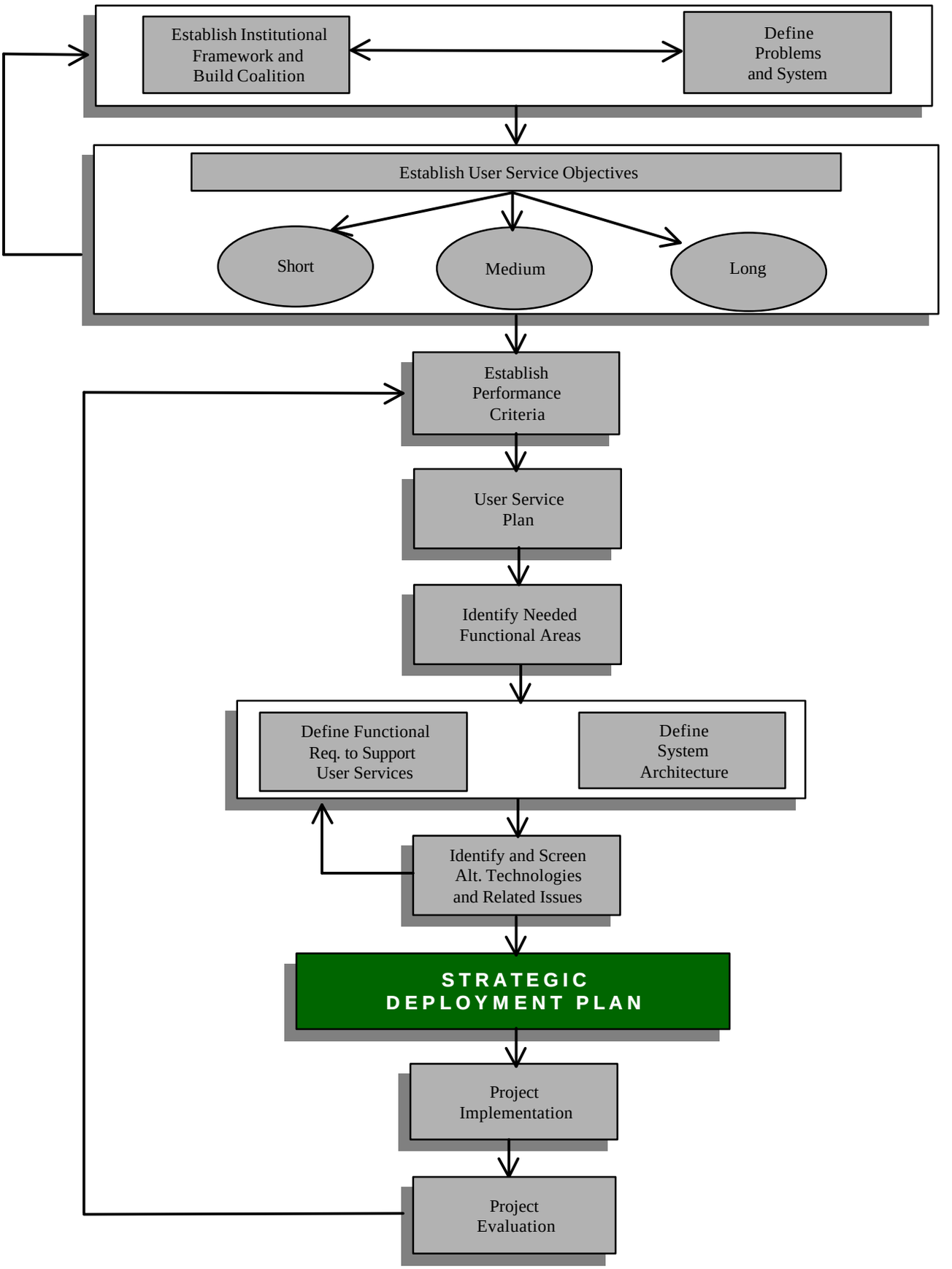
Executive Summary

PENNSYLVANIA TURNPIKE COMMISSION

ITS EARLY DEPLOYMENT PROGRAM

STRATEGIC DEPLOYMENT PLAN



PENNSYLVANIA TURNPIKE COMMISSION

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Strategic Deployment Plan

Executive Summary

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EXECUTIVE SUMMARY

1.0 INTRODUCTION

The Pennsylvania Turnpike's Intelligent Transportation System (ITS) Early Deployment Project is following the basic ITS planning process established by the Federal Highway Administration (FHWA). This ITS Planning Process is shown in Figure E- 1. The FHWA established this process to assure that all of the ITS early deployment planning studies are conducted in a uniform manner, and that all of the required factors and issues are addressed. The first eight steps in this process were completed as part of the current project. The remaining two steps involve the actual implementation of the projects that are selected on the basis of these initial activities.

The essence of the ITS Planning Process is to develop each ITS Program on the basis of the needs of the users and operators of the transportation facilities. Although the process is the same nationwide, the results are customized in each community to address their particular set of local needs.

As shown in Figure E-l, the Strategic Deployment Plan is the final step of the ITS Planning Process. This plan provides guidance for the Pennsylvania Turnpike to incorporate ITS technologies into their transportation improvement projects. The plan outlines the steps taken as part of the ITS planning process including results of interviews, data collection activities, and analyses. Finally, the plan also identifies various projects incorporating ITS application, their phasing, priorities, and how they help meet the goals and objectives identified in the User Service Plan.

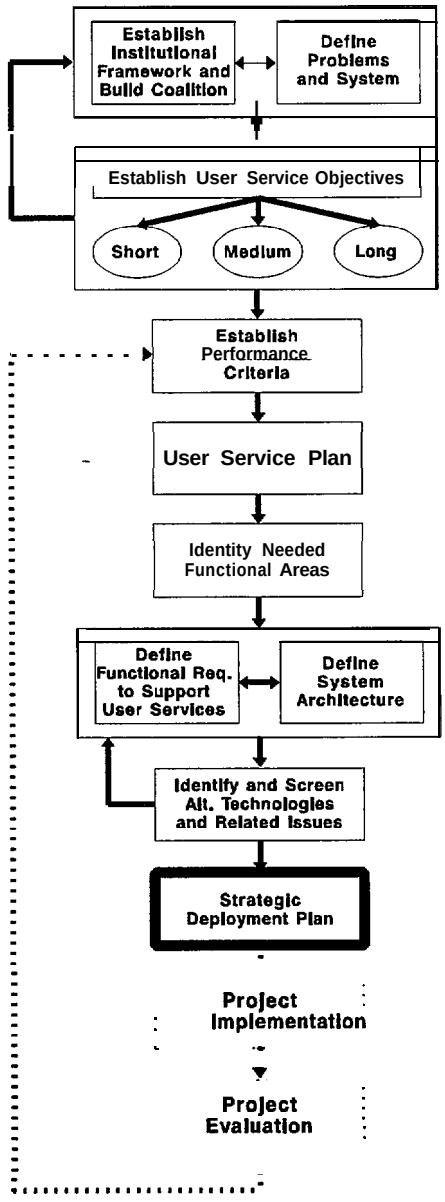

FIGURE E-1
ITS PLANNING PROCESS

2.0 EXISTING AND PROPOSED SYSTEMS

The Pennsylvania Turnpike forms a vital transportation link within the eastern portion of the nation connecting Pennsylvania with Ohio in the west and with New Jersey in the east. Through interchanges with other major highways, the Turnpike also connects Pennsylvania to New York, West Virginia, Virginia, Maryland and Delaware.

2.1 Turnpike Traffic Volumes

Traffic entering the Pennsylvania Turnpike in 1994 has grown 4.2% from the previous year. Passenger vehicles accounted for 87.7% of the 1994 traffic volume while the remaining 12.3% were commercial vehicles. It should be noted however, that commercial vehicle traffic accounted for 46% of the total revenue collected by the Turnpike during 1994. In addition, the 7.2% increase in commercial vehicle traffic between 1993 and 1994 was almost twice the percent increase in passenger vehicle traffic.

Turnpike interchanges with the greatest traffic volumes are in the Philadelphia area, Interchanges 24 thru 28. A second series of heavy interchange volumes exists around the Pittsburgh area at Interchanges 3 thru 8. The interchanges in these two metropolitan areas account for more than 50% of the total vehicles entering and departing the Turnpike system.

The increase in commercial vehicle volume at key interchanges on the Turnpike from 1993 to 1994 emphasizes the increasingly important role the Pennsylvania Turnpike plays throughout the eastern portion of the nation and within Pennsylvania in commercial transportation. Available system-wide data indicates that the length of an average truck trip, 60.8 miles, is nearly twice the length of an average passenger vehicle trip, 3 1.9 miles.

2.2 Accident Data

The Turnpike Commission is continually working to improve the safety conditions along the highway. This emphasis on safety is partially reflected in the low rate of injuries and fatalities on the highway. Despite these safety improvements, there are still several areas that are accident "hot spots." An identification of mile-long segments with a higher number of accidents was performed as part of the project using accident data from 1992, 1993 and 1994. A summary of accident locations is provided in Figure 3 of the Strategic Deployment Plan.

2.3 Incident Management

The response to incidents occurring on the Turnpike has been well organized. Three primary methods for identifying incidents are available to Pennsylvania Turnpike motorist and include push button call boxes, cellular * 11 telephone service, and emergency 800 telephone service.

Since 1989 a system of push button call boxes placed at one-mile intervals along the Turnpike mainline has been used for identifying incidents. In recent years the motoring public has also played

an increasing role in the reporting of incidents through the Turnpike's * 11 cellular telephone number which is directly linked to the Communications Center. Data from 1992, 1993 and 1994 indicate that the number of *11 calls and calls to the Turnpike's emergency 800 number substantially exceeds the number of requests for assistance received through the call boxes.

The Turnpike also utilizes the communication system in the Pennsylvania State Police vehicles, maintenance trucks, and staff vehicles to relay messages of incidents that have been detected by Turnpike personnel traveling on the roadway. In addition, the Pennsylvania State Police Troop T patrols monitor CB channel 9 for requests for assistance.

The Turnpike has several operational characteristics in place and has also adopted several procedures to expedite response and clearance of incidents once they are identified. Perhaps the most significant of these is the use of the Communications Center for the dispatching of both Turnpike personnel and Troop T of the Pennsylvania State Police. The Turnpike has also established contract service agreements with many fire and rescue departments, and ambulance services located near the roadway which allow these resources to be quickly mobilized. On-site coordination of the response and clearance of major incidents is handled through the Incident Command System that has been adopted for use by the Turnpike and the State Police. The response to these major incidents is also facilitated by preexisting arrangements with the operators of heavy duty wrecker and recovery equipment, and with firms specializing in the clean up of incidents involving hazardous materials.

2.4 Communications Center

The Turnpike's Communication Center plays a key role when incidents occur on the Turnpike as well as providing ongoing communications support for normal maintenance and law enforcement activities. Unfortunately, many of the key features of the communication system, such as the microwave radio system, have major components approaching twenty years in age. While several plans for upgrading the communication equipment have been proposed, only improvement to the microwave system has been funded to date. The funds necessary to provide the Communications Center with additional state-of-the-art equipment have not been allocated.

In spite of the ever increasing volume of communications traffic, the Turnpike's Communications Center functions today with virtually the same number of people that it did 30 years ago. The situation, in part, results in an increased need for overtime work by the existing personnel. Data from 1992, 1993 and 1994 show an average annual overtime requirement that amounts to approximately three extra people, assuming an eight-hour workday. Between 1992 and 1994 the annual cost of overtime work by Communications Center personnel climbed from $90,000 to more than $130,000.

2.5 Coordination with Existing and Proposed ITS Projects

In addition to the Pennsylvania Turnpike, the Pennsylvania Department of Transportation (PennDOT) and the I-95 Corridor Coalition are also moving ahead with ITS projects in Pennsylvania. PennDOT District 4-O will soon begin an early deployment study for a motorist advisory and incident management ITS project for the area around W&es-Barre and Scranton. District 6-O has constructed

a limited ITS installation on I-95 in Philadelphia that includes closed circuit television (CCTV) units and Variable Message Signs (VMS) and will implement a traffic monitoring and incident management system for I-476 (Blue Route) during 1996. District 6-O is planning for the installation of CCTV units and VMS on U.S. Route 202 from Ring of Prussia southwest to U.S. Route 30. District 11-O is proceeding with the final design of a traffic surveillance and advisory system on the Penn Lincoln Parkway in Pittsburgh that will extend from the Turnpike Interchange 6 near Monroeville to the I-79/I-279 interchange. This District is also involved with an early deployment study for installation of ITS technology along the I-79 corridor extending from Washington to Erie.

The I-95 Corridor Coalition has several initiatives under way in the Philadelphia area. The Coalition is currently focusing on short-term early action ITS improvements aimed at improving motorist information systems and is also studying longer term actions which are likely to focus on a uniform electronic toll collection system integrated communications and a corridor-wide traveler information system.

3.0 INSTITUTIONAL FRAMEWORK

The Pennsylvania Turnpike Commission (PTC), as an independent agency of the Commonwealth of Pennsylvania, operates under the direction of a five-member Board of Commissioners. The Commissioners, one of whom is the Pennsylvania Secretary of Transportation as an ex-officio member, are appointed by the Governor and approved by the Pennsylvania State Senate.

3.1 Toll System Operation and Revenue Sources

Revenues for the operations and maintenance of the Turnpike are secured primarily from user tolls. Trust indentures established in conjunction with the sale of bonds require an independent Consulting Engineer, currently Michael Baker, Jr., Inc., to provide ongoing review of Turnpike operations and maintenance. Baker issues an annual report summarizing the condition of the toll road, revenues and expenditures. With the exception of emergency work and bonds for expansion, all technical projects to be implemented by the Turnpike must be included on the Reserve Maintenance Fund Program.

3.2 Turnpike Interface with Other Agencies

The operation and maintenance of the Pennsylvania Turnpike are generally carried out exclusively by its various operating divisions. Involvement with outside agencies is limited to necessary coordination with PennDOT regarding roadway system interface, other turnpike authorities at the system termini, and other state or federal review agencies as required by state or federal statute.

In general, reconstruction projects and existing system improvements are implemented by the Turnpike through its engineering department. Approval and review of these projects are primarily internal except for coordination with PennDOT and other state permitting agencies. However, for system expansions or existing system improvements involving federal funding, the level of involvement by PennDOT and the Federal Highway Administration increases substantially and includes review and approval of all project phases.

3.3 ITS Project Design Development

Design development and implementation of an ITS program will involve input from many of the functional departments of the Turnpike. Currently, the Turnpike has an internal committee "the ITS Working Croup" that review ITS program design parameters, establish implementation schedules, and measure system performance. As established during the strategic deployment study, it would be useful to maintain a second advisory committee that includes representatives from the Turnpike's internal committee, PennDOT and FHWA to provide direction and guidance to the PTC as well as coordination with other agency ITS projects.

A third advisory committee should be established consisting of Turnpike system users. This source of input should be continued through either a formalized advisory committee or informal meetings with various Turnpike user groups.

3.4 Funding of ITS Projects

Several funding scenarios are available for the design and construction of ITS projects including both public and private sources.

The utilization of Turnpike funding is potentially available for both design and construction of ITS projects. Availability is contingent upon the project being included on the annual improvement program. All ITS projects, including those that are initiated and funded wholly by the Pennsylvania Turnpike Commission, will require coordination with outside agencies.

As permitted under the 1991 Intermodal Surface Transportation Efficiency Act (ISTEA) legislation, federal highway funds could potentially be utilized in conjunction with matching PTC funds. The availability of FHWA funding is controlled by PennDOT, and in metropolitan areas such as Philadelphia and Pittsburgh, by the Delaware Valley Regional Planning Commission and the Southwestern Pennsylvania Regional Planning Commission, respectively. The level of FHWA funding could range from 50% to 80%.

Recent experience in the ITS marketplace and input gathered from various Turnpike users indicates a high potential for a public/private partnership to fund installation of select ITS projects. This could involve a mix of PTC, private, and potentially federal in-kind contributions toward the design and construction of specific ITS applications.

4.0 PROBLEM DEFINITION AND OPPORTUNITIES

A major component of the work performed on this project has been the identification of key problem areas and issues that can be addressed through the use of ITS technologies. The first step in identifying these key problem areas and issues was developing an understanding of the Pennsylvania Turnpike system and how it functions as a major transportation link within Pennsylvania and surrounding states. This initial step consisted of gathering and assimilating current data regarding the existing Turnpike system.

The data review established the basis for collecting additional information through meetings, interviews, surveys of Turnpike users, and surveys of individuals and groups associated with the Turnpike. The objective was to identify the key system problems and issues to be addressed in this project. Data collected included:

- **Pennsylvania Turnpike Patron Survey** - more than 400 individual patron surveys were conducted.
- **AAA Patron Survey/Irwin Park & Ride** - 29 commuters using the Irwin Park & Ride lot were interviewed and AAA administered 177 interviews to their members.
- **Commercial User Group Survey** - Nineteen commercial trucking firms participated in the commercial user group survey.
- **AAA Representative Interviews** - A focus group meeting was conducted with representatives from six affiliated AAA clubs in Pennsylvania, as well as representatives from the Pennsylvania Federation of AAA and the Pennsylvania Travel Council.
- **Interviews with PennDOT District Staff and Other Agencies** - Interviews with representatives from seven PennDOT District offices, the Ohio Turnpike, and West Virginia Department of Transportation were conducted.
- **Commercial Vehicle Operators** - As part of the patron surveys conducted at the Pennsylvania Turnpike rest areas, truck drivers and bus drivers were interviewed.
- **Interviews with Traffic Information Providers** - Interviews were conducted with traffic information providers serving Pittsburgh, Harrisburg and Philadelphia.
- **Bus Companies** - Interviews were conducted with three commercial bus operators.
- **Major Traffic Generator Interviews** - Interviews were conducted with four major traffic generators.
- **Interviews with Pennsylvania Turnpike** Staff - Interviews with Pennsylvania Turnpike staff members have been conducted to help identify problems and potential ITS solutions regarding Turnpike operations.

4.1 Synthesis of Problems and Opportunities

Based on the system data collected, compiled, and obtained from these meetings, interviews and surveys, a comprehensive list of Turnpike system problem areas and issues that could be addressed by ITS technologies was established. This list is shown in Table E-l. Priorities were assigned to these statements, as shown in parentheses, on a scale of 3 to 6 with three being the lowest and six being the highest priority.

TABLE E-l
SUMMARY OF PROBLEM AND OPPORTUNITY STATEMENTS

TRAVEL AND TRANSPORTATION MANAGEMENT

- Determination of incident characteristics is sometimes inefficient. (6)
- Timely and accurate information about incidents, delays, alternate routes and weather is not adequately shared with travelers and traffic information providers. (6)
- "Good Samaritan" calls are sometimes inaccurate. (6)
- Communication Center needs upgrading to match increased activity & responsibilities (6)
- Alternatives are needed for two-way operation of vehicles in tunnels (6)
- Congestion at selected toll plazas should be reduced. (6)
- Traffic information providers are interested in operating systems (4)
- Bus drivers want advance notice of congestion at service plazas **(4)**

I'RAFFIC DEMAND MANAGEMENT

- Minimal efforts are being made to encourage car-pooling. (4)
- Off-Peak travel should be encouraged. (4)

ELECTRONIC PAYMENT

- Electronic Payment system should be useable for other Turnpike services. (6)
- Existing credit card system needs reporting & cancellation improvements. (3)

COMMERCIAL VEHICLE OPERATIONS

- Hazmat permit process should be coordinated with requirements of other agencies. (6)
- Distribution of construction, weather & traffic information to drivers and dispatchers should be enhanced. (6)
- Vehicle location systems are being utilized by several large operators. (6)

(x) - Assigned priorities, on a scale of three to six, with three being the lowest and six being the highest priority.

5.0 USER SERVICE OBJECTIVES

The May 1994 Draft of the "National Program Plan for Intelligent Vehicle-Highway Systems" (IVHS) established six "bundles" which represent logical groupings of the then recognized 28 IVHS User Services. The March 1995 release of the "National ITS Program Plan" reorganized these user services into seven bundles and reflected the addition of Emissions Testing and Mitigation, the 29th user service. The most recently suggested user service, Centralized Information Management, has been added within the Travel and Transportation Management bundle by another ITS deployment study. Table E-2 shows the most current listing of the user service bundles and all 30 of these user services.

5.1 Relationship Between ITS User Services and Problems

The next step in establishing the User Service objectives was to establish the relationships between the statements of ITS related problems and opportunities and the ITS User Services for the following bundles:

- Travel and Transportation Management
- Travel Demand Management
- Electronic Payment
- Commercial Vehicle Operations

The User Services were ranked on the basis of their relationships to the problem and opportunity statements and their ability to be implemented. These two sets of rankings were combined to produce a composite ranking of the ITS User Services and establish the short-, medium-, and long-term implementation priorities. These results, together with specific objectives and typical improvement programs for each identified ITS User Service are shown in Table E-3.

6.0 PERFORMANCE CRITERIA

Performance criteria will be used to quantify and document the degree to which the ITS User Services are achieving their objectives. This evaluation of the performance of the User Services is an essential part of the ongoing process of improving the overall operation of the Pennsylvania Turnpike. Documentation of these improvements will also play an important role in securing additional funding for further enhancements.

The process of selecting these performance criteria involved identifying the characteristics of desirable criteria, developing a list of candidate performance criteria for each User Service, reviewing these candidate criteria with the project steering committee, and selecting the recommended criteria with the aid of the steering committee. The selected performance criteria are shown in Table E-4.

TABLE E-2
ITS USER SERVICES

Travel and Transportation Management

- En-Route Driver Information
- Route Guidance
- Traveler Services Information
- Traffic Control
- Incident Management
- Emissions Testing and Mitigation [1]
- Centralized Information Management [2]

Travel Demand Management

- Pre-trip Travel Information
- Ride Matching and Reservation
- Demand Management and Operations [3]

Public Transportation Operations

- Public Transportation Management
- En-Route Transit Information
- Personalized Public Transit
- Public Travel Security

Electronic Payment

- Electronic Payment Services

Commercial Vehicle Operations

- Commercial Vehicle Electronic Clearance
- Automated Roadside Safety Inspection
- On-Board Safety Monitoring
- Commercial Vehicle Administrative Process
- Hazardous Materials Incident Response
- Freight Mobility [4]

Emergency Management

- Emergency Notification and Personal Security
- Emergency Vehicle Management

Advanced Vehicle Control and Safety Systems

- Longitudinal Collision Avoidance
- Lateral Collision Avoidance
- Intersection Collision Avoidance
- Vision Enhancement for Crash Avoidance
- Safety Readiness
- Pre-Crash Restraint Deployment
- Automated Highway Systems

1 Added July 1994
2 Added by COMPARE Project
3 Renamed from Travel Demand Management
4 Renamed from Commercial Fleet Management

TABLE E-3
ITS USER SERVICE OBJECTIVES AND TYPICAL IMPROVEMENT PROGRAMS

ITS User Service	Specific Objectives	Typical Improvement Programs
En-Route Driver Information	Warn drivers of dangers and delays	Highway Advisory Radio (HAR) and Variable Message Signs (VMS)
Electronic Payment Services	Facilitate Commercial Vehicle Operations (CVO) & reduce congestion at toll plazas	E-ZPass and Credit card system improvements
Incident Management	Improve timeliness and accuracy of information	Surveillance, improved location markers & Call Boxes, upgrade Commo, weather monitoring
Centralized Information Management	Improve availability of real-time incident data	Real-time database, Local and Wide Area Networks
Pre-Trip Travel Information	Forewarn travelers of major incidents	Information system upgrades for roadway and weather conditions
Traffic Control	Improve safety in tunnels during maintenance	Lane control signals and VMS at tunnels
Commercial Vehicle Administration Process	Reduce Hazardous Material (HAZMAT) permit requirements	Permitting information system upgrade
Freight Mobility	Facilitate CVO and improve productivity	Traffic and Toll Account Information System upgrades
Hazardous Material Incident Response	Improve information and coordination at HAZMAT incidents	Give responders phone numbers of CVO dispatchers
Demand Management and Operations	Reduce peak hour travel	Park & Ride Lot program, time-of-day price differential
Ride Matching and Reservation	Increase auto occupancy	Support existing car-pool matching programs
Traveler Services Information	Reduce congestion at service plazas	Monitoring systems and HAR/VMS

Key:

Short-term Priority Medium-term Priority Long-term Priority

TABLE E-4
RECOMMENDED PERFORMANCE CRITERIA FOR THE ITS USER SERVICES

ITS USER SERVICE	PERFORMANCE CRITERIA
En-Route Driver Information	Motorist perception of message quality and accuracy as indicated through surveys and complaints.
Electronic Payment Services	Number and/or percent of electronic transactions. Length and duration of backup at toll lanes. Comparisons of backup on ETTM and non-ETTM lanes. Maximum number of days required to open/cancel an account.
Incident Management	Average duration of incidents by type. Average length of the backup behind the incident. Frequency and severity of secondary accidents. Number and/or percent of false alarms that are identified before assistance is dispatched.
Centralized Information Management	Number of tunes incident related data is entered or retrieved. Perception of the availability of information by Turnpike personnel and others.
Pre-Trip Travel Information	Volume reduction at selected interchanges during major incidents. Number of calls to Turnpike traffic/weather information line. Motorist perception of the quality of pre-trip travel information as indicated through surveys and complaints.
Traffic Control (at Tunnels)	Number or severity of accidents during restricted operations. Number of encroachments or violations of lane restrictions.
Commercial Vehicle Administration	Number of pages or lines on the required forms. CVO perception of the streamlining of required administrative procedures as indicated through surveys and complaints.
Freight Mobility	Estimated Number of ton-miles. Number of tons at selected toll plazas (estimated from vehicle class). Number of tolls paid by trucks at selected toll plazas.
Hazmat Incident Response	Average incident duration for Hazmat incidents, by type. Number of calls to CVO dispatchers of vehicles involved within 1/2-hour.
Demand Management & Operations	Number and/or percent of autos with 2+occupants. Ratio of vehicles operating in “off-peak periods” and/or “peak periods” by vehicle class. Percent of car pools based on surveys.
Ride Matching & Reservation	Number and/or percent of autos with 2+occupants.
Traveler Services Information	Motorist perception of parking availability and the quality of other traveler services information as indicated through surveys and complaints.

7.0 RESPONSIBILITIES OF THE TURNPIKE AND OTHER ORGANIZATIONS

The responsibilities of the various public and private sector organizations involved in the implementation of ITS User Services are identified in a series of discussions based around the individual core group of twelve User Services that are of interest to the Turnpike. A complete series of definitions for these User Services is contained in Appendix H of the Strategic Deployment Plan. Although all of these User Services are of interest to the Turnpike, there are several in which it has no, or very little, direct responsibility. This does not mean that these User Services should be dismissed from further consideration. However, it does indicate that the Turnpike may play a supporting role rather than a lead role in their implementation.

8.0 FUNCTIONAL REQUIREMENTS

The twelve Core User Services identified in the User Service Plan can, to a greater or lesser degree, be implemented using some or all of the functional areas associated with that service as identified in the National ITS Program Plan (NPP) The selection of the preferred set of functions began with a review of these functions. The set of functions listed in the NPP for a given user service represent a "full deployment" configuration; however, it is not necessary to use the full functionality to implement a given user service. Other system configurations which do not provide full functionality can be appropriate for the initial phase of implementation or as an interim step in the ITS implementation process. The advantages of an alternative configuration for the short term are reduced capital expenditures and early deployment of some aspects of the user services to customers.

The process of generating alternative system configurations began by first identifying the most basic functions required for a given Core User Service. This basic set of functions represents the minimum amount of functionality that could be used to implement the Core User Service. Additional alternatives were derived by selecting additional functions that would upgrade the basic configuration to provide extra capability. This additive process was continued until most or all of the functions defined in the NPP for the given Core User Service were included. Other user services were represented by a number of independent options that can be implemented alone or in conjunction with one another.

The analysis of identified alternative system configurations was based on two sets of factors. The first set of factors addresses aspects related to the difficulty of successfully implementing the alternative system configurations. A second set of factors, derived from the National ITS Program Plan, assesses the degree to which the alternative system configurations satisfy regional goals for the Pennsylvania Turnpike.

A preliminary comparison of alternatives for each user service was performed by plotting the ratings for the satisfaction against the implementation diiculty ratings. In essence, this is similar to a benefits and costs comparison. In this analysis, the benefits are all relative assessments of the degree to which the regional goals are satisfied by each alternative and the costs are relative assessments of the difficulties that will be encountered in implementing the alternative.

A recommendation of the preferred system configurations for each Core User Service was selected based on a combination of factors that included the goal satisfaction to implementation difficulty ratios, as well as discussions with the Turnpike Steering Committee to take into account their judgement and knowledge regarding Turnpike operations and potential funding constraints. These preferred system configurations are shown in Table E-5. A detailed list of projects to achieve the preferred system configuration can be found appended to this document.

TABLE E-5
SUMMARY OF PREFERRED SYSTEM CON-FIGURATION RECOMMENDATIONS [1]

Priority	User Service	Recommended System Configuration
&a Pe mf-	En-Route Driver Information	Improved Variable Message Signs + Highway Advisory Radio System + Telephone Link to En-Route Information + Upgraded Kiosks at Service Plazas
	Electronic Payment	Electronic Toll and Traffic Management (E-ZPass)
	Incident Management	Mobile Phone Notification + Surveillance + Variable Message Signs + Highway Advisory Radio
	Centralized Information	Improved E-Mail + Widespread Paging System
	Pre-Trip Travel Information	Interjurisdictional Information System
5„ 5 45 St-	Traffic Control	Signal Control + Variable Message System
	Commercial Vehicle Administration	Electronic Filing of Credentials + Haztnat Permit Information on Transponder
	Freight Mobility	Add Credit Card Phones to Select Areas
	Hazmat Incident Response	Provide Hazmat Database Access
	Demand Management & Operations	Off-Peak Toll Discounts/On-Peak Toll Surcharges
	Ride Matching & Reservations	An alternative was not recommended for this user service because the user service does not significantly help achieve the regional goals of the Turnpike.
LONG TERM	Traveler Services Information	Telephone Link to Traveler Service Information

[1] A detailed list of the projects to achieve the recommended system configuration is appended to this report.

9.0 SYSTEM ARCHITECTURE

System architecture refers to the way components are connected together to form an integrated system capable of many tasks. In this report, the components are the existing and recommended tools that the Turnpike can use to provide the core User Services that have been identified as part of this ITS Strategic Deployment Plan and presented in Table E-3.

The ITS system architecture design is based on several major design concepts which reflect the overall system requirements for the Turnpike. Since the Strategic Deployment Plan serves as a guide for future ITS project implementation, the design concepts are additional recommendations that should be followed in implementing the projects and user services. The following is a list of the major design concepts:

Redundancy all mission critical equipment at, the Communication Center should be backed up by a redundant piece of equipment. This feature prevents a system breakdown in the event of equipment failure or a disaster.

Open System Design - the system should be based, to the extent possible, on a hardware and software independent (or "open") design. This provides the consumer with hardware and software choices without as much risk of obsolescence that is inherent in proprietary systems.

Modular System - allows economical expansion of the intelligent transportation system as technologies improve and system needs change. The independence of the modules or subsystems also provides less risk of a system breakdown in the event of equipment failures or operator error.

Centralized Processing - most of the information collected by roadside equipment and other sources are communicated to the Turnpike headquarters for processing and storage. This design approach provides superior security and better control of critical tasks.

Communication Backbone - is based on a communications infrastructure "backbone" over which high volumes of data are efficiently transmitted from roadside equipment and remote facilities to the Turnpike Headquarters. The linear character of the Turnpike right-of-way and infrastructure closely matches the "backbone" topology.

Integrated Control and Display - should be used to provide Turnpike operators at the Communications Center maximum productivity and minimum response time to urgent situations. By integrating control and display features on the workstations, there is less need for operators to physically access separate equipment in order to initiate a system task or command.

Semi-Automatic Operation - this approach optimizes response time and resources for the situation at hand by presenting an operator with the appropriate options that are retrieved from a library of responses.

The system architecture was based around three broad categories of system components based on geographic location and relationship to Turnpike operations: Roadside Equipment; Headquarters Equipment; and Remote User Equipment-

Roadside equipment provides all of the infrastructure for collecting information including traffic conditions, weather, electronic toll transactions, equipment operation, help requests, etc. In addition, the roadside equipment consists of fixed-location equipment for disseminating information to the Turnpike patrons, e.g., variable message signs (VMS), highway advisory radio (HAR), and TravelBoards at the service plazas. Without the physical infrastructure provided by the roadside equipment, the Turnpike cannot collect and disseminate the information that is part of an intelligent transportation system.

The headquarters equipment consists of local and wide area networks, workstations, and subsystems that process data and control equipment. This equipment serves the staff of the Pennsylvania Turnpike and the Pennsylvania State Police. Subsystems process the information that is collected by roadside equipment and perform specific tasks such as provide information on weather conditions, process electronic toll transactions, and allow control of video cameras.

There is a total of 13 subsystems proposed to provide the Core User Services identified in this ITS Strategic Deployment Plan. The term "subsystem" is used here to represent a group of physical components that perform a task in the overall ITS system; for example, video control, incident and work zone management, or weather monitoring.

Workstations provide the operator interface for controlling the subsystems and the roadside equipment. The workstations allow Turnpike operators and other employees at the headquarters building to retrieve information, issue system commands, and communicate with others.

The Local Area Networks (LAN) and the Wide Area Network (WAN) consists of the hardware and software necessary for providing data and digitized video communications between different elements of the system. This includes cabling, network servers, bridges and routers, software, and any other equipment required to operate the network. The LAN provides data transmission between the workstations and the subsystem components including the central processing equipment. The WAN connects devices on the LAN to remote user equipment so that communication is provided to Turnpike personnel in the field, patrons, and other parties outside of the Turnpike. Security features are built into the WAN so that unauthorized access is not provided to outside parties.

Remote user workstations provide Turnpike field personnel with access to the centralized equipment located at the Turnpike headquarters. For example, the E-ZPass system can send packets of electronic toll transaction data to the central computers for processing or, a maintenance person at a remote location can check on equipment repair records stored on a central database located at the Turnpike headquarters building.

Remote user equipment consists of FAX machines, portable computers, pagers, and other portable devices that can be used to get information or otherwise communicate to equipment and/or staff at the Turnpike headquarters or elsewhere. For example, a Turnpike patron could request weather and

traffic information from a telephone or a maintenance person could be notified of an incident via their pager.

Detailed diagrams of the recommended system architecture are shown in Section 9, Figures 10 and 11 of the ITS Strategic Deployment Plan and detailed descriptions of all subsystems are presented in Appendix 0.

10.0 IMPLEMENTATION PLAN

10.1 Projects Implementing the User Services

Table E-5 shows the major projects that are associated with the User Services. Section 10 of the Strategic Deployment Plan contains a complete listing of the projects that implement various functions associated with the user services. This listing includes the major projects and other projects that are associated with them. A detailed explanation of these projects is provided in Appendix P. Figure E-2 contains the project description for the CCTV system as an example of the material contained in these descriptions.

10.2 Funding

These ITS projects compete with other construction and maintenance projects for funding from the Turnpike's revenues. Suggested supplementary funding sources that could be utilized in implementing ITS projects are as follows:

The Inter-modal Surface Transportation Efficiency Act of 1991 provides opportunities to use federal funds on toll facility improvement projects. If this funding becomes available to the Turnpike, ITS elements within the project limits should be incorporated into these construction projects so part of their implementation cost can be provided through federal matching funds.

Discussions should be opened with PennDOT concerning subcontracting with the Turnpike for use of the Turnpike's communications infrastructure, and for the Turnpike's operation of ITS elements located on PennDOT roadways near the Turnpike. Mutually acceptable agreements would benefit both parties and provide a fair return to the Turnpike that offset the additional costs that would be incurred.

A dedicated revenue stream should be established for ITS projects from advertising that is "sold" on ITS related improvement projects. The sources for this revenue stream may include the "sale" of CCTV pictures to the Media; the placement of advertisements on VMS units, the enhanced telephone information system, and the Internet Home Page; and fees charged to major trip generators whose periodic activities require the display of alternate access routes and other increased activities by the communications center personnel.

FIGURE E-2
SAMPLE PROJECT DESCRIPTION

Project	CCTV Installation (TS20)
Priority:	High
Prerequisites:	Implementation of Fiber optic network or Microwave system improvements. (TWl0 or SCl0)
Comments:	Should be staged in limited areas in conformance with communication system upgrades and "hot spot" analysis.
Justification:	Provides operations staff, managers, administrators and commissioners with a view of accidents, weather conditions, maintenance, construction and other activities and conditions in areas where cameras are installed. Particularly useful in assessing accident severity and the types of assistance that are required at accident sites. Cameras at toll plazas could be used to assess backup at the toll plazas and the need for additional toll lanes or collection personnel.
Funding:	In many jurisdictions local TV stations broadcast pictures of traffic as part of their news coverage and have paid the costs associated with transmitting these pictures from the Traffic Operations Center to the TV studio. In New Jersey, one private sector business is paying the costs of camera installation in return for exclusive broadcast rights. The Turnpike should be able to "sell" its CCTV pictures to local stations whose viewers are regular Turnpike users.

Appendix

HARRIS

PENNSYLVANIA TURNPIKE COMMISSION

APPENDIX

PROJECTS IMPLEMENTING USER SERVICE F'UNCTIONS

PROJECTS IMPLEMENTING USER SERVICE FUNCTIONS

Traffic Surveillance Function

Project TSl0	Probe Vehicle Monitoring
Project TS20	CCTV Installation

Weather Surveillance Function

Project WSl0	Deploy Weather & Roadway Monitoring Sensors
Project WS20	Exchange Weather & Roadway Monitoring Information w/ PennDOT

Variable Displays Function

Project VDl0	Provide Traveler Information on Travel Boards
Project VD20	Variable Message Sign Installation

Individual Traveler Interface

Project IT10	Enhance Turnpike Traveler Information System
Project IT20	Establish a Home Page for the Turnpike on the Internet

One-Way Communications

Project OW 10	Implement HAR System

Two-Way Mobile Communications

Project TWl0	Upgrade Microwave Communications System
Project TW20	Upgrade Communications Center operation w/Additional Operators
Project TW30	Install a Computer Aided Dispatch System for Police and Maintenance Personnel
Project TW40	Upgrade Communications to Troopers and Maintenance Personnel

Stationary Communications

Project SC 10	Implement Fiber optic Communications System
Project SC20	Upgrade Local Area Network at Turnpike Headquarters for Traffic Management System Compatibility
Project SC30	Upgrade Wide Area Network for Traffic Management System Compatibility

Traffic Control

Project TCl0	Provide Tunnel Lane Control Signal Status Monitoring at the Communications Center
Project TC20	Install VMS Units Upstream of Crossovers for Tunnels
Project TC30	Provide Automatic Truck Rollover Warning Signs at Selected Locations

Traffic Control Data Processing

Project TDl0	Install Lane Control / VMS Interconnect for Two-way Tunnel Operation

Database Processing

Project DP10	Implement Automated Coordination and Broadcast of Information on Bulletin Board, FAX, Pager, and Travel Board, etc.
Project DP20	Implement Automated Coordination of HAR and Telephone Information Messages
Project DP30	Establish a Database with Information for Hazmat Carriers

Interagency Coordination

Project IC10	Check/Update Existing Broadcast Fax System
Project IC20	Investigate Sharing of Operations Center Facilities & Personnel w/PennDOT
Project IC30	Investigate Sharing of Communication System Upgrades w/PennDOT
Project IC40	Obtain CCTV Pictures from PennDOT Cameras
Project IC50	Exchange Traffic Flow & Lane closure information w/PennDOT, ODOT, NJ Turnpike

Payment Systems

Project PS10	Legislation Enabling Photo based Toll Violation Ticketing
Project PS20	Investigate/Change Restrictions on the Placement of Transponders on Widows
Project PS30	Implement E-ZPass on Turnpike

Commercial Vehicle Operations Projects

Project CV10	Make Account Information Available to CVOs
Project CV20	Make Location Information (from transponders) available to CVOs
Project CV30	Improve and Simplify Hazmat Permit Processing
Project CV40	Identify Private Sector Partner to Provide Truck Staging Areas Near Interchanges
Project CV50	Add Additional Pay-Telephones at Select Locations
Project CV60	Incorporate Hazmat Permit Information onto E-ZPass Tag

Complementary Projects

Project CP10	Identify Private Sector Funding Opportunities for ITS Initiatives
Project CP20	Install Incident Alert Flashers at Turnpike Facilities
Project CP30	Provide Additional Location Markers Between Mile Markers
Project CP40	Upgrade Larse Telemetry System
Project CP50	Obtain authorization to collect surcharges for peak-period trips and short trips
Project CP60	Encourage Ride-Matching Activities by Others
Project CP70	Develop Automated Systems for Collecting Performance Measures