1)
Fleet Credentials and Taxes Management and Reporting	(FMS2)
Fleet HAZMAT Management	(FMS3)
Fleet Maintenance Management	(FMS5)
Freight Administration and Management	(FMS4)

Functions performed by Commercial Fleet Management include: Vehicle pre-clearance, vehicle administration, and on-board safety monitoring. To perform these functions, communications links are required to various other subsystems and Equipment Packages in the ITS architecture. Examples of communications requirements are: FMC to vehicles in transit and the drivers, FMC to CVO fleet managers, FMC to government agencies, and FMC to financial clearinghouse(s).

It is assumed that the physical structure that houses the FMC operations staff, maintenance personnel, and equipment is in-place. Although the building infrastructure is assumed in-place, as well as some operations staff, maintenance personnel, and equipment, there are some components to the subsystem which are either upgrades, or additions to the existing operations. These incremental expenses are attributed to the ITS architecture expense.

There is minimal expense for ITS trained operations and maintenance staff and related equipment included in recurring expenditures. Many of the existing commercial fleet management centers throughout the US are currently staffed with trained controllers, supervisors and maintenance personnel. The minimal amount expenditures for training are explicitly noted in the recurring expenditures.

Each Equipment Package is described below.

4.6.7.1 Fleet Administration, (FMS1)

This Equipment Package provides route plan information from the FMS to the TMS for network performance evaluation. It also provides for vehicle tracking, dispatch, and reporting to the fleet management center personnel.

4.6.7.2 Fleet Credentials and Taxes Management and Reporting, (FMS2)

This Equipment Package provides the Fleet Management Subsystem the capabilities to purchase credentials and file trip reports electronically by the fleet managers, to perform automated preclearance at the roadside facilities, and electronically manage the credentials checking by the roadside commercial vehicle inspectors. The electronic purchase is performed in accordance with developing standards such that a single integrated system for

electronic payments might develop ensuring that deployment across multiple agency political boundaries is performed without degradation. Inherent to credential management is the management of the vehicles, with a prerequisite of the vehicle tracking software from the Fleet Administration Equipment Package (FMS1).

Add-on software and databases are included as well as additional workstations and wireless communication capability for transmission of information to and from the fleet.

4.6.7.3 Fleet HAZMAT Management, (FMS3)

This Equipment Package provides the Fleet Management Subsystem the capabilities to enhance the Fleet Administration Equipment Package functions by adding HAZMAT tracking. The additional requirements to perform this function include enhanced processing and enhanced fleet management software. In order to effectively track HAZMAT cargo, communication interfaces to Information Service Providers, Emergency Management, and Traffic Management Subsystems are provided, including additional communication software.

4.6.7.4 Fleet Maintenance Management, (FMS5)

This Equipment Package provides the capability to use vehicle mileage data to automatically generate preventative maintenance schedules for each specific vehicle by utilizing vehicle tracking data from the prerequisite Fleet Administration Equipment Package. In addition, capability to automatically ensure that proper service personnel are provided information for maintenance activities and to record and verify that maintenance work was performed is provided. These capabilities are performed utilizing fleet management software.

4.6.7.5 Freight Administration and Management, (FMS4)

This Equipment Package provides the communication necessary to track cargo from source to destination via links to intermodal freight shippers and depots. There are also communication links to cargo routing services.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Fleet Administration (FMS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Vehicle Location Interface	20	10	15			Existing Systems		10	
	Vehicle Tracking and Scheduling	20	40	100					40	
	Digital Communication Device (3 per FMS)	5	1.1	3			Per Loral, Rockwell		1.1	
	System Integration	20	300	500			Experience		300	
	Workstations (1)	10	5	10			in Similar		5	
							Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.						Existing Workstation			
							for Operator			
							Interface			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Software @ 10% of Capital Cost		4	10					4	
	ISP/TMC Wireline Communication DS0 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	Payment Instrument Wireline Communication DS0 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.7-1 FLEET ADMINISTRATION, (FMS1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Fleet Credentials and Taxes Management and Reporting (FMS2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Wireless Communication	5	0.5	1			Existing Technologies		0.5	
	Electronic Credential Purchase Software	20	20	40			Per Loral, Rockwell		20	
	Database and Management for Trip Reports	20	40	100			Experience		40	
	Database Management for Preclearance	20	20	40			in Similar		20	
	Processor and Integration	20	215	500			Integration Projects		215	
	Workstation (3)	5	15	30			Existing Workstation		15	
							for Operator			
	Note : Software is off-the-shelf technology and unit price does						Interface			
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Workstations @ 2% of Capital Cost		0.3	0.6					0.3	
	Wireline Communication DS1 from Data									
	Loading (see Common Equipment in Section 5.6)		4.8	8.4			Current Price Structure		4.8	
							from GTE			
	Additional Staff Salary and Benefits (5 @ 75k)		337	412					337	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.7-2 FLEET CREDENTIALS AND TAXES MANAGEMENT AND REPORTING, (FMS2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Fleet HAZMAT Management (FMS3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Vehicle Tracking and Scheduling Enhancement	20	20	40					20	
	Wirelines to ISP, ERMS & TMC (3 Total)	20	1.5	3			Existing Technology		1.5	
	Workstation (1 Dedicated)	10	5	10			Existing Workstation		5	
							for Operator			
	Note : Software is off-the-shelf technology and unit price does						Interface			
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Software @ 2% of Capital Cost		0.4	0.8					0.4	
	Maintenance for Workstation @ 2% of Capital Cost		0.1	0.2					0.1	
	EM Wireline Communication DS0 from Data									
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			Current Price Structure		0.6	
							from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.7-3 FLEET HAZMAT MANAGEMENT, (FMS3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Fleet Maintenance Management (FMS5)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	100	200			Per Loral, Rockwell		100	
	Processor/Software Upgrades	20	20	40			Experience		20	
							in Similar			
							Integration Projects			
	Communication Lines DS1 to Maintenance Facility	20	0.5	1			Existing Technology		0.5	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for System @ 2% of Capital Cost		2.4	4.8					2.4	
	Wireline Communication DS1 from Data									
	Loading (see Common Equipment in Section 5.6)		4.8	8.4			Current Price Structure		4.8	
							from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.7-4 FLEET MAINTENANCE MANAGEMENT, (FMS5)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Freight Administration and Management (FMS4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Communication Interface to Intermodal Freight Depot	10	1	2			Current Prices		1	
	Communication Interface to Intermodal Freight Shipper	10	1	2			Current Prices		1	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Freight Depot Wireline Communication DS0 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	Freight Shipper Wireline Communication DS0 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.7-5 FLEET ADMINISTRATION AND MANAGEMENT, (FMS4)

4.6.8. Information Service Provider Subsystem (ISP)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Basic Information Broadcast	(ISP1)
EM Route Plan Information Dissemination	(ISP2)
Infrastructure Provided Dynamic Ridesharing	(ISP3)
Infrastructure Provided Route Selection	(ISP4)
Infrastructure Provided Yellow Pages & Reservation	(ISP5)
Interactive Infrastructure Information	(ISP6)
ISP Advanced Integrated Control Support	(ISP7)
ISP Probe Information Collection	(ISP8)

A description of these Equipment Packages is provided below.

4.6.8.1 Basic Information Broadcast, (ISP1)

This Equipment Package provides the capabilities to collect, process, store, bill, and disseminate traveler information including traveler, transit, ridematching, traffic, and parking information. The traveler information includes maintaining a database of local area services available to travelers with up-to-the-minute information and providing an interactive connectivity between, sponsors, and providers of services. The transit information includes the latest available information on transit routes and schedules, transit transfer options, transit fares, and real-time schedule adherence. The traffic information includes latest available information on traffic and highway conditions, and current situation information in real-time including incidents, road construction, recommended routes, current speeds on specific routes, current parking conditions in key areas, schedules for any current or soon to start events, and current weather situations.

This Equipment Package also provides users with real-time travel related information while they are traveling, and disseminate the information to assist the travelers in making decisions about transfers and modification of trips. The Equipment Package is the first of the ISP Subsystem Equipment Packages. Further services rely on ISP1 equipment for a basis.

These capabilities are provided using equipment such as a fixed facility with dedicated network servers, workstations for each employee, map data bases, and a communications system such as a data subcarrier multiplexing device. Pricing includes the lease space of an FM Subcarrier.

4.6.8.2 EM Route Plan Information Dissemination, (ISP2)

This Equipment Package provides route plan information for the Emergency Management Subsystem. Routes are computed based on the requests for route plans and current traffic

conditions. This equipment package relies on ISP4, ISP6, and ISP1, for basic equipment and provides additional service with equipment add-ons.

4.6.8.3 Infrastructure Provided Dynamic Ridesharing, (ISP3)

This Equipment Package has as prerequisite the capabilities of the Interactive Infrastructure Information Equipment Package, ISP6, and Basic Information Broadcast Equipment Package, ISP1. In addition, this Equipment Package provides the capability to provide specific dynamic ridesharing, including rider and driver information and reservations.

Additional equipment includes additional workstations and communication lines. Also added is the expense of liability insurance (as identified in the legal and institutional evaluation activities in the Implementation Strategy Document.

4.6.8.4 Infrastructure Provided Route Selection, (ISP4)

This Equipment Package has as prerequisite the capabilities of the Interactive Infrastructure Information Equipment Package, ISP6 and Basic Information Broadcast Equipment Package, ISP1. In addition, this Equipment Package provides the capability to provide specific directions to travelers by receiving origin and destination requests from travelers, generating route plans, returning the calculated plans to the users, and then potentially logging the route plans with Traffic Management Subsystem. This additional capability is provided using additional equipment such as software for route planning and traffic measurements along with additional map data base upgrades.

4.6.8.5 Infrastructure Provided Yellow Pages & Reservation, (ISP5)

This Equipment Package has as prerequisite the capabilities of the Interactive Infrastructure Information Equipment Package, ISP6 and Basic Information Broadcast Equipment Package, ISP1. In addition, this Equipment Package provides the capability to provide specific traveler information, such as Yellow Pages information, with reservation capabilities. This capability is provided using additional equipment such as software for yellow pages database and reservation systems, additional staff and workstations along with additional communication lines.

4.6.8.6 Interactive Infrastructure Information, (ISP6)

This Equipment Package has as prerequisite the capabilities of the Basic Information Broadcast Equipment Package. This Equipment Package augments the Basic Information Broadcast Equipment Package by providing the capabilities for interactive traveler information. Required equipment includes additional workstations, and computer server, staff, trip planning software, and communication lines.

4.6.8.7 ISP Advanced Integrated Control Support, (ISP7)

This Equipment Package supports the traffic management center provision of real-time optimized signal control by providing ISP route planning information. Prerequisite Equipment Packages include ISP8, ISP4, ISP6, and ISP1. This capability is provided utilizing system upgrades for hardware and software with additional communication lines.

4.6.8.8 ISP Probe Information Collection, (ISP8)

This Equipment Package supports the collection of vehicle probe data by the ISP. It provides the capability to accept and process probe vehicle information. This capability is provided through the use of additional hardware and probe vehicle control and tracking software.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Basic Information Broadcast (ISP1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Two Processors (Servers)	5	27	33			Per Loral, Rockwell		27	
	Workstations (5)	5	13.5	16.5			Experience in Similar		13.5	
	Integration	20	90	110			Integration Projects		90	
	Database Software	20	25	50			Per Loral, Rockwell		25	
	Traffic Analysis Software (includes some product development)	20	250	500			Experience in Similar		250	
	Map Database Software	2	15	30			Integration Projects		15	
	Communication Lines DS1	20	0.5	1			Existing Technology		0.5	
	Communication Lines DS0	20	0.5	1			Existing Technology		0.5	
	Communication Lines DS0	20	0.5	1			Existing Technology		0.5	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development, unless noted otherwise.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Hardware Systems @ 2% of Capital Cost		0.81	0.99			Estimate		0.81	
	Maintenance for Software Systems @ 5% of Capital Cost		13.75	27.5			Estimate		13.75	
	Wireline Communication DS1 from Data									
	Loading (see Common Equipment in Section 5.6)		4.8	8.4			Current Price Structure		4.8	
	Wireline Communication DS0 from Data									
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			Current Price Structure		0.6	
	Wireline Communication DS0 from Data									
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			Current Price Structure		0.6	
	Staff (2@50K to 75K +1@75K to 100K)		175	250			Estimate		175	
	FM Subcarrier Lease (10 to 20K per month)		120	240			Estimate from Phase I		120	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.8-1 BASIC INFORMATION BROADCAST, (ISP1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

EM Route Plan Information Dissemination (ISP2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Processor (Server)	5	13.5	16.5			Existing Technology		13.5	
	Route Guidance Software Upgrade (from ISP4)	20	50	100			Per Loral, Rockwell Experience in Similar Integration Projects		50	
	Note : Software is off-the-shelf technology and unit price does not reflect product development, unless noted otherwise.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Hardware Systems @ 2% of Capital Cost		0.27	0.33			Estimate		0.27	
	Maintenance for Software Systems @ 5% of Capital Cost		2.5	5			Estimate		2.5	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.8-2 EM ROUTE PLAN INFORMATION DISSEMINATION, (ISP2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Infrastructure Provided Dynamic Ridesharing (ISP3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Workstations (2 Additional)	5	5.4	6.6			Existing Technology		5.4	
							Per Loral, Rockwell			
	Rideshare Pkg Software (includes some product development)	20	100	200			Experience in Similar		100	
							Integration Projects			
	Communication Lines DS0	20	0.5	1			Existing Technology		0.5	
	Communication Lines DS0	20	0.5	1			Existing Technology		0.5	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development, unless noted otherwise.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Hardware Systems @ 2% of Capital Cost		0.108	0.132			Estimate		0.108	
	Maintenance for Software Systems @ 5% of Capital Cost		5	10			Estimate		5	
	Liability Insurance (50 to 100K per Year)		50	100			Estimate		50	
	Wireline Communication DS0 from Data									
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			Current Price Structure		0.6	
	Wireline Communication DS0 from Data									
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			Current Price Structure		0.6	
	Staff (1@50 to 75K for two shifts)		100	150			Estimate		100	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.8-3 INFRASTRUCTURE PROVIDED DYNAMIC RIDESHARING, (ISP3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Infrastructure Provided Route Selection (ISP4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Route Selection Software	20	250	500			Per Loral, Rockwell		250	
							Experience in Similar			
	Map Database Software Upgrade	2	100	200			Integration Projects		100	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development, unless noted otherwise.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Software Systems @ 5% of Capital Cost		12.5	25			Estimate		12.5	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.8-4 INFRASTRUCTURE PROVIDED ROUTE SELECTION, (ISP4)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Infrastructure Provided Yellow Pages & Reservation (ISP5)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Workstations (2)	5	5.4	6.6			Existing Technology		5.4	
	Automated Reservation Software	20	100	200			Per Loral, Rockwell		100	
	Yellow Pg DB Software (includes some product development)	20	250	500			Experience in Similar		250	
							Integration Projects			
	Communication Lines DS0 for Yellow Pages Providers	20	0.5	1			Existing Technology		0.5	
	Note : Software is off-the-shelf technology and unit price does not reflect product development, unless noted otherwise.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Hardware Systems @ 2% of Capital Cost		0.108	0.132			Estimate		0.108	
	Maintenance for Software Systems @ 5% of Capital Cost		17.5	35			Estimate		17.5	
	Wireline Communication DS0 from Data									
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			Current Price Structure		0.6	
	Staff (1@50 to 75K for two shifts)		100	150			Estimate		100	
	Note : Salary Costs are fully loaded prices (Base Salary, Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.8-5 INFRASTRUCTURE PROVIDED YELLOW PAGES & RESERVATION, (ISP5)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Interactive Infrastructure Information (ISP6)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Additional Processor (Server)	5	13.5	16.5			Per Loral, Rockwell		13.5	
	Workstations (2)	5	5.4	6.6			Experience in Similar		5.4	
	Integration	20	90	110			Integration Projects		90	
							Per Loral, Rockwell			
	Trip Planning Software (includes some product development)	20	250	500			Experience in Similar		250	
							Integration Projects			
	Communication Lines DS1	20	0.5	1			Existing Technology		0.5	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development, unless noted otherwise.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Hardware Systems @ 2% of Capital Cost		0.378	0.462			Estimate		0.378	
	Maintenance for Software Systems @ 5% of Capital Cost		12.5	25			Estimate		12.5	
	Wireline Communication DS1 from Data									
	Loading (see Common Equipment in Section 5.6)		4.8	8.4			Current Price Structure		4.8	
	Wireline Communication DS0 from Data									
	Staff (1@50K to 75K for two shifts)		100	150			Estimate		100	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.8-6 INTERACTIVE INFRASTRUCTURE INFORMATION, (ISP6)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

ISP Advanced Integrated Control Support (ISP7)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Additional DASD/ Processor Power	5	25	50			Per Loral, Rockwell		25	
							Experience in Similar			
	Integration	20	90	110			Integration Projects		90	
	Automated Communications w/ TMC Software	20	100	200			Per Loral, Rockwell		100	
							Experience in Similar			
							Integration Projects			
	Communication Lines DS1	20	0.5	1			Existing Technology		0.5	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development, unless noted otherwise.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Hardware Systems @ 2% of Capital Cost		0.5	1			Estimate		0.5	
	Maintenance for Software Systems @ 5% of Capital Cost		5	10			Estimate		5	
	Wireline Communication DS1 from Data									
	Loading (see Common Equipment in Section 5.6)		4.8	8.4			Current Price Structure		4.8	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.8-7 ISP ADVANCED INTEGRATED CONTROL SUPPORT, (ISP7)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

ISP Probe Information Collection (ISP8)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
							Per Loral, Rockwell			
	Upgrade Software process probe data into link data	20	250	500			Experience in Similar		250	
	(includes some product development)						Integration Projects			
							Existing Technology			
							Existing Technology			
							Existing Technology			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development, unless noted otherwise.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Software Systems @ 5% of Capital Cost		12.5	25			Estimate		12.5	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.8-8 ISP PROBE INFORMATION COLLECTION, (ISP8)

4.6.9. Personal Information Access Subsystem (PIAS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Personal Basic Information Reception	(PIA1)
Personal Interactive Information Reception	(PIA2)
Personal Mayday I/F	(PIA3)
Personal Route Guidance	(PIA4)

Each Equipment Package is described below.

4.6.9.1 Personal Basic Information Reception, (PIA1)

This Equipment Package provides the capability for travelers to interface with the ISP Subsystem Basic Information Broadcast Equipment Package and receive formatted traffic advisories including accurate traveling information concerning available travel options and their availability, and congestion information from their Personal Information Access Subsystem to include their homes, place of work, major trip generation sites, personal portable devices, and over multiple types of electronic media such as facsimile machines, portable AM/FM radios, and a pager processor.

This Equipment Package provides the processing of requested routing information by access to portions of TMC (or service provider), and of periodic requested location input from the traveler. This processor configures traveler routing as necessary. This type of mobile computer is currently called a "Personal Data Assistant" or PDA. Due to its small size the PDA may be further classified as a "subnotebook" or "palmtop" computer. The wireless communications capability may be built into the PDA, or may be incorporated in a separate module installed through a physical connector interface. The communication module may have attached to it the a separate antenna for wireless RF communications or may have the antenna built into the communications module or build into the PDA. The air interface for the communications module is the wireless RF WAN communications mode specified in this architecture. For purposes of the cost analysis this air interface is CDPD (Cellular Digital Packet Data.) Although other one way modes of communication may be free, this assumption was made in lieu of a service charge.

Similarly the location module can be built into the unit or also attached as a separate module using the same or similar interface standard. The location module indicates to the processor the location of the PDA/traveler. The technology used to implement this is design dependent, but for the purpose of cost analysis could use the GPS (Global Positioning System) satellite signals, possibly augmented with differential correction data received over the wireless data communications channel.

The remote system acts as the access point for external agents to the ITS system. This system ensures a common external interface (human and/or machine) while implementing

appropriate access security measures. Each Equipment Package accommodates request processing, external interfacing and internal interfacing. It is through a communication network that this system communicates with other subsystems in the ITS architecture. It is assumed that other external access systems to ITS architecture such as home PC's and work PC's already exist as part of the no ITS baseline. Only the remote access systems (PDA's) are used for this cost analysis. It is assumed that the other ITS architecture subsystems are in-place, and supporting facilities are operating. For example, the physical building that houses the operations for the remote access are included in the expenses for other subsystems and are not attributable to this system. The human interface operator is also assumed to be part of the other subsystems or terminators for the ITS architecture, specifically attributed to the staffing plans for the TMC and transit facilities. It is also assumed that maintenance personnel assigned to the TMC, and Roadside subsystems facilitate maintenance for the kiosk locations, in terms of physical repair.

4.6.9.2 Personal Interactive Information Reception, (PIA2)

This Equipment Package provides the capability for travelers to interface with the ISP Subsystem Infrastructure Equipment Packages including the Interactive Information Equipment Package, the Infrastructure Provided Route Selection, Yellow Pages and Reservation, and Ridesharing Equipment Packages. These capabilities are provided using the Personal Information Access Subsystem equipment such as cellular telephone, interactive TV, Personal Computer, and pager with alpha display using communication medium and equipment such as two-way radio, CATV, and wireless data transceivers.

PIA4 is a prerequisite package for PIA2. The equipment for PIA2 differs from PIA1 in that it is a separate equipment list allowing two way information exchange, and has higher processing level. Reflectively, PIA2 is subject to higher unit prices. This equipment is independent of PIA1 equipment.

4.6.9.3 Personal Mayday I/F, (PIA3)

This Equipment Package provides the capability to initiate a distress signal and cancel a prior issued manual request for help using the Personal Information Access Subsystem. This capability is provided using equipment such as a processor to automatically dial the Emergency Management Subsystem and provide location.

Specified equipment is similar in complexity to the equipment in PIA1. This technology is already installed in current model automobiles. It is assumed that this technology can be adapted to the PDA devices, or something similar.

4.6.9.4 Personal Route Guidance, (PIA4)

This Equipment Package provides the capability for route guidance. Thus, this Equipment Package provides the capability to receive travel information from the infrastructure, and perform the route planning process by itself. These capabilities are provided using equipment

such as a processor with GIS software and GUI using communication medium and equipment such as dialup lines, mobile satellite telephone, wireline modem, and wireline telephone.

This equipment differs from PIA1 in that it is a separate equipment list which is more sophisticated and reflectively, subject to higher unit prices. This equipment is independent of PIA1 equipment.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Personal Basic Information Reception (PIA1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Personal Digital Assistant	7	0.25	0.4			Existing Technology		0.25	
							Price Structure			
	Modem Interface	7	0.1	0.15			PCMCIA Prices		0.1	
	Separate Antenna for Wireless Capability	7	0.08	0.1			Existing Technology		0.08	
							Price Structure			
	GPS/DGPS	7	0.5	0.8			Current Prices		0.5	
							(GPS World)			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication - Low Usage		0.18	0.2			Current Price Structure		0.18	
	(See Common Equipment in Section 5.6)						from GTE			
	PDA Maintenance @ 2% of Capital Cost		0.01	0.01					0.01	
	GPS/DGPS Maintenance @ 5% of Capital Cost		0.03	0.04					0.03	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.9-1 PERSONAL BASIC INFORMATION RECEPTION, (PIA1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Personal Interactive Information Reception (PIA2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Personal Digital Assistant Software Add-on	7	0.1	0.2			Existing Technology		0.1	
							Price Structure			
	Note : Software is off-the-shelf technology and unit price does not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Monthly Service fee to ISP ($5-10/Month)		0.06	0.12					0.06	
	PDA Maintenance @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.9-2 PERSONAL INTERACTIVE INFORMATION RECEPTION, (PIA2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Personal Mayday I/F (PIA3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Limited Processing & Multilight Display	7	0.25	0.4			Existing Technology		0.25	
							Price Structure			
	Modem Interface	7	0.1	0.15			PCMCIA Prices		0.1	
	Separate Antenna for Wireless Capability	7	0.08	0.1			Existing Technology		0.08	
							Price Structure			
	GPS/DGPS	7	0.5	0.8			Current Prices		0.5	
							(GPS World)			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Monthly Service fee to ISP ($10-15/Month)		0.12	0.18					0.12	
	Maintenance for Processor, Modem, Antenna @ 2% capital cost		0.01	0.02					0.01	
	Maintenance for GPS, DGPS @ 5% capital cost		0.03	0.04					0.03	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.9-3 PERSONAL MAYDAY I/F, (PIA3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Personal Route Guidance (PIA4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Personal Digital Assistant	7	0.4	0.6			Existing Technology		0.4	
							Price Structure			
	Modem Interface	7	0.1	0.15			PCMCIA Prices		0.1	
	Separate Antenna for Wireless Capability	7	0.08	0.1			Existing Technology		0.08	
							Price Structure			
	Additional GIS / GUI Capability	7	0.1	0.15					0.1	
	GPS/DGPS	7	0.5	0.8			Current Prices		0.5	
							(GPS World)			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Monthly Service fee to ISP ($10-15/Month)		0.12	0.18					0.12	
	Wireless Communication - Low Usage		0.18	0.2			Current Price Structure		0.18	
	(See Common Equipment in Section 5.6)						from GTE			
	PDA Maintenance @ 2% of Capital Cost		0.01	0.02					0.01	
	GPS/DGPS Maintenance @ 5% of Capital Cost		0.03	0.04					0.03	
	Maintenance of Hardware Components:									
	(Processor @ 2% of Capital Cost)		0.01	0.01					0.01	
	(GPS @ 5% of Capital Cost)		0.01	0.02					0.01	
	(GIS/GUI @ 5% of Capital Cost)		0.01	0.01					0.01	
	(Cell Based Radio @ 2% of Capital Cost)		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.9-4 PERSONAL ROUTE GUIDANCE, (PIA4)

4.6.10. Parking Management Subsystem (PMS)

This subsystem contains only one Equipment Package, Parking Management Subsystem (PMS1). This Equipment Package provides the capability to detect and classify properly equipped vehicles entering and exiting the parking facility, and to maintain database information with parking availability and pricing structure information. This capability is provided through the utilization of active/passive tag readers and database software containing parking pricing structure and current availability housed in a parking structure. Communications interface, to the ISP subsystem for information access, with wireline modem using wireline telephone is also supported.

The Parking Management Subsystem manages parking lots, provides parking status information to travelers, processes parking reservation requests, and communicates with the TMC, TRMS and ISP for information processing, and electronic payment services. The parking lot locations are assumed to be part of the No ITS Baseline. Also included in the existing system are the miscellaneous ramp meters, and signals identifying parking lot availability. Parking attendants, barriers and gates are also assumed to be present with or without the implementation of ITS. Video camera surveillance for security, variable message signs, and card readers are assumed to exist in the parking lot systems with or without the implementation of ITS functions.

Communication lines for each parking system are assumed to already exist in the form of both "twisted pair" telephone lines, and other levels of wireline capacity in close proximity to the sites. Only the connection links from the processor locations to adjacent communication lines are required. Additional equipment for data communication and added capacity for wire communications are included in the expense tabulation for each system.

Operations and maintenance for the system is assumed to be affected through an annual service contract to an Information Service Provider to perform hardware maintenance. This expense is estimated to be a lump sum annual service contract for each service subscriber. This subsystem processes information within the parking lot system and coordinates through the TMC communication system requests received from outside the system or sent to the system. Physical components required for the service (some of which already exist in the No ITS Baseline described above) include software and processor, communication links, video cameras, variable message signs, miscellaneous signal display, card readers, and meters. The processing system is an on-line system which processes all parking reservations and payments for parking lots and parking structures. The system also processes transactions which are paid by credit cards or debit cards. The module is connected to various types of electronic payment user interfaces (fixed or mobile, via beacon or cellular) and to the parking lot administration system. The module requires a separate software, processor, and workstation per parking lot location.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Parking Management (PMS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Entrance / Exit Ramp Meters	10	2	5			Existing Technology		2	
	Tag Readers	10	2	5			Toll Road Tags	2-5	2	
	Database and Software for Billing & Pricing	10	10	15					10	
	Note: Software is off-the-shelf technology and unit price does									
	not reflect product development									
	CPU - 486 Workstation & Printer	5	2	5					2	
	Communication Lines DS0 for Operator to PMS	20	0.5	1			Existing Technology		0.5	
	DS0 to DMV & Enforcement & Financial Institution	20	0.5	1			Existing Technology		0.5	
	DS1 to ISP	20	0.5	1			Existing Technology		0.5	
	DS1 to Parking Service Provider	20	0.5	1			Existing Technology		0.5	
	DS1 to TRMS	20	0.5	1			Existing Technology		0.5	
	DS3 to TMS	20	3	5			Existing Technology		3	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Tag Readers Maintenance Contract @ 10% of Capital Cost		0.2	0.5					0.2	
	Entrance / Exit Ramp Meters @ 10% of Capital Cost		0.2	0.5					0.2	
	Database for Billing & Pricing @ 10% of Capital Cost		1	2					1	
	PMS Wireline Communication DS0 from Data Loading		0.6	1.2			Current Price Strucure		0.6	
	(see Common Equipment in Section 5.6)						from GTE			
	DMV Wireline Communication DS0 from Data Loading		0.6	1.2					0.6	
	(see Common Equipment in Section 5.6)									
	ISP Wireline Communication DS1 from Data Loading		4.8	8.4					4.8	
	(see Common Equipment in Section 5.6)									
	TRMS Wireline Communication DS1 from Data Loading		4.8	8.4					4.8	
	(see Common Equipment in Section 5.6)									
	TMS Wireline Communication DS3 from Data Loading		24	72					24	
	(see Common Equipment in Section 5.6)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.10-1 PARKING MANAGEMENT SUBSYSTEM, (PMS1)

4.6.11. Planning Subsystem (PS)

This subsystem contains only one Equipment Package, Data Collection and ITS Planning (PS1). This service collects data from all center functions in support of ITS planning activities. Staff requirements are only those dedicated to ITS activities. This staff may consist of MPO employees, or other regional planners.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Data Collection and ITS Planning (PS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Workstations (3)	10	15	30			Existing Technology		15	
	Software and Processing	10	20	40			Existing Technology		20	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	2 Full Time - Mid Level Planners @ 150k each		270	330					270	
	1 Half Time Senior Level Planner @ 200k each		180	220					180	
	Note: Salary Costs are Fully Loaded Prices (Base Salary, Overhead,									
	Overtime, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.11-1 DATA COLLECTION AND ITS PLANNING, (PS1)

4.6.12. Roadway Subsystem (RS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Automated Road Signing	(RS1)
Roadside Signal Priority	(RS2)
Roadway Freeway Control	(RS3)
Roadway Signal Controls	(RS4)
Roadway Basic Surveillance	(RS5)
Roadway HOV Usage	(RS6)
Roadway In-Vehicle Signing	(RS7)
Roadway Incident Detection	(RS8)
Roadway Intersection Collision System	(RS9)
Roadway Pollution and Environmental Hazards Indicators	(RS10)
Roadway Probe Beacons	(RS11)
Roadway Reversible Lanes	(RS12)
Roadway Systems for AHS	(RS13)
Roadway Traffic Information Dissemination	(RS14)

For the cost analysis, the roadway network is assumed to be partially outfitted with roadway sensors. As part of the No ITS Baseline it is assumed that the Central Business District (CBD) is already subject to a signal control system. This system requires software upgrades to meet the specifications of the ITS system, and requires hardware replacement as components reach the end of their useful life. However, these system components are in-place, and would be an expense with or without the implementation of ITS. The additional expense for signal control stems from the use of enhanced technology in area wide signal controls. These costs are incurred when existing systems reach the end of their useful life. The evaluatory design parameters for the signal system emulate a staggered deployment time frame in order to match typical technology replacements.

Traffic control and monitoring for incident detection is performed via roadway loop detectors, camera surveillance and radar units, also assumed to be part of the existing infrastructure, although in limited use. Likewise variable message signs, and video cameras are assumed to be in limited use. These components are also expected to exist and maintain their existence in the future regardless of ITS implementation. The additional expense for these roadside physical elements stems from the increased coverage of traffic control and monitoring.

Roadside communication systems are assumed to be in-place along the entire roadway network. Telephone lines, cable lines and power lines are all assumed to be readily available for supporting the ITS architecture. The expense associated with utilizing these power and communication lines is included in the architecture as an annual operation expense, and the expenses for connections are included in the unit prices for individual devices.

The roadside maintenance staff and equipment departments are assumed to be in existence and operating. The maintenance department for non-ITS roadside components is assumed to also be responsible for the ITS roadside components. Specific component maintenance expenses related to ITS implementation are detailed in the following worksheets. These maintenance expenses are counted as recurring expenditures. No expenditure for training maintenance staff is included in the recurring expenditure. It is assumed that as the system management strategies for these devices become increasingly complex, this complexity is offset by the increased user interfaces which becomes easier to use and require less initial training. Many of the roadside maintenance departments throughout the US are currently staffed with trained electricians, electrical engineers, supervisors and other technically trained maintenance personnel. Training expenses for these staff members are assumed to be minimal, and part of the normal maintenance operation expenses of maintaining roadside equipment.

The Non-recurring expenses associated with connecting specific devices to these existing systems have been included in the unit prices for the particular devices. The basis for this cost analysis assumes that connections from additional loop detectors, cameras, radar units, and variable message signs average approximately 300 feet in length. The effective life cycle of these communications connections are assumed to be the same as the devices they serve. The maintenance cost of the communications links is imbedded in the line lease costs and are, therefore, not specifically identified in the cost analysis. The basis for the lease cost stems from the previously discussed wireline communications common equipment in section 4.6, above. The number and type of leased lines and their unit costs are included in the Equipment Package worksheets.

Each Equipment Package is described below.

4.6.12.1 Automated Road Signing, (RS1)

Roadside beacons which may be locally and autonomously controlled from probe transmissions or centrally controlled from the virtual TMC.

4.6.12.2 Roadside Signal Priority, (RS2)

This Equipment Package provides the capability to receive vehicle signal priority requests and control roadside signals accordingly. This package is dependent on the existence of RS4, Signal Controls. The add-on unit prices are for software and processor upgrades to the existing signal control system. The wireline communication line expenditures are taken into account in the TMS subsystem.

4.6.12.3 Roadway Freeway Control, (RS3)

This Equipment Package provides the functionality to control freeway traffic. Thus, a prerequisite Equipment Package for this package is RS5, Basic Surveillance, and RS14

Roadway Traffic Information Dissemination. This package utilizes the information from these prerequisite packages in combination with new equipment to provide freeway traffic management. New equipment includes ramp meters, their controllers, power supplies, etc. The CMS and other freeway control effectors which control traffic on freeways are in RS14.

4.6.12.4 Roadway Signal Controls, (RS4)

This Equipment Package provides the capabilities to control traffic signals at major intersections and on arterials roadways for urban areas. This Equipment Package is generally constrained to a single jurisdiction. Multijurisdictional coordination is accomplished through the TMS subsystem. The equipment in this package includes local controller upgrades and connections to the linked signal system.

4.6.12.5 Roadway Basic Surveillance, (RS5)

This Equipment Package provides the capabilities to monitor traffic flow through major intersections and on major arterials and highways for urban areas and to monitor road conditions using fixed equipment such as loop detectors and wireline communications. Standard color video cameras are used for image surveillance in conjunction with loop detection systems. Other devices may be available in the current state-of-the-practice roadway surveillance projects throughout the US There are numerous technical and financial tradeoffs for any of the systems. This analysis is best performed on a site specific local deployment platform. The leased line wireline communication costs are delineated in the TMS subsystem.

4.6.12.6 Roadway HOV Usage, (RS6)

This Equipment Package provides the capability to detect the HOV lane usage using sensor equipment. For lanes that become HOV or High Occupancy Toll (HOT) lanes during certain time of the day, it provides display equipment to notify users of their status. The leased line wireline communication costs are delineated in the TMS subsystem.

4.6.12.7 Roadway In-Vehicle Signing, (RS7)

This Equipment Package provides the capability to detect local traffic flow conditions, corroborate them with a traffic management subsystem, and distribute them to the user over a short-range interface such as a radio beacon. These beacons are one way communication devices.

4.6.12.8 Roadway Incident Detection, (RS8)

This Equipment Package provides incident detection capability to reside at the roadside. For example, advanced CCTV's with built-in incident detection algorithms would allow the actual detection function to be roadside rather than transmitting images to a center for visual or automated detection.

4.6.12.9 Roadway Intersection Collision System, (RS9)

This Equipment Package provides the capability to determine the probability of a collision in the intersection and send appropriate warnings and/or control actions to the approaching vehicles using a short-range interface. This Equipment Package also provides the capability that the traffic control signals provide signal indication information to the vehicles using a short-range interface and the vehicle performs the determination of the probability of collision in the intersection. This package covers intersections between vehicles and railroad at grade crossings. The prerequisite Equipment Package for this package are RS4 and RS2.

4.6.12.10 Roadway Pollution and Environmental Hazards Indicators, (RS10)

This Equipment Package provides the capability for remote communications for collecting and transmitting air pollution due to vehicle emission data and environmental hazards such as icy road conditions and fog. Roadside devices for collecting environmental conditions and emissions monitoring are included in this roadside Equipment Package. Other expenditures for Emissions and Environmental Data Management are identified in the EMMS subsystem.

4.6.12.11 Roadway Probe Beacons, (RS11)

This Equipment Package provides the capabilities to monitor traffic flow in major intersections and on main highways for urban areas and to monitor road conditions using mobile equipment and wireless communication. For example, vehicle probe data or aerial surveillance data. These beacons are two way communication devices.

4.6.12.12 Roadway Reversible Lanes, (RS12)

This Equipment Package provides the capability for control of reversible lanes using sensor and actuator type equipment. This Equipment Package also provides the capability to notify users the direction of the reversible lanes using electronic lane signs.

4.6.12.13 Roadway Systems for AHS, (RS13)

This Equipment Package provides the capability of safely controlling access to and egress from an Automated Highway System. This Equipment Package also provides the capability for roadside to vehicle communication. These capabilities are provided using equipment such as a lane check-in or check-out beacon and special purpose vehicle signing beacons. Access control devices may use RS12 equipment.

4.6.12.14 Roadway Traffic Information Dissemination, (RS14)

This Equipment Package provides the roadside elements of traffic information dissemination including CMS and HAR. Also included are the fixed message signs which are fiber optic advanced warning signs. Some of these fiber optic advanced warning signs are connected to

remote roadside locations which are specifically targeted as either environmental hazards or main decision points for alternate traffic routing. The wireline communications to these devices are depicted in the TMS subsystem.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Automated road signing (RS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Radio Beacons (per location)	5	5	8			Ref. Seimens Exist.		5	
							Technology Prices			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Beacon Maintenance (10% of Capital Cost)		0.5	0.8					0.5	
	Leased Line Costs borne by TMC									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-1 AUTOMATED ROAD SIGNING, (RS1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadside Signal Priority (RS2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Receiver (per intersection - 2 total)	5	4	8			Existing Technology ref.		4	
	Signal Controller - Add-on to base capability (per intersection)	10	2	5			Massachusetts Highway		2	
							Department per LBA projects			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Testing & Calibration Annual Contract ($50 per intersection)		0.05	0.2			Exist. Tech.	0.1	0.05	
	Leased Line Costs borne by TMC									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-2 ROADSIDE SIGNAL PRIORITY, (RS2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Freeway Control (RS3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Ramp Meters (per location)						Existing Site			
	Controller, Power etc. included	5	30	50			Installations		30	
							Prices from			
							New England			
							and Virginia			
							Projects per			
							LBA			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Leased Line Costs borne by TMCS							0.1		
	Maintenance for Ramp Meters @ 5% of Capital Cost		1.5	2.5					1.5	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-3 ROADSIDE FREEWAY CONTROL, (RS3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Signal Controls (RS4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Linked Signal System LAN	20	40	70			Existing Technology ref.		40	
	Local Controller Upgrades (per intersection)	20	5	10			Massachusetts Highway		5	
							Department per LBA projects			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Leased Line Costs borne by TMC									
	Maintenance for LAN @ 2% of Capital Cost		0.8	1.4					0.8	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-4 ROADWAY SIGNAL CONTROLS, (RS4)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Basic Surveillance (RS5)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Loops - 1 Double Set w/ Controller, Power, etc. (per location)	5	5	8			Existing Site	6	5	
							Installations			
	Video Cameras (color)	10	30	50			Prices from	40	30	
	Towers (per camera location)	20	30	50			New England	30	30	
							and Virginia			
							Projects per			
							LBA			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Loop Replacement Maintenance (10% of capital)		0.5	0.8					0.5	
	Ramp Meters (5% of capital)		1.5	2.5					1.5	
	Video Cameras (2% of capital)		0.6	1					0.6	
	Leased Line Costs borne by TMC									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-5 ROADWAY BASIC SURVEILLANCE, (RS5)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway HOV Usage (RS6)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Loop Detectors (1 double set)	5	5	8			Existing Site	6	5	
	Fixed Lane Signals (each)	20	6	8			Installations	6	6	
	Fixed Message Boards (each)	20	50	75			Prices from	50	50	
	Video Monitoring / Enforcement (each)	20	30	50			New England	40	30	
	Software / Billing Enforcement	20	30	50			and Virginia	40	30	
							Projects per			
							LBA			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Loop Detectors (10% of capital)		0.5	0.8			Estimate		0.5	
	Fixed Lane Signals (10% of capital)		0.6	0.8			Estimate		0.6	
	Fixed Message Boards (5% of capital)		2.5	4			Estimate		2.5	
	Video Cameras (2% of capital)		0.6	1			Estimate		0.6	
	Enforcement Maintenance (10% of capital)		3	5			Estimate		3	
	Leased Line Costs borne by TMC									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-6 ROADWAY HOV USAGE, (RS6)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway In-Vehicle Signing (RS7)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Signal Transmitter (4 Beacons per intersection)	5	5	8			Ref. Seimens Exist.		5	
	Localized Controller	10	3	8			Technology Prices		3	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Beacon Maintenance (10% of Capital Cost)		0.5	0.8			Exist. Tech.		0.5	
	Communication from TMC to Beacons is included in TMC Costs									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-7 ROADWAY IN-VEHICLE SIGNING, (RS7)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Incident Detection (RS8)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Advanced CCTV w/detection algorithm (per location)	10	30	50			Exist. Tech.	30	30	
	Towers for Mounting (per location)	20	30	50			Exist. Tech.	30	30	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	CCTV (10% of capital)		3	5					3	
	Leased Line Costs borne by TMC									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-8 ROADWAY INCIDENT DETECTION, (RS8)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Intersection Collision System (RS9)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Communication Lines (use existing)									
	Communication to Local Signage (per site)	20	6	9			15k / mile	8	6	
	Roadside Hardware,Software and sensors (per intersection)	10	100	200			Estimate		100	
							Per Loral, Rockwell exper. in			
							Similar Integration Projects			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Unknown									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-9 ROADWAY INTERSECTION COLLISION SYSTEM, (RS9)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Pollution and Environmental Hazards Indicators (RS10)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Continuous Emissions Monitoring Stations Design	10	3	6			Ref. EPA 454-		3	
	(per emissions design)						R-93-042			
	Types - NO, NO2, NOx Analyzer	10	7	11					7	
	- Ozone Analyzer	10	6	8					6	
	- SO2 Analyzer	10	7	11					7	
	- CO Analyzer	10	7	11					7	
	Peripherals (per emissions type)	10	13	17					13	
	Shelter, Site Preparation (per site)	20	16	20					16	
	Environmental Site Installation	20	25	30					25	
	Equipment (Humidity, Pressure, Temperature, Wind, Precip., etc)	10	20	25					20	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	TMC Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-10 ROADWAY POLLUTION AND ENVIRONMENTAL HAZARDS INDICATORS, (RS10)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Probe Beacons (RS11)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Radio Beacons (per location)	5	5	8			Ref. Seimens Exist.		5	
							TechnologyPrices			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Beacon Maintenance (10% of Capital Cost)		0.5	0.8			Exist. Tech.		0.5	
	Leased Line Costs borne by TMC									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-11 ROADWAY PROBE BEACONS, (RS11)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Reversible Lanes (RS12)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Gates (per location)	20	100	150			Existing Site	100	100	
	CMS (per location)	20	50	75			Installations	50	50	
	Loop Detectors (double set, per location)	5	5	8			Prices from	6	5	
	Wireline to CMS (0.5 mile upstation)	20	6	9			New England	8	6	
	Software & Hardware at site	20	25	50			and Virginia	25	25	
							Projects per			
	Note : Software is off-the-shelf technology and unit price does						LBA			
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Gates (2% of capital)		2	3			Estimate		2	
	CMS (5% of capital)		2.5	4			Estimate		2.5	
	Loops (10% of capital)		0.5	0.8			Estimate		0.5	
	Leased Line Costs borne by TMC									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-12 ROADWAY REVERSIBLE LANES, (RS12)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Systems for AHS (RS13)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Check In / Check Out Beacons	10	5	8			Estimate		5	
	Signing (beacons)	10	5	8			Estimate		5	
	Access Control devices may utilize RS12 equipment									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Leased Lines from TMC to beacons borne by TMCs									
	Beacon Maintenance (10% of Capital Cost)		0.5	0.8			Exist. Tech.		0.5	
	Beacon Maintenance (10% of Capital Cost)		0.5	0.8			Exist. Tech.		0.5	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-13 ROADWAY SYSTEMS FOR AHS, (RS13)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Roadway Traffic Information Dissemination (RS14)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	CMS	20	80	120			Existing	100	80	
	HAR	20	16	20			Existing	16	16	
	Fixed Fiber Optic Advanced Warning Signs	10	10	15			Existing	12	10	
	Fixed Fiber Optic Advanced Warning Signs at Remote EMS Loc.	10	18	22			Existing	20	18	
	Tower Structures for CMS	20	100	150			Existing	100	100	
							per LBA			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	CMS (5% of capital)		4	6			Estimate		4	
	HAR (5% of capital)		0.8	1			Estimate		0.8	
	Fixed Fiber Optic Advanced Warning Signs (5% of capital)		0.5	0.8			Estimate		0.5	
	Fixed Fiber Optic Advanced Warning Signs at Remote EMS Loc.		1.8	2.2			Estimate		1.8	
	(10% of capital)									
	Leased Line Costs borne by TMCS									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.12-14 ROADWAY TRAFFIC INFORMATION DISSEMINATION, (RS14)

4.6.13. Remote Traveler Support Subsystem (RTS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Remote Basic Information Reception	(RTS5)
Remote Interactive Information Reception	(RTS1)
Remote Mayday I/F	(RTS2)
Remote Transit Fare Management	(RTS3)
Remote Transit Security I/F	(RTS4)

Each Equipment Package is described below.

4.6.13.1 Remote Basic Information Reception, (RTS5)

This Equipment Package provides the capability for travelers to interface with the ISP Subsystem Basic Information Broadcast Equipment Package and receive formatted traffic advisories including accurate traveling information concerning available travel options and their availability, and congestion information at the Remote Traveler Subsystem. The interface used for this package is a kiosk. Wireline communications to the kiosks are included in a leased line unit price per kiosk, as described in section 4.6, above.

4.6.13.2 Remote Interactive Information Reception, (RTS1)

This Equipment Package provides the capability for travelers to interface with the ISP Subsystem Infrastructure Equipment Packages including the Interactive Interactive Information Equipment Package, the Infrastructure Provided Route Selection, Yellow Pages and Reservation, and Dynamic Ridesharing Equipment Packages. These capabilities are provided using the Remote Traveler Subsystem equipment such as interactive TV and kiosk using communication medium and equipment such as CATV and wireline and wireless data transceivers. (Wireless communication is possible but not priced in this analysis.) This Equipment Package has a prerequisite Equipment Package RTS5. Equipment for RTS1 include processor add-ons to the existing system in RTS5, as well as additional communication requirements, and an interactive information display.

4.6.13.3 Remote Mayday I/F, (RTS2)

This Equipment Package provides the capability to initiate a distress signal and cancel a prior issued manual request for help using the Remote Traveler Subsystem. This capability is provided using equipment such as a processor to automatically dial the Emergency Management Subsystem and provide location. This equipment may be stand alone devices, similar to the emergency MAYDAY devices in the PIAS subsystem, or may be incorporated into the kiosk location in RTS5. The difference in this equipment from the equipment in the PIAS subsystem is the absence of the GPS/DGPS requirement as the Remote Mayday I/F is at a fixed location.

4.6.13.4 Remote Transit Fare Management, (RTS3)

This Equipment Package provides the capability for the traveler to use a fare medium for all applicable surface transportation services, to pay without stopping, have payment media automatically identified as void and/or invalid and eligibility verified, and allow for third party payment from a remote location, i.e., other than the transit vehicle. In addition, capability to provide expansion into other uses for payment medium such as retail and telephone and for off-line billing for fares paid by agencies is supported.

This Equipment Package is independent of the kiosk locations in terms of functionality. However, in practice these locations may be the most likely locals for remote ITS services. The equipment for this remote ticket vending include ticket vending machines, similar to the SMART CARD technology. Wireline communication to the electronic payment instrument and financial institutions is provided through existing lines. The lease line charge for these lines are as described in the common equipment section 4.6, above.

4.6.13.5 Remote Transit Security I/F, (RTS4)

This Equipment Package provides the capability to monitor the safety of transit users at Remote Traveler Subsystem locations with direct interface to the Transit Management Subsystem. The equipment for this package augments the MAYDAY I/F located at kiosks, as well as adding security to the transit customers along the transit routes. This equipment is independent of RS5.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Remote Basic Information Reception (RTS5)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Kiosks-based Unit w/ Stand Alone Interface	7	35	50			Ref George Mason		35	
	Integration per Kiosk	7	10	12			Pilot Test on		10	
							Portable Kiosks			
	Wireline Communications Interface	7	0.8	1					0.8	
	Wireless Capability	7	0.1	0.2					0.1	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	RTS To ISP Wireline - DS1 Type from Data Loading		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			
	Maintenance of Kiosks @ 10% of Capital Cost		3.5	5					3.5	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.13-1 REMOTE BASIC INFORMATION RECEPTION, (RTS5)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Remote Interactive Information Reception (RTS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software Upgrade & Integration						Ref. George Mason			
	to Existing Kiosks Processor	5	10	12			Pilot Test on		10	
							Portable Kisks			
	Interactive Information Display Interface									
	(Upgrade from Existing Interface)	5	5	8					5	
	Additional Interface to Communication Lines									
	(2 @ 0.8 to 1.0 per Line)	5	1.6	2					1.6	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance of Interface for Display @ 10% of Capital Cost		0.5	0.8					0.5	
	Wireline Communication RTS to ISP included in RTS									
	RTS to Map Update Provider Wireline Communications DS0						Current Price Structure			
	from Data Loading (see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	RTS to TRUS Wireline Communication DS3 from Data									
	Loading (see Common Equipment in Section 5.6)		24	72					24	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.13-2 REMOTE INTERACTIVE INFORMATION RECEPTION, (RTS1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Remote Mayday I/F (RTS2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Interface for Limited Processor	2	0.1	0.15			Existing Technology		0.1	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Communication Line DS0 from Data Loading		0.6	1.2			Current Price Structure		0.6	
	(see Common Equipment in Section 5.6)						from GTE			
	Maintenance on Interface @ 2% of Capital Cost		0.02	0.03					0.02	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.13-3 REMOTE MAYDAY I/F, (RTS2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Remote Transit Fare Management (RTS3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Ticket Vending Machine for Smart Card	5	37	40			Reference ITI Cost Study		37	
							(FHWA) and Washington			
	Software & Integration	20	3	5			METRO and GOCARD System		3	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Communication Line to Electronic Payment Instrument DS0 from		4.8	8.4					4.8	
	Data Loading Analyses (See Common Equipment in Section 5.6)									
	Maintenance: Equipment @ 5% of Capital		1.8	2					1.8	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.13-4 REMOTE TRANSIT FARE MANAGEMENT, (RTS3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Remote Transit Security I/F (RTS4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	CCTV (Interior Fixed Mount)	10	4	5			Existing Site Installations		4	
	Integration (per Location)	10	2	2.5			Prices from New England		2	
							& Virginia Projects per LBA			
	(Image Processing & Video Walls performed @ Transit Center)									
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Communication Line DS1 per Data Loading Analyses		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			
	Maintenance CATV @ 2% of Capital Cost		0.08	0.1					0.08	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.13-5 REMOTE TRANSIT SECURITY I/F, (RTS4)

4.6.14. Toll Administration Subsystem (TAS)

This subsystem contains only one Equipment Package Toll Administration, (TAS1). This Equipment Package provides the capability to maintain database information with pricing structure information. This capability is provided through database software containing pricing structure and current traffic conditions on the transportation network obtained from the Transportation Management Center. This capability allows the determination of dynamic tolls according to congestion levels for demand management. Communications interface with wireline modem using wireline telephone is also supported. Dependent on the arrangement with the financial institutions, this Equipment Package may also contain a billing database. Wireline communications to the TMC, ISP, TMS, TRMS, and Toll Service Provider are included per the data loading analysis communication requirements as described in the common equipment section 4.6, above.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Toll Administration (TAS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	486 / Pentium PC w/1 gigabyte, 2 Workstations, Printer, Modem	5	10	15			486 CPU		10	
	Software - Database (local)	10	20	40			Per Loral, Rockwell exper. in		20	
	Note: Software is off-the-shelf technology and unit price does						similar Integration Projects			
	not reflect product development									
	National Database Coord.	10	20	40					20	
	Communication Line DS0 to other agencies, DMV/ Enforcement									
	Agency/ Financial Institution	20	0.5	1					0.5	
	Communication Line DS1 to ISP	20	0.5	1					0.5	
	Communication Line DS1 toTCS	20	0.5	1					0.5	
	Communication Line DS1 to TMS	20	0.5	1					0.5	
	Communication Line DS1 to TRMS	20	0.5	1					0.5	
	Communication Line DS3 to Toll Service Provider	20	3	5					3	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Database Management Contract @ 10% of Capital Cost		5	10				Current Price	5	
	No Additional Staff							Structure		
	Agency Wireline Communication DS0 per Data Loading		0.6	1.2				from GTE	0.6	
	(see Common Equipment in Section 5.6)									
	ISP Wireline Communication DS1 per Data Loading		4.8	8.4					4.8	
	(see Common Equipment in Section 5.6)									
	TCS Wireline Communication DS1 per Data Loading		4.8	8.4					4.8	
	(see Common Equipment in Section 5.6)									
	TMS Wireline Communication DS1 per Data Loading		4.8	8.4					4.8	
	(see Common Equipment in Section 5.6)									
	TRMS Wireline Communication DS1 per Data Loading		4.8	8.4					4.8	
	(see Common Equipment in Section 5.6)									
	Toll Service Provider " DS3 "		24	72					24	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.14-1 TOLL ADMINISTRATION, (TAS1)

4.6.15. Toll Collection Subsystem (TCS)

This subsystem contains only one Equipment Package, Toll Plaza Toll Collection (TCS1): This Equipment Package provides existing toll plazas the capability to identify properly equipped vehicles and automatically perform toll collection with transaction confirmation. These capabilities are provided with an active tag reader and vehicle identification software running on a workstation type processor. Automated billing and notification to authorities of violations is supported using a wireline modem and telephone.

A suitable camera, sensor, software and processor system is utilized to identify violators. These are controlled or activated by sensors. The processing capability incorporates the use of either a localized data base of violators or connect directly to the TAS for access to a centralized data base of violators. At each toll location, violation detection surveillance is implemented via cameras. Full surveillance coverage includes an average of one cameras for every two lanes. Each camera is a stationary unit with magnification lenses. A series of sensors that are linked to the electronic payment systems are linked to the communication network and the software and processor for violation detection. These sensors detect violations and signal the module processor to initiate the video use, as well as the data base checks. These sensors are included in the reader system unit price.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Toll Plaza Toll Collection (TCS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Readers (per lane)	10	2	5			Exist. Tech.		2	
	Mainline Structure	20	10	15			Lightweight		10	
	High Speed Cameras Price Per Lane (Avg. 2 Lanes / 1 Camera)	10	5	10			Sign Structure		5	
	Enforcement - included in regular operations									
	Database (local) & Software	10	5	10					5	
	Note: Software is off-the-shelf technology and unit price does									
	not reflect product development									
	Communication line DSI to TAS	20	0.5	1					0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance Contract (per reader) @ 10% of Capital Cost		0.2	0.5					0.2	
	Camera Maintenance @ 10% of Capital Cost		0.5	1					0.5	
	Database Management (local)		0	0						
	(Net Staff Reduction Using AVI)									
	TAS Wireline Communication DSI per Data Loading		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			

FIGURE 4.6.15-1 TOLL COLLECTION SUBSYSTEM, (TCS1)

4.6.16. Traffic Management Subsystem (TMS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Collect Traffic Surveillance	TMS1
Distributed Road Management	TMS2
TMC Advanced Signal Control	TMS3
TMC Regional Traffic Control	TMS4
TMC Based Freeway Control	TMS5
TMC Basic Signal Control	TMS6
TMC for AHS	TMS7
TMC HOV/Reversible Lane Management	TMS8
TMC Incident Detection	TMS9
TMC Incident Dispatch Coordination/Communication	TMS10
TMC Input to In-Vehicle Signing	TMS11
TMC Multi-Modal Coordination	TMS12
TMC Probe Information Collection	TMS13
TMC Toll/Parking Coordination	TMS14
TMC Traffic Information Dissemination	TMS15
TMC Traffic Network Performance Evaluation	TMS16
Traffic Maintenance	TMS17

It is assumed that the building for the Traffic Management Center is already in place to some limited extent. There is no initial construction of a dedicated facility. The expense for the facility is in recurring expenditures of rental costs. The initial basic communication lines are in-place, and only those changes necessary to incorporate the additional capabilities are included in the analysis.

An annual rent charge of $18.00 per square foot is assumed, with an estimated average of 250 square feet per staff member. This unit price for floor space rental equates to an additional $4,500 to the average annual staff unit prices. Average annual staff unit prices vary according to the functions performed. Generally, it is anticipated that a base salary is multiplied by a benefits factor for overhead, overtime, other benefits, to which an additional $4,500 is added for building rent.

The map data base is assumed to be developed by third party vendors and is purchased by the TMC. An annual update of the database for the life cycle of the database (prior to a major update) is assumed to be included in the purchase price of the database. The database area coverage includes all roads and attributes (lanes, one-way streets, speed limits, restrictions, key features, sites, buildings, etc.). An independent supplier provides data base updates.

Each Equipment Package is described below.

4.6.16.1 Collect Traffic Surveillance, (TMS1)

This Equipment Package collects, stores, and provides electronic access to the traffic surveillance data. The surveillance data source is the Roadside Subsystem. Wireline communications are provided in this Equipment Package which collect the information from the RS subsystem, as well as connect the information flow to the EMMS subsystem and other outside agencies. These wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.2 Distributed Road Management, (TMS2)

This is a virtual TMC in the sense that it manages road conditions over a very diverse area with no or limited congestion but significant weather. Added in this package capability is the communication to other TMC's and outside agencies. These wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.3 TMC Advanced Signal Control, (TMS3)

This Equipment Package collects route planning information and integrates and uses this information in predicting future traffic conditions and optimizing the traffic control strategy for these conditions. These capabilities are achieved through real-time communication of logged routes from an Information Service Provider on the wireline communication link. Using the same communication link, the planned control strategies can be passed back to the Information Service Provider so that the intended strategies can be reflected in future route planning. Prerequisite packages include, TMS6, TMS4, and TMS16, the latter of which allows for the implementation of the advanced signal control plans.

4.6.16.4 TMC Regional Traffic Control, (TMS4)

This Equipment Package provides capabilities additional to those provided by the TMC Basic Signal Control Equipment Package for analyzing, controlling, and optimizing area-wide traffic flow. These capabilities provide for wide area optimization integrating control of a network signal system with control of freeway, preferential treatment for transit vehicles and HOV, considering current demand as well as expected demand with a goal of providing the capability for signal prioritization timing and real-time traffic adaptive control integrated and consistent, avoiding conflicting controls issues. These capabilities are best provided using a Traffic Management Center (TMC) to monitor and manage freeway ramp meters and intersection traffic signals and software to process traffic information and implement traffic management measures (e.g., ramp metering, signalization, and traffic coordination between both local and regional jurisdiction). The TMC is able to communicate with other TMCs in order to receive and transmit traffic information on neighboring jurisdictions. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.5 TMC Based Freeway Control, (TMS5)

This Equipment Package provides the control system for efficient freeway management including integration of surveillance information with freeway road geometry, as well as vehicle control such as ramp metering, CMS, HAR. This package provides the interface to coordinated TMC Equipment Packages for information dissemination to the public. Prerequisite packages include TMS1 and TMS15. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.6 TMC Basic Signal Control, (TMS6)

This Equipment Package provides the capability to traffic managers to monitor and manage the traffic flow in major intersections and on major arterials for urban areas as well as alleviate traffic related problems of rural areas with the primary concern of detecting and verifying incidents and providing this information to emergency management service providers. This capability includes analyzing and reducing the collected data from traffic surveillance equipment as feedback to control processes and for control strategies. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.7 TMC for AHS, (TMS7)

This Equipment Package provides the capability to exercise control over those devices utilized for AHS traffic and vehicle control. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.8 TMC HOV/Reversible Lane Management, (TMS8)

This Equipment Package provides the capability to manage HOV lanes by coordinating freeway ramp meters and connector signals with HOV lane usage signals, and giving preferential treatments to HOV lanes to encourage drivers to carpool. This Equipment Package also provides the capability for access and management of reversible lane facilities, including the direction of traffic flow changes during the day, especially between the peak hours and dedication of more lanes to the congestion direction during special events. This is effected through the RS subsystem. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.9 TMC Incident Detection, (TMS9)

This Equipment Package provides the capability to traffic managers to detect and verify incident. This capability includes analyzing and reducing the collected data from traffic surveillance equipment, including predicted incidents and hazardous conditions. the communication lines to RS equipment utilize the lines in TMS1.

4.6.16.10 TMC Incident Dispatch Coordination/Communication, (TMS10)

This Equipment Package provides the capability for an incident response formulation function minimizing the incident potential, incident impacts, and/or resources required for incident management including proposing and facilitating the dispatch of emergency response and service vehicles as well as coordinating response with all appropriate cooperating agencies. This package has a prerequisite of TMS9.

4.6.16.11 TMC Input to In-Vehicle Signing, (TMS11)

This Equipment Package provides the capability to allow traffic managers input to operation and maintenance of the roadway vehicle signing devices.

4.6.16.12 TMC Multi-Modal Coordination, (TMS12)

This Equipment Package provides the capability of coordination activities with various modal entities. Included in this coordination is signal control at the traffic management subsystem to provide signal priority for transit vehicles. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.13 TMC Probe Information Collection, (TMS13)

This Equipment Package provides the capability to accept and process probe vehicle information. This capability is provided through the use of additional hardware and probe vehicle control and tracking software.

4.6.16.14 TMC Toll/Parking Coordination, (TMS14)

This Equipment Package provides the transportation management center with the capability to transform and transmit network traffic congestion information to the Toll Administration or Parking Management so that dynamic pricing for demand management is possible. Communications are supported using a wireline modem. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.15 TMC Traffic Information Dissemination, (TMS15)

This Equipment Package provides the capability to disseminate incident related information to travelers, potential travelers, and private Information Service Providers. These capabilities are provided using a workstation type processor within a facility connected to traveler information providers by utilizing existing wireline links. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.16 TMC Traffic Network Performance Evaluation, (TMS16)

This Equipment Package provides the capability to predict travel demand patterns to support traffic flow optimization, demand management, and incident management. This Equipment Package requires the data collected by surveillance Equipment Packages as well as input from other management subsystems including the ISP Subsystem, and Transit Management Subsystem. Output from this package flows to the PS subsystem for transportation planning. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.16.17 Traffic Maintenance, (TMS17)

This Equipment Package provides traffic maintenance facilities. Prerequisite packages include TMS1, TMS14, TMS4 and TMS15.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Collect Traffic Surveillance (TMS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Communication Lines -									
	from TMS to DMV & Enforcement Agency Type DS0	20	0.5	1					0.5	
	from TMS to RS Type DS3	20	3	5					3	
	from TMS to EMMS Type DS0	20	0.5	1					0.5	
	from RS to EMMS Type DS0	20	0.5	1					0.5	
	from RS to TMS Type DS3	20	3	5					3	
	Processor and Software	20	135	165			Estimate		135	
	Integration	20	225	275			Per Loral, Rockwell exper. in		225	
							similar Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Processor & Software @ 5% of Capital Cost		18	22					18	
	TMS to Agencies Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	TMS to RS Wireline Communication DS3 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		24	72			from GTE		24	
	TMS to EMMS Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	RS to EMMS Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	RS to TMS Wireline Communication DS3 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		24	72			from GTE		24	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-1 COLLECT TRAFFIC SURVEILLANCE, (TMS1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Distributed Road Management (TMS2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software and Integration, Installation and 1 year Maintenance	10	135	165			Per Loral, Rockwell exper. in		135	
	Integration with other TMCs	10	225	275			similar Integration Projects		225	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	Communication Line DS0 from TMC to other Agencies	20	0.5	1			Existing Technology Prices		0.5	
	Communication Line DS3 from TMC to other TMC	20	3	5			Existing Technology Prices		3	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Operators (2 at 50% of the time, at $100,000)		90	110					90	
	Transporation Engineer (1 at 50% of the time, at $100,000)		45	55					45	
	Maintenance Contract		45	55					45	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	Agency Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	TMC Wireline Communication DS3 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		24	72			from GTE		24	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-2 DISTRIBUTED ROAD MANAGEMENT, (TMS2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Advanced Signal Control (TMS3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software Installation and 1 year Maintenance	5	22.5	27.5			Existing Site Installations prices		22.5	
	Integration	20	180	220			from Massachusetts Highway		180	
	Hardware (1 Workstation)	5	5	10			Department per LBA projects		5	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	Closed loop signal system communication is through existing									
	TMS 6 lines									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Transportation Engineer (2 at $100,000)		180	220					180	
	Systems Analyst (1 at 50% of the time at $75,000)		34	41					34	
	Maintenance Contract		90	110					90	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-3 TMC ADVANCED SIGNAL CONTROL, (TMS3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Regional Traffic Control (TMS4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software and Integration, Installation and 1 year Maintenance	10	135	165			Per Loral, Rockwell exper. in		135	
	Integration with other TMCs	10	225	275			similar Integration Projects		225	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	Communication Line DS0 from TMC to other Agencies	20	0.5	1			Existing Technology Prices		0.5	
	Communication Line DS3 from TMC to other TMC	20	3	5			Existing Technology Prices		3	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Operators (2 at 50% of the time, at $100,000)		90	110					90	
	Transporation Engineer (1 at 50% of the time, at $100,000)		45	55					45	
	Maintenance Contract		45	55					45	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	Agency Wireline Communication DS0 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	
	TMC Wireline Communication DS3 from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		24	72			from GTE		24	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-4 TMC REGIONAL TRAFFIC CONTROL, (TMS4)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC based Freeway Control (TMS5)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software and Integration, Installation and 1 year Maintenance	5	180	220			Existing Site Installations		180	
	Hardware (3 Workstations)	5	15	30			Prices from New England		15	
							and Virginia Projects per LBA			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	TMC To RS Communication Line; DS1 Type	20	0.5	1			Existing Technology		0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireline Communication DS1 from Data Loading		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			
	Operators (2 @ 50% of the Time, @ $100,000)		90	110			Existing Site Installations		90	
							Prices from New England			
	Maintenance Technicians (2 @ $75,000)		135	165			and Virginia Projects per LB/		135	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-5 TMC BASED FREEWAY CONTROL, (TMS5)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Basic Signal Control (TMS6)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software and Integration, Installation and 1 year Maintenance	5	180	220			Existing Site Installations		180	
	Hardware (3 Workstations)	5	15	30			Prices from New England		15	
							and Virginia Projects per LBA			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	TMC To RS Communication Line; DS1 Type	20	0.5	1			Existing Technology		0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireline Communication DS1 from Data Loading		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			
	Operators (2 @ 50% of the Time, @ $100,000)		90	110			Existing Site Installations		90	
	Transportation Engineer (1 at 50% of the time, at $100,000)		45	55			Prices from New England		45	
	Update Timing Plans ($2,000 per system per month for every 10						and Virginia Projects per LBA			
	systems)		216	264					216	
	Signal Maintenance Technicians (2 @ $75,000)		135	165					135	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-6 TMC BASIC SIGNAL CONTROL, (TMS6)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC for AHS (TMS7)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software Installation and 1 year Maintenance	5	45	55			Estimate Per Loral, Rockwell		45	
	Integration	20	225	275			Experience in Similar		225	
							Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	TMS to RS Communication Line; DS0 Type	20	0.5	1			Existing Technology		0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Transportation Engineers (5 at $100,000)		450	550			Phase 1 Document Review		450	
	System Maintenance @ 5% of Capital Cost		12	17			Average Price Ranges		12	
	Technicians (2 at $75,000)		135	165					135	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	RS Wireline Communication DS0 from Data Loading		0.6	1.2			Current Price Structure		0.6	
	(see Common Equipment in Section 5.6)						from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-7 TMC FOR AHS, (TMS7)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC HOV/Reversible Lane Management (TMS8)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software Development and Integration	10	180	220			Existing Site		180	
	Hardware (1 Workstation)	5	2.7	3.3			Installations		2.7	
	19" Monitor	5	2.7	3.3			Prices from		2.7	
	Software Upgrade for Controllers	3	45	55			New England		45	
							and Virginia			
	Software Development is fine tune adjustments for local installations.						Projects per			
	Otherwise, Software is off-the-shelf technology and unit price does						LBA			
	not reflect product development.									
	TMS to RS Communication Line; DS1 Type	20	0.5	1			Existing Technology		0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Operator (2 for 4 hours each, at $100,000 for 8 hours)		90	110					90	
	Maintenance of Equipment @ 5% of Capital Cost		12	14					12	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	RS Wireline Communication DS1 from Data Loading		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-8 TMC HOV/REVERSIBLE LANE MANAGEMENT, (TMS8)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Incident Detection (TMS9)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Hardware (4 Servers)	5	54	66			Existing Site Installations		54	
	Hardware (5 Workstations)	5	25	50			Metropolitan Boston ITS		25	
	Software (off-the-shelf and developed)	5	90	110			Phase 1 Deployment and		90	
	Integration	20	90	110			MHD Central Artery CANA		90	
	Laser Printer (2)	5	2.7	3.3			Incident Management		2.7	
	19" Video Monitors (5)	5	13.5	16.5			Project per LBA		13.5	
	Video Wall (3x3=9 monitors w/video switch, etc.)	5	27	33					27	
	Communication Line Utilizes TMS1 Line									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Operators (4 Analysts @ $100,000 and 1 Manager @ $150,000)		495	605			Existing Site Installations		495	
							Metropolitan Boston ITS			
							Phase 1 Deployment and			
							MHD Central Artery CANA			
							Incident Management			
							Project per LBA			
	O&M for Equipment (Hardware and Software) @ 5% of Capital Cost		15	20					15	
	Maintenance Technicians (2) (@ $75,000)		135	165					135	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-9 TMC INCIDENT DETECTION, (TMS9)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Incident Dispatch Coordination/Communication (TMS10)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Hardware (1 Workstation)	5	2.7	3.3			Existing Site		2.7	
	Software	2	13.5	16.5			Installations		13.5	
	19" Monitor	5	2.7	3.3			Prices from		2.7	
	Integration	20	180	220			New England		180	
							and Virginia			
	Note : Software is off-the-shelf technology and unit price does						Projects per			
	not reflect product development.						LBA			
	TMC to EM Communication Line; DS0 Type	20	0.5	1			Existing Technology		0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Incident Management Coordinator (1 @ $100,000)		90	110			Existing Site installations		90	
	Equipment Maintenance @ 5% of Capital Cost		1	1.2			Prices from New England and		1	
	Note : Salary Costs are fully loaded prices (Base Salary,						Virginia Projects per LBA			
	Overtime, Overhead, Benefits, etc.)									
	Shortwave Radio Access (No Additional Cost)									
	Wireline Communication DS0 from Data Loading		0.6	1.2			Current Price Structure		0.6	
	(see Common Equipment in Section 5.6)						from GTE			
	Emergency Traffic Management Staff not Included									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-10 TMC INCIDENT DISPATCH COORDINATION/COMMUNICATION, (TMS10)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Input to In-Vehicle Signing (TMS11)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	45	55			Estimate Per Loral, Rockwell		45	
	Software Installation and 1 year Maintenance	5	18	22			Experience in Similar		18	
							Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Operator (1 for 4 hours per day at $100,000)		45	55					45	
	Weather Advisory Reporting		9	11					9	
	Shortwave Communication to Beacons		13.5	16.5					13.5	
	No Other Additional Staff as Operations are Automated									
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-11 TMC INPUT TO IN-VEHICLE SIGNING, (TMS11)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Multi-Modal Coordination (TMS12)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	90	110			Estimate Per Loral, Rockwell		90	
	Software Installation and 1 year Maintenance	20	18	22			Experience in Similar		18	
							Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	TMC to TRMS Communication Line; DS1 Type	20	0.5	1			Existing Technology		0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Additional Staff (2) @ $75,000 each		135	165					135	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	TRMS Wireline Communication DS1 from Data Loading		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-12 TMC MULTI-MODAL COORDINATION, (TMS12)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Probe Information Collection (TMS13)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	135	165			Estimate Per Loral, Rockwell		135	
	Software Installation and 1 year Maintenance	5	18	22			Experience in Similar		18	
	Hardware (1 Workstation)	3	5	10			Integration Projects		5	
	Note : Software is off-the-shelf technology and unit price does not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Operator (1 for 4 hours per day at $100,000)		45	55					45	
	Maintenance for Power, Servicing and Repair (10% of Capital Cost)		16	19					16	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-13 TMC PROBE INFORMATION COLLECTION, (TMS13)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Toll/Parking Coordination (TMS14)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software Installation and 1 year Maintenance	5	22.5	27.5			Estimate Per Loral, Rockwell		22.5	
	Integration	20	90	110			Experience in Similar		90	
							Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	TMC to PMS Communications Line; DS1 Type	20	0.5	1			Existing Technology		0.5	
	TMC to TAS Communications Line; DS0 Type	20	0.5	1			Existing Technology		0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance @ 5% of Capital Cost		6	7					6	
	PMS Wireline Communication DS1 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		4.8	8.4			from GTE		4.8	
	TAS Wireline Communication DS0 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-14 TMC TOLL/PARKING COORDINATION, (TMS14)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Traffic Information Dissemination (TMS15)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Hardware (1 Workstation)	5	5	10			Existing Site Installations		5	
	Software	5	18	22			Prices from New England		18	
	Integration	20	90	110			and Virginia Projects per LBA		90	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	TMC to Event Communications Line; DS0 Type	20	0.5	1			Existing Technology		0.5	
	TMC to ISP Communications Line; DS3 Type	20	3	5			Existing Technology		3	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Operator (1) @ $100,000		90	110					90	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	Maintenance @ 5% of Capital Cost		5	7					5	
	Shortwave Radio Access		0	0						
	ISP Wireline Communication DS3 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		24	72			from GTE		24	
	Other Wireline Communication DS0 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		0.6	1.2			from GTE		0.6	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-15 TMC TRAFFIC INFORMATION DISSEMINATION, (TMS15)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

TMC Traffic Network Performance Evaluation (TMS16)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Hardware (5 Workstations)	5	13.5	16.5			Estimate Per Loral, Rockwell		13.5	
	Software (Off-the-shelf and developed)	5	450	550			Experience in Similar		450	
	Integration with other Servers at TMC	20	180	220			Integration Projects		180	
	Integration with ISP and TMS	20	180	220					180	
	TMC TO PS Communication Line; DS3 Type	20	3	5			Existing Technology		3	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Transportation Engineers / Analysts (5 at avg. $100,000)		450	550					450	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	Maintenance of system components @ 5% of Capital Cost		23	28					23	
	PS Wireline Communication DS3 from Data						Current Price Structure			
	Loading (see Common Equipment in Section 5.6)		24	72			from GTE		24	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-16 TMC TRAFFIC NETWORK PERFORMANCE EVALUATION, (TMS16)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Traffic Maintenance (TMS17)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software and Database Add-on to TMS5 & TMS6	5	20	40			Estimate per LBA		20	
	Communication Line to TAS through TMS1 & TMS14									
	Communication Line to TMC's through TMS4									
	Communication Line to ISP through TMS1 & TMS15									
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Additional Staff - 1 Transportation Engineer @ $100,000		90	110					90	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.16-17 TRAFFIC MAINTENANCE, (TMS17)

4.6.17. Transit Management Subsystem (TRMS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Fleet Maintenance Management	TRM1
Transit Center Fare and Load Management	TRM2
Transit Center Fixed-Route Operations	TRM3
Transit Center Multi-Modal Coordination	TRM4
Transit Center Paratransit Operations	TRM5
Transit Center Security	TRM6
Transit Center Tracking and Dispatch	TRM7

The Transit Management Subsystem (TRMS) is the centralized control center for providing transit planning, scheduling, operation planning, personnel scheduling, and maintenance scheduling, and paratransit interface. The architecture is designed to allow one center to provide services to any number of independent public transit operators, or to accommodate multiple interconnected centers. The information generated from each operator is centrally managed by the Transit Management Center. This information is in turn shared with the TMC, ISP and PS subsystems to provide complete public transportation information.

In the cost estimate, a Transit Management Center exists. This existing center performs non-ITS operations, scheduling and other planning activities. It is assumed that the physical structure that houses the operations staff, maintenance personnel, and equipment is in-place. It is also assumed that the maintenance staff, public transport vehicle operators, paratransit operators, dispatchers and other operations staff are already in-place, and would exist as a public transit expense without the introduction of ITS. Only the incremental expense of incorporating ITS functions is included in the cost analysis.

It is assumed that the basic communication lines are in-place, and that only those changes necessary to incorporate the additional capabilities are included. The Non-recurring expense is attributable to hardware required to implement the communication system. The Recurring expense is attributable to the dedicated line charges as required capacity is noted from the data loading analysis. Previous detail on this wireline and wireless communication expenditures is located in section 4.6 under common equipment.

Each Equipment Package is described below.

4.6.17.1 Fleet Maintenance Management, (TRM1)

This Equipment Package provides the capability to use vehicle mileage data to automatically generate preventative maintenance schedules for each specific vehicle by utilizing vehicle tracking data from the prerequisite tracking Equipment Package (TRM7). In addition, capability to automatically ensure that proper service personnel are provided information for maintenance activities and to record and verify that maintenance work was performed is

provided. These capabilities are performed utilizing fleet management software. This package tracks and processes maintenance records for each vehicle, balances the maintenance schedule with the operation schedule, as well as performs scheduling activities for maintenance and operations staff. Components include software and processor, communication links, operations building, staff and maintenance staff. It is assumed that the maintenance staff and operation staff are already included in the No ITS Baseline. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.17.2 Transit Center Fare and Load Management, (TRM2)

This Equipment Package provides the capability to accept collected data required to determine accurate ridership levels and implement variable and flexible fare structures. Support is provided for the traveler for use of a fare medium for all applicable surface transportation services, to pay without stopping, have payment media automatically identified as void and/or invalid and eligibility verified, and allow for third party payment. In addition, capability to provide expansion into other uses for payment medium such as retail and telephone and for off-line billing for fares paid by agencies is supported. This Equipment Package also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility, sensor data to be transmitted from the transit vehicles to a facility, and data transmission from individual facilities to a central facility for processing/analysis if desired. These capabilities are provided through a workstation type processor with GUI, high capacity storage, ride share software housed in a building with dialup lines and wireline telephone as provided in the prerequisite packages TRM3 and TRM7. Additional communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.17.3 Transit Center Fixed-Route Operations, (TRM3)

This Equipment Package provides the capability to automate the planning and scheduling, allowing improvements in fixed-route routes and services to develop, printing and disseminating schedules, and automatically updating customer service operator systems with the most current schedule. In addition, this package provides the capability to assign drivers to routes in a fair manner while minimizing labor and overtime services, including driver preferences and qualifications, and automatically tracking and validating the number of work hours performed by each individual driver. These capabilities are provided through the utilization of dispatch and fleet management software running on a workstation type processor, located in package TRM7. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.17.4 Transit Center Multi-Modal Coordination, (TRM4)

This Equipment Package provides the transit management subsystem the capability to determine the need for transit priority on routes and at certain intersections and request transit

vehicle priority at these locations. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.17.5 Transit Center Paratransit Operations, (TRM5)

This Equipment Package provides the capability to automate the planning and scheduling, allowing improvements in paratransit routes and services to develop, printing and disseminating schedules, and automatically updating customer service operator systems with the most current schedule. In addition, this package provides the capability to assign drivers to routes in a fair manner while minimizing labor and overtime services, including driver preferences and qualifications, and automatically tracking and validating the number of work hours performed by each individual driver

The package facilitates other processes providing responses to overall travel demands that are outside the realm of regularly scheduled public transit services. The components include software and processor, a display, a transceiver, communications links, operations building, staff and maintenance. Communication wirelines are included in TRM7.

4.6.17.6 Transit Center Security, (TRM6)

This Equipment Package provides the capability to monitor key transit locations and transit vehicles with both video and audio systems automatically alerting operators and police of potential incidents and supporting traveler activated alarms. The monitoring equipment also include capabilities to assist in responding to terrorist incidents. Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

4.6.17.7 Transit Center Tracking and Dispatch, (TRM7)

This Equipment Package provides the capabilities for monitoring transit vehicle locations in real time and determining vehicle schedule adherence. In addition, capability to determine optimum scenarios for schedule adjustment is provided. The package also furnishes users with real-time travel related information, continuously updated with real-time information from each transit system within the local area of jurisdiction, inclusive of all transportation modes, from all providers of transportation services, and provide users with the latest available information on transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents conditions, weather conditions, and special events. This package also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility.

A dedicated processor is required with sufficient memory to store all incoming processed sensors, and data, to determine public transit vehicle traffic management strategies, planning vehicle operations and scheduling. The software and processor also provides data base information to the TMC. Operator stations are required with monitors and input keyboards.

Communication wirelines are sized according to the data loading analysis, as described in the common equipment section 4.6, above.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Fleet Maintenance Management (TRM1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	100	200			Per Loral, Rockwell		100	
	Processor / Software Upgrades	20	20	40			Experience in similar		20	
							Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	Communication Line DS1 Maintenance	20	0.5	1					0.5	
	Maintenance Facility Communications Line; DS1 Type									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for System @ 2% of Capital Cost		2.4	4.8					2.4	
	Wireline Communication DS1 from Data Loading		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.17-1 FLEET MAINTENANCE MANAGEMENT, (TRM1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Transit Center Fare and Load Management (TRM2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	250	500			Per Loral, Rockwell		250	
	Software Upgrade	20	40	60			Experience in similar		40	
							Integration Projects			
	Communication DS1 Line to Enforcement Agency	20	0.5	1			Existing Technology		0.5	
	Communication DS0 Line to PS	20	0.5	1					0.5	
	Communication DS0 Line to Financial Institution	20	0.5	1					0.5	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Software @ 2% of Capital Cost		0.8	1.2					0.8	
	Enforcement Agency Wireline Communication DS1 from Data		4.8	8.4			Current Price Structure		4.8	
	Loading (see Common Equipment in Section 5.6)						from GTE			
	PS Wireline Communication DS0 from Data		0.6	1.2			Current Price Structure		0.6	
	Loading (see Common Equipment in Section 5.6)						from GTE			
	Financial Institution Wireline Communication DS0 from Data		0.6	1.2			Current Price Structure		0.6	
	Loading (see Common Equipment in Section 5.6)						from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.17-2 TRANSIT CENTER FARE AND LOAD MANAGEMENT, (TRM2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Transit Center Fixed-Route Operations (TRM3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	225	500			Per Loral, Rockwell		225	
	Processor/Software Upgrade, Installation and 1 yr. Maintenance	20	20	40			Experience in similar		20	
							Integration Projects			
	Communication DS3 Line to Operations	20	3	5					3	
	Communication DS1 Line to Operations	20	0.5	1					0.5	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Add'l. Staff (3) Salary and Benefits @ $75,000 each average		202	247					202	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	Maintenance for Processor @ 2% of Capital Cost		0.4	0.8					0.4	
	Operations Wireline Communication DS3 from Data		24	72			Current Price Structure		24	
	Loading (see Common Equipment in Section 5.6)						from GTE			
	Operations Wireline Communication DS1 from Data		4.8	8.4			Current Price Structure		4.8	
	Loading (see Common Equipment in Section 5.6)						from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.17-3 TRANSIT CENTER FIXED-ROUTE OPERATIONS, (TRM3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Transit Center Multi-Modal Coordination (TRM4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	90	110			Estimate Per Loral, Rockwell		90	
	Software and Local DB Add-on	20	18	22			Experience in Similar		18	
	Note : Software is off-the-shelf technology and unit price does						Integration Projects			
	not reflect product development.									
	Workstation	10	5	10			Existing Technology		5	
	Communication Line to RTS4 & EM Through DS0 Type Line	20	0.5	1			Existing Technology		0.5	
	Communication Line to PS through DS1 Type Line	20	0.5	1			Existing Technology		0.5	
	Communication Line to other TRM's through DS1 Type Line	20	0.5	1			Existing Technology		0.5	
	Communication Line to Intermodal Transportion Service Provider									
	through DS3 Type Line	20	3	5			Existing Technology		3	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Processor @ 2% of Capital Cost		0.4	0.5					0.4	
	Maintenance for Workstation @ 5% of Capital Cost		0.2	0.5					0.2	
	RTS & EM Wireline Communications DS0 from Data Loading		0.6	1.2			Current Price Structure		0.6	
	(see Common Equipment in Section 5.6)						from GTE			
	PS Wireline Communication DS1 from Data Loading		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			
	TRM Wireline Communication DS1 from Data Loading		4.8	8.4			Current Price Structure		4.8	
	(see Common Equipment in Section 5.6)						from GTE			
	Wireline Communication DS3 from Data Loading		24	72			Current Price Structure		24	
	(see Common Equipment in Section 5.6)						from GTE			
	Intermodal Transportation Service Provider									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.17-4 TRANSIT CENTER MULTI-MODAL COORDINATION, (TRM4)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Transit Center Paratransit Operations (TRM5)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	100	200			Per Loral, Rockwell		100	
	Processor/Software Upgrade, Installation and 1 yr. Maintenance	20	40	60			Experience in similar		40	
							Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	Communication included in TRM7									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Processor @ 2% of Capital Cost		0.8	1.2					0.8	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.17-5 TRANSIT CENTER PARATRANSIT OPERATIONS, (TRM5)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Transit Center Security (TRM6)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Video Monitors (5 per site)	10	15	20			Existing Technology		15	
	Integration	20	250	500			Per Loral, Rockwell		250	
	Server	10	40	60			Experience in similar		40	
							Integration Projects			
	Workstations (3)	10	15	30			Existing Technology		15	
							Workstation for			
							Operator Interface			
	Communication Line DS0 to Remote CATV's	20	0.5	1					0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Additional Staff (3) @ $75,000 each average		202	247					202	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	Maintenance for Video Monitors @ 5% of Capital Cost		0.8	1					0.8	
	Maintenance for Server @ 2% of Capital Cost		0.8	1.2					0.8	
	Maintenance for Workstations @ 2% of Capital Cost		0.3	0.6					0.3	
	Remote CATV Wireline Communication DS0 from Data		0.6	1.2			Current Price Structure		0.6	
	Loading (see Common Equipment in Section 5.6)						from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.17-6 TRANSIT CENTER SECURITY, (TRM6)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Transit Center Tracking and Dispatch (TRM7)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Vehicle Location Interface	20	10	15			Existing Technology		10	
	TMS Communication line; DS1 Type	20	0.5	0.1					0.5	
	PIAS & Others Communication Line; DS0 Type	20	0.5	1					0.5	
	Communication Line DS3 (2) 1 Line to ISP & 1 Line to RTS	20	6	10					6	
	Vehicle Tracking & Scheduling	20	40	100			Per Loral, Rockwell		40	
	Database and Information Storage	20	20	40			Experience in similar		20	
	Schedule Adjustment Software	20	40	80			Integration Projects		40	
	Real Time Travel Information Software	20	215	500					215	
	Integration	20	500	1000					500	
	Workstations (3)	10	15	30			Existing Technology		15	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Building Space (Add'l. req'd. for ITS tech. - $12-18 / S.F., 500 S.F.)		6	9					6	
	Database Management Contract @ 10% of DB Scheduling		6	1.2					6	
	Additional Staff (3) @ $75,000 each		202	247					202	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	TMS Wireline Communication DS1 from Data		4.8	8.4			Current Price Structure		4.8	
	Loading (see Common Equipment in Section 5.6)						from GTE			
	PIAS & Others Wireline Communication DS0 from Data		0.6	1.2					0.6	
	Loading (see Common Equipment in Section 5.6)									
	ISP Wireline Communication DS3 from Data		24	72					24	
	Loading (see Common Equipment in Section 5.6)									
	RTS Wireline Communication DS3 from Data		24	72					24	
	Loading (see Common Equipment in Section 5.6)									

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.17-7 TRANSIT CENTER TRACKING AND DISPATCH, (TRM7)

4.6.18. Transit Vehicle Subsystem (TRVS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
On-board Maintenance	TRV1
On-board Transit Driver I/F	TRV2
On-board Transit Fare and Load Management	TRV3
On-board Transit Security	TRV4
On-board Trip Monitoring	TRV7
On-board Vehicle Signal Coordination	TRV5
Vehicle Dispatch Support	TRV6

In determining the communication expenses for these Equipment Packages, the following assumptions were used. The wireless data loading communication usage for TRV2, TRV3, and TRV7, are based on the following additional assumptions.

1 (Transit services for vehicle fares) is performed at the end of the day in the yard via U2 interface not by CDPD. This removes the data flow from the CDPD cost equation, and is key to reducing the unit price per vehicle. Other data flows for this Equipment Package utilize CDPD communications.

2. The dataflow from TRVS to TRMS for loading etc., is sent every two minutes.

These changes have been made from the data loading analysis to create more realistic data rates. The resulting utilization for these Equipment Packages are: TRV2 required usage 820 Kbytes per month; TRV3 required usage 2,360 Kbytes per month; TRV7 required usage 3,180 Kbytes per month

Typical equipment for each Equipment Package is described below.

4.6.18.1 On-board Maintenance, (TRV1)

This Equipment Package provides the capability to use transit vehicle mileage data to automatically generate preventative maintenance schedules for each specific bus by utilizing vehicle tracking data and storing with a trip computer. It also provides the capability for real-time condition monitoring on board the vehicle, and transmission of this information via two-way communication to the management center. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

4.6.18.2 On-board Transit Driver I/F, (TRV2)

This Equipment Package provides the capabilities for automated planning and scheduling, by collecting data for schedule generation. Capability is also provided to automatically determine optimum scenarios for schedule adjustment. The Equipment Package also

furnishes transit travelers with real-time travel related information, continuously updated with real-time information from each transit system within the local area of jurisdiction, inclusive of all transportation modes, from all providers of transportation services, and provide users with the latest available information on transit routes, schedules, transfer options, fares, real-time schedule adherence, current incidents conditions, weather conditions, and special events. This package also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility, on-board safety sensor data to be transmitted from the transit vehicles to a facility, and data transmission from individual facilities to a central facility for processing/analysis if desired. These communication capabilities are provided through cell based radio system. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above. Vehicle location is provided through TRV7.

4.6.18.3 On-board Transit Fare and Load Management, (TRV3)

This Equipment Package provides the capability to collect data required to determine accurate ridership levels and implement variable and flexible fare structures. Support is provided for the traveler for use of a fare medium for all applicable surface transportation services, to pay without stopping, have payment media automatically identified as void and/or invalid and eligibility verified, and allow for third party payment. In addition, capability to provide expansion into other uses for payment medium such as retail and telephone and for off-line billing for fares paid by agencies is supported. This Equipment Package also supports the capability for two-way voice communication between the transit vehicle driver and a facility, two-way data communication between the transit vehicles and a facility, sensor data to be transmitted from the transit vehicles to a facility, and data transmission from individual facilities to a central facility for processing/analysis if desired. These capabilities require integration with the TRV2 Equipment Package cell based radio for communication. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

4.6.18.4 On-board Transit Security, (TRV4)

This Equipment Package provides the capability to monitor the safety of transit vehicles using on-board video images, as well as other safety sensors, processors and communications from the prerequisite On-board Transit Driver Interface Equipment Package (TRV2). Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

4.6.18.5 On-board Trip Monitoring, (TRV7)

This Equipment Package provides the Transit Vehicle Subsystem the capabilities to support fleet management with automatic vehicle location and automated mileage and fuel reporting and auditing. This includes only the equipment on board the vehicle to support this function including the vehicle location devices such as GPS equipment, communication interfaces, a

processor to record trip length, and the sensors/actuators/interfaces necessary to record mileage and fuel usage. The prerequisite equipment in TRV2 is required for communications. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

4.6.18.6 On-board Vehicle Signal Coordination, (TRV5)

This Equipment Package provides the capability for vehicles to request signal priority or preemption, through communication either to the roadside or to the traffic management center. This equipment is independent of other packages. However, the package deployment must be coordinated with the TMS and RS subsystems Equipment Packages for signal control.

4.6.18.7 Vehicle Dispatch Support, (TRV6)

This Equipment Package forwards dispatch requests to the driver and forwards acknowledgements to the center. This Equipment Package also supports display and operator coordination for demand response transactions. This package relies on the existence of the equipment in TRV2. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board Maintenance (TRV1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Transit Vehicle Communications Interface	10	1	2			Existing Technology		1	
	Mileage & End Reporting Sensors	10	0.25	0.5			Existing Technology		0.25	
	On-board Processor for Trip Reporting and Data Storage	10	0.1	0.15			Comparable to 286 CPU		0.1	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication Med from Data		0.6	0.7			Current Price Structure		0.6	
	Loading (see Common Equipment in Section 5.6)						from GTE			
	Maintenance for Sensors @ 2% of Capital Cost		0.01	0.02					0.01	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Communications Interface @ 5% of Capital Cost		0.05	0.1					0.05	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.18-1 ON-BOARD MAINTENANCE (TRV1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board Transit Driver I/F (TRV2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Cell Based Radio w/ Data Capacity	10	0.15	0.25			Current Technology Price		0.15	
							Range 0.1 to 1.0			
	On-board Schedule Processor & DB	10	0.3	0.5			Comparable Technology		0.3	
							286 CPU w/ Database			
	On-board TV Monitor w/ Real Time Schedule & DB Interface	10	4	5			Existing Technology in		4	
	for fare, routes, incidents, weather						Transit Facilities			
	On-board Safety Sensor Manually Operated	2	0.1	0.15			Existing Technology		0.1	
							"Panic Button"			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Driver to Facility & Vehicle Display to Facility Wireless		0.18	0.2			Current Price Structure		0.18	
	CDPD Communications Medium Use		0.6	0.6			from GTE		0.6	
	Maintenance for Cell Radio @ 5% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for CATV @ 5% of Capital Cost		0.2	0.25					0.2	
	Maintenance for Safety Sensor @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.18-2 ON-BOARD TRANSIT DRIVER I/F, (TRV2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board Transit Fare and Load Management (TRV3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	On-board Ridership Sensor System	10	0.4	0.6			Existing Technology		0.4	
	On-board Flex Fare System DBX Processor	10	0.3	0.5			Comparable Technology		0.3	
	On-board Farebox & Smart Card Reader	10	0.5	1			286 CPU w/ DB		0.5	
							Ref. FTA & Sandia Nat'l Labs			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Driver to Facility & Vehicle Display to Facility Wireless		0.18	0.2			Current Price Structure		0.18	
	CDPD Communications High		1.2	1.4			from GTE		1.2	
	Maintenance for Sensors @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Farebox @ 5% of Capital Cost		0.01	0.05					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.18-3 ON-BOARD TRANSIT FARE AND LOAD MANAGEMENT, (TRV3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board Transit Security (TRV4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	On-board Safety Sensor Processor	10	0.1	0.15			Comparable Technology		0.1	
							286 CPU w/ DB			
	On-board CCTV	10	4	5			Existing Technology		4	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication Low for Video Processing from Data		0.18	0.2			Current Price Structure		0.18	
	Loading (see Common Equipment in Section 5.6)						from GTE			
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for CCTV @ 5% of Capital Cost		0.2	0.25					0.2	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.18-4 ON-BOARD TRANSIT SECURITY, (TRV4)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board Trip Monitoring (TRV7)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Processor/Trip Computer	10	0.1	0.15			Existing Technology		0.1	
	Automated Mileage & Fuel Reporting Sensors Communications	10	0.25	0.5			Comparable Technology		0.25	
	Interface through TRV2						286 CPU w/ DB			
	AVL - GPS/DGPS	10	0.5	0.8			Current Price Structure		0.5	
							(Ref. GPS World)			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communications High Plus Excess Use		1.308	1.499			Current Price Structure		1.308	
							from GTE			
	Maintenance for Trip Computer @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Censors @ 5% of Capital Cost		0.01	0.02					0.01	
	Maintenance for GPS/DGPS @ 2% of Capital Cost		0.01	0.02					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.18-5 ON-BOARD TRIP MONITORING, (TRV7)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

On-board Vehicle Signal Coordination (TRV5)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	On-board Processor & DB	10	0.3	0.5			Comparable Technology		0.3	
							286 CPU w/ DB			
	Cell Based Radio System & Data Transceiver Capability	10	0.15	0.25			Current Technology Voice		0.15	
							Radios (0.1 to 1.0)			
	GPS/DGPS	10	0.5	0.8			Current Price Structure		0.5	
							(Ref. GPS World)			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Cell Radio @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for GPS/DGPS @ 2% of Capital Cost		0.01	0.02					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.18-6 ON-BOARD TRIP MONITORING, (TRV5)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Dispatch Support (TRV6)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	No New Equipment									
	Relies on TRV2									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication Low from Data		0.18	0.2			Current Price Structure		0.18	
	Loading (see Common Equipment in Section 5.6)						from GTE			

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.18-7 ON-BOARD VEHICLE DISPATCH SUPPORT, (TRV6)

4.6.19. Personal Vehicle Subsystem (VS)

This subsystem contains the following Equipment Packages:

Equipment Package Name	Descriptor
Basic Vehicle Reception	VS1
Driver Safety Monitoring System	VS2
Driver Visibility Improvement System	VS3
In-Vehicle Signing System	VS4
Interactive Vehicle Reception	VS5
Probe Vehicle Software	VS6
Smart Probe	VS7
Vehicle Intersection Collision Warning	VS8
Vehicle Intersection Control	VS9
Vehicle Lateral Control	VS10
Vehicle Lateral Warning System	VS11
Vehicle Longitudinal Control	VS12
Vehicle Longitudinal Warning System	VS13
Vehicle Mayday I/F	VS14
Vehicle Pre-Crash Safety Systems	VS15
Vehicle Route Guidance	VS16
Vehicle Safety Monitoring System	VS17
Vehicle Systems for AHS	VS18
Vehicle Toll/Parking I/F	VS19

Each Equipment Package is described below.

4.6.19.1 Basic Vehicle Reception, (VS1)

This Equipment Package provides the capability for drivers to interface with the ISP Subsystem's Basic Information Broadcast Equipment Package and receive formatted traffic advisories including accurate traveling information concerning available travel options and their availability, and congestion information in their vehicle. These capabilities are based upon the reception of infrastructure information using in-vehicle devices such as an in-vehicle AM/FM radio with data subcarrier connected with the existing audio system and a dash-mounted LCD. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

4.6.19.2 Driver Safety Monitoring System, (VS2)

This Equipment Package provides the capability to determine the driver's condition and warn the driver of potential dangers. This package includes driver sensors to assess the suitability of the driver (e.g., fitness and alertness) to assume manual control of the vehicle.

4.6.19.3 Driver Visibility Improvement System, (VS3)

The Equipment Package provides the capability to augment the vehicle operator's ability to see objects in the vehicle path in conditions where driving visibility is poor (e.g., bad weather, night driving, etc.). These capabilities are provided using equipment such as on-board sensor system (e.g., an infrared sensor system) to create images that in turn could be relayed to the driver using a heads-up display. The on-board systems to implement this package include a local sensor system, an image creation and processing capability, and a visual display to the driver.

4.6.19.4 In-Vehicle Signing System, (VS4)

This Equipment Package provides the capability to assist individuals with impaired vision, individuals needing local guidance in areas that the driver is unfamiliar, and implemented in a manner that augments existing signs. This package also provides the capability to customize warnings, utilize data from roadside environmental sensors, and provide travelers with information on road conditions and with precautionary reminder messages. These capabilities are provided through the use of equipment such as an interface to active tag reader and processor to display the information from the active tag. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

4.6.19.5 Interactive Vehicle Reception, (VS5)

This Equipment Package provides the capability for drivers to interface with the ISP Subsystem's Infrastructure Equipment Packages including the Interactive Infrastructure Information Equipment Package, the Infrastructure Provided Route Selection, Yellow Pages and Reservation, and Dynamic Ridesharing Equipment Packages. A prerequisite Equipment Package for this service is VS16. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

4.6.19.6 Probe Vehicle Software, (VS6)

This Equipment Package includes capabilities for the probe vehicle to identify its location, measure traffic conditions such as link travel time and speed and possibly environmental hazards such as icy road conditions, and transmit these data to either the ISP or TMC. A prerequisite Equipment Package for this service is VS16. Wireless communications are provided in VS16, Vehicle Route Guidance.

4.6.19.7 Smart Probe, (VS7)

This Equipment Package provides for Vehicle Probes with added capability and intelligence to sense and send road conditions as the vehicle travels. Road conditions may include weather and roadway surface conditions, potholes, rough road in addition to speeds.

Communication functionality may be provided as part of VS16, Vehicle Route Guidance or independently with a vehicle tag.

4.6.19.8 Vehicle Intersection Collision Warning, (VS8)

This Equipment Package provides the capability for the detection of an impending collision with a moving or stationary object prior to crash impact in an intersection with notification provided to the driver of the presence of potentially hazardous situations and need for immediate collision avoidance action. These capabilities are provided through the use of equipment such as an intersection hazard warning sensor and actuator.

4.6.19.9 Vehicle Intersection Control, (VS9)

This Equipment Package provides the capability for the detection of an impending collision with a moving or stationary object prior to crash impact in an intersection and automatically avoid the intersection collision. These capabilities are provided through the use of equipment such as an intersection hazard warning sensor and actuator.

4.6.19.10 Vehicle Lateral Control, (VS10)

This Equipment Package provides the capability for lateral control of a vehicle on roads to allow “hands off” driving, automating the steering control function. This capability is provided through the use of equipment provided to detect lanes, obstacles or vehicles to the sides of the vehicle. This sensor information is processed on board the vehicle, and appropriate steering control actions are initiated using steering actuators. Appropriate lane maintenance may thus be maintained automatically.

4.6.19.11 Vehicle Lateral Warning System, (VS11)

This Equipment Package allows for lateral warning. It utilizes safety sensors and collision sensors . It requires on-board sensors to monitor the areas to the sides of the vehicle and present warnings to the driver about potential hazards.

4.6.19.12 Vehicle Longitudinal Control, (VS12)

This Equipment Package provides the capability for longitudinal control of a vehicle on roads to allow “feet off” driving, automating the function of speed control, acceleration, and braking. This capability is provided through the use of equipment to detect obstacles or vehicles in the longitudinal path of the vehicle. This sensor information is processed on board the vehicle, and appropriate control actions (acceleration, braking, or maintaining speed) are initiated using accelerator and/or brake actuators. Appropriate following distances may thus be maintained automatically.

4.6.19.13 Vehicle Longitudinal Warning System, (VS13)

This Equipment Package allows for longitudinal warning. It utilizes safety sensors and collision sensors. It requires on-board sensors to monitor the areas in front of and behind the vehicle and present warnings to the driver about potential hazards.

4.6.19.14 Vehicle Mayday I/F, (VS14)

This Equipment Package provides the capability for an in-vehicle manually initiated distress signal with capability to cancel a prior issued manual request for help. This capability includes automatically identifying that a collision had occurred using equipment such as collision detection sensors with interface to MAYDAY type equipment that would automatically detect vehicle problems and for some cases, automatically send appropriate distress signals to the Emergency Management Subsystem. This equipment is similar in nature to that of PIAS Personal Mayday I/F Equipment Package. The vehicle location information for this package is provided through the prerequisite Equipment Package VS16. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

4.6.19.15 Vehicle Pre-Crash Safety Systems, (VS15)

This Equipment Package provides the capability to sense local conditions, determine collision probability, and deploy a pre-crash safety system. These capabilities are provided by equipment such as on-board sensors to determine the location or distance away and closing rates of neighboring vehicles or other roadway obstacles. These detection systems are supplemented by additional sensors for existing weather and roadway conditions and roadway geometry. A processor in the vehicle assimilates this information and determine the probability of a collision with the other vehicle or obstacle. If the collision probability is high, it deploys a pre-crash safety system either to avoid the accident or to reduce the accident severity.

4.6.19.16 Vehicle Route Guidance, (VS16)

This Equipment Package provides the capability of Route Guidance. Thus, this package provides the capability to receive travel information from the infrastructure, but perform the route planning process in the vehicle. These capabilities are provided using equipment such as a processor with GIS software and GUI using communication medium and equipment such as mobile satellite telephone or cellular telephone. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

4.6.19.17 Vehicle Safety Monitoring System, (VS17)

This Equipment Package provides the capability to diagnose critical components of the vehicle and warn the driver of potential dangers. These capabilities use equipment such as a

set of on-board sensors to monitor continuously the vehicle condition and performance, including steering, braking, acceleration, emissions, fuel economy, engine performance, etc. Problems with any of these systems are identified using processors on board the vehicle, providing a timely display to the driver of the situation. The sensors provide warnings to the driver in the event of a serious condition (e.g., likely failure or damage). A prerequisite Equipment Package for this service is VS16 for the GUI capability.

4.6.19.18 Vehicle Systems for AHS, (VS18)

This Equipment Package provides the capability for "hands-off" and "feet off" operations of an equipped vehicle on the automated portion of the highway system including the longitudinal control, lateral control for lane change/merge and roadway departure, regulating the vehicle speed and steering control, and sensing impending hazards and responding appropriately. These capabilities are provided by systems on board the vehicle to regulate longitudinal and lateral control maneuvers, including acceleration, braking, and steering functions. The capability to control access to the automated highway system is provided through an automated check-in procedure in which the vehicle and driver are checked for their fitness.

4.6.19.19 Vehicle Toll/Parking I/F, (VS19)

This Equipment Package provides the capability for vehicle operators to pay toll without stopping their vehicles and pay for parking without the use of cash. These capabilities are provided through the use of equipment such as an active tag interface and debit/credit card interface. Wireless communications are provided in accordance with the data loading analysis, as described in the common equipment section 4.6, above.

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Basic Vehicle Reception (VS1)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	In Vehicle AM/FM Radio w/data subcarrier connection	7	0.15	0.18	$1x10^5$	$1x10^6$	Exist. Technology		0.15	
	Existing Audio System		0	0			Exist. Technology			
	Dash Mounted LCD	7	0.05	0.1	$1x10^5$	$1x10^6$	Exist. Technology		0.05	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication Low from Broadcast		0	0						

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-1 BASIC VEHICLE RECEPTION, (VS1)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Driver Safety Monitoring System (VS2)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Safety Collection Processor and Software	7	0.03	0.05	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.03	
	Driver Condition Sensors	7	0.4	0.8	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.4	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Sensors @ 5% of Capital Cost		0.02	0.04					0.02	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-1 DRIVER SAFETY MONITORING SYSTEM, (VS2)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Driver Visibility Improvement System (VS3)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	In-Vehicle Camera	7	0.4	0.6	$1x10^5$	$1x10^6$	Per Loral, Rockwell		0.4	
	Software and Processor	7	0.1	0.2	$1x10^5$	$1x10^6$	Exper. in similar		0.1	
	Heads-Up Display	7	0.5	1	$1x10^5$	$1x10^6$	Integration Projects		0.5	
	Infra-red Sensors (Local sensor system)	7	0.2	0.4			Comparative Technology		0.2	
							Night Vision Enhancement			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Display @ 5% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Sensors @ 5% of Capital Cost		0.03	0.05					0.03	
	Maintenance for Camera @ 5% of Capital Cost		0.01	0.02					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-3 DRIVER VISIBILITY IMPROVEMENT SYSTEM, (VS3)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

In-Vehicle Signing System (VS4)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Interface to Active Tag Reader	7	0.05	0.1	$1x10^5$	$1x10^6$	Per Loral, Rockwell exper. in		0.05	
	Processor for Active Tag Decode	7	0.05	0.1	$1x10^5$	$1x10^6$	Similar Integration Projects,		0.05	
	Display device for messages	7	0.06	0.2	$1x10^5$	$1x10^6$	and Seimens Automotive Est.		0.06	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication Low from Short Range System		0	0						
	Maintenance for Equipment @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-4 IN-VEHICLE SIGNING SYSTEM, (VS4)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Interactive Vehicle Reception (VS5)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software and Processor Upgrade	7	0.1	0.15	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.1	
	Note : Software is off-the-shelf technology and unit price does not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Monthly ISP Service Fee ($5-$10/per month)		0.06	0.12					0.06	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-5 INTERACTIVE VEHICLE RECEPTION, (VS5)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Probe Vehicle Software (VS6)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software and Processor for communication to roadside	7	0.05	0.15	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.05	
	infrastructure, Signal Generator, Message Generator									
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication Included in VS16						Current Price Structure			
	(see Common Equipment in Section 5.6)		0	0			from GTE			
	Maintenance for Equipment @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-6 PROBE VEHICLE SOFTWARE, (VS6)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Smart Probe (VS7)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Roadway Surface Sensors (roughness)	7	0.2	0.3			Ref. Seimens Automotive Est.		0.2	
	Roadway (temperature)	7	0.05	0.1			Ref. Seimens Automotive Est.		0.05	
	Air (temperature)	7	0.02	0.05			Existing Technology		0.02	
	Air (relative humidity)	7	0.05	0.1			Existing Technology		0.05	
	Air (relative wind - pilot tube)	7	0.05	0.1			Existing Technology		0.05	
	Software and Processor for transmission of data	7	0.1	0.2			Ref. Seimens Automotive Es		0.1	
	Active Tag	7	0.02	0.05	$1x10^5$	$1x10^6$	Exist. Technology		0.02	
	Tag Processor for Active Tag Decode	7	0.05	0.1	$1x10^5$	$1x10^6$	Exist. Technology		0.05	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	No Wireless Communication Cost from Data Loading		0	0						
	Maintenance for Equipment @ 2% of Capital Cost		0.009	0.016					0.0088	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-7 SMART PROBE, (VS7)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Intersection Collision Warning (VS8)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software / Processor for infrastructure transmitted information	7	0.05	0.1	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.05	
	Interface to In-Vehicle Signing and Audio System	7	0.03	0.05	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.03	
	Note : Software is off-the-shelf technology and unit price does not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Equipment @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-8 VEHICLE INTERSECTION COLLISION WARNING, (VS8)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Intersection Control (VS9)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Software and Processor to link to Longitudinal and Lateral	7	0.2	0.4	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.2	
	Vehicle Control Modules based on input signal from Vehicle									
	Intersection Collision Warning Equipment Package									
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Equipment @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-9 VEHICLE INTERSECTION CONTROL, (VS9)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Lateral Control (VS10)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Advanced Steering Control	7	0.5	0.6	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.5	
	Lane Sensors in Vehicle (proximity lateral sensors in separate	7	0.5	0.6	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.5	
	Equipment Package)									
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Equipment @ 2% of Capital Cost		0.02	0.02					0.02	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-10 VEHICLE LATERAL CONTROL, (VS10)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Lateral Warning System (VS11)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Lateral Sensors MMW Radar	7	0.3	0.5	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.3	
	In-Vehicle Display / Warning Interface	7	0.05	0.1	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.05	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Equipment @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-11 VEHICLE LATERAL WARNING SYSTEM, (VS11)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Longitudinal Control (VS12)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Adaptive Cruise Control									
	Automatic Braking	7	0.1	0.2	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.1	
	Automatic Accelerating	7	0.05	0.1	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.05	
	Note : Software is off-the-shelf technology and unit price does not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Equipment @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-12 VEHICLE LONGITUDINAL CONTROL, (VS12)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Longitudinal Warning System (VS13)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Longitudinal Sensors MMW Radar	7	0.3	0.5	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.3	
	In-Vehicle Display / Warning Interface	7	0.05	0.1	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.05	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Equipment @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-13 VEHICLE LONGITUDINAL WARNING SYSTEM, (VS13)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Mayday I/F (VS14)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Collision Detection Sensor	7	0.05	0.5	$1x10^5$	$1x10^6$	Existing Technology		0.05	
	Interface for Mayday Processor	7	0.1	0.15	$1x10^5$	$1x10^6$	comparable to Air bag sensors		0.1	
	I/F for Wireless Communication	7	0.1	0.15	$1x10^5$	$1x10^6$	& Mayday panic button services		0.1	
	Note : Software is off-the-shelf technology and unit price does not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Monthly ISP Service Fee (10-$15/per month)		0.12	0.18					0.12	
	Maintenance for Equipment @ 2% of Capital Cost		0.01	0.02					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-14 VEHICLE MAYDAY I/F, (VS14)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Pre-Crash Safety Systems (VS15)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Vehicle Condition Sensors	7	0.1	0.2	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.1	
	Vehicle Performance Sensors	7	0.4	0.6	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.4	
	Software / Processor	7	0.1	0.15	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.1	
	Interface to other Equipment Packages	7	0.4	1	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.4	
	Pre-crash Safety Systems Deployment Actuators	7	0.1	0.2	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.1	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Equipment @ 2% of Capital Cost		0.01	0.03					0.01	
	Maintenance for Sensors @ 5% of Capital Cost		0.03	0.04					0.03	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-15 VEHICLE PRE-CRASH SAFETY SYSTEMS, (VS15)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Route Guidance (VS16)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	GUI	7	0.05	0.1	$1x10^5$	$1x10^6$	Per Loral, Rockwell		0.05	
	GIS Software	7	0.2	0.3	$1x10^5$	$1x10^6$	Exper. in similar		0.2	
	Limited Processor	7	0.1	0.15	$1x10^5$	$1x10^6$	Integration Projects		0.1	
	GPS / DGPS	7	0.25	0.5			Current Prices (GPS World)		0.25	
	Wireless Data Transceiver	7	0.2	0.4	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.2	
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication Low from Data Loading						Current Price Structure			
	(see Common Equipment in Section 5.6)		0.18	0.2			from GTE		0.18	
	Monthly ISP Service Fee (10-$15/per month)		0.12	0.18					0.12	
	Maintenance for GPS @ 2% of Capital Cost		0.01	0.02					0.01	
	Maintenance for GUI @ 5% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Transceiver @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-16 VEHICLE ROUTE GUIDANCE, (VS16)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Safety Monitoring System (VS17)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Safety Collection Processor	7	0.03	0.05	$1x10^5$	$1x10^6$	Per Loral, Rockwell		0.03	
	Vehicle Condition Sensors (6 at $50 each)	7	0.18	0.3	$1x10^5$	$1x10^6$	Exper. in similar		0.18	
	Vehicle Data Storage	7	0.05	0.1	$1x10^5$	$1x10^6$	Integration Projects		0.05	
	Note : Software is off-the-shelf technology and unit price does not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Sensors @ 5% of Capital Cost		0.01	0.02					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-17 VEHICLE SAFETY MONITORING SYSTEM, (VS17)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Systems for AHS (VS18)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Short-range Vehicle to Vehicle Transceiver	7	0.2	0.3	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.2	
	Roadway Sensor I/F	7	0.2	0.3	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.2	
	Steering Actuator I/F	7	0.2	0.3	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.2	
	Turn Signal Actuator I/F	7	0.05	0.2	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.05	
	Longitudinal & Lateral Equipment Package I/F	7	0.2	0.3	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Est.		0.2	
	Vehicle Speed Control Sensors	7	0.2	0.3	$1x10^5$	$1x10^6$	Ref. Seimens Automotive Es		0.2	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Processor @ 2% of Capital Cost		0.01	0.02					0.01	
	Maintenance for Sensors @ 5% of Capital Cost		0.01	0.01					0.01	
	Maintenance for Transceiver @ 2% of Capital Cost		0.01	0.01					0.01	

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-18 VEHICLE SYSTEMS FOR AHS, (VS18)

Equipment Package Unit Price Worksheet

Equipment List and Price Ranges

Vehicle Toll/Parking I/F (VS19)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Active Tag Interface	7	0.02	0.05	$1x10^5$	$1x10^6$	Exist. Technology		0.02	
	Debit / Credit Card I/F	7	0.02	0.05	$1x10^5$	$1x10^6$	Exist. Technology		0.02	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Wireless Communication via Beacon		0	0						

** All prices are in thousands of 1995 dollars.*

FIGURE 4.6.19-19 VEHICLE TOLL/PARKING I/F, (VS19)

5. SAMPLE EXPENDITURE CALCULATIONS - MAJOR URBAN AREA

The Phase II cost evaluation of the National ITS Architecture includes an evaluation of three separate scenarios. Each scenario represents a typical deployment area and is to provide a frame of reference for similar implementations of the architecture. A high level description of the major urban area, Urbansville, is included in the Evaluatory Design Document. A more in-depth description of Urbansville is located in the "Urban Scenario Guide, Urbansville, Phase II" scenario description document. The scenario description is a common description utilized for numerous architecture evaluation activities, including: the cost evaluation, the data loading, benefit analysis, as well as technical performance analyses. Thus, the results of the various architecture evaluation activities are all based upon one common set of assumptions. These sets of assumptions are set forth in the Evaluatory Design Document. Additional assumptions that provide greater detail and justification are provided in this Cost Analysis Document in sections 4.6.1 through 4.6.19.

The cost analysis time frame evaluates deployment milestones as specified in the Phase II Deliverable Guidelines at the five, ten and twenty year stages in the deployment. Technology selection and developmental insights are based on these milestones equating to the calendar years 1997, 2002, and 2012, respectively.

5.1 Examination of Equipment Package Worksheets

Equipment Package Worksheets are included in the previous sections 4.6.1 through 4.6.19. Each worksheet lists equipment and price ranges for that equipment, including hardware and software, as well as operation (additional staffing) and maintenance requirements. The price ranges represent state-of-the-practice equipment using installed construction bid prices for some packages, state-of-the-art equipment using comparable technology (often referenced to equipment manufacturers' estimated unit prices for comparable technology, e.g. Seimens Automotive) and developing technology (also using comparable technology and referenced to integration and systems engineering companies' and equipment manufacturers' estimated unit prices for comparable technology.)

The unit price justification is noted in the Common Equipment section of 4.6 and in the worksheets' column for "Comparative Technology." In the worksheets, where "Existing Technology" is noted, the prices represent typical unit prices for equipment found in catalogs, such as Sweet's Engineering and Retrofit, a catalog for construction cost estimating for current, off-the-shelf technology. Other references to price justification indicate specific construction bid prices for recent contracts. These prices are actual bid prices for installation. Where these two forms of justification were not available, some estimations are provided through consultations with experts in respective fields for manufacturing, and system integration. Lastly, some prices which are less certain are estimates based on professional judgement.

5.2 Identification and Evaluation of Quantities and Market Size

For the Equipment Package parameters, the quantity of items purchased influences the unit price for the equipment. Obviously, price breaks come into effect when larger quantities are purchased. For existing technology, many equipment prices are at a steady state price (exhibited in the far right columns of the Equipment Worksheets.) The prices are generally not subject to wide fluctuations based on quantities. Newer technology, or services which are on the front end of a market/product development curve, are subject to wide price ranges. For Urbansville, two sets of market penetrations were analyzed, a high and a low scenario. For the cost evaluation activities the low value of the unit price ranges was utilized for all Equipment Packages.

5.3 Calculation of Expenditures

Expenditures are calculated automatically through the linked spreadsheet programs. Included in the calculation are non-recurring expenditures (one-time capital costs) and recurring expenditures (annual operation and maintenance costs). The non-recurring expenditures are incurred in accordance with the Evaluatory Design Document deployment quantities for the five, ten and twenty deployment years. The recurring expenditures are incurred in the deployment year and every year thereafter.

Non-recurring expenditures also include the expenditures for asset replacement at the end of its useful life. These expenditures are automatically incorporated into the spreadsheet utilizing the "Years to Replacement" column in the Equipment Package Worksheets. This tabulation of non-recurring expenditures continues from the year of initial deployment through the analysis time frame. This evaluation is important when considering comparative technologies and life cycle costs (see previous section on life cycle costing.)

5.4 Results

Tabulated below are the non-recurring and recurring expenditures for an individual user for three levels of service. Basic service provides the capability for drivers to interface with the ISP Subsystem's Basic Information Broadcast Equipment Package, receive formatted traffic advisories including accurate traveling information concerning available travel options, their availability, and congestion information in their vehicle. Basic Service also provides Vehicle MAYDAY service. Mid-range Service provides the Basic services plus In-Vehicle hardware, and software for Vehicle Route Guidance and Interactive Vehicle Reception. The comprehensive Service provides the Basic and Mid-range Services plus equipment for In-Vehicle Signing, Probe Vehicle Software, Smart Probe, and Vehicle Route Guidance.

INDIVIDUAL NON-RECURRING EXPENDITURES

Basic Service	VS1, VS14	$450
Mid-range Service	Basic+VS5,VS16	$1,350

Comprehensive Service	Mid-Range+VS4,VS6,VS7, VS19	$2,140

If all vehicle Equipment Packages including safety systems are combined, the total per vehicle non-recurring expenditure is $8,310.

INDIVIDUAL MONTHLY RECURRING EXPENDITURES

		Operation	Maintenance
Basic Service	VS1, VS14	$10	$1
Mid-range Service	Basic+VS5,V16	$35	<$5
Comprehensive Service	Mid-Range+VS4,VS6,VS7, VS19	$35	<$8

The monthly service charges for in-vehicle services are in the range of $0 to $43 per month for individual users (based on average usage) and are comparable to current service cost experiences for cellular telephone service.

Scenario expenditures for Mountainville are classified into likely stakeholder responsibility for funding. The resulting allocations are presented below.

Urbansville High Market Penetration
Twenty Year Non-Recurring Expenditure Totals

Stakeholder	Percent of Total Funding Requirements
Government	12%
Commercial	7%
Individual	81%

Urbansville Low Market Penetration
Twenty Year Non-Recurring Expenditure Totals

Stakeholder	Percent of Total Funding Requirements
Government	22%
Commercial	10%
Individual	68%

The summary expenditures for the Urbansville Equipment Packages are provided in the following pages. The non-recurring expenditures are tabulated below for the deployment milestone in the evaluation period. Note that the summations consists of the expenditures for the year stated plus the expenditures for the four previous years. The numbers presented for the recurring expenditures represent the expenditures for operation and maintenance during the deployment milestone years. Note that the non-recurring expenditures include replacement expenditures for reinvestment of equipment at the end of its' useful life.

The first of the analysis results, are for a low level market penetration, consistent with the evaluatory design parameters for deployment penetration. The second set of results are for the high level market penetration. The last results page is reflective of the government expenditures.

Equipment Package Expenditures for Low Market Penetration

		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20
CVA1	Credentials and Taxes Administration	$277	$1	$16	$281	$281	$281
CVA2	CV Information Exchange	$22	$0	$0	$77	$77	$77
CVA3	CV Safety Administration	$40	$0	$0	$0	$0	$0
CVA4	International CV Administration	$41	$0	$0	$136	$136	$136
CVC1	Citation and Accident Electronic Recording	$0	$0	$0	$0	$0	$0
CVC2	International Border Crossing	$326	$0	$80	$9	$9	$9
CVC3	Roadside Electronic Screening	$0	$0	$0	$0	$0	$0
CVC4	Roadside Safety Inspection	$0	$0	$0	$0	$0	$0
CVC5	Roadside WIM	$0	$0	$0	$0	$0	$0
CVS1	On-board Cargo Monitoring	$0	$150	$733	$0	$394	$1,919
CVS2	On-board CV Electronic Data	$38	$378	$2,536	$11	$122	$741
CVS3	On-board CV Safety	$81	$367	$2,184	$2	$13	$62
CVS4	On-board Trip Monitoring	$3,130	$14,143	$105,325	$393	$2,169	$13,224
EM1	Emergency and Incident Management Communication	$0	$6	$19	$0	$7	$29
EM2	Emergency Mayday and E-911 I/F	$105	$105	$420	$2	$5	$9
EM3	Emergency Response Management	$0	$91	$363	$0	$136	$546
EM4	Emergency Vehicle Routing and communications	$0	$1	$4	$0	$1	$5
EMM1	Emissions and Environmental Data Management	$1	$0	$0	$107	$107	$107
EVS1	On-board EV Incident Management Communication	$511	$1,329	$6,878	$84	$304	$1,136
EVS2	On-board Vehicle Signal Coordination	$422	$1,098	$5,682	$93	$336	$1,256
FMS1	Fleet Administration	$3,561	$5,353	$9,083	$52	$130	$260
FMS2	Fleet Credentials and Taxes Management and Reporting	$3,105	$4,813	$8,538	$3,421	$8,553	$17,105
FMS3	Fleet HAZMAT Management	$27	$106	$158	$1	$6	$11
FMS4	Freight Administration and Management	$20	$30	$100	$12	$30	$60
FMS5	Fleet Maintenance Management	$1,205	$1,808	$3,013	$72	$180	$360
ISP1	Basic Information Broadcast	$422	$1,337	$2,312	$316	$1,262	$2,524
ISP2	EM Route Plan Information Dissemination	$0	$0	$508	$0	$0	$22
ISP3	Infrastructure Provided Dynamic Ridesharing	$0	$0	$213	$0	$0	$313
ISP4	Infrastructure Provided Route Selection	$0	$350	$2,950	$0	$13	$100
ISP5	Infrastructure Provided Yellow Pages & Reservation	$0	$1,068	$1,812	$0	$355	$946
ISP6	Interactive Infrastructure Information	$359	$1,097	$1,589	$118	$471	$941
ISP7	ISP Advanced Integrated Control Support	$0	$0	$431	$0	$0	$21
ISP8	ISP Probe Information Collection	$250	$750	$1,000	$13	$50	$100
PIA1	Personal Basic Information Reception	$187	$1,036	$4,207	$44	$289	$951
PIA2	Personal Interactive Information Reception	$20	$769	$3,046	$14	$552	$2,118
PIA3	Personal Mayday I/F	$187	$12,039	$60,495	$32	$2,103	$10,376
PIA4	Personal Route Guidance	$237	$15,275	$35,946	$76	$4,995	$11,500
PMS1	Parking Management	$215	$665	$2,010	$362	$1,448	$3,620
PS1	Data Collection and ITS Planning	$0	$35	$35	$0	$450	$450

FIGURE 5.3-1 URBANSVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR LOW MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for Low Market Penetration

		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20
RS1	Automated road signing	$0	$0	$0	$0	$0	$0
RS10	Roadway Pollution and Environmental Hazards Indicators	$2,080	$3,120	$8,350	$12	$30	$60
RS11	Roadway Probe Beacons	$225	$375	$1,500	$23	$38	$113
RS12	Roadway Reversible Lanes	$1,860	$50	$100	$50	$50	$50
RS13	Roadway Systems for AHS	$0	$0	$1,000	$0	$0	$100
RS14	Roadway Traffic Information Dissemination	$10,812	$0	$0	$419	$419	$419
RS2	Roadside Signal Priority	$1,536	$3,328	$11,776	$13	$32	$77
RS3	Roadway Freeway Control	$900	$1,320	$3,090	$45	$66	$89
RS4	Roadway Signal Controls	$11,520	$23,040	$34,560	$205	$614	$1,229
RS5	Roadway Basic Surveillance	$16,750	$45,000	$128,600	$910	$3,510	$10,166
RS6	Roadway HOV Usage	$1,210	$50	$100	$72	$72	$72
RS7	Roadway In-Vehicle Signing	$0	$200	$525	$0	$13	$25
RS8	Roadway Incident Detection	$600	$1,200	$2,700	$30	$90	$180
RS9	Roadway Intersection Collision System	$0	$0	$2,756	$0	$0	$0
RTS1	Remote Interactive Information Reception	$0	$830	$3,320	$0	$1,255	$3,765
RTS2	Remote Mayday I/F	$3	$8	$40	$16	$31	$124
RTS3	Remote Transit Fare Management	$1,000	$1,925	$9,700	$165	$330	$1,320
RTS4	Remote Transit Security I/F	$0	$600	$1,200	$0	$488	$976
RTS5	Remote Basic Information Reception	$1,148	$1,148	$10,328	$208	$415	$1,660
TAS1	Toll Administration	$56	$10	$60	$49	$49	$49
TCS1	Toll Plaza Toll Collection	$315	$0	$168	$77	$77	$77
TMS1	Collect Traffic Surveillance	$735	$368	$735	$136	$203	$339
TMS10	TMC Incident Dispatch Coordination/Communication	$199	$232	$755	$92	$183	$458
TMS11	TMC Input to In-Vehicle Signing	$0	$0	$63	$0	$0	$68
TMS12	TMC Multi-Modal Coordination	$217	$109	$217	$280	$419	$699
TMS13	TMC Probe Information Collection	$0	$158	$209	$0	$61	$122
TMS14	TMC Toll/Parking Coordination	$114	$136	$317	$11	$23	$46
TMS15	TMC Traffic Information Dissemination	$233	$163	$371	$239	$359	$598
TMS16	TMC Traffic Network Performance Evaluation	$0	$827	$4,233	$0	$497	$2,485
TMS17	Traffic Maintenance	$40	$60	$160	$180	$270	$450
TMS2	Distributed Road Management	$0	$0	$0	$0	$0	$0
TMS3	TMC Advanced Signal Control	$0	$0	$623	$0	$0	$912
TMS4	TMC Regional Traffic Control	$0	$364	$1,087	$0	$205	$614
TMS5	TMC based Freeway Control	$391	$586	$1,561	$460	$689	$1,149
TMS6	TMC Basic Signal Control	$391	$390	$780	$982	$982	$982
TMS7	TMC for AHS	$0	$0	$271	$0	$0	$598
TMS8	TMC HOV/Reversible Lane Management	$462	$332	$1,529	$214	$320	$534
TMS9	TMC Incident Detection	$604	$727	$1,878	$1,290	$1,935	$3,225
TRM1	Fleet Maintenance Management	$121	$121	$121	$7	$14	$22

FIGURE 5.3-1 URBANSVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR LOW MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for Low Market Penetration

		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20
TRM2	Transit Center Fare and Load Management	$292	$292	$292	$7	$14	$20
TRM3	Transit Center Fixed-Route Operations	$249	$249	$249	$231	$462	$694
TRM4	Transit Center Multi-Modal Coordination	$0	$235	$128	$0	$70	$104
TRM5	Transit Center Paratransit Operations	$140	$140	$140	$1	$2	$2
TRM6	Transit Center Security	$321	$321	$461	$205	$409	$614
TRM7	Transit Center Tracking and Dispatch	$0	$1,694	$877	$0	$535	$802
TRV1	On-board Maintenance	$0	$1,634	$3,017	$0	$811	$1,497
TRV2	On-board Transit Driver I/F	$2,493	$3,122	$10,653	$553	$1,222	$2,257
TRV3	On-board Transit Fare and Load Management	$658	$794	$2,682	$773	$1,706	$3,151
TRV4	On-board Transit Security	$0	$2,481	$9,164	$0	$236	$872
TRV5	On-board Vehicle Signal Coordination	$0	$575	$2,123	$0	$18	$67
TRV6	Vehicle Dispatch Support	$0	$0	$0	$99	$218	$402
TRV7	On-board Trip Monitoring	$466	$563	$1,900	$733	$1,619	$2,990
VS1	Basic Vehicle Reception	$3,555	$15,844	$123,177	$0	$0	$0
VS10	Vehicle Lateral Control	$0	$0	$23,924	$0	$0	$478
VS11	Vehicle Lateral Warning System	$0	$0	$41,868	$0	$0	$1,196
VS12	Vehicle Longitudinal Control	$0	$0	$17,943	$0	$0	$1,196
VS13	Vehicle Longitudinal Warning System	$0	$33,948	$209,339	$0	$970	$5,981
VS14	Vehicle Mayday I/F	$13,332	$25,466	$103,048	$6,933	$20,175	$46,653
VS15	Vehicle Pre-Crash Safety Systems	$0	$0	$26,316	$0	$0	$957
VS16	Vehicle Route Guidance	$4,266	$26,772	$99,964	$1,813	$13,191	$40,671
VS17	Vehicle Safety Monitoring System	$4,622	$20,597	$160,130	$356	$1,940	$11,962
VS18	Vehicle Systems for AHS	$0	$0	$2,512	$0	$0	$72
VS19	Vehicle Toll/Parking I/F	$711	$841	$10,281	$0	$0	$0
VS2	Driver Safety Monitoring System	$0	$8,342	$102,875	$0	$582	$7,177
VS3	Driver Visibility Improvement System	$0	$0	$28,709	$0	$0	$1,435
VS4	In-Vehicle Signing System	$0	$3,104	$38,279	$0	$194	$2,392
VS5	Interactive Vehicle Reception	$533	$5,286	$17,280	$320	$3,492	$10,048
VS6	Probe Vehicle Software	$89	$881	$2,481	$18	$194	$478
VS7	Smart Probe	$0	$0	$0	$0	$0	$0
VS8	Vehicle Intersection Collision Warning	$0	$0	$957	$0	$0	$120
VS9	Vehicle Intersection Control	$0	$0	$4,785	$0	$0	$239

FIGURE 5.3-1 URBANSVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR LOW MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration

		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20
CVA1	Credentials and Taxes Administration	$277	$1	$16	$281	$281	$281
CVA2	CV Information Exchange	$22	$0	$0	$77	$77	$77
CVA3	CV Safety Administration	$40	$0	$0	$0	$0	$0
CVA4	International CV Administration	$41	$0	$0	$136	$136	$136
CVC1	Citation and Accident Electronic Recording	$0	$0	$0	$0	$0	$0
CVC2	International Border Crossing	$326	$0	$80	$9	$9	$9
CVC3	Roadside Electronic Screening	$0	$0	$0	$0	$0	$0
CVC4	Roadside Safety Inspection	$0	$0	$0	$0	$0	$0
CVC5	Roadside WIM	$0	$0	$0	$0	$0	$0
CVS1	On-board Cargo Monitoring	$136	$165	$1,833	$357	$787	$4,798
CVS2	On-board CV Electronic Data	$75	$756	$4,057	$22	$243	$1,186
CVS3	On-board CV Safety	$162	$734	$3,277	$5	$26	$94
CVS4	On-board Trip Monitoring	$7,826	$26,719	$168,520	$983	$4,337	$21,159
EM1	Emergency and Incident Management Communication	$12	$6	$8	$15	$22	$29
EM2	Emergency Mayday and E-911 I/F	$210	$210	$420	$5	$9	$9
EM3	Emergency Response Management	$182	$91	$361	$273	$409	$546
EM4	Emergency Vehicle Routing and communications	$2	$2	$3	$2	$4	$5
EMM1	Emissions and Environmental Data Management	$1	$0	$0	$107	$107	$107
EVS1	On-board EV Incident Management Communication	$1,022	$2,659	$6,878	$169	$608	$1,136
EVS2	On-board Vehicle Signal Coordination	$845	$2,196	$5,682	$187	$672	$1,256
FMS1	Fleet Administration	$8,903	$8,930	$12,824	$130	$260	$442
FMS2	Fleet Credentials and Taxes Management and Reporting	$7,763	$8,150	$12,418	$8,553	$17,105	$29,079
FMS3	Fleet HAZMAT Management	$133	$133	$183	$6	$11	$17
FMS4	Freight Administration and Management	$50	$50	$170	$30	$60	$102
FMS5	Fleet Maintenance Management	$3,013	$3,013	$4,218	$180	$360	$612
ISP1	Basic Information Broadcast	$422	$1,337	$2,312	$316	$1,262	$2,524
ISP2	EM Route Plan Information Dissemination	$0	$127	$435	$0	$6	$22
ISP3	Infrastructure Provided Dynamic Ridesharing	$0	$106	$543	$0	$156	$938
ISP4	Infrastructure Provided Route Selection	$0	$1,050	$3,250	$0	$38	$100
ISP5	Infrastructure Provided Yellow Pages & Reservation	$356	$1,073	$1,467	$118	$473	$946
ISP6	Interactive Infrastructure Information	$359	$1,097	$1,589	$118	$471	$941
ISP7	ISP Advanced Integrated Control Support	$0	$216	$1,128	$0	$10	$62
ISP8	ISP Probe Information Collection	$250	$750	$1,000	$13	$50	$100
PIA1	Personal Basic Information Reception	$1,867	$3,023	$42,072	$442	$1,157	$9,511
PIA2	Personal Interactive Information Reception	$201	$1,114	$6,686	$141	$920	$4,539
PIA3	Personal Mayday I/F	$1,867	$22,584	$82,277	$321	$4,207	$13,834
PIA4	Personal Route Guidance	$2,369	$28,655	$78,889	$763	$9,991	$24,642
PMS1	Parking Management	$645	$920	$3,625	$1,086	$2,534	$6,516
PS1	Data Collection and ITS Planning	$0	$35	$35	$0	$450	$450

FIGURE 5.3-2 URBANSVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR HIGH MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration								
		Non-Recurring Expenditures			Recurring Expenditures			
		Yrs	Yrs	Yrs	Average Annual Expenditures			
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20	
RS1	Automated road signing	$0	$0	$0	$0	$0	$0	
RS10	Roadway Pollution and Environmental Hazards Indicators	$2,080	$3,120	$8,350	$12	$30	$60	
RS11	Roadway Probe Beacons	$225	$375	$1,500	$23	$38	$113	
RS12	Roadway Reversible Lanes	$1,860	$50	$100	$50	$50	$50	
RS13	Roadway Systems for AHS	$0	$0	$1,000	$0	$0	$100	
RS14	Roadway Traffic Information Dissemination	$10,812	$0	$0	$419	$419	$419	
RS2	Roadside Signal Priority	$3,072	$6,656	$18,176	$26	$64	$109	
RS3	Roadway Freeway Control	$1,320	$1,770	$3,540	$66	$89	$89	
RS4	Roadway Signal Controls	$23,040	$34,560	$46,080	$410	$1,024	$1,843	
RS5	Roadway Basic Surveillance	$22,750	$45,000	$134,600	$910	$3,510	$10,166	
RS6	Roadway HOV Usage	$1,210	$50	$100	$72	$72	$72	
RS7	Roadway In-Vehicle Signing	$0	$200	$525	$0	$13	$25	
RS8	Roadway Incident Detection	$600	$1,200	$2,700	$30	$90	$180	
RS9	Roadway Intersection Collision System	$0	$2,756	$8,006	$0	$0	$0	
RTS1	Remote Interactive Information Reception	$415	$830	$4,150	$628	$1,255	$5,020	
RTS2	Remote Mayday I/F	$3	$8	$40	$16	$31	$124	
RTS3	Remote Transit Fare Management	$1,000	$1,925	$9,700	$165	$330	$1,320	
RTS4	Remote Transit Security I/F	$600	$1,200	$2,400	$488	$1,464	$1,952	
RTS5	Remote Basic Information Reception	$1,148	$1,148	$10,328	$208	$415	$1,660	
TAS1	Toll Administration	$56	$10	$60	$49	$49	$49	
TCS1	Toll Plaza Toll Collection	$315	$0	$168	$77	$77	$77	
TMS1	Collect Traffic Surveillance	$735	$368	$735	$136	$203	$339	
TMS10	TMC Incident Dispatch Coordination/Communication	$399	$264	$634	$183	$275	$458	
TMS11	TMC Input to In-Vehicle Signing	$0	$63	$36	$0	$68	$68	
TMS12	TMC Multi-Modal Coordination	$217	$109	$217	$280	$419	$699	
TMS13	TMC Probe Information Collection	$158	$181	$423	$61	$122	$244	
TMS14	TMC Toll/Parking Coordination	$114	$136	$431	$11	$23	$57	
TMS15	TMC Traffic Information Dissemination	$233	$163	$371	$239	$359	$598	
TMS16	TMC Traffic Network Performance Evaluation	$827	$2,117	$4,434	$497	$1,491	$2,485	
TMS17	Traffic Maintenance	$40	$60	$160	$180	$270	$450	
TMS2	Distributed Road Management	$0	$0	$0	$0	$0	$0	
TMS3	TMC Advanced Signal Control	$0	$0	$1,038	$0	$0	$1,520	
TMS4	TMC Regional Traffic Control	$364	$364	$1,811	$205	$409	$1,023	
TMS5	TMC based Freeway Control	$391	$586	$1,561	$460	$689	$1,149	
TMS6	TMC Basic Signal Control	$196	$195	$195	$491	$491	$0	
TMS7	TMC for AHS	$0	$0	$271	$0	$0	$598	
TMS8	TMC HOV/Reversible Lane Management	$462	$332	$1,529	$214	$320	$534	
TMS9	TMC Incident Detection	$604	$727	$1,878	$1,290	$1,935	$3,225	
TRM1	Fleet Maintenance Management	$241	$121	$0	$14	$22	$22	

FIGURE 5.3-2 URBANSVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR HIGH MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration

		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20
TRM2	Transit Center Fare and Load Management	$583	$292	$0	$14	$20	$20
TRM3	Transit Center Fixed-Route Operations	$497	$249	$0	$462	$694	$694
TRM4	Transit Center Multi-Modal Coordination	$0	$353	$15	$0	$104	$104
TRM5	Transit Center Paratransit Operations	$280	$140	$0	$2	$2	$2
TRM6	Transit Center Security	$641	$321	$210	$409	$614	$614
TRM7	Transit Center Tracking and Dispatch	$847	$1,694	$45	$267	$802	$802
TRV1	On-board Maintenance	$740	$1,735	$3,017	$367	$1,228	$1,497
TRV2	On-board Transit Driver I/F	$4,987	$3,573	$10,902	$1,107	$1,851	$2,257
TRV3	On-board Transit Fare and Load Management	$1,315	$884	$2,682	$1,545	$2,585	$3,151
TRV4	On-board Transit Security	$2,247	$5,269	$9,164	$214	$715	$872
TRV5	On-board Vehicle Signal Coordination	$0	$1,150	$2,123	$0	$36	$67
TRV6	Vehicle Dispatch Support	$0	$0	$0	$197	$330	$402
TRV7	On-board Trip Monitoring	$932	$626	$1,900	$1,466	$2,453	$2,990
VS1	Basic Vehicle Reception	$10,665	$28,133	$249,909	$0	$0	$0
VS10	Vehicle Lateral Control	$0	$0	$119,622	$0	$0	$2,392
VS11	Vehicle Lateral Warning System	$0	$13,579	$125,603	$0	$388	$3,589
VS12	Vehicle Longitudinal Control	$0	$5,820	$53,830	$0	$388	$3,589
VS13	Vehicle Longitudinal Warning System	$622	$135,171	$419,299	$18	$3,880	$11,962
VS14	Vehicle Mayday I/F	$22,220	$50,527	$201,653	$11,554	$37,828	$93,305
VS15	Vehicle Pre-Crash Safety Systems	$0	$0	$131,584	$0	$0	$4,785
VS16	Vehicle Route Guidance	$14,221	$94,414	$588,406	$6,044	$46,170	$244,029
VS17	Vehicle Safety Monitoring System	$9,244	$91,631	$320,260	$711	$7,760	$23,924
VS18	Vehicle Systems for AHS	$0	$0	$25,120	$0	$0	$718
VS19	Vehicle Toll/Parking I/F	$2,133	$5,627	$49,982	$0	$0	$0
VS2	Driver Safety Monitoring System	$0	$41,708	$257,187	$0	$2,910	$17,943
VS3	Driver Visibility Improvement System	$0	$0	$143,546	$0	$0	$7,177
VS4	In-Vehicle Signing System	$1,422	$14,097	$77,980	$89	$970	$4,785
VS5	Interactive Vehicle Reception	$1,778	$17,621	$49,626	$1,067	$11,639	$28,709
VS6	Probe Vehicle Software	$356	$1,584	$6,337	$71	$388	$1,196
VS7	Smart Probe	$0	$0	$0	$0	$0	$0
VS8	Vehicle Intersection Collision Warning	$0	$155	$3,828	$0	$19	$478
VS9	Vehicle Intersection Control	$0	$0	$9,570	$0	$0	$478

FIGURE 5.3-2 URBANSVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR HIGH MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration							
Government Stakeholder		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
Subsystem	Subsystem Name	1-5	6-10	11-20	5	10	20
CVAS	Commmercial Vehicle Administration Subsystem	$379	$1	$16	$494	$494	$494
CVCS	Commercial Vehicle Check Subsystem	$326	$0	$80	$9	$9	$9
EMS	Emergency Management Subsystem	$406	$309	$792	$295	$444	$589
EMMS	Environmental And Emmisions Management Subsystem	$1	$0	$0	$107	$107	$107
EVS	Emergency Vehicle Subsystem	$1,867	$4,855	$12,560	$356	$1,280	$2,392
PMS	Parking Management Subsystem	$645	$920	$3,625	$1,086	$2,534	$6,516
PS	Planning Subsystem	$0	$35	$35	$0	$450	$450
RS	Roadside Subsystem	$66,969	$95,737	$224,677	$2,017	$5,397	$13,225
RTS	Remote Traveler Subsystem	$1,600	$3,125	$12,100	$653	$1,794	$3,272
TAS	Toll Administration Subsystem	$56	$10	$60	$49	$49	$49
TCS	Toll Collection Subsystem	$315	$0	$168	$77	$77	$77
TMS	Traffic Management Subsystem	$4,738	$5,662	$15,721	$4,246	$7,075	$13,446
TRMS	Transit Management Subsystem	$3,089	$3,168	$270	$1,168	$2,258	$2,258
TRVS	Transit Vehicle Subsystem	$10,220	$13,236	$29,788	$4,897	$9,198	$11,238
					Expenditures are in constant 1995 dollars in		(1,000's)
		$90,609	$127,057	$299,892	$15,452	$31,165	$54,121

FIGURE 5.3-3 URBANSVILLE SUMMARY GOVERNMENT ONLY EXPENDITURES FOR HIGH MARKET PENETRATION

6. SAMPLE EXPENDITURE CALCULATIONS - INTER-URBAN AREA

The Phase II cost evaluation of the National ITS Architecture includes an evaluation of three separate scenarios. Each scenario represents a typical deployment area and is to provide a frame of reference for similar implementations of the architecture. A high level description of the inter-urban area, Thruville, is included in the Evaluatory Design Document. A more in-depth description of Thruville is located in the "Inter-Urban Scenario Guide, Thruville, Phase II" scenario description document. The scenario description is a common description utilized for numerous architecture evaluation activities, including: the cost evaluation, the benefit analysis, as well as technical performance analyses. Thus, the results of the various architecture evaluation activities are all based upon one common set of assumptions.

The cost analysis evaluates five, ten and twenty year deployment milestones.

6.1 Examination of Equipment Package Worksheets

Equipment Package Worksheets are included in the previous sections 4.6.1 through 4.6.19. Each worksheet lists equipment and price ranges for that equipment, including hardware and software, as well as operation (additional staffing) and maintenance requirements. The price ranges represent state-of-the-practice equipment using installed construction bid prices for some packages, state-of-the-art equipment using comparable technology (often referenced to equipment manufacturers' estimated unit prices for comparable technology, e.g. Seimens Automotive) and developing technology (also using comparable technology and referenced to integration and systems engineering companies' and equipment manufacturers' estimated unit prices for comparable technology.)

The unit price justification is noted in the Common Equipment section of 4.6 and in the worksheets' column for "Comparative Technology." In the worksheets, where "Existing Technology" is noted, the prices represent typical unit prices for equipment found in catalogs, such as Sweet's Engineering and Retrofit, a catalog for construction cost estimating for current, off-the-shelf technology. Other references to price justification indicate specific construction bid prices for recent contracts. These prices are actual bid prices for installation. Where these two forms of justification were not available, some estimations are provided through consultations with experts in respective fields for manufacturing, and system integration. Lastly, some prices which are less certain are estimates based on professional judgement.

6.2 Identification and Evaluation of Quantities and Market Size

For the Equipment Package parameters, the quantity of items purchased influences the unit price for the equipment. Obviously, price breaks come into effect when larger quantities are purchased. For existing technology, many equipment prices are at a steady state price (exhibited in the far right columns of the Equipment Worksheets.) The prices are generally not subject to wide fluctuations based on quantities. Newer technology, or services which are on the front end of a market/product development curve, are subject to wide price ranges.

For Thruville, two sets of market penetrations were analyzed, a high and a low scenario. For the cost evaluation activities the low value of the unit price ranges was utilized for all Equipment Packages.

6.3 Calculation of Expenditures

Expenditures are calculated automatically through the linked spreadsheet programs. Included in the calculation are non-recurring expenditures (one-time capital costs) and recurring expenditures (annual operation and maintenance costs). The non-recurring expenditures are incurred in accordance with the Evaluatory Design Document deployment quantities for the five, ten and twenty deployment years. The recurring expenditures are incurred in the deployment year and every year thereafter.

Non-recurring expenditures also include the expenditures for asset replacement at the end of its useful life. These expenditures are automatically incorporated into the spreadsheet utilizing the "Years to Replacement" column in the Equipment Package Worksheets. This tabulation of non-recurring expenditures continues from the year of initial deployment through the analysis time frame. This evaluation is important when considering comparative technologies and life cycle costs (see previous section on life cycle costing.)

6.4 Results

Similar to the results from the Urbansville analysis, tabulated below are the non-recurring and recurring expenditures for a minimal basic service a mid-range service, and a comprehensive service, that would be experienced by one individual in the individual consumers group. As stated in section 4.6.19, the unit price of equipment for in-vehicle devices are based on existing technology, or nationally developed technology which takes advantage of national market deployment price breaks.

Basic service provides the capability for drivers to interface with the ISP Subsystem's Basic Information Broadcast Equipment Package, receive formatted traffic advisories including accurate traveling information concerning available travel options, their availability, and congestion information in their vehicle. Basic Service also provides Vehicle MAYDAY service. Mid-range Service provides the Basic services plus In-Vehicle hardware, and software for Vehicle Route Guidance and Interactive Vehicle Reception. The comprehensive Service provides the Basic and Mid-range Services plus equipment for In-Vehicle Signing, Probe Vehicle Software, Smart Probe, and Vehicle Route Guidance.

INDIVIDUAL NON-RECURRING EXPENDITURES

Basic Service	VS1, VS14	$450
Mid-range Service	Basic+VS5,VS16	$1,350
Comprehensive Service	Mid-Range+VS4,VS6,VS7, VS19	$2,140

If all vehicle Equipment Packages including safety systems are combined, the total per vehicle non-recurring expenditure is $8,310.

INDIVIDUAL MONTHLY RECURRING EXPENDITURES

		Operation	Maintenance
Basic Service	VS1, VS14	$10	$1
Mid-range Service	Basic+VS5,V16	$35	<$5
Comprehensive Service	Mid-Range+VS4,VS6,VS7, VS19	$35	<$8

The monthly service charges for in-vehicle services are in the range of $0 to $43 per month for individual users (based on average usage) and are comparable to current service cost experiences for cellular telephone service.

Scenario expenditures for Mountainville are classified into likely stakeholder responsibility for funding. The resulting allocations are presented below.

Thruville High Market Penetration
Twenty Year Non-Recurring Expenditure Totals

Stakeholder	Percent of Total Funding Requirements
Government	13%
Commercial	5%
Individual	82%

Thruville Low Market Penetration
Twenty Year Non-Recurring Expenditure Totals

Stakeholder	Percent of Total Funding Requirements
Government	27%
Commercial	6%
Individual	67%

The summary expenditures for the Thruville Equipment Packages are provided in the following pages. The non-recurring expenditures are tabulated below for the deployment milestone in the evaluation period. Note that the summations consists of the expenditures for the year stated plus the expenditures for the four previous years. The numbers presented for the recurring expenditures represent the expenditures for operation and maintenance during the deployment milestone years. Note that the non-recurring expenditures include replacement expenditures for reinvestment of equipment at the end of its' useful life.

The first of the analysis results, are for a low level market penetration, consistent with the evaluatory design parameters for deployment penetration. The second set of results are for the high level market penetration. The last results page is reflective of the government expenditures.

Equipment Package Expenditures for Low Market Penetration								
		Non-Recurring Expenditures			Recurring Expenditures			
		Yrs	Yrs	Yrs	Average Annual Expenditures			
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20	
CVA1	Credentials and Taxes Administration	$553	$1	$32	$562	$562	$562	
CVA2	CV Information Exchange	$43	$0	$0	$154	$154	$154	
CVA3	CV Safety Administration	$80	$0	$0	$0	$0	$0	
CVA4	International CV Administration	$0	$0	$0	$0	$0	$0	
CVC1	Citation and Accident Electronic Recording	$40	$0	$0	$3	$3	$3	
CVC2	International Border Crossing	$0	$0	$0	$0	$0	$0	
CVC3	Roadside Electronic Screening	$651	$0	$160	$17	$17	$17	
CVC4	Roadside Safety Inspection	$88	$6	$12	$5	$5	$5	
CVC5	Roadside WIM	$30	$0	$30	$2	$2	$2	
CVS1	On-board Cargo Monitoring	$0	$68	$300	$0	$178	$786	
CVS2	On-board CV Electronic Data	$18	$170	$1,038	$5	$55	$303	
CVS3	On-board CV Safety	$39	$164	$895	$1	$6	$26	
CVS4	On-board Trip Monitoring	$1,143	$4,855	$33,129	$144	$753	$4,160	
EM1	Emergency and Incident Management Communication	$0	$6	$7	$0	$7	$15	
EM2	Emergency Mayday and E-911 I/F	$0	$105	$210	$0	$2	$5	
EM3	Emergency Response Management	$0	$91	$181	$0	$136	$273	
EM4	Emergency Vehicle Routing and communications	$0	$1	$2	$0	$1	$2	
EMM1	Emissions and Environmental Data Management	$0	$1	$0	$0	$107	$107	
EVS1	On-board EV Incident Management Communication	$245	$635	$2,946	$40	$145	$487	
EVS2	On-board Vehicle Signal Coordination	$202	$524	$2,434	$45	$161	$538	
FMS1	Fleet Administration	$356	$713	$734	$5	$16	$26	
FMS2	Fleet Credentials and Taxes Management and Reporting	$311	$637	$714	$342	$1,026	$1,711	
FMS3	Fleet HAZMAT Management	$0	$27	$5	$0	$1	$1	
FMS4	Freight Administration and Management	$2	$4	$10	$1	$4	$6	
FMS5	Fleet Maintenance Management	$121	$241	$241	$7	$22	$36	
ISP1	Basic Information Broadcast	$422	$493	$1,156	$316	$631	$1,262	
ISP2	EM Route Plan Information Dissemination	$0	$0	$254	$0	$0	$11	
ISP3	Infrastructure Provided Dynamic Ridesharing	$0	$0	$106	$0	$0	$156	
ISP4	Infrastructure Provided Route Selection	$0	$350	$1,550	$0	$13	$50	
ISP5	Infrastructure Provided Yellow Pages & Reservation	$0	$712	$733	$0	$236	$473	
ISP6	Interactive Infrastructure Information	$359	$378	$794	$118	$235	$471	
ISP7	ISP Advanced Integrated Control Support	$0	$0	$0	$0	$0	$0	
ISP8	ISP Probe Information Collection	$0	$0	$250	$0	$0	$13	
PIA1	Personal Basic Information Reception	$93	$491	$1,813	$22	$138	$407	
PIA2	Personal Interactive Information Reception	$10	$367	$1,304	$7	$264	$906	
PIA3	Personal Mayday I/F	$93	$5,743	$25,883	$16	$1,004	$4,437	
PIA4	Personal Route Guidance	$118	$7,287	$15,388	$38	$2,385	$4,918	
PMS1	Parking Management	$65	$157	$503	$109	$362	$905	
PS1	Data Collection and ITS Planning	$0	$35	$35	$0	$450	$450	

FIGURE 6.3-1 THRUVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR LOW MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for Low Market Penetration								
		Non-Recurring Expenditures			Recurring Expenditures			
		Yrs	Yrs	Yrs	Average Annual Expenditures			
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20	
RS1	Automated road signing	$0	$0	$0	$0	$0	$0	
RS10	Roadway Pollution and Environmental Hazards Indicators	$0	$2,600	$4,175	$0	$15	$30	
RS11	Roadway Probe Beacons	$0	$275	$735	$0	$28	$46	
RS12	Roadway Reversible Lanes	$0	$4,650	$250	$0	$125	$125	
RS13	Roadway Systems for AHS	$0	$0	$1,000	$0	$0	$100	
RS14	Roadway Traffic Information Dissemination	$5,400	$5,724	$36	$213	$426	$426	
RS2	Roadside Signal Priority	$624	$1,352	$4,784	$5	$13	$31	
RS3	Roadway Freeway Control	$0	$1,050	$2,640	$0	$53	$80	
RS4	Roadway Signal Controls	$0	$0	$0	$0	$0	$0	
RS5	Roadway Basic Surveillance	$0	$70,050	$70,000	$0	$4,290	$6,994	
RS6	Roadway HOV Usage	$0	$3,025	$250	$0	$180	$180	
RS7	Roadway In-Vehicle Signing	$0	$240	$630	$0	$15	$30	
RS8	Roadway Incident Detection	$0	$1,680	$1,440	$0	$84	$114	
RS9	Roadway Intersection Collision System	$0	$0	$0	$0	$0	$0	
RTS1	Remote Interactive Information Reception	$0	$415	$1,660	$0	$628	$1,883	
RTS2	Remote Mayday I/F	$1	$4	$20	$8	$16	$62	
RTS3	Remote Transit Fare Management	$520	$961	$4,850	$86	$165	$660	
RTS4	Remote Transit Security I/F	$0	$0	$300	$0	$0	$244	
RTS5	Remote Basic Information Reception	$597	$551	$5,187	$108	$208	$830	
TAS1	Toll Administration	$56	$10	$60	$49	$49	$49	
TCS1	Toll Plaza Toll Collection	$450	$0	$240	$110	$110	$110	
TMS1	Collect Traffic Surveillance	$368	$0	$368	$68	$68	$136	
TMS10	TMC Incident Dispatch Coordination/Communication	$199	$32	$278	$92	$92	$183	
TMS11	TMC Input to In-Vehicle Signing	$0	$0	$0	$0	$0	$0	
TMS12	TMC Multi-Modal Coordination	$109	$0	$109	$140	$140	$280	
TMS13	TMC Probe Information Collection	$0	$0	$158	$0	$0	$61	
TMS14	TMC Toll/Parking Coordination	$0	$114	$159	$0	$11	$23	
TMS15	TMC Traffic Information Dissemination	$0	$117	$163	$0	$120	$239	
TMS16	TMC Traffic Network Performance Evaluation	$0	$0	$1,653	$0	$0	$994	
TMS17	Traffic Maintenance	$0	$20	$60	$0	$90	$180	
TMS2	Distributed Road Management	$0	$0	$0	$0	$0	$0	
TMS3	TMC Advanced Signal Control	$0	$0	$208	$0	$0	$304	
TMS4	TMC Regional Traffic Control	$0	$0	$364	$0	$0	$205	
TMS5	TMC based Freeway Control	$0	$0	$391	$0	$0	$460	
TMS6	TMC Basic Signal Control	$0	$0	$0	$0	$0	$0	
TMS7	TMC for AHS	$0	$0	$0	$0	$0	$0	
TMS8	TMC HOV/Reversible Lane Management	$0	$231	$557	$0	$107	$214	
TMS9	TMC Incident Detection	$0	$302	$727	$0	$645	$1,290	
TRM1	Fleet Maintenance Management	$0	$121	$121	$0	$7	$14	

FIGURE 6.3-1 THRUVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR LOW MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for Low Market Penetration								
		Non-Recurring Expenditures			Recurring Expenditures			
		Yrs	Yrs	Yrs	Average Annual Expenditures			
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20	
TRM2	Transit Center Fare and Load Management	$0	$292	$292	$0	$7	$14	
TRM3	Transit Center Fixed-Route Operations	$249	$249	$249	$231	$462	$694	
TRM4	Transit Center Multi-Modal Coordination	$0	$0	$0	$0	$0	$0	
TRM5	Transit Center Paratransit Operations	$140	$140	$140	$1	$2	$2	
TRM6	Transit Center Security	$0	$321	$391	$0	$205	$409	
TRM7	Transit Center Tracking and Dispatch	$0	$1,694	$877	$0	$535	$802	
TRV1	On-board Maintenance	$0	$555	$929	$0	$275	$461	
TRV2	On-board Transit Driver I/F	$892	$1,017	$3,295	$198	$415	$695	
TRV3	On-board Transit Fare and Load Management	$0	$493	$826	$0	$580	$970	
TRV4	On-board Transit Security	$0	$841	$2,821	$0	$80	$268	
TRV5	On-board Vehicle Signal Coordination	$0	$195	$654	$0	$6	$21	
TRV6	Vehicle Dispatch Support	$0	$0	$0	$0	$74	$124	
TRV7	On-board Trip Monitoring	$167	$183	$585	$262	$550	$921	
VS1	Basic Vehicle Reception	$1,703	$7,575	$52,951	$0	$0	$0	
VS10	Vehicle Lateral Control	$0	$0	$0	$0	$0	$0	
VS11	Vehicle Lateral Warning System	$0	$0	$17,937	$0	$0	$512	
VS12	Vehicle Longitudinal Control	$0	$0	$7,687	$0	$0	$512	
VS13	Vehicle Longitudinal Warning System	$0	$15,642	$86,404	$0	$447	$2,469	
VS14	Vehicle Mayday I/F	$6,385	$12,171	$44,821	$3,320	$9,649	$19,987	
VS15	Vehicle Pre-Crash Safety Systems	$0	$0	$11,275	$0	$0	$410	
VS16	Vehicle Route Guidance	$2,043	$12,802	$43,042	$868	$6,309	$17,425	
VS17	Vehicle Safety Monitoring System	$2,213	$9,848	$68,837	$170	$928	$5,125	
VS18	Vehicle Systems for AHS	$0	$0	$1,076	$0	$0	$31	
VS19	Vehicle Toll/Parking I/F	$341	$402	$4,440	$0	$0	$0	
VS2	Driver Safety Monitoring System	$0	$3,990	$44,074	$0	$278	$3,075	
VS3	Driver Visibility Improvement System	$0	$0	$12,300	$0	$0	$615	
VS4	In-Vehicle Signing System	$0	$1,484	$16,400	$0	$93	$1,025	
VS5	Interactive Vehicle Reception	$255	$2,528	$7,430	$153	$1,670	$4,305	
VS6	Probe Vehicle Software	$0	$464	$1,025	$0	$93	$205	
VS7	Smart Probe	$0	$0	$0	$0	$0	$0	
VS8	Vehicle Intersection Collision Warning	$0	$0	$0	$0	$0	$0	
VS9	Vehicle Intersection Control	$0	$0	$0	$0	$0	$0	

FIGURE 6.3-1 THRUVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR LOW MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration								
		Non-Recurring Expenditures			Recurring Expenditures			
		Yrs	Yrs	Yrs	Average Annual Expenditures			
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20	
CVA1	Credentials and Taxes Administration	$553	$1	$32	$562	$562	$562	
CVA2	CV Information Exchange	$43	$0	$0	$154	$154	$154	
CVA3	CV Safety Administration	$80	$0	$0	$0	$0	$0	
CVA4	International CV Administration	$0	$0	$0	$0	$0	$0	
CVC1	Citation and Accident Electronic Recording	$40	$0	$0	$3	$3	$3	
CVC2	International Border Crossing	$0	$0	$0	$0	$0	$0	
CVC3	Roadside Electronic Screening	$651	$0	$160	$17	$17	$17	
CVC4	Roadside Safety Inspection	$88	$6	$12	$5	$5	$5	
CVC5	Roadside WIM	$30	$0	$30	$2	$2	$2	
CVS1	On-board Cargo Monitoring	$65	$71	$751	$170	$355	$1,964	
CVS2	On-board CV Electronic Data	$36	$340	$1,661	$10	$110	$485	
CVS3	On-board CV Safety	$77	$328	$1,341	$2	$12	$38	
CVS4	On-board Trip Monitoring	$2,857	$9,139	$53,006	$359	$1,506	$6,655	
EM1	Emergency and Incident Management Communication	$6	$6	$1	$7	$15	$15	
EM2	Emergency Mayday and E-911 I/F	$105	$105	$210	$2	$5	$5	
EM3	Emergency Response Management	$91	$91	$180	$136	$273	$273	
EM4	Emergency Vehicle Routing and communications	$1	$1	$2	$1	$2	$2	
EMM1	Emissions and Environmental Data Management	$0	$1	$0	$0	$107	$107	
EVS1	On-board EV Incident Management Communication	$490	$1,271	$2,946	$81	$291	$487	
EVS2	On-board Vehicle Signal Coordination	$405	$1,050	$2,434	$89	$322	$538	
FMS1	Fleet Administration	$1,068	$716	$1,460	$16	$26	$47	
FMS2	Fleet Credentials and Taxes Management and Reporting	$932	$668	$1,397	$1,026	$1,711	$3,079	
FMS3	Fleet HAZMAT Management	$27	$0	$32	$1	$1	$2	
FMS4	Freight Administration and Management	$6	$4	$18	$4	$6	$11	
FMS5	Fleet Maintenance Management	$362	$241	$482	$22	$36	$65	
ISP1	Basic Information Broadcast	$422	$493	$1,156	$316	$631	$1,262	
ISP2	EM Route Plan Information Dissemination	$0	$64	$218	$0	$3	$11	
ISP3	Infrastructure Provided Dynamic Ridesharing	$0	$106	$224	$0	$156	$469	
ISP4	Infrastructure Provided Route Selection	$0	$700	$1,700	$0	$25	$50	
ISP5	Infrastructure Provided Yellow Pages & Reservation	$356	$361	$733	$118	$236	$473	
ISP6	Interactive Infrastructure Information	$359	$378	$794	$118	$235	$471	
ISP7	ISP Advanced Integrated Control Support	$0	$0	$431	$0	$0	$21	
ISP8	ISP Probe Information Collection	$0	$250	$500	$0	$13	$38	
PIA1	Personal Basic Information Reception	$926	$1,408	$18,119	$219	$552	$4,067	
PIA2	Personal Interactive Information Reception	$100	$528	$2,873	$70	$439	$1,941	
PIA3	Personal Mayday I/F	$926	$10,745	$35,312	$159	$2,008	$5,916	
PIA4	Personal Route Guidance	$1,175	$13,634	$33,898	$378	$4,769	$10,538	
PMS1	Parking Management	$172	$231	$905	$290	$652	$1,629	
PS1	Data Collection and ITS Planning	$0	$35	$35	$0	$450	$450	
	FIGURE 6.3-2 THRUVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR HIGH MARKET PENETRATION							195

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration								
		Non-Recurring Expenditures			Recurring Expenditures			
		Yrs	Yrs	Yrs	Average Annual Expenditures			
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20	
RS1	Automated road signing	$0	$0	$0	$0	$0	$0	
RS10	Roadway Pollution and Environmental Hazards Indicators	$0	$2,600	$4,175	$0	$15	$30	
RS11	Roadway Probe Beacons	$0	$275	$735	$0	$28	$46	
RS12	Roadway Reversible Lanes	$0	$4,650	$250	$0	$125	$125	
RS13	Roadway Systems for AHS	$0	$0	$1,000	$0	$0	$100	
RS14	Roadway Traffic Information Dissemination	$5,400	$5,824	$136	$213	$426	$426	
RS2	Roadside Signal Priority	$1,248	$2,704	$7,384	$10	$26	$44	
RS3	Roadway Freeway Control	$0	$1,590	$3,690	$0	$80	$105	
RS4	Roadway Signal Controls	$0	$0	$0	$0	$0	$0	
RS5	Roadway Basic Surveillance	$0	$70,050	$70,000	$0	$4,290	$6,994	
RS6	Roadway HOV Usage	$0	$3,025	$250	$0	$180	$180	
RS7	Roadway In-Vehicle Signing	$0	$240	$630	$0	$15	$30	
RS8	Roadway Incident Detection	$0	$1,680	$1,440	$0	$84	$114	
RS9	Roadway Intersection Collision System	$0	$0	$0	$0	$0	$0	
RTS1	Remote Interactive Information Reception	$216	$415	$2,075	$326	$628	$2,510	
RTS2	Remote Mayday I/F	$0	$3	$20	$0	$16	$62	
RTS3	Remote Transit Fare Management	$520	$961	$4,850	$86	$165	$660	
RTS4	Remote Transit Security I/F	$0	$300	$900	$0	$244	$732	
RTS5	Remote Basic Information Reception	$597	$551	$5,187	$108	$208	$830	
TAS1	Toll Administration	$56	$10	$60	$49	$49	$49	
TCS1	Toll Plaza Toll Collection	$450	$0	$240	$110	$110	$110	
TMS1	Collect Traffic Surveillance	$368	$0	$368	$68	$68	$136	
TMS10	TMC Incident Dispatch Coordination/Communication	$199	$32	$278	$92	$92	$183	
TMS11	TMC Input to In-Vehicle Signing	$0	$0	$0	$0	$0	$0	
TMS12	TMC Multi-Modal Coordination	$109	$0	$109	$140	$140	$280	
TMS13	TMC Probe Information Collection	$158	$23	$214	$61	$61	$122	
TMS14	TMC Toll/Parking Coordination	$114	$23	$159	$11	$11	$23	
TMS15	TMC Traffic Information Dissemination	$117	$23	$163	$120	$120	$239	
TMS16	TMC Traffic Network Performance Evaluation	$827	$464	$1,754	$497	$497	$994	
TMS17	Traffic Maintenance	$20	$20	$60	$90	$90	$180	
TMS2	Distributed Road Management	$0	$0	$0	$0	$0	$0	
TMS3	TMC Advanced Signal Control	$0	$0	$415	$0	$0	$608	
TMS4	TMC Regional Traffic Control	$364	$0	$724	$205	$205	$409	
TMS5	TMC based Freeway Control	$0	$196	$586	$0	$230	$460	
TMS6	TMC Basic Signal Control	$0	$0	$0	$0	$0	$0	
TMS7	TMC for AHS	$0	$0	$0	$0	$0	$0	
TMS8	TMC HOV/Reversible Lane Management	$0	$231	$557	$0	$107	$214	
TMS9	TMC Incident Detection	$0	$302	$727	$0	$645	$1,290	
TRM1	Fleet Maintenance Management	$0	$241	$121	$0	$14	$22	
	FIGURE 6.3-2 THRUVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR HIGH MARKET PENETRATION							196

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration								
		Non-Recurring Expenditures			Recurring Expenditures			
		Yrs	Yrs	Yrs	Average Annual Expenditures			
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20	
TRM2	Transit Center Fare and Load Management	$0	$583	$292	$0	$14	$20	
TRM3	Transit Center Fixed-Route Operations	$497	$249	$0	$462	$694	$694	
TRM4	Transit Center Multi-Modal Coordination	$0	$0	$0	$0	$0	$0	
TRM5	Transit Center Paratransit Operations	$280	$140	$0	$2	$2	$2	
TRM6	Transit Center Security	$0	$641	$461	$0	$409	$614	
TRM7	Transit Center Tracking and Dispatch	$847	$1,694	$45	$267	$802	$802	
TRV1	On-board Maintenance	$265	$576	$929	$131	$417	$461	
TRV2	On-board Transit Driver I/F	$1,779	$1,134	$3,380	$395	$629	$695	
TRV3	On-board Transit Fare and Load Management	$469	$278	$826	$551	$878	$970	
TRV4	On-board Transit Security	$804	$1,751	$2,821	$76	$243	$268	
TRV5	On-board Vehicle Signal Coordination	$0	$390	$654	$0	$12	$21	
TRV6	Vehicle Dispatch Support	$0	$0	$0	$35	$112	$124	
TRV7	On-board Trip Monitoring	$332	$197	$585	$523	$834	$921	
VS1	Basic Vehicle Reception	$5,108	$13,448	$107,605	$0	$0	$0	
VS10	Vehicle Lateral Control	$0	$0	$0	$0	$0	$0	
VS11	Vehicle Lateral Warning System	$0	$6,495	$53,811	$0	$186	$1,537	
VS12	Vehicle Longitudinal Control	$0	$2,783	$23,062	$0	$186	$1,537	
VS13	Vehicle Longitudinal Warning System	$298	$62,271	$173,106	$9	$1,788	$4,937	
VS14	Vehicle Mayday I/F	$10,641	$24,151	$87,514	$5,533	$18,092	$39,974	
VS15	Vehicle Pre-Crash Safety Systems	$0	$0	$56,374	$0	$0	$2,050	
VS16	Vehicle Route Guidance	$6,810	$45,145	$252,804	$2,894	$22,081	$104,547	
VS17	Vehicle Safety Monitoring System	$4,427	$43,818	$137,673	$341	$3,711	$10,250	
VS18	Vehicle Systems for AHS	$0	$0	$10,763	$0	$0	$308	
VS19	Vehicle Toll/Parking I/F	$1,022	$2,690	$21,521	$0	$0	$0	
VS2	Driver Safety Monitoring System	$0	$19,947	$110,184	$0	$1,392	$7,687	
VS3	Driver Visibility Improvement System	$0	$0	$61,499	$0	$0	$3,075	
VS4	In-Vehicle Signing System	$0	$7,422	$32,799	$0	$464	$2,050	
VS5	Interactive Vehicle Reception	$851	$8,427	$21,351	$511	$5,567	$12,300	
VS6	Probe Vehicle Software	$0	$928	$2,562	$0	$186	$512	
VS7	Smart Probe	$0	$0	$0	$0	$0	$0	
VS8	Vehicle Intersection Collision Warning	$0	$0	$0	$0	$0	$0	
VS9	Vehicle Intersection Control	$0	$0	$0	$0	$0	$0	

FIGURE 6.3-2 THRUVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR HIGH MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration							
Government Stakeholder		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
Subsystem	Subsystem Name	1-5	6-10	11-20	5	10	20
CVAS	Commmercial Vehicle Administration Subsystem	$676	$1	$32	$716	$716	$716
CVCS	Commercial Vehicle Check Subsystem	$809	$6	$202	$27	$27	$27
EMS	Emergency Management Subsystem	$203	$203	$393	$147	$295	$295
EMMS	Environmental And Emmisions Management Subsystem	$0	$1	$0	$0	$107	$107
EVS	Emergency Vehicle Subsystem	$895	$2,321	$5,380	$170	$612	$1,025
PMS	Parking Management Subsystem	$172	$231	$905	$290	$652	$1,629
PS	Planning Subsystem	$0	$35	$35	$0	$450	$450
RS	Roadside Subsystem	$6,648	$92,638	$89,690	$223	$5,268	$8,194
RTS	Remote Traveler Subsystem	$520	$1,261	$5,750	$86	$409	$1,392
TAS	Toll Administration Subsystem	$56	$10	$60	$49	$49	$49
TCS	Toll Collection Subsystem	$450	$0	$240	$110	$110	$110
TMS	Traffic Management Subsystem	$2,273	$1,313	$6,110	$1,283	$2,264	$5,137
TRMS	Transit Management Subsystem	$1,624	$3,548	$918	$731	$1,935	$2,154
TRVS	Transit Vehicle Subsystem	$3,649	$4,327	$9,193	$1,712	$3,126	$3,459
						Expenditures are in constant 1995 dollars in	(1,000's)
		$17,974	$105,894	$118,907	$5,545	$16,021	$24,744

FIGURE 6.3-3 THRUVILLE SUMMARY GOVERNMENT ONLY EXPENDITURES FOR HIGH MARKET PENETRATION

7. SAMPLE EXPENDITURE CALCULATIONS - RURAL AREA

The Phase II cost evaluation of the National ITS Architecture includes an evaluation of three separate scenarios. Each scenario represents a typical deployment area and is to provide a frame of reference for similar implementations of the architecture. A high level description of the rural area, Mountainville, is included in the Evaluatory Design Document. A more in-depth description of Mountainville is located in the "Rural Scenario Guide, Mountainville, Phase II" scenario description document. The scenario description is a common description utilized for numerous architecture evaluation activities, including: the cost evaluation, the benefit analysis, as well as technical performance analyses. Thus, the results of the various architecture evaluation activities are all based upon one common set of assumptions.

The cost analysis evaluates five, ten and twenty year deployment milestones as specified in the Phase II Deliverable Guidelines

7.1 Examination of Equipment Package Worksheets

Equipment Package Worksheets are included in the previous sections 4.6.1 through 4.6.19. Each worksheet lists equipment and price ranges for that equipment, including hardware and software, as well as operation (additional staffing) and maintenance requirements. The price ranges represent state-of-the-practice equipment using installed construction bid prices for some packages, state-of-the-art equipment using comparable technology (often referenced to equipment manufacturers' estimated unit prices for comparable technology, e.g. Seimens Automotive) and developing technology (also using comparable technology and referenced to integration and systems engineering companies' and equipment manufacturers' estimated unit prices for comparable technology.)

The unit price justification is noted in the Common Equipment section of 4.6 and in the worksheets' column for "Comparative Technology." In the worksheets, where "Existing Technology" is noted, the prices represent typical unit prices for equipment found in catalogs, such as Sweet's Engineering and Retrofit, a catalog for construction cost estimating for current, off-the-shelf technology. Other references to price justification indicate specific construction bid prices for recent contracts. These prices are actual bid prices for installation. Where these two forms of justification were not available, some estimations are provided through consultations with experts in respective fields for manufacturing, and system integration. Lastly, some prices which are less certain are estimates based on professional judgement.

7.2 Identification and Evaluation of Quantities and Market Size

For the Equipment Package parameters, the quantity of items purchased influences the unit price for the equipment. Obviously, price breaks come into effect when larger quantities are purchased. For existing technology, many equipment prices are at a steady state price (exhibited in the far right columns of the Equipment Worksheets.) The prices are generally not subject to wide fluctuations based on quantities. Newer technology, or services which are

on the front end of a market/product development curve, are subject to wide price ranges. For Mountainville, two sets of market penetrations were analyzed, a high and a low scenario. For the cost evaluation activities the low value of the unit price ranges was utilized for all Equipment Packages.

7.3 Calculation of Expenditures

Expenditures are calculated automatically through the linked spreadsheet programs. Included in the calculation are non-recurring expenditures (one-time capital costs) and recurring expenditures (annual operation and maintenance costs). The non-recurring expenditures are incurred in accordance with the Evaluatory Design Document deployment quantities for the five, ten and twenty deployment years. The recurring expenditures are incurred in the deployment year and every year thereafter.

Non-recurring expenditures also include the expenditures for asset replacement at the end of its useful life. These expenditures are automatically incorporated into the spreadsheet utilizing the "Years to Replacement" column in the Equipment Package Worksheets. This tabulation of non-recurring expenditures continues from the year of initial deployment through the analysis time frame. This evaluation is important when considering comparative technologies and life cycle costs (see previous section on life cycle costing.)

7.4 Results

Similar to the results from the Urbansville analysis, tabulated below are the non-recurring and recurring expenditures for a minimal basic service a mid-range service, and a comprehensive service, that would be experienced by one individual in the individual consumers group. As stated in section 4.6.19, the unit price of equipment for in-vehicle devices are based on existing technology, or nationally developed technology which takes advantage of national market deployment price breaks.

Basic service provides the capability for drivers to interface with the ISP Subsystem's Basic Information Broadcast Equipment Package, receive formatted traffic advisories including accurate traveling information concerning available travel options, their availability, and congestion information in their vehicle. Basic Service also provides Vehicle MAYDAY service. Mid-range Service provides the Basic services plus In-Vehicle hardware, and software for Vehicle Route Guidance and Interactive Vehicle Reception. The comprehensive Service provides the Basic and Mid-range Services plus equipment for In-Vehicle Signing, Probe Vehicle Software, Smart Probe, and Vehicle Route Guidance.

INDIVIDUAL NON-RECURRING
EXPENDITURES

Basic Service	VS1, VS14	$450
Mid-range Service	Basic+VS5,VS16	$1,350
Comprehensive Service	Mid-Range+VS4,VS6,VS7, VS19	$2,140

If all vehicle Equipment Packages including safety systems are combined, the total per vehicle non-recurring expenditure is $8,310.

INDIVIDUAL MONTHLY RECURRING EXPENDITURES

		Operation	Maintenance
Basic Service	VS1, VS14	$10	$1
Mid-range Service	Basic+VS5,V16	$35	<$5
Comprehensive Service	Mid-Range+VS4,VS6,VS7, VS19	$35	<$8

The monthly service charges for in-vehicle services are in the range of $0 to $43 per month for individual users (based on average usage) and are comparable to current service cost experiences for cellular telephone service.

Scenario expenditures for Mountainville are classified into likely stakeholder responsibility for funding. The resulting allocations are presented below.

Mountainville High Market Penetration
Twenty Year Non-Recurring Expenditure Totals

Stakeholder	Percent of Total Funding Requirements
Government	36%
Commercial	18%
Individual	46%

Mountainville Low Market Penetration
Twenty Year Non-Recurring Expenditure Totals

Stakeholder	Percent of Total Funding Requirements
Government	54%
Commercial	18%
Individual	28%

The summary expenditures for the Mountainville Equipment Packages are provided in the following pages. The non-recurring expenditures are tabulated below for the deployment milestone in the evaluation period. Note that the summations consists of the expenditures for the year stated plus the expenditures for the four previous years. The numbers presented for the recurring expenditures represent the expenditures for operation and maintenance during the deployment milestone years. Note that the non-recurring expenditures include replacement expenditures for reinvestment of equipment at the end of its' useful life.

The first of the analysis results, are for a low level market penetration, consistent with the evaluatory design parameters for deployment penetration. The second set of results are for the high level market penetration. The last results page is reflective of the government expenditures.

Equipment Package Expenditures for Low Market Penetration

		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20
CVA1	Credentials and Taxes Administration	$277	$1	$16	$281	$281	$281
CVA2	CV Information Exchange	$22	$0	$0	$77	$77	$77
CVA3	CV Safety Administration	$40	$0	$0	$0	$0	$0
CVA4	International CV Administration	$0	$0	$0	$0	$0	$0
CVC1	Citation and Accident Electronic Recording	$20	$0	$0	$2	$2	$2
CVC2	International Border Crossing	$0	$0	$0	$0	$0	$0
CVC3	Roadside Electronic Screening	$326	$0	$80	$9	$9	$9
CVC4	Roadside Safety Inspection	$44	$3	$6	$2	$2	$2
CVC5	Roadside WIM	$15	$0	$15	$1	$1	$1
CVS1	On-board Cargo Monitoring	$0	$1	$4	$0	$2	$10
CVS2	On-board CV Electronic Data	$0	$3	$12	$0	$1	$4
CVS3	On-board CV Safety	$0	$3	$11	$0	$0	$0
CVS4	On-board Trip Monitoring	$20	$79	$524	$2	$12	$66
EM1	Emergency and Incident Management Communication	$0	$0	$6	$0	$0	$7
EM2	Emergency Mayday and E-911 I/F	$0	$105	$105	$0	$2	$2
EM3	Emergency Response Management	$0	$0	$91	$0	$0	$136
EM4	Emergency Vehicle Routing and communications	$0	$0	$1	$0	$0	$1
EMM1	Emissions and Environmental Data Management	$0	$1	$0	$0	$54	$54
EVS1	On-board EV Incident Management Communication	$1	$1	$9	$0	$0	$2
EVS2	On-board Vehicle Signal Coordination	$1	$1	$8	$0	$0	$2
FMS1	Fleet Administration	$0	$356	$7	$0	$5	$5
FMS2	Fleet Credentials and Taxes Management and Reporting	$0	$311	$31	$0	$342	$342
FMS3	Fleet HAZMAT Management	$0	$0	$0	$0	$0	$0
FMS4	Freight Administration and Management	$0	$2	$2	$0	$1	$1
FMS5	Fleet Maintenance Management	$0	$121	$0	$0	$7	$7
ISP1	Basic Information Broadcast	$0	$0	$422	$0	$0	$316
ISP2	EM Route Plan Information Dissemination	$0	$0	$0	$0	$0	$0
ISP3	Infrastructure Provided Dynamic Ridesharing	$0	$0	$0	$0	$0	$0
ISP4	Infrastructure Provided Route Selection	$0	$0	$0	$0	$0	$0
ISP5	Infrastructure Provided Yellow Pages & Reservation	$0	$0	$0	$0	$0	$0
ISP6	Interactive Infrastructure Information	$0	$0	$359	$0	$0	$118
ISP7	ISP Advanced Integrated Control Support	$0	$0	$0	$0	$0	$0
ISP8	ISP Probe Information Collection	$0	$0	$0	$0	$0	$0
PIA1	Personal Basic Information Reception	$0	$0	$13	$0	$0	$3
PIA2	Personal Interactive Information Reception	$0	$1	$7	$0	$1	$5
PIA3	Personal Mayday I/F	$0	$47	$198	$0	$8	$34
PIA4	Personal Route Guidance	$0	$0	$17	$0	$0	$5
PMS1	Parking Management	$0	$0	$0	$0	$0	$0
PS1	Data Collection and ITS Planning	$0	$0	$0	$0	$0	$0

FIGURE 7.3-1 MOUNTAINVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR LOW MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for Low Market Penetration

		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20
RS1	Automated road signing	$0	$125	$375	$0	$13	$25
RS10	Roadway Pollution and Environmental Hazards Indicators	$0	$208	$334	$0	$1	$2
RS11	Roadway Probe Beacons	$0	$125	$375	$0	$13	$25
RS12	Roadway Reversible Lanes	$0	$0	$0	$0	$0	$0
RS13	Roadway Systems for AHS	$0	$0	$0	$0	$0	$0
RS14	Roadway Traffic Information Dissemination	$0	$426	$18	$0	$14	$14
RS2	Roadside Signal Priority	$0	$0	$0	$0	$0	$0
RS3	Roadway Freeway Control	$0	$0	$0	$0	$0	$0
RS4	Roadway Signal Controls	$0	$0	$0	$0	$0	$0
RS5	Roadway Basic Surveillance	$0	$0	$0	$0	$0	$0
RS6	Roadway HOV Usage	$0	$0	$0	$0	$0	$0
RS7	Roadway In-Vehicle Signing	$0	$160	$420	$0	$10	$20
RS8	Roadway Incident Detection	$0	$0	$0	$0	$0	$0
RS9	Roadway Intersection Collision System	$0	$0	$0	$0	$0	$0
RTS1	Remote Interactive Information Reception	$0	$0	$0	$0	$0	$0
RTS2	Remote Mayday I/F	$0	$0	$0	$0	$0	$0
RTS3	Remote Transit Fare Management	$0	$0	$0	$0	$0	$0
RTS4	Remote Transit Security I/F	$0	$0	$0	$0	$0	$0
RTS5	Remote Basic Information Reception	$0	$0	$0	$0	$0	$0
TAS1	Toll Administration	$0	$0	$0	$0	$0	$0
TCS1	Toll Plaza Toll Collection	$0	$0	$0	$0	$0	$0
TMS1	Collect Traffic Surveillance	$0	$0	$0	$0	$0	$0
TMS10	TMC Incident Dispatch Coordination/Communication	$0	$199	$78	$0	$92	$92
TMS11	TMC Input to In-Vehicle Signing	$0	$0	$0	$0	$0	$0
TMS12	TMC Multi-Modal Coordination	$0	$0	$0	$0	$0	$0
TMS13	TMC Probe Information Collection	$0	$0	$0	$0	$0	$0
TMS14	TMC Toll/Parking Coordination	$0	$0	$0	$0	$0	$0
TMS15	TMC Traffic Information Dissemination	$0	$117	$46	$0	$120	$120
TMS16	TMC Traffic Network Performance Evaluation	$0	$0	$0	$0	$0	$0
TMS17	Traffic Maintenance	$0	$0	$0	$0	$0	$0
TMS2	Distributed Road Management	$0	$364	$360	$0	$205	$205
TMS3	TMC Advanced Signal Control	$0	$0	$0	$0	$0	$0
TMS4	TMC Regional Traffic Control	$0	$0	$0	$0	$0	$0
TMS5	TMC based Freeway Control	$0	$0	$0	$0	$0	$0
TMS6	TMC Basic Signal Control	$0	$0	$0	$0	$0	$0
TMS7	TMC for AHS	$0	$0	$0	$0	$0	$0
TMS8	TMC HOV/Reversible Lane Management	$0	$0	$0	$0	$0	$0
TMS9	TMC Incident Detection	$0	$0	$0	$0	$0	$0
TRM1	Fleet Maintenance Management	$0	$0	$121	$0	$0	$7

FIGURE 7.3-1 MOUNTAINVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR LOW MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for Low Market Penetration

		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20
TRM2	Transit Center Fare and Load Management	$0	$0	$292	$0	$0	$7
TRM3	Transit Center Fixed-Route Operations	$0	$0	$249	$0	$0	$231
TRM4	Transit Center Multi-Modal Coordination	$0	$0	$0	$0	$0	$0
TRM5	Transit Center Paratransit Operations	$0	$0	$140	$0	$0	$1
TRM6	Transit Center Security	$0	$0	$321	$0	$0	$205
TRM7	Transit Center Tracking and Dispatch	$0	$847	$15	$0	$267	$267
TRV1	On-board Maintenance	$0	$9	$15	$0	$5	$7
TRV2	On-board Transit Driver I/F	$0	$0	$50	$0	$0	$11
TRV3	On-board Transit Fare and Load Management	$0	$0	$13	$0	$0	$16
TRV4	On-board Transit Security	$0	$0	$45	$0	$0	$4
TRV5	On-board Vehicle Signal Coordination	$0	$0	$0	$0	$0	$0
TRV6	Vehicle Dispatch Support	$0	$0	$0	$0	$0	$2
TRV7	On-board Trip Monitoring	$0	$0	$9	$0	$0	$15
VS1	Basic Vehicle Reception	$15	$60	$407	$0	$0	$0
VS10	Vehicle Lateral Control	$0	$0	$0	$0	$0	$0
VS11	Vehicle Lateral Warning System	$0	$0	$138	$0	$0	$4
VS12	Vehicle Longitudinal Control	$0	$0	$59	$0	$0	$4
VS13	Vehicle Longitudinal Warning System	$0	$26	$138	$0	$1	$4
VS14	Vehicle Mayday I/F	$55	$95	$349	$28	$78	$153
VS15	Vehicle Pre-Crash Safety Systems	$0	$0	$87	$0	$0	$3
VS16	Vehicle Route Guidance	$0	$60	$440	$0	$26	$187
VS17	Vehicle Safety Monitoring System	$19	$78	$529	$1	$7	$39
VS18	Vehicle Systems for AHS	$0	$0	$0	$0	$0	$0
VS19	Vehicle Toll/Parking I/F	$0	$0	$0	$0	$0	$0
VS2	Driver Safety Monitoring System	$0	$32	$338	$0	$2	$24
VS3	Driver Visibility Improvement System	$0	$0	$95	$0	$0	$5
VS4	In-Vehicle Signing System	$0	$12	$126	$0	$1	$8
VS5	Interactive Vehicle Reception	$0	$22	$55	$0	$13	$33
VS6	Probe Vehicle Software	$0	$0	$4	$0	$0	$1
VS7	Smart Probe	$0	$4	$43	$0	$0	$1
VS8	Vehicle Intersection Collision Warning	$0	$0	$0	$0	$0	$0
VS9	Vehicle Intersection Control	$0	$0	$0	$0	$0	$0

FIGURE 7.3-1 MOUNTAINVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR LOW MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration								
		Non-Recurring Expenditures			Recurring Expenditures			
		Yrs	Yrs	Yrs	Average Annual Expenditures			
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20	
CVA1	Credentials and Taxes Administration	$277	$1	$16	$281	$281	$281	
CVA2	CV Information Exchange	$22	$0	$0	$77	$77	$77	
CVA3	CV Safety Administration	$40	$0	$0	$0	$0	$0	
CVA4	International CV Administration	$0	$0	$0	$0	$0	$0	
CVC1	Citation and Accident Electronic Recording	$20	$0	$0	$2	$2	$2	
CVC2	International Border Crossing	$0	$0	$0	$0	$0	$0	
CVC3	Roadside Electronic Screening	$326	$0	$80	$9	$9	$9	
CVC4	Roadside Safety Inspection	$44	$3	$6	$2	$2	$2	
CVC5	Roadside WIM	$15	$0	$15	$1	$1	$1	
CVS1	On-board Cargo Monitoring	$1	$1	$9	$2	$5	$23	
CVS2	On-board CV Electronic Data	$1	$4	$20	$0	$1	$6	
CVS3	On-board CV Safety	$1	$4	$17	$0	$0	$0	
CVS4	On-board Trip Monitoring	$49	$151	$839	$6	$25	$105	
EM1	Emergency and Incident Management Communication	$6	$0	$1	$7	$7	$7	
EM2	Emergency Mayday and E-911 I/F	$105	$0	$105	$2	$2	$2	
EM3	Emergency Response Management	$91	$0	$90	$136	$136	$136	
EM4	Emergency Vehicle Routing and communications	$1	$0	$1	$1	$1	$1	
EMM1	Emissions and Environmental Data Management	$0	$1	$0	$0	$54	$54	
EVS1	On-board EV Incident Management Communication	$1	$5	$9	$0	$1	$2	
EVS2	On-board Vehicle Signal Coordination	$1	$4	$8	$0	$1	$2	
FMS1	Fleet Administration	$356	$1	$363	$5	$5	$10	
FMS2	Fleet Credentials and Taxes Management and Reporting	$311	$16	$342	$342	$342	$684	
FMS3	Fleet HAZMAT Management	$0	$0	$0	$0	$0	$0	
FMS4	Freight Administration and Management	$2	$0	$4	$1	$1	$2	
FMS5	Fleet Maintenance Management	$121	$0	$121	$7	$7	$14	
ISP1	Basic Information Broadcast	$0	$0	$422	$0	$0	$316	
ISP2	EM Route Plan Information Dissemination	$0	$0	$0	$0	$0	$0	
ISP3	Infrastructure Provided Dynamic Ridesharing	$0	$0	$0	$0	$0	$0	
ISP4	Infrastructure Provided Route Selection	$0	$0	$350	$0	$0	$13	
ISP5	Infrastructure Provided Yellow Pages & Reservation	$0	$0	$0	$0	$0	$0	
ISP6	Interactive Infrastructure Information	$0	$0	$359	$0	$0	$118	
ISP7	ISP Advanced Integrated Control Support	$0	$0	$0	$0	$0	$0	
ISP8	ISP Probe Information Collection	$0	$0	$0	$0	$0	$0	
PIA1	Personal Basic Information Reception	$7	$11	$140	$2	$4	$31	
PIA2	Personal Interactive Information Reception	$0	$2	$14	$0	$1	$10	
PIA3	Personal Mayday I/F	$7	$86	$272	$1	$16	$45	
PIA4	Personal Route Guidance	$0	$24	$168	$0	$8	$54	
PMS1	Parking Management	$0	$0	$0	$0	$0	$0	
PS1	Data Collection and ITS Planning	$0	$0	$0	$0	$0	$0	

FIGURE 7.3-2 MOUNTAINVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR HIGH MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration								
		Non-Recurring Expenditures			Recurring Expenditures			
		Yrs	Yrs	Yrs	Average Annual Expenditures			
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20	
RS1	Automated road signing	$0	$125	$375	$0	$13	$25	
RS10	Roadway Pollution and Environmental Hazards Indicators	$0	$208	$334	$0	$1	$2	
RS11	Roadway Probe Beacons	$0	$125	$375	$0	$13	$25	
RS12	Roadway Reversible Lanes	$0	$0	$0	$0	$0	$0	
RS13	Roadway Systems for AHS	$0	$0	$0	$0	$0	$0	
RS14	Roadway Traffic Information Dissemination	$0	$476	$68	$0	$14	$14	
RS2	Roadside Signal Priority	$0	$0	$0	$0	$0	$0	
RS3	Roadway Freeway Control	$0	$0	$0	$0	$0	$0	
RS4	Roadway Signal Controls	$0	$0	$0	$0	$0	$0	
RS5	Roadway Basic Surveillance	$0	$0	$0	$0	$0	$0	
RS6	Roadway HOV Usage	$0	$0	$0	$0	$0	$0	
RS7	Roadway In-Vehicle Signing	$0	$160	$420	$0	$10	$20	
RS8	Roadway Incident Detection	$0	$0	$0	$0	$0	$0	
RS9	Roadway Intersection Collision System	$0	$0	$0	$0	$0	$0	
RTS1	Remote Interactive Information Reception	$0	$0	$0	$0	$0	$0	
RTS2	Remote Mayday I/F	$0	$0	$0	$0	$0	$0	
RTS3	Remote Transit Fare Management	$0	$0	$0	$0	$0	$0	
RTS4	Remote Transit Security I/F	$0	$0	$30	$0	$0	$24	
RTS5	Remote Basic Information Reception	$0	$0	$0	$0	$0	$0	
TAS1	Toll Administration	$0	$0	$0	$0	$0	$0	
TCS1	Toll Plaza Toll Collection	$0	$0	$0	$0	$0	$0	
TMS1	Collect Traffic Surveillance	$0	$0	$0	$0	$0	$0	
TMS10	TMC Incident Dispatch Coordination/Communication	$0	$199	$78	$0	$92	$92	
TMS11	TMC Input to In-Vehicle Signing	$0	$0	$63	$0	$0	$68	
TMS12	TMC Multi-Modal Coordination	$0	$0	$0	$0	$0	$0	
TMS13	TMC Probe Information Collection	$0	$0	$0	$0	$0	$0	
TMS14	TMC Toll/Parking Coordination	$0	$0	$0	$0	$0	$0	
TMS15	TMC Traffic Information Dissemination	$0	$117	$46	$0	$120	$120	
TMS16	TMC Traffic Network Performance Evaluation	$0	$0	$0	$0	$0	$0	
TMS17	Traffic Maintenance	$0	$0	$0	$0	$0	$0	
TMS2	Distributed Road Management	$0	$364	$360	$0	$205	$205	
TMS3	TMC Advanced Signal Control	$0	$0	$0	$0	$0	$0	
TMS4	TMC Regional Traffic Control	$0	$0	$364	$0	$0	$205	
TMS5	TMC based Freeway Control	$0	$0	$0	$0	$0	$0	
TMS6	TMC Basic Signal Control	$0	$0	$0	$0	$0	$0	
TMS7	TMC for AHS	$0	$0	$0	$0	$0	$0	
TMS8	TMC HOV/Reversible Lane Management	$0	$0	$0	$0	$0	$0	
TMS9	TMC Incident Detection	$0	$0	$0	$0	$0	$0	
TRM1	Fleet Maintenance Management	$0	$121	$0	$0	$7	$7	
	FIGURE 7.3-2 MOUNTAINVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR HIGH MARKET PENETRATION							207

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration

		Non-Recurring Expenditures			Recurring Expenditures		
		Yrs	Yrs	Yrs	Average Annual Expenditures		
EP ID	Equipment Package Name	1-5	6-10	11-20	5	10	20
TRM2	Transit Center Fare and Load Management	$0	$292	$0	$0	$7	$7
TRM3	Transit Center Fixed-Route Operations	$0	$249	$0	$0	$231	$231
TRM4	Transit Center Multi-Modal Coordination	$0	$0	$0	$0	$0	$0
TRM5	Transit Center Paratransit Operations	$0	$140	$0	$0	$1	$1
TRM6	Transit Center Security	$0	$321	$70	$0	$205	$205
TRM7	Transit Center Tracking and Dispatch	$0	$847	$15	$0	$267	$267
TRV1	On-board Maintenance	$0	$15	$15	$0	$7	$7
TRV2	On-board Transit Driver I/F	$0	$50	$54	$0	$11	$11
TRV3	On-board Transit Fare and Load Management	$0	$13	$13	$0	$16	$16
TRV4	On-board Transit Security	$0	$45	$45	$0	$4	$4
TRV5	On-board Vehicle Signal Coordination	$0	$0	$0	$0	$0	$0
TRV6	Vehicle Dispatch Support	$0	$0	$0	$0	$2	$2
TRV7	On-board Trip Monitoring	$0	$9	$9	$0	$15	$15
VS1	Basic Vehicle Reception	$44	$106	$829	$0	$0	$0
VS10	Vehicle Lateral Control	$0	$0	$0	$0	$0	$0
VS11	Vehicle Lateral Warning System	$0	$52	$412	$0	$1	$12
VS12	Vehicle Longitudinal Control	$0	$22	$177	$0	$1	$12
VS13	Vehicle Longitudinal Warning System	$2	$128	$415	$0	$4	$12
VS14	Vehicle Mayday I/F	$91	$189	$680	$47	$146	$306
VS15	Vehicle Pre-Crash Safety Systems	$0	$0	$432	$0	$0	$16
VS16	Vehicle Route Guidance	$0	$119	$1,885	$0	$51	$801
VS17	Vehicle Safety Monitoring System	$38	$351	$1,059	$3	$30	$79
VS18	Vehicle Systems for AHS	$0	$0	$0	$0	$0	$0
VS19	Vehicle Toll/Parking I/F	$0	$0	$0	$0	$0	$0
VS2	Driver Safety Monitoring System	$0	$160	$844	$0	$11	$59
VS3	Driver Visibility Improvement System	$0	$0	$472	$0	$0	$24
VS4	In-Vehicle Signing System	$0	$60	$251	$0	$4	$16
VS5	Interactive Vehicle Reception	$0	$75	$157	$0	$45	$94
VS6	Probe Vehicle Software	$0	$2	$8	$0	$0	$2
VS7	Smart Probe	$0	$16	$85	$0	$0	$1
VS8	Vehicle Intersection Collision Warning	$0	$0	$0	$0	$0	$0
VS9	Vehicle Intersection Control	$0	$0	$0	$0	$0	$0

FIGURE 7.3-2 MOUNTAINVILLE SUMMARY EQUIPMENT PACKAGE EXPENDITURES FOR HIGH MARKET PENETRATION

Expenditures are in constant 1995 dollars in (1,000's)

Equipment Package Expenditures for High Market Penetration							
Government Stakeholder		**Non-Recurring Expenditures**			**Recurring Expenditures**		
		Yrs	**Yrs**	**Yrs**	**Average Annual Expenditures**		
Subsystem	**Subsystem Name**	**1-5**	**6-10**	**11-20**	**5**	**10**	**20**
CVAS	Commmercial Vehicle Administration Subsystem	$338	$1	$16	$358	$358	$358
CVCS	Commercial Vehicle Check Subsystem	$405	$3	$101	$14	$14	$14
EMS	Emergency Management Subsystem	$203	$0	$196	$147	$147	$147
EMMS	Environmental And Emmisions Management Subsystem	$0	$1	$0	$0	$54	$54
EVS	Emergency Vehicle Subsystem	$2	$8	$17	$0	$2	$3
PMS	Parking Management Subsystem	$0	$0	$0	$0	$0	$0
PS	Planning Subsystem	$0	$0	$0	$0	$0	$0
RS	Roadside Subsystem	$0	$1,094	$1,572	$0	$50	$87
RTS	Remote Traveler Subsystem	$0	$0	$30	$0	$0	$24
TAS	Toll Administration Subsystem	$0	$0	$0	$0	$0	$0
TCS	Toll Collection Subsystem	$0	$0	$0	$0	$0	$0
TMS	Traffic Management Subsystem	$0	$679	$911	$0	$416	$688
TRMS	Transit Management Subsystem	$0	$1,968	$85	$0	$718	$718
TRVS	Transit Vehicle Subsystem	$0	$133	$137	$0	$55	$55
					Expenditures are in constant 1995 dollars in (1,000's)		
		$948	$3,887	$3,065	$519	$1,814	$2,148

FIGURE 7.3-3 MOUNTAINVILLE SUMMARY GOVERNMENT ONLY EXPENDITURES FOR HIGH MARKET PENETRATION

APPENDIX A -List of Acronyms

A

ABS	Antilock Brake System
ADA	Americans with Disabilities Act
AFD	Architecture Flow Diagram
AID	Architecture Interconnect Diagram
AHS	Automated Highway System
AMPS	Advanced Mobile Phone System
ATIS	Advanced Traveler Information System
ATM	Asynchronous Transfer Mode
ATMS	Advanced Traffic Management System
AVCS	Advanced Vehicle Control System
AVI	Automated Vehicle Identification
AVL	Automated Vehicle Location
AVO	Automated Vehicle Operation

C

CAAA	Clean Air Act Amendment
CASE	Computer Aided Systems Engineering
CCTV	Closed Circuit TV
CDMA	Code Division Multiple Access
CDPD	Cellular Digital Packet Data
CMS	Changeable Message System
COTR	Contracting Officer Technical Representative
CSP	Communication Service Provider
CVAS	Commercial Vehicle Administration Subsystem
CVCS	Commercial Vehicle Check Subsystem
CVISN	Commercial Vehicle Information Systems and Networks
CVS	Commercial Vehicle Subsystem
CVO	Commercial Vehicle Operations

D

DAB	Digital Audio Broadcast
DD	Data Dictionary
DDE	Data Dictionary Element
DFD	Data Flow Diagram
DGPS	Differential Global Positioning System
DOD	Department of Defense
DOT	Department of Transportation
DMV	Department of Motor Vehicles
DSRC	Dedicated Short Range Communications
DTA	Dynamic Traffic Assignment

E

ECPA	Electronic Communications Privacy Act
EDI	Electronic Data Interchange
EPA	Environmental Protection Agency
EM	Emergency Management Subsystem
EMC	Emergency Management Center
EMMS	Emissions Management Subsystem
ESMR	Enhanced SMR
ETA	Expected Time of Arrival
ETTM	Electronic Toll and Traffic Management

F

FARS	Fatal Accident Reporting System
FCC	Federal Communications Commission for the U.S.
FHWA	Federal Highway Administration
FIPS	Federal Information Processing Standard
FOT	Field Operational Test
FMS	Fleet Management Subsystem
FPR	Final Program Review
FTA	Federal Transit Administration

G

GIS	Geographic Information System
GPS	Global Positioning System

H

HAR	Highway Advisory Radio
HAZMAT	HAZardous MATerial(s)
HOV	High Occupancy Vehicle
HUD	Head–Up Display

I

IEEE	Institute of Electrical and Electronics Engineers, Inc.
IVIS	In Vehicle Information System
IP	Internet Protocol
IPR	Interim Program Review
ISO	International Standards Organization
ISP	Information Service Provider
ISTEA	Intermodal Surface Transportation Efficiency Act
ITE	Institute of Transportation Engineers
ITI	Intelligent Transportation Infrastructure
ITS	Intelligent Transportation Systems
ITS AMERICA	Intelligent Transportation Society of America
IVHS	Intelligent Vehicle Highway Systems

L

LAN	Local Area Network
LCD	Liquid Crystal Display
LED	Light Emitting Diode
LEO	Low–Earth Orbit satellite system
LPD	Liability and Property Damage
LRMP	Location Reference Messaging Protocol
LRMS	Location Reference Messaging Standard

M

MAN	Metropolitan Area Network
MAUT	Multiattribute Utility Theory
MMI	Man–Machine Interface (or Interaction)
MOE	Measure Of Effectiveness
MPO	Metropolitan Planning Organization
MPH	Miles per Hour
MTC	Metro Traffic Control

N

NA	National Architecture
NAR	National Architecture Review
NEMA	National Electrical Manufacturers Association
NHPN	National Highway Planning Network
NHTSA	National Highway Traffic Safety Administration
NII	National Information Infrastructure (aka Information Superhighway)
NTCIP	National Transportation Communications for ITS Protocol

O

OEM	Original Equipment Manufacturer
OSI	Open Systems Interconnection
OTP	Operational Test Plan

P

PCS	Personal Communications System
PDA	Personal Digital Assistant
PIAS	Personal Information Access Subsystem
PMS	Parking Management Subsystem
PS	Planning Subsystem
PSA	Precursor System Architecture
PSPEC	Process Specification
PSTN	Public Switched Telephone Network

Q

QFD	Quality Functional Deployment

R

R&D	Research and Development
RDS	Radio Data Systems
RDS–TMC	Radio Data Systems incorporating a Traffic Message Channel
RTA	Regional Transit Authority
RS	Roadway Subsystem
RTS	Remote Traveler Support Subsystem

S

SAE	Society of Automotive Engineers
SDO	Standards Development Organization
SMR	Specialized Mobile Radio
SONET	Synchronous Optical Network
SOV	Single Occupancy Vehicle
STMF	Simple Transportation Management Framework
SQL	Standard Query Language

T

TAS	Toll Administration Subsystem
TCS	Toll Collection Subsystem
TDM	Travel Demand Management
TDMA	Time Division Multiple Access
TIGER	Topologically Integrated Geographic Encoding & Referencing files
TMC	1. Traffic Management Center 2. Traffic Message Channel. See RDS–TMC
TMS	Traffic Management Subsystem
TRMC	Transit Management Center
TRMS	Transit Management Subsystem
TRT	Technical Review Team
TRVS	Transit Vehicle Subsystem

V

VMS	Variable Message Sign
VRC	Vehicle/Roadside Communications
VS	Vehicle Subsystem

W

WAN	Wide Area Network
WIM	Weigh–in Motion
WWW	World Wide Web

ITS Architecture
Cost Analysis
Addendum for Highway Rail Interface (HRI)
Final Delivery

Prepared by the
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US Department of Transportation
Washington, D. C. 20590

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Cost Analysis Addendum for HRI
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1. INTRODUCTION

The goal of the Highway Rail Interface (HRI) addendum to the Cost Analysis for Phase 2 of the National ITS Architecture project is to produce a high-level estimate of the expenditures associated with implementing the physical elements and the functional capabilities of the HRI User Service as it is likely to be deployed under the confines of the National ITS Architecture. A second goal of the HRI cost evaluation is to provide a costing tool for ITS implementors. The range of unit prices and quantities provided throughout the evaluation may be used in determining appropriate deployment plans and strategies.

The analysis addresses expenditures for equipment deployment, as well as operations and maintenance for the subsystems identified in the physical architecture. The HRI cost evaluation is based on the updated Phase II physical architecture which includes additions to and modifications of the subsystems listed below.

- Roadway Subsystem (RS)
- Traffic Management Subsystem (TMS)

In accordance with FHWA costing guidelines, the phase two analyses include the cost evaluation of three distinct deployment scenarios. These scenarios cover an urban, inter-urban, and rural settings over 5, 10, and 20 year time frames measured from 1992 according to FHWA guidelines. For HRI the same scenarios and time frames will be used. Not all HRI related equipment packages are deployed in each scenario. However, among the three scenarios, each HRI related equipment package is deployed in at least one area. The analyses assume a twenty-year deployment period and account for both non-recurring and recurring costs (operations and maintenance activities).

The accuracy of any cost evaluation is a function of evaluating the state-of-the-practice, the state-of-the-art, or the yet to be defined technology. The delivery of HRI related services encompasses all three of these situations. Where the state-of-the-practice technology is being deployed in the delivery of ITS services, the accuracy of the cost evaluation is significantly better than cost estimates for developing technology and those technologies which are still in the research stages. This being the case, the unit prices for near term deployed and currently deployed ITS systems rely on existing price catalogs, state's department of transportation construction pay item ranges, as well as other public records including construction bid unit prices.

Where feasible, a range of estimates is provided for specific technology equipment. This range should be balanced with local construction pricing indices, such as the Means Cost Estimating Indices.

1.1 Organization of Report

This HRI addendum to the Cost Analysis report is separated into seven main sections.

After this introduction section 2 outlines the objectives of the National ITS Architecture Cost Evaluation for HRI.

Section 3 provides a basic definition of the terms utilized in the HRI costing exercise. The relationships of ITS User Services to the deployable physical devices which provide the required functionality of the services is provided in chapter two.

Section 4 details the methodology for determining expenditures for each ITS HRI service through the deployment of Equipment Packages. This methodology can be used for determining the expenditures for

each Equipment Package based on any specified scenario. For HRI, the quantities of equipment packages as deployed in the three scenarios are also defined in section 4 instead of creating a standalone Evaluatory Design Document for HRI.

Sections 5, 6, and 7 provide examples of expenditure calculations for the specified scenarios, Urbansville, Thruville, and Mountainville, respectively. These sections demonstrate the execution of the methodology outlined in section 4, as well as demonstrate the assumptions necessary in determining the costing parameters.

1.2 Relationship to Other Documents

This report is written as part of a series of reports for the National ITS Architecture Program. While much of this report may be used without outside reference, there is specific reliance of the HRI Cost Analysis on several of the other documents.

The Physical and Logical Architecture documents represent the core descriptions of the national architecture structure. Their relationship to the cost document is significant in that the bases for the cost evaluation are deployment scenarios as functions of the national architecture.

The Theory of Operations provides a description of how the architecture provides for user services. The concepts of this document have been incorporated into the Cost Evaluation document through the establishment of sample deployment scenarios.

The Implementation Strategy describes the various issues and concerns in deploying ITS services. Stakeholder relationships, required interactions, and potential partnerships are detailed as they relate to implementing various services. The Implementation Strategy develops the concept of market packages that are used to group services that are allocated to the User Services and are used in cost/benefit analysis.

For HRI the information that was previously defined in the Evaluatory Design Document is included in section 4.5 of this document. That section identifies the parameters utilized to evaluate the architecture and market penetration values for each of the affected equipment packages.

1.3 Relationship to the ITS National Architecture

This Cost Analysis Addendum for HRI contains an evaluation of expenditures for sample deployments of HRI related ITS services. By its nature, a cost for the architecture itself cannot be quantified. What is quantified is the expenditure of sample implementations of the architecture, or system designs of HRI related ITS service deployments. These are sample deployments and do not encompass all deployment variations possible under the architecture framework.

2. OBJECTIVES

The objectives of the HRI cost evaluation of the National ITS Architecture can be summarized as follows:

1. To produce a high-level cost estimate of the implementation of the functional capabilities supported by the architecture.

2. To allocate expenditures into recurring, and non-recurring (including life cycle expenditures) categories.

3. To support analysis of design tradeoffs and provide expenditure data for analyzing the implementation alternatives.

4. To develop quantity, prices and expenditure estimates of the ITS architecture implementation to aid in FHWA's overall evaluation of alternative implementation strategies.

5. To develop estimates of the level and time line of the estimated government investment necessary for the ITS architecture deployment.

6. To provide elemental costs for implementors, which allow the Equipment Package Unit Price Worksheets to be utilized in costing ITS implementations for any designated deployment.

3. EQUIPMENT PACKAGE DEFINITION

The expenditures and unit prices utilized in this ITS National Architecture Evaluation for HRI represent the final price of the installed equipment instead of the manufacturer's cost of production. A manufacturer's cost of production is only one factor in determining the final price for a product which the market will bear and for which a reasonable profit may be made. Research and development costs, production costs, transportation costs, intermediary shippers' and handlers' costs, marketing costs, and retail markups are all a part of the determination of the final retail price of a product. These items are very difficult to estimate in developing manufacturing industries. Therefore, the expenditures presented in this analysis represent estimates of retail prices for equipment and staff based on comparable technology retail pricing, or estimates of market prices based on historical pricing strategies for specific industries.

Formulating unit prices for the devices involves cost recovery concepts and the following considerations:

- The total cumulative volume of that product which will be sold to all possible customers, over a period of years.
- The cost of software per product that is generally spread across all customer volumes, but includes considerations that a portion of that software was used previously, and / or if it can be shared by another product under development.
- Considerable tooling expense, and test equipment capital expense in the manufacturing of electronics.
- The cost of product recall if it is related to the safety or emissions;
- Target pricing policies, wherein the component product supplier is given a specified selling price. This policy invariably leads to a negotiating process involving component product specifications, and quality control issues.

To develop Unit Prices this analysis compares the Equipment Packages to similarly available commercial products. In addition, these comparisons are tempered by the likely total volumes of the product by a given supplier.

The basis for cost analysis is the set of HRI related Equipment Packages and the two affected subsystems of the Physical Architecture.

Subsystems perform transportation functions (e.g., collect data from the roadside, perform route planning, etc.) All of the functions are defined in the logical architecture as process specifications. Processes that are likely to be collected together under one physical agency, jurisdiction, or physical unit are grouped together into a subsystem. This grouping is done to optimize the overall expected performance of the resulting ITS deployments taking into consideration anticipated communication technologies, performance, risk, deployment, etc.

The Equipment Packages represent subsets of functionality within a single Subsystem. The HRI Equipment Packages are described in sections 4.6.

4. METHODOLOGY

This section outlines the steps necessary to determine a specific ITS deployment scenario's expenditures that are independent from the prescribed Urbansville, Thruville, and Mountainville scenarios provided by FHWA.

For reference, sample calculations for deployed services are provided in Sections 5, 6, and 7 for the prescribed typical areas, the urban area, interurban area, and rural area. The cost evaluation in these later chapters evaluates five, ten and twenty year deployment milestones based on the evaluatory design parameters and market penetrations which, for HRI, are specified in section 4.5. The analyses also assumes operations and maintenance schedules for this period, during which all devices remain operable and expenditures required to facilitate the Market Packages are incurred through life cycle costing.

4.1 Summary of Approach

The cost evaluation is conducted based on 1995 constant dollars for the unit prices in determining Equipment Package expenditure. The evaluation approach discussed below may be used by other groups implementing ITS services in determining conceptual pricing and expenditures for various services. The essential steps in cost evaluations are outlined below:

1. Definition of the ITS baseline for HRI that represents a reference point for the development and cost analysis of a future deployment.

2. Identification of the HRI related Market Packages that provide various levels of service to the users at various costs. The selection of Equipment Packages for the HRI User Service will span across Subsystems, as Market Packages require the functionality from multiple architectural Subsystems.

3. Examination of the lists of equipment as itemized in the Equipment Package Worksheets.

4. Examination of unit prices for end user services and/or packages of such equipment.

5. Identification and evaluation of equipment, quantities, and timing for a local deployment.

6. Calculation of the parametric quantities.

7. Calculation of the expenditure matrices for Equipment Packages.

8. Summation of Equipment Package expenditures to determine Market Packages expenditures.

The outputs of this analysis are the following:

- Equipment Package identification and existing technology components listing

- Matrices of Quantities for each scenario

- Matrices of unit prices for each Equipment Package

- Matrices of expenditures for each Equipment Package, for the specific scenario, for the analysis period.

4.2 End User Expenditures

End user expenditures, for any deployment, are the results of multiplying the quantities of items purchased for that deployment with the unit prices for each quantity item to be deployed in the scenario. The Equipment Packages are the basis for pricing strategies of an ITS deployment and are segregated by the architectural Subsystems. Each Equipment Package will have a time period of deployment, defined by the planned evolutionary deployment.

Of the various stakeholder groups represented across all of ITS, the Public/Government Sector is the only stakeholder group affected by the HRI unique equipment packages.

For every Equipment Package, there are two financial flows: (1) non-recurring expenditures, the initial funding or financing of service delivery and (2) recurring expenditures, the expenditures for continual operation and maintenance of the Equipment Packages.

Recurring expenditure items include consumables for the equipment as well as for service fees and access expenditures. Replacement devices with useful lives of one year or less are included in the recurring expenditure tabulations.

4.3 Life Cycle Costing

Life cycle expenditures for the non-recurring HRI related items are accounted for by full replacement at the end of the scheduled useful life. Refer to the original Cost Analysis document for more information.

The life cycle expenditures for alternative technology used in Equipment Packages may be evaluated and compared using the baseline deployment technology listed in the Worksheets.

4.4 Analytical Tools

Included with this document are spreadsheets for calculating end user expenditures for specific deployments, and other variations on the three FHWA provided scenarios.

The HRI cost analysis uses the same scenarios and time frames analyzed in the original Cost Analysis. An evaluatory design for the HRI specific components is included in section 4.5.

In these spreadsheets the annual expenditures are tabulated in the matrix for a total of twenty years. As certain Market Packages are deployed and become operational, the recurring operation and maintenance expenditures become activated, and the life cycle for the system components begins.

The Equipment Package Unit Price Worksheets contain the itemized listings of equipment as well as additional staffing requirements, equipment maintenance requirements, and operations required communications.

These assumptions and deployment designs for the three typical design scenarios provide some insight into selecting parameters for each Equipment Package.

4.5 Analytical Procedure

The HRI cost evaluation procedure develops an expenditure profile for the HRI User Service and the associated Market Packages. The expenditure profile includes a time frame for analysis in order to

evaluate life cycle costs, as well as to obtain a feeling for the relative dimensions of non-recurring costs (initial capital expenditures) and recurring costs (annual operation and maintenance expenditures.)

4.5.1 Definition of ITS Baseline

For the purposes of the Cost Analysis, the ITS baseline is a definition of what ITS equipment is in place prior to the start of the analysis period. The baseline for analysis, in general, assumes that there is no current ITS technology deployed. For each implementor's scenario, an inventory of existing systems is necessary. This inventory includes such items as signal controller technology, existing closed loop signal controls, existing traffic control/management facility capabilities and limitations, existing transit facility technology, existing emergency facilities, existing communication network along the roadway infrastructure, etc.

For HRI, many intersections have already been equipped with active gates and signals. This cost analysis will assume that a percentage of the HRIs in the regions under study will have been equipped with the active gates and will not include that cost in the total cost to deploy the ITS Equipment Packages. There is also assumed to be an existing set of traffic management roadside equipment including adjacent closed-loop signal control and communications to the Traffic Management Center (TMC).

4.5.2 Market Package Selection

For the HRI User Service 3 new Market Packages have been created:

- Standard Railroad Grade Crossing
- Advanced Railroad Grade Crossing
- Railroad Operations Coordination

In addition, 4 existing market packages satisfy elements of the HRI User Service:

- In Vehicle Signing
- Surface Street Control
- Traffic Information Dissemination
- Intersection Collision Avoidance

The deployment timing for Equipment Packages is detailed in the market penetrations of the equipment packages being deployed as part of these market packages.

Table 4-1 shows the relationship of market packages, equipment packages, and subsystems for the new and some of the existing market packages which satisfy the HRI requirements.

Table 4-1. Market Package to Equipment Package Relationship

Market Package	Market Package Name	Subsystem	Equipment Package Name
ATIS9	In Vehicle Signing	TMS	TMC Input to In-Vehicle Signing
		RS	Roadway In-Vehicle Signing
		VS	In-Vehicle Signing System
ATMS03	Surface Street Control	TMS	Traffic Maintenance
		TMS	TMC Basic Signal Control
		RS	Roadway Signal Controls
ATMS06	Traffic Information Dissemination	RS	Roadway Traffic Information Dissemination

Market Package	Market Package Name	Subsystem	Equipment Package Name
		TMS	TMC Traffic Information Dissemination
ATMS13	Standard Railroad Grade Crossing	RS	Standard Rail Crossing
		TMS	HRI Traffic Management
ATMS14	Advanced Railroad Grade Crossing	RS	Advanced Rail Crossing
		TMS	HRI Traffic Management
ATMS15	Railroad Operations Coordination	TMS	Rail Operations Coordination
AVSS10	Intersection Collision Avoidance	RS	Roadway Intersection Collision System
		VS	Vehicle Intersection Control

The equipment packages that make up Surface Street Control will not be listed in this cost analysis for HRI because the equipment is already considered in the current ITS cost model. The equipment packages that make up Intersection Collision Avoidance will not be listed either because the quantities deployed will be essentially zero in the time frames covered by this analysis.

4.5.3 Identification of Architectural Subsystems

This step identifies the required subsystems for the implementation of the HRI Market Packages. As shown in Table 4-1 there are 3 subsystems affected by the addition of HRI:

- Roadway Subsystem
- Traffic Management Subsystem
- Vehicle Subsystem

For this cost analysis none of the equipment packages located in the vehicle subsystem will be priced under the expectation that no additional cost will be placed on the consumer specifically for HRI. The Equipment Packages included in this cost analysis are as follows:

- HRI Traffic Management -This equipment package monitors highway-rail intersection (HRI) equipment at the roadside which manages highway traffic.
- Rail Operations Coordination - This resides in the TMS to coordinate with the rail operators as well as the other TMS functions.
- Standard Rail Crossing - This equipment package detects oncoming trains and controls the crossing gates/signals as well as pass the information to any adjacent signals to preempt the normal light timing.
- Advanced Rail Crossing - Additional functionality is incorporated here to detect entrapped vehicles in the 4 quadrant gate system and notify the engineers through the wayside equipment.
- Roadway In-Vehicle Signing - The analysis of this existing equipment package includes the additional signing beacons to be placed around the HRIs.
- Roadway Traffic Information Dissemination - The analysis of this existing equipment package includes a number of additional changeable message signs that will be added around many of the HRIs.

4.5.4 Examination of Equipment Package Worksheets

Equipment Package Worksheets are included in the section 4.6. Each worksheet lists equipment and price ranges for that equipment, including hardware and software, as well as operation (additional staffing) and

maintenance requirements. A review of the equipment listed and a comparison to the preferred local technology may yield different expenditure estimates. The price ranges represent state-of-the-practice equipment using installed construction bid prices for some packages, state-of-the-art equipment using comparable technology and developing technology, also using comparable technology.

4.5.5 Identification and Evaluation of Quantities and Market Size

The quantity of items purchased influences the unit price for the equipment. Price breaks come into effect when larger quantities are purchased. One consideration to take into account, when developing the parametric quantities is the existing product development curve. For existing technology, many equipment prices are at a steady state price. The prices are generally not subject to wide fluctuations based on quantities. Newer technology or services which are on the front end of a market/product development curve are subject to wide price ranges. Early deployments are obviously higher priced. The implementor may make a judgement as to the particular product development based on the existence of other similar systems in operation.

For HRI an evaluatory design is captured by defining specific implementations for each of the HRI related equipment packages present in the 3 scenarios (urban, interurban, and rural). The urban scenario, Urbansville, is based upon the area surrounding and including Detroit, MI. The counties included are Macomb, Oakland, and Wayne counties. The interurban scenario, Thruville, depicts the region along the New Jersey turnpike. The counties included are Burlington, Camden, and Gloucester counties in New Jersey. The rural scenario, Mountainville, is based on Lincoln county, Montana.

The total population for which each of the equipment packages being studied is applicable is defined as a list of parameters. These parameters are quantified based on available statistical information, data provided by the government in the scenario definitions, or assumptions about the deployment of ITS.

For HRI, one existing parameter will be retained as is from the Evaluatory Design and Cost Analysis published at the time of the National Architecture Review (NAR):

- Traffic_Management_Centers: The number of TMCs grows over time in Urbansville and Thruville as more municipalities implement ITS. Mountainville is not expected to have a TMC.

For HRI, 2 new parameters have been added:

- Passive_HRIs_Upgraded: A database report from the Federal Railroad Administration developed in December 1996 lists the number of passive (no gates or signals) as well as active (gates or signals) in each of the counties that make up the Evaluation Scenarios for the ITS architecture development. This parameter is considered the total number of crossings in the region under study that will likely be upgraded to an active set of equipment over the next 20 years. It was derived from the total number of passive crossings and multiplied by one-half to account for crossings that will be closed or left as passive. This figure was loosely based on planning information from the Toledo Metropolitan Area Council of Governments (TMACOG) concerning the status of their inventory of some 517 crossings. Of that total 142 were public crossings with crossbucks. TMACOG has a published plan to upgrade the crossings to Gates and lights over the next 20 years if they are in either a corridor where train speeds are greater than 80 mph or either high train traffic or high motor vehicle traffic. The result is that 74 of the 142 passive crossings are planned to be upgraded. These passive crossings are candidates for deployment of the Standard Rail Crossing equipment package.

- Active_HRIs: The number of at-grade highway rail intersections that are currently equipped with active gates and/or signals is from the same FRA database report for the counties in the evaluation scenarios. These active crossings will either be equipped with the Standard Rail Crossing package or the Advanced Rail Crossing package.

The quantities of two existing parameters will be increased to support HRI:

- Changeable Message Signs: Adjacent to some of the HRIs, these signs will receive input from the TMS to display an advisory message about an oncoming or passing train. This is not as large, nor does it display as complex a message set as the CMS located along freeways but it will accept input and be able to display any of 2 or 3 very brief messages. For this evaluation, theses signs will be located at 40% of the passive and active Highway Rail Intersections that are being installed with the ITS packages.

- In-Vehicle Signing Beacons: At some HRIs, a beacon type device will be used to receive input from the TMS and broadcast an advisory to nearby vehicles equipped with in-vehicle signage. For this evaluation, theses beacons will be located at 25% of the passive and active Highway Rail Intersections that are being installed with the ITS packages.

The evaluatory design parameters for HRI are shown in Table 4-2 below.

Table 4-2. Evaluation Parameters for HRI

		Urbansville			Thruville			Mountainville		
Source Parameters	**Basis**	**5 yr**	**10 yr**	**20 yr**	**5 yr**	**10 yr**	**20 yr**	**5 yr**	**10 yr**	**20 yr**
Centers										
Traffic_Management_Centers	NAR Ev Design	2	3	5	1	1	2	0	0	0
Roadway Characteristics										
Passive_HRIs_Upgraded	FRA Data; 1/2 of Current Passive HRIs	109	109	109	61	61	61	10	10	10
Active_HRIs	FRA Data	559	559	559	230	230	230	5	5	5
CMS for HRI	40% of Passive/Active HRIs	267	267	267	116	116	116	6	6	6
In-Vehicle Signing Beacons for HRI	25% of Passive/Active HRIs	167	167	167	73	73	73	4	4	4

For each equipment package being studied a market penetration is developed by scenario and time frame. Expected market penetrations are based upon studies from the University of Michigan Transportation Research Institute (UMTRI), research done during phase I of the architecture program by the Rockwell team, and expert opinions of team members for users services not covered by the other services. Also useful in building the penetration matrices was the Market Package Deployment Timing in the Implementation Strategy document.

Four new equipment packages have been identified to be added for HRI:

- HRI Traffic Management: Penetration is expected to grow from 0 at 5 years to 100% of all TMCs equipped at 20 years for Urban and Interurban. This package will not be deployed in a rural environment.

- Rail Operations Coordination: Penetration is expected to grow from 0 at 5 years to 100% of all TMCs equipped at 20 years for Urban and Interurban. This package will not be deployed in a rural environment.

- Standard Rail Crossing: Penetration is expected to grow from 0 at 5 years to 50% of all intersections that have active equipment over the next 20 years. This includes the HRIs that are now passive crossings but will be upgraded to active in this overall timeframe.

- Advanced Rail Crossing: Penetration is expected to grow from 0 at 5 years to 10% of all Active rail intersections equipped at 20 years. This based on the estimated number of crossings along what are expected to be come high speed rail routes in the next 20 years. In the TMACOG planning data this includes as many as 48 of their 188 active public crossings, or 25%. This analysis will use a figure of 10% with the understanding that other crossings may be grade separated or closed entirely to accommodate the higher speed services.

Components of 2 existing equipment packages will be increased to account for the rail crossings.

- Roadway In-Vehicle Signing: Installment, or penetration, is expected to grow from 0 at 5 years to 100% of all possible HRI beacon locations at 20 years.

- Roadway Traffic Information Dissemination: Installment, or penetration, is expected to grow from 0 at 5 years to 100% of all possible HRI CMS locations at 20 years.

Table 4-3 lists the estimated penetrations for each of the HRI related equipment packages for each geographic scenario and time frame.

Table 4-3. Market Penetrations for HRI

Subsystem	EP ID	Equipment Package	Source Parameters	5 yr Low	5 yr High	10 yr Low	10 yr High	20 yr Low	20 yr High
Urbansville - Urban Scenario									
TMS	TMS18	HRI Traffic Management	TMCs	0%	0%	33%	66%	60%	100%
TMS	TMS19	Rail Operations Coordination	TMCs	0%	0%	33%	66%	60%	100%
RS	RS15a	Standard Rail Crossing	Active_HRIs	0%	0%	15%	33%	30%	50%
RS	RS15b	Standard Rail Crossing	Passive_HRIs_Upgraded	0%	0%	15%	33%	30%	50%
RS	RS16	Advanced Rail Crossing	Active_HRIs	0%	0%	3%	7%	6%	10%
RS	RS7a	Roadway In-Vehicle Signing -- Additional for HRI	In-Vehicle Signing Beacons for HRI	0%	0%	33%	66%	60%	100%
RS	RS14a	Roadway Traffic Information Dissemination -- Additional for HRI	CMS for HRI	0%	0%	33%	66%	60%	100%
Thruville - Interurban Scenario									
TMS	TMS18	HRI Traffic Management	TMCs	0%	0%	30%	60%	60%	100%
TMS	TMS19	Rail Operations Coordination	TMCs	0%	0%	30%	60%	60%	100%
RS	RS15a	Standard Rail Crossing	Active_HRIs	0%	0%	15%	30%	30%	50%
RS	RS15b	Standard Rail Crossing	Passive_HRIs_Upgraded	0%	0%	15%	30%	30%	50%
RS	RS16	Advanced Rail Crossing	Active_HRIs	0%	0%	3%	6%	6%	10%
RS	RS7a	Roadway In-Vehicle Signing -- Additional for HRI	In-Vehicle Signing Beacons for HRI	0%	0%	30%	60%	60%	100%
RS	RS14a	Roadway Traffic Information Dissemination -- Additional for HRI	CMS for HRI	0%	0%	30%	60%	60%	100%

Subsystem	EP ID	Equipment Package	Source Parameters	5 yr Low	5 yr High	10 yr Low	10 yr High	20 yr Low	20 yr High
Mountainville - Rural Scenario									
TMS	TMS18	HRI Traffic Management	TMCs	0%	0%	0%	0%	0%	0%
TMS	TMS19	Rail Operations Coordination	TMCs	0%	0%	0%	0%	0%	0%
RS	RS15a	Standard Rail Crossing	Active_HRIs	0%	0%	15%	30%	30%	50%

Subsystem	EP ID	Equipment Package	Source Parameters	5 yr Low	5 yr High	10 yr Low	10 yr High	20 yr Low	20 yr High
RS	RS15b	Standard Rail Crossing	Passive_HRIs_Upgraded	0%	0%	15%	30%	30%	50%
RS	RS16	Advanced Rail Crossing	Active_HRIs	0%	0%	3%	6%	6%	10%
RS	RS7a	Roadway In-Vehicle Signing -- Additional for HRI	In-Vehicle Signing Beacons for HRI	0%	0%	30%	60%	60%	100%
RS	RS14a	Roadway Traffic Information Dissemination -- Additional for HRI	CMS for HRI	0%	0%	30%	60%	60%	100%

The quantities of equipment packages that are used in the cost analysis is computed by multiplying each of the market penetrations against its source parameter. Table 4-4 lists the calculated quantities (parameter x penetration) for each of the HRI related equipment packages for each geographic scenario and time frame.

Table 4-4. HRI Evaluatory Design Quantities

Subsystem	EP ID	Equipment Package	5 yr Low	5 yr High	10 yr Low	10 yr High	20 yr Low	20 yr High
Urbansville - Urban Scenario								
TMS	TMS18	HRI Traffic Management	0	0	1	2	3	5
TMS	TMS19	Rail Operations Coordination	0	0	1	2	3	5
RS	RS15a	Standard Rail Crossing	0	0	84	184	168	280
RS	RS15b	Standard Rail Crossing	0	0	16	36	33	55
RS	RS16	Advanced Rail Crossing	0	0	17	39	34	56
RS	RS7a	Roadway In-Vehicle Signing -- Additional for HRI	0	0	55	110	100	167
RS	RS14a	Roadway Traffic Information Dissemination -- Additional for HRI	0	0	88	176	160	267
Thruville - Interurban Scenario								
TMS	TMS18	HRI Traffic Management	0	0	0	1	1	2
TMS	TMS19	Rail Operations Coordination	0	0	0	1	1	2
RS	RS15a	Standard Rail Crossing	0	0	35	69	69	115
RS	RS15b	Standard Rail Crossing	0	0	9	18	18	30
RS	RS16	Advanced Rail Crossing	0	0	7	14	14	23
RS	RS7a	Roadway In-Vehicle Signing -- Additional for HRI	0	0	22	44	44	73
RS	RS14a	Roadway Traffic Information Dissemination -- Additional for HRI	0	0	35	70	70	116
Mountainville - Rural Scenario								
TMS	TMS18	HRI Traffic Management	0	0	0	0	0	0
TMS	TMS19	Rail Operations Coordination	0	0	0	0	0	0
RS	RS15a	Standard Rail Crossing	0	0	1	2	2	3
RS	RS15b	Standard Rail Crossing	0	0	2	3	3	5
RS	RS16	Advanced Rail Crossing	0	0	0	0	0	1
RS	RS7a	Roadway In-Vehicle Signing -- Additional for HRI	0	0	1	2	2	4
RS	RS14a	Roadway Traffic Information Dissemination -- Additional for HRI	0	0	2	4	4	6

4.5.6 Calculation of Expenditure Matrices for Equipment Packages

Expenditure Matrices are calculated automatically through the linked spreadsheet programs. Included in the calculation are non-recurring expenditures (one-time capital costs) and recurring expenditures (annual operation and maintenance costs). The non-recurring expenditures are incurred during the year of deployment for the five, ten and twenty deployment years. The recurring expenditures are incurred in the deployment year and every year thereafter.

Non-recurring expenditures also include the asset replacement at the end of its useful life. These expenditures are automatically incorporated into the spreadsheet utilizing the "Years to Replacement" column in the Equipment Package Worksheets.

4.5.7 Summary of Equipment Package Expenditures

This step tabulates the Equipment Package expenditures for the government stakeholder which are attributable to government investment which is all of the expenditures for HRI.

4.6 Equipment Package Worksheets

The Equipment Package Worksheets presented below are only those Equipment Packages which are involved in providing HRI services as defined in the previous sections. These Equipment Packages are contained in two subsystems, Roadway and Traffic Management. These Equipment Package Unit Price Worksheets describe the various pieces of equipment, computer software, and hardware, as well as operation and maintenance components that are required to provide the functional services as described in the Equipment Package definitions. As noted in the previous Cost Analysis Document, there is some common equipment through the various subsystems. This equipment centered around the communications equipment and usage for wireline and wireless service.

For this HRI Cost Analysis, the common equipment description for wireline service is repeated below.

Wireline Communication levels stem from the communication layer of the architecture and the resulting usage rates for data, voice, and image transfer from Equipment Packages across Subsystems and from Equipment Package to Equipment Package within each Subsystem. The wireline unit prices are based upon current pricing structure for telephone company provided circuits. These are based on leased digital circuits, which appear to be the most feasible option notwithstanding the preferences of the local implementors.

A full life cycle cost analysis for the tradeoff of leased verses owned lines for implementors is a local study which must take into account many factors that are external to a strictly accounting function of life cycle costing. The information provided in this cost analysis may be used by local implementors as a comparison for these local studies.

The types of the leased lines for these circuits are grouped into three categories. These include the DS0 circuits which have a capacity of 56 Kbps, the DS1 circuits (comparable to a T1 rate) have a capacity of 1.544 Mbps, and the DS3 circuits which have a capacity of 44.736 Mbps. Individual circuits may be multiplexed to provide a desired data rate that falls somewhere in the middle of these ranges.

The prices for these line types are based upon national averages for GTE services. National studies have found that some charges may vary as much as 100% between telephone companies and regions. The unit prices utilized represent both high and low ranges for typical leased lines. The typical distance for these prices is eight to fifteen miles, but most of the cost is not distance sensitive. The part of the communication link from the telephone central office to the equipment using the line is not a major component of the total line cost. The length of line between central telephone offices is the chief component of the unit prices. Many telephone companies have upgraded their central offices to digital transmission facilities thus providing the cost of analog leased lines, with a maximum guaranteed data rate of 9600 baud, to be approximately the same cost as the DS0 digital lines. The unit prices for these lines are described below. The prices given may be discounted further (up to 50%) for multiple line users and long term (five year)

commitments or contracts. This discounting is advantageous, but not relied upon for this cost analysis as the decisions for these discounts usually falls under the institutional layer of the architecture.

		Monthly Price	
Line Type	**Available Capacity**	**Low**	**High**
DS0	56 Kbps	$50	$100
DS1	1.544 Mbps	$400	$700
DS3	44.736 Mbps	$2000	$6000

For this HRI Cost Analysis, there is only one line type required, DS0. Wireless communications are provided for In-Vehicle Signing through the beacons located at the highway - rail intersections. This type of communication service does not have a direct communication cost to the user.

4.6.1 Traffic Management Subsystem, (TMS)

As stated earlier, this subsystem has two Equipment Packages which are factors in providing HRI services. These Equipment Packages are the following:

Equipment Package Name	**Descriptor**
HRI Traffic Management	TMS18
Rail Operations Coordination	TMS19

These descriptors represent a continuation of descriptors utilized in the previous cost analysis. Each Equipment Package function and pertinent equipment is described below.

4.6.1.1 HRI Traffic Management (TMS18)

This Equipment Package monitors highway-rail intersection (HRI) equipment at the roadside which manages highway traffic. Various levels of roadside equipment may be interfaced to, and supported by, this equipment package to include standard speed active warning systems and high speed systems which provide additional information on approaching trains and detect and report on obstructions in the HRI. This Equipment Package remotely monitors and reports the status of this roadside equipment. A two way interface supports explicitly status requests or remote control plan updates to be generated by this Equipment Package. Status may also be received periodically in the absence of a request or asynchronously in the event of a detected failure or other unsafe condition at the intersection.

This Equipment Package builds on the existence of the Traffic Management Center. There is no construction of a dedicated facility. The expense for the facility is in recurring expenditures of rental costs. The initial basic communication lines are in-place, and only those changes necessary to incorporate the additional capabilities are included in the analysis.

Average annual staff unit prices vary according to the functions performed. Generally, it is anticipated that a base salary is multiplied by a benefits factor for overhead, overtime, other benefits, including $4,500 for building rent. This number is based on an assumed annual rent charge of $18 per square foot with an estimated average of 250 square foot per staff member.

This Equipment Package builds on the existence of TMC Basic Signal Control (TMS6). Equipment add-ons for include software for increased signal control and part time staffing support. It is assumed that this function will be performed by staff assigned to multiple duties. Therefore, the labor cost of the staff is assumed to be split between functionality and Equipment Packages. Thus, only fifty percent of the staff time and labor expense is attributable to this Equipment Package.

Communication lines for transmitting to roadside signal controllers is included in TMS6.

4.6.1.2 Rail Operations Coordination (TMS19)

This Equipment Package provides strategic coordination between rail operations and traffic management centers. It receives train schedules, maintenance schedules, and any other forecast events which will result in highway-rail intersection (HRI) closures from Rail Operations. The provided information is used to develop forecast HRI closure times and durations which may be applied in advanced traffic control strategies or delivered as enhanced traveler information. This Equipment Package includes the processing and algorithms necessary to derive HRI closure times and the communications capabilities necessary to communicate with rail operations and interface to the traffic control and information distribution capabilities included in other Traffic Management Subsystem Equipment Packages.

This Equipment Package also builds on the existence of the Traffic Management Center. There is no construction of a dedicated facility. The expense for the facility is in recurring expenditures of rental costs. The initial basic communication lines are in-place, and only those changes necessary to incorporate the additional capabilities are included in the analysis.

Average annual staff unit prices vary according to the functions performed. Generally, it is anticipated that a base salary is multiplied by a benefits factor for overhead, overtime, other benefits, including $4,500 for building rent. This number is based on an assumed annual rent charge of $18 per square foot with an estimated average of 250 square foot per staff member.

This Equipment Package builds on the existence of TMC Advanced Signal Control (TMS3), and TMC Basic Signal Control (TMS6). Equipment add-ons include software used to coordinate with rail operators, derive HRI closure times, provide the communications capabilities necessary to communicate with rail operations, and interface to the traffic control and information distribution capabilities. Additional staff is required in the TMC to perform this work. It is assumed that this function will be performed by staff assigned to multiple duties. Therefore, the labor cost of the staff is assumed to be split between functionality and Equipment Packages. Thus, only fifty percent of the staff time and labor expense is attributable to this Equipment Package.

An additional communication line is required for coordination activities with rail operators. Refer to the previous discussion on wireline communication costs.

Table 4-5. Unit Price Worksheet HRI Traffic Management (TMS18)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	90	110			Estimate Per Lockheed Martin		90	
	Software Installation and 1 year Maintenance	5	18	22			and Rockwell Experience in		18	
							Similar Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Operators (1 at 50% of the time, at $100,000)		45	55					45	
	Software Maintenance Contract @ 5% of Capital Cost		1.8	2.2					1.8	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									

** All prices are in thousands of 1995 dollars.*

Table 4-6. Unit Price Worksheet Rail Operations Coordination (TMS19)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Integration	20	90	110			Estimate Per Lockheed Martin a		90	
	Software Installation and 1 year Maintenance	5	18	22			and Rockwell Experience in		18	
							Similar Integration Projects			
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
	Communication Line DS0 from TMC to other Rail Operators	20	0.5	1			Existing Technology Prices		0.5	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Operators (1 at 50% of the time, at $100,000)		45	55					45	
	Software Maintenance Contract @ 5% of Capital Cost		1.8	2.2					1.8	
	Note : Salary Costs are fully loaded prices (Base Salary,									
	Overtime, Overhead, Benefits, etc.)									
	Agency Wireline Communication DS0		0.6	1.2			Current Price Structure		0.6	
							from GTE			

** All prices are in thousands of 1995 dollars.*

4.6.2 Roadway Subsystem, (RS)

This subsystem has two new Equipment Packages and two modified Equipment Packages which are factors in providing HRI services. These Equipment Packages are the following:

Equipment Package Name	Descriptor
Standard Rail Crossing	RS15
Advanced Rail Crossing	RS16
Roadway In-Vehicle Signing - Additional for HRI	RS7 (a)
Roadway Traffic Information Dissemination - Additional for HRI	RS14 (a)

These descriptors represent a continuation of descriptors utilized in the previous cost analysis. Each Equipment Package function and pertinent equipment is described below.

4.6.2.1 Standard Rail Crossing (RS15)

This Equipment Package manages highway traffic at highway-rail intersections (HRIs) where rail operational speeds are typically less than 80 miles per hour. Either passive (e.g., the crossbuck sign) or active warning systems (e.g., flashing lights and gates) are supported depending on the specific requirements for each intersection. These traditional HRI warning systems may also be augmented with other standard traffic management devices. The warning systems are activated on notification by interfaced wayside equipment of an approaching train. The equipment at the HRI may also be interconnected with adjacent signalized intersections so that local control can be adapted to highway-rail intersection activities. Health monitoring of the HRI equipment and interfaces is performed; detected abnormalities are reported through interfaces to the wayside equipment and the traffic management subsystem.

Active warning systems are used for this cost analysis. For the Standard Rail Crossing, a two quadrant gate system is provided. Depending on the region in which the equipment package is deployed, many crossings will already be equipped with active gates and/or signals. The cost for new two quadrant gates for these HRIs are included as part of the unit price worksheet, but this expense is only included for the crossings that are currently passive crossings and will need to be upgraded to 2-quadrant gate systems. This is shown in the Results sections for each region. Equipment Package RS15a is for the crossings that are already active crossings. Equipment Package RS15b is for the crossings that are currently passive crossings. See Sections 5.4, 6.4, and 7.4.

The Intelligent Interface Controller (IIC) used for this HRI is assumed to be similar to a 170 type controller. Other equipment includes the Pedestrian Warning Signal and/or Gates, communication lines from the IIC to the wayside equipment, and train detection circuitry.

Staffing requirements were not considered explicitly for this Equipment Package. Rather, a broader approach (percentage of capital costs) was used in estimating the operation and maintenance costs. These percentages were estimated based on rail operation statistical averages.

4.6.2.2 Advanced Rail Crossing (RS16)

This Equipment Package manages highway traffic at highway-rail intersections (HRIs) where rail operational speeds are typically greater than 80 miles per hour or where more sophisticated signaling and communications are deemed necessary. It includes all capabilities from the Standard Rail Crossing Equipment Package and augments these with additional safety features to mitigate the risks associated with higher rail speeds and higher risk crossings. The active warning systems supported by this package include

positive barrier systems which preclude entrance into the intersection when the barriers are activated. Like the Standard Rail Crossing Equipment Package, the HRI equipment is activated on notification by wayside equipment which detects, or communicates with the approaching train. In this Equipment Package, additional information about the arriving train is also provided by the wayside equipment so that the train's direction of travel, its estimated time of arrival, and the estimated duration of closure may be derived. This enhanced information may be conveyed to the driver prior to, or in context with, warning system activation. This Equipment Package also includes detection capabilities which enable it to detect an entrapped or otherwise immobilized vehicle within the HRI and provide an immediate notification to the wayside equipment and traffic management.

For the Advanced Rail Crossing, a four quadrant gate system is provided, along with a sensor system for detecting entrapped vehicles. For this cost analysis a vision based wide area detector was used. These devises currently exist and comparative technology unit prices are referenced in the worksheet.

The Intelligent Interface Controller (IIC) used for this HRI is assumed to be similar to a 170 type controller. Other equipment includes the Pedestrian Warning Signal and/or Gates, communication lines from the IIC to the wayside equipment, and train detection circuitry.

Staffing requirements were not considered explicitly for this Equipment Package. Rather, a broader approach (percentage of capital costs) was used in estimating the operation and maintenance costs. These percentages were estimated based on rail operation statistical averages.

4.6.2.3 Roadway In-Vehicle Signing - Additional for HRI [RS7 (a)]

This Equipment Package provides the capability to detect local traffic flow conditions, corroborate them with a traffic management subsystem, and distribute them to the user over a short-range interface such as a radio beacon.

For this HRI Cost Analysis, the equipment depicted in the unit price worksheet is similar to that used for the same Equipment Package in the previous Cost Analysis. The difference is a slight adjustment in unit price based on a reduction of the number of beacons at the HRI intersection from four to two.

4.6.2.4 Roadway Traffic Information Dissemination - Additional for HRI [RS14 (a)]

This Equipment Package provides the roadside elements of traffic information dissemination through smaller, less complex CMS. These Changeable Message Signs are not as large, nor do they contain the complex message sets of the previous units. These signs are estimated to utilize three lines of twelve inch high letters. Local memory would house the message sets, two or three variations. These signs are existing technology and the unit prices used are representative of prices from a fiber optic sign manufacturer.

Table 4-7. Unit Price Worksheet Standard Rail Crossing (RS15)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Train Detector Circuitry	20	15	20			Existing Technology Engineer's		15	
	Gates for a 2-Quandrant Gate**	20	40	50			Estimate based on bid prices		40	
	Signals for a 2-Quandrant Gate**	20	35	40			for New England		35	
	Intelligent Interface Controller (IIC)	10	8	10			170 Type Controller		8	
	Communications Line from IIC to Wayside Int Equip (WIE)	20	1	1.5					1	
	Assume two track xing w/ two 0.5 mile comm lines									
	Pedestrian Warning Signal and Gates	20	10	15			Existing Technology		10	
	*** Note: 2-Quadrant Gates/Signals not included in currently active HRIs*									
	Communication Line from RS to TMS is included in TMS									
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Equipment									
	Train Detector Circuitry @ 5% of Capital Cost		0.75	1					0.75	
	Gates for a 2-Quandrant Gate @ 5% of Capital Cost**		2	2.5					2	
	Signals for a 2-Quandrant Gate @ 2% of Capital Cost**		0.7	0.8					0.7	
	Intelligent Interface Controller (IIC) @ 5 % of Capital Cost		0.4	0.5					0.4	
	Communications Line from IIC to (WIE) @ 2% of Capital Cost		0.02	0.03					0.02	
	Pedestrian Warning Signal @ 2% of Capital Cost		0.2	0.3					0.2	
	*** Note: 2-Quadrant Gates/Signals not included in currently active HRIs*									

** All prices are in thousands of 1995 dollars.*

Table 4-8. Unit Price Worksheet Advanced Rail Crossing (RS16)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Train Detector Circuitry	20	15	20			Existing Technology Engineer's		15	
	Gates for a 4-Quandrant Gate	20	65	75			Estimate based on bid prices		65	
	Signals for a 4-Quandrant Gate	20	50	55			for New England		50	
	Intelligent Interface Controller (IIC)	10	8	10			170 Type Controller		8	
	Communications Line from IIC to Wayside Int Equip (WIE)	20	1	1.5					1	
	Assume two track xing w/ two 0.5 mile comm lines									
	Pedestrian Warning Signal and Gates	20	10	15			Existing Technology		10	
	Entrapped Vehicle Detection Camera, w/ poles & controller	10	25	30			Existing Technology		25	
							"Mobilizer", Autoscope or sim.			
							vision based wide area tracking			
	Communication Line from RS to TMS is included in TMS									
	Note : Software is off-the-shelf technology and unit price does									
	not reflect product development.									
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Maintenance for Equipment									
	Train Detector Circuitry @ 5% of Capital Cost		0.75	1					0.75	
	Gates for a 4-Quandrant Gate @ 5% of Capital Cost		3.25	3.75					3.25	
	Signals for a 4-Quandrant Gate @ 2% of Capital Cost		1	1.1					1	
	Intelligent Interface Controller (IIC) @ 5 % of Capital Cost		0.4	0.5					0.4	
	Communications Line from IIC to (WIE) @ 2% of Capital Cost		0.02	0.03					0.02	
	Pedestrian Warning Signal @ 2% of Capital Cost		0.2	0.3					0.2	
	Entrapped Vehicle Detection @ 5% of Capital Cost		1.25	1.5					1.25	

** All prices are in thousands of 1995 dollars.*

Table 4-9. Unit Price Worksheet Roadway In-Vehicle Signing for HRI (RS7a)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	Signal Transmitter (2 Beacons per intersection)	5	3	5			Ref. Seimens Exist.		3	
	Localized Controller	10	3	8			Technology Prices		3	
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	Beacon Maintenance (10% of Capital Cost)		0.3	0.5			Exist. Tech.		0.3	
	Communication from TMC to Beacons is included in TMC Costs									

** All prices are in thousands of 1995 dollars.*

Table 4-10. Unit Price Worksheet Roadway Traffic Information Dissemination for HRI (RS14a)

	Equipment Description	Years to Replacement (Life Cycle)	Unit Price (Low)	Unit Price (High)	Quantity (Low)	Quantity (High)	Comparative Technology	Retail Price *	Unit Price	Quantity
Non-Recurring (Initial Capital Investment)			**Introductory State ***						**Steady State ***	
	CMS three line, with 12 inch letters, precanned messages	20	10	15			Existing Technology, Reference		10	
							FDS manufacturer price			
Recurring (Operations & Maintenance)			**Introductory State ***						**Steady State ***	
	CMS (5% of capital)		0.5	0.75			Estimate		0.5	
	Leased Line Costs borne by TMCs									

** All prices are in thousands of 1995 dollars.*

5. SAMPLE EXPENDITURE CALCULATIONS - MAJOR URBAN AREA

The Highway-Rail Interface addendum to the Phase 2 Cost Analysis of the National ITS Architecture includes an evaluation of three separate scenarios. Each scenario represents a typical deployment area and is to provide a frame of reference for similar implementations of the architecture. A high level description of the major urban area, Urbansville, is included in the original Evaluatory Design Document. A more in-depth description of Urbansville is located in the "Urban Scenario Guide, Urbansville, Phase II" scenario description document. This HRI Cost Analysis addendum utilizes the existing Urbansville description and augments it with HRI specific descriptions. These descriptions are provided in the beginning sections of this document.

The cost analysis time frame evaluates deployment milestones as specified in the Phase II Deliverable Guidelines at the five, ten and twenty year stages in the deployment. Technology selection and developmental insights are based on these milestones equating to the calendar years 1997, 2002, and 2012, respectively.

5.1 Examination of Equipment Package Worksheets

Equipment Package Worksheets are included in the previous sections 4.6.1 through 4.6.2. Each worksheet lists equipment and price ranges for that equipment, including hardware and software, as well as operation (additional staffing) and maintenance requirements. The price ranges represent state-of-the-practice equipment using installed construction bid prices for some packages, state-of-the-art equipment using comparable technology (often referenced to equipment manufacturers' estimated unit prices for comparable technology) and developing technology (also using comparable technology and referenced to integration and systems engineering companies' and equipment manufacturers' estimated unit prices for comparable technology.)

The unit price justification is noted in the worksheets' column for "Comparative Technology." In the worksheets, where "Existing Technology" is noted, the prices represent typical unit prices for equipment found in catalogs, such as Sweet's Engineering and Retrofit, a catalog for construction cost estimating for current, off-the-shelf technology. Other references to price justification indicate specific construction bid prices for recent contracts. These prices are actual bid prices for installation. Where these two forms of justification were not available, some estimations are provided through consultations with experts in respective fields for manufacturing, and system integration. Lastly, some prices which are less certain are estimates based on professional judgment.

5.2 Identification and Evaluation of Quantities and Market Size

For the Equipment Package parameters, the quantity of items purchased influences the unit price for the equipment. Obviously, price breaks come into effect when larger quantities are purchased. For existing technology, many equipment prices are at a steady state price (exhibited in the far right columns of the Equipment Worksheets.) The prices are generally not subject to wide fluctuations based on quantities. Newer technology, or services which are on the front end of a market/product development curve, are subject to wide price ranges. For Urbansville, two sets of market penetrations were analyzed, a high and a low scenario. For the cost evaluation activities the low value of the unit price ranges was utilized for all Equipment Packages.

5.3 Calculation of Expenditures

Expenditures are calculated automatically through the linked spreadsheet programs. Included in the calculation are non-recurring expenditures (one time capital costs) and recurring expenditures (annual operation and maintenance costs). The non-recurring expenditures are incurred in accordance with the Evaluatory Design Document deployment quantities for the five, ten and twenty deployment years. The recurring expenditures are incurred in the deployment year and every year thereafter.

Non-recurring expenditures also include the expenditures for asset replacement at the end of its useful life. These expenditures are automatically incorporated into the spreadsheet utilizing the "Years to Replacement" column in the Equipment Package Worksheets. This tabulation of non-recurring expenditures continues from the year of initial deployment through the analysis time frame. This evaluation is important when considering comparative technologies and life cycle costs (see previous section on life cycle costing.)

5.4 Results

The summary expenditures for the Urbansville HRI Equipment Packages are provided in the following pages. The non-recurring expenditures are tabulated below for the deployment milestone in the evaluation period. Note that the summations consists of the expenditures for the year stated plus the expenditures for the four previous years. The numbers presented for the recurring expenditures represent the expenditures for operation and maintenance during the deployment milestone years. Note that the non-recurring expenditures include replacement expenditures for reinvestment of equipment at the end of its' useful life.

The first of the analysis results, are for a low level market penetration, consistent with the evaluatory design parameters for deployment penetration. The second set of results are for the high level market penetration. For each of the scenarios, it was assumed that the HRIs that are already equipped with active gates/signals would not require that equipment. Thus, for Urbansville, the expenditure for the gates and signals for the HRIs in RS15a were not included in the full expenditure calculated from the unit price worksheets. RS15b includes the cost of the gates/signals for a 2-quadrant system.

All expenditures for Urbansville are in 1,000s of dollars based on 1995 prices.

Table 5-1. Urbansville Non-Recurring Expenditures for Low Market Penetration

		Non-Recurring Expenditures		
EP ID	**Equipment Package Name**	**1-5 yrs**	**6-10 yrs**	**11-20 yrs**
TMS18	HRI Traffic Management	$0	$108	$252
TMS19	Rail Operations Coordination	$0	$109	$253
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$2,856	$3,528
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$1,744	$1,981
RS16	Advanced Rail Crossing	$0	$2,958	$3,094
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$330	$765
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$880	$720

Table 5-2. Urbansville Recurring Expenditures for Low Market Penetration

		Average Annual Recurring Expenditures		
EP ID	**Equipment Package Name**	**Year 5**	**Year 10**	**Year 20**
TMS18	HRI Traffic Management	$0	$47	$140
TMS19	Rail Operations Coordination	$0	$47	$142
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$115	$230
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$65	$134
RS16	Advanced Rail Crossing	$0	$117	$234
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$17	$30
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$44	$80

Table 5-3. Urbansville Non-Recurring Expenditures for High Market Penetration

		Non-Recurring Expenditures		
EP ID	**Equipment Package Name**	**1-5 yrs**	**6-10 yrs**	**11-20 yrs**
TMS18	HRI Traffic Management	$0	$216	$396
TMS19	Rail Operations Coordination	$0	$217	$398
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$6,256	$4,736
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$3,924	$2,359
RS16	Advanced Rail Crossing	$0	$6,786	$3,270
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$660	$1,332
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$1,760	$910

Table 5-4. Urbansville Recurring Expenditures for High Market Penetration

		Average Annual Recurring Expenditures		
EP ID	**Equipment Package Name**	**Year 5**	**Year 10**	**Year 20**
TMS18	Rail Operations Coordination	$0	$95	$237
TMS19	HRI Traffic Management	$0	$94	$234
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$115	$230
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$65	$134
RS16	Advanced Rail Crossing	$0	$117	$234
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$33	$50
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$88	$134

6. SAMPLE EXPENDITURE CALCULATIONS - INTER-URBAN AREA

A high level description of the inter-urban area, Thruville, is included in the original Evaluatory Design Document. A more in-depth description of Thruville is located in the "Inter-urban Scenario Guide, Thruville, Phase II" scenario description document. Similar to the Urbansville sample expenditures, this HRI Cost Analysis addendum utilizes the existing Thruville description and augments it with HRI specific descriptions. These descriptions are provided in the beginning sections of this document.

The cost analysis time frame evaluates deployment milestones as specified in the Phase II Deliverable Guidelines at the five, ten and twenty year stages in the deployment. Technology selection and developmental insights are based on these milestones equating to the calendar years 1997, 2002, and 2012, respectively.

6.1 Examination of Equipment Package Worksheets

Equipment Package Worksheets are included in the previous sections 4.6.1 through 4.6.2. Each worksheet lists equipment and price ranges for that equipment, including hardware and software, as well as operation (additional staffing) and maintenance requirements. The price ranges represent state-of-the-practice equipment using installed construction bid prices for some packages, state-of-the-art equipment using comparable technology (often referenced to equipment manufacturers' estimated unit prices for comparable technology) and developing technology (also using comparable technology and referenced to integration and systems engineering companies' and equipment manufacturers' estimated unit prices for comparable technology.)

The unit price justification is noted in the worksheets' column for "Comparative Technology." In the worksheets, where "Existing Technology" is noted, the prices represent typical unit prices for equipment found in catalogs, such as Sweet's Engineering and Retrofit, a catalog for construction cost estimating for current, off-the-shelf technology. Other references to price justification indicate specific construction bid prices for recent contracts. These prices are actual bid prices for installation. Where these two forms of justification were not available, some estimations are provided through consultations with experts in respective fields for manufacturing, and system integration. Lastly, some prices which are less certain are estimates based on professional judgment.

6.2 Identification and Evaluation of Quantities and Market Size

For the Equipment Package parameters, the quantity of items purchased influences the unit price for the equipment. Obviously, price breaks come into effect when larger quantities are purchased. For existing technology, many equipment prices are at a steady state price (exhibited in the far right columns of the Equipment Worksheets.) The prices are generally not subject to wide fluctuations based on quantities. Newer technology, or services which are on the front end of a market/product development curve, are subject to wide price ranges.

Similar to Urbansville, for Thruville, two sets of market penetrations were analyzed, a high and a low scenario. For the cost evaluation activities the low value of the unit price ranges was utilized for all Equipment Packages.

6.3 Calculation of Expenditures

Expenditures are calculated automatically through the linked spreadsheet programs. Included in the calculation are non-recurring expenditures (one time capital costs) and recurring expenditures (annual operation and maintenance costs). The non-recurring expenditures are incurred in accordance with the Evaluatory Design Document deployment quantities for the five, ten and twenty deployment years. The recurring expenditures are incurred in the deployment year and every year thereafter.

Non-recurring expenditures also include the expenditures for asset replacement at the end of its useful life. These expenditures are automatically incorporated into the spreadsheet utilizing the "Years to Replacement" column in the Equipment Package Worksheets. This tabulation of non-recurring expenditures continues from the year of initial deployment through the analysis time frame. This evaluation is important when considering comparative technologies and life cycle costs (see previous section on life cycle costing.)

6.4 Results

The summary expenditures for the Thruville HRI Equipment Packages are provided in the following pages. The non-recurring expenditures are tabulated below for the deployment milestone in the evaluation period. Note that the summations consists of the expenditures for the year stated plus the expenditures for the four previous years. The numbers presented for the recurring expenditures represent the expenditures for operation and maintenance during the deployment milestone years. Note that the non-recurring expenditures include replacement expenditures for reinvestment of equipment at the end of its' useful life.

The first of the analysis results, are for a low level market penetration, consistent with the evaluatory design parameters for deployment penetration. The second set of results are for the high level market penetration. For each of the scenarios, it was assumed that the HRIs that are already equipped with active gates/signals would not require that equipment. Thus, for Thruville, the expenditure for the gates and signals for the HRIs in RS15a were not included in the full expenditure calculated from the unit price worksheets. RS15b includes the cost of the gates/signals for a 2-quadrant system.

All expenditures for Thruville are in 1,000s of dollars based on 1995 prices.

Table 6-1. Thruville Non-Recurring Expenditures for Low Market Penetration

		Non-Recurring Expenditures		
EP ID	**Equipment Package Name**	**1-5 yrs**	**6-10 yrs**	**11-20 yrs**
TMS18	HRI Traffic Management	$0	$0	$108
TMS19	Rail Operations Coordination	$0	$0	$109
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$1,190	$1,436
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$981	$1,053
RS16	Advanced Rail Crossing	$0	$1,218	$1,274
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$132	$330
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$350	$350

Table 6-2. Thruville Recurring Expenditures for Low Market Penetration

		Average Annual Recurring Expenditures		
EP ID	**Equipment Package Name**	**Year 5**	**Year 10**	**Year 20**
TMS18	HRI Traffic Management	$0	$0	$47
TMS19	Rail Operations Coordination	$0	$0	$47
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$48	$95
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$37	$73
RS16	Advanced Rail Crossing	$0	$48	$96
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$7	$13
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$18	$35

Table 6-3. Thruville Non-Recurring Expenditures for High Market Penetration

		Non-Recurring Expenditures		
EP ID	**Equipment Package Name**	**1-5 yrs**	**6-10 yrs**	**11-20 yrs**
TMS18	HRI Traffic Management	$0	$108	$144
TMS19	Rail Operations Coordination	$0	$109	$145
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$2,346	$2,116
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$1,962	$1,452
RS16	Advanced Rail Crossing	$0	$2,436	$1,678
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$264	$570
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$700	$460

Table 6-4. Thruville Recurring Expenditures for High Market Penetration

		Average Annual Recurring Expenditures		
EP ID	**Equipment Package Name**	**Year 5**	**Year 10**	**Year 20**
TMS18	HRI Traffic Management	$0	$47	$94
TMS19	Rail Operations Coordination	$0	$47	$95
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$95	$158
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$73	$122
RS16	Advanced Rail Crossing	$0	$96	$158
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$13	$22
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$35	$58

7. SAMPLE EXPENDITURE CALCULATIONS - RURAL AREA

A high level description of the rural area, Mountainville, is included in the original Evaluatory Design Document. A more in-depth description of Mountainville is located in the "Rural Scenario Guide, Mountainville, Phase II" scenario description document. Similar to the Urbansville sample expenditures, this HRI Cost Analysis addendum utilizes the existing Mountainville description and augments it with HRI specific descriptions. These descriptions are provided in the beginning sections of this document.

The cost analysis time frame evaluates deployment milestones as specified in the Phase II Deliverable Guidelines at the five, ten and twenty year stages in the deployment. Technology selection and developmental insights are based on these milestones equating to the calendar years 1997, 2002, and 2012, respectively.

7.1 Examination of Equipment Package Worksheets

Equipment Package Worksheets are included in the previous sections 4.6.1 through 4.6.2. Each worksheet lists equipment and price ranges for that equipment, including hardware and software, as well as operation (additional staffing) and maintenance requirements. The price ranges represent state-of-the-practice equipment using installed construction bid prices for some packages, state-of-the-art equipment using comparable technology (often referenced to equipment manufacturers' estimated unit prices for comparable technology) and developing technology (also using comparable technology and referenced to integration and systems engineering companies' and equipment manufacturers' estimated unit prices for comparable technology.)

The unit price justification is noted in the worksheets' column for "Comparative Technology." In the worksheets, where "Existing Technology" is noted, the prices represent typical unit prices for equipment found in catalogs, such as Sweet's Engineering and Retrofit, a catalog for construction cost estimating for current, off-the-shelf technology. Other references to price justification indicate specific construction bid prices for recent contracts. These prices are actual bid prices for installation. Where these two forms of justification were not available, some estimations are provided through consultations with experts in respective fields for manufacturing, and system integration. Lastly, some prices which are less certain are estimates based on professional judgment.

7.2 Identification and Evaluation of Quantities and Market Size

For the Equipment Package parameters, the quantity of items purchased influences the unit price for the equipment. Obviously, price breaks come into effect when larger quantities are purchased. For existing technology, many equipment prices are at a steady state price (exhibited in the far right columns of the Equipment Worksheets.) The prices are generally not subject to wide fluctuations based on quantities. Newer technology, or services which are on the front end of a market/product development curve, are subject to wide price ranges.

Similar to Urbansville, for Mountainville, two sets of market penetrations were analyzed, a high and a low scenario. For the cost evaluation activities the low value of the unit price ranges was utilized for all Equipment Packages.

7.3 Calculation of Expenditures

Expenditures are calculated automatically through the linked spreadsheet programs. Included in the calculation are non-recurring expenditures (one time capital costs) and recurring expenditures (annual operation and maintenance costs). The non-recurring expenditures are incurred in accordance with the Evaluatory Design Document deployment quantities for the five, ten and twenty deployment years. The recurring expenditures are incurred in the deployment year and every year thereafter.

Non-recurring expenditures also include the expenditures for asset replacement at the end of its useful life. These expenditures are automatically incorporated into the spreadsheet utilizing the "Years to Replacement" column in the Equipment Package Worksheets. This tabulation of non-recurring expenditures continues from the year of initial deployment through the analysis time frame. This evaluation is important when considering comparative technologies and life cycle costs (see previous section on life cycle costing.)

7.4 Results

The summary expenditures for the Mountainville HRI Equipment Packages are provided in the following pages. The non-recurring expenditures are tabulated below for the deployment milestone in the evaluation period. Note that the summations consists of the expenditures for the year stated plus the expenditures for the four previous years. The numbers presented for the recurring expenditures represent the expenditures for operation and maintenance during the deployment milestone years. Note that the non-recurring expenditures include replacement expenditures for reinvestment of equipment at the end of its' useful life.

The first of the analysis results, are for a low level market penetration, consistent with the evaluatory design parameters for deployment penetration. The second set of results are for the high level market penetration. For each of the scenarios, it was assumed that the HRIs that are already equipped with active gates/signals would not require that equipment. Thus, for Mountainville, the expenditure for the gates and signals for the HRIs in RS15a were not included in the full expenditure calculated from the unit price worksheets. RS15b includes the cost of the gates/signals for a 2-quadrant system.

All expenditures for Mountainville are in 1,000s of dollars based on 1995 prices.

Table 7-1. Mountainville Non-Recurring Expenditures for Low Market Penetration

		Non-Recurring Expenditures		
EP ID	**Equipment Package Name**	**1-5 yrs**	**6-10 yrs**	**11-20 yrs**
TMS18	HRI Traffic Management	$0	$0	$0
TMS19	Rail Operations Coordination	$0	$0	$0
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$34	$42
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$218	$125
RS16	Advanced Rail Crossing	$0	$0	$0
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$6	$15
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$20	$20

Table 7-2. Mountainville Recurring Expenditures for Low Market Penetration

		Average Annual Recurring Expenditures		
EP ID	**Equipment Package Name**	**Year 5**	**Year 10**	**Year 20**
TMS18	HRI Traffic Management	$0	$0	$0
TMS19	Rail Operations Coordination	$0	$0	$0
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$1	$3
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$8	$12
RS16	Advanced Rail Crossing	$0	$0	$0
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$0	$1
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$1	$2

Table 7-3. Mountainville Non-Recurring Expenditures for High Market Penetration

		Non-Recurring Expenditures		
EP ID	**Equipment Package Name**	**1-5 yrs**	**6-10 yrs**	**11-20 yrs**
TMS18	Rail Operations Coordination	$0	$0	$0
TMS19	HRI Traffic Management	$0	$0	$0
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$68	$50
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$327	$242
RS16	Advanced Rail Crossing	$0	$0	$174
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$12	$30
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$40	$20

Table 7-4. Mountainville Recurring Expenditures for High Market Penetration

		Average Annual Recurring Expenditures		
EP ID	**Equipment Package Name**	**Year 5**	**Year 10**	**Year 20**
TMS18	Rail Operations Coordination	$0	$0	$0
TMS19	HRI Traffic Management	$0	$0	$0
RS15 (a)	Standard Rail Crossing (Currently Active HRIs)	$0	$3	$4
RS15 (b)	Standard Rail Crossing (Currently Passive HRIs)	$0	$12	$20
RS16	Advanced Rail Crossing	$0	$0	$7
RS7 (a)	Roadway In-Vehicle Signing for HRI	$0	$1	$1
RS14 (a)	Roadway Traffic Information Dissemination for HRI	$0	$2	$3